

Safe Use of Liquid Nitrogen Operational Procedure

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Operational Procedure for the Safe Storage, Use and Transport of Liquid Nitrogen

Introduction

It is the aim of NHS Lothian that all persons handling, storing and using Liquid Nitrogen are fully aware of the risks posed and are not exposed to unnecessary danger. This guidance has been produced in order to meet this aim. Line Managers need to bring the guidance to the attention of those with specific responsibilities for Liquid Nitrogen storage and dispensing facilities and all staff who dispense and/or use Liquid Nitrogen in their work.

This guidance has five sections: -

Section 1 Hazards

Outlines the main hazards associated with Liquid Nitrogen.

Section 2 Precautions

Describes the precautions to take to prevent anyone coming to harm.

Section 3 Training

Details the training necessary for persons handling Liquid Nitrogen

Section 4 Small Scale Use of Liquid Nitrogen

Describes measures necessary when handling Liquid Nitrogen on a laboratory/clinic scale.

Further and more comprehensive information can be found in the British Compressed Gases Association's Code of Practice CP30 - "The Safe Use of Liquid Nitrogen Dewars up To 50 Litres", rev 2, 2013.

For the purpose of this Procedure the term dewar shall mean a vacuum insulated vessel operating at less than 0.5 bar(g).

Section 5 Bulk Storage of Liquid Nitrogen

Describes measures necessary for bulk storage facilities.

Further and more comprehensive information can be found in the British Compressed Gases Association's Code of Practice CP36-"Cryogenic liquid storage at user's premises", re 2, 2013 and the British Compressed Gases Association's Code of Practice CP39 –module 1 "In-service requirements of cryogenic storage system at user premises", rev 1, 2016.

1. Hazards

Liquid Nitrogen is a colourless, odourless liquid boiling at -196°C. It is not toxic and does not support life or combustion. The density changes with temperature and critically below 5.5°C, the gas is heavier than air. As a liquid the gas will expand to 683 times its volume.

1.1. Cold Burns and Frostbite

Exposure of skin to very low temperatures can produce effects similar to a burn. Prolonged exposure to cold can result in frostbite. If unprotected skin should come into contact with a very cold surface it may stick fast as the natural moisture on the skin is frozen. Flesh can be torn whilst trying to break free therefore appropriate Personal Protective Equipment should always be worn (see Section 2.2).

All cold burns must be reported to a first-aider for treatment. Such treatment would include:

- for a severe burn calling an ambulance
- flushing the area with tepid water but, in order to avoid tissue damage, a forceful flow of water should NOT be used
- not applying direct heat
- moving the casualty to a warm place (approximately 22 C, 70 F)
- continuing to flush the affected area of the skin with tepid water
- loosening the casualty's clothing and removing any tight jewellery
- keeping the patient warm and at rest
- not allowing the patient to smoke and avoiding hot beverages

1.2. Oxygen Deficiency (spillages & venting/leaking dewars)

Upon evaporation Liquid Nitrogen will expand to 683 times its volume. It will cause asphyxiation if it is at a concentration sufficient to displace the Oxygen in a room. Especially at risk are areas with little or no air movement, particularly enclosed spaces with little or no ventilation. In this case a specific risk assessment is required. There is little or no warning to the individual that s/he is in an Oxygen deficient atmosphere. Asphyxiation will take one of two forms:

Sudden Asphyxia - in sudden asphyxia i.e. inhalation of a gas containing practically no Oxygen, unconsciousness is immediate. Death can follow in a few minutes unless immediate remedial action is taken.

Gradual Asphyxia - sudden asphyxia is the most common form encountered but gradual asphyxia can occur as Oxygen levels in the atmosphere decrease. Symptoms are shown below:

Oxygen in Air, Signs and Symptoms of Persons at Rest

21% 14%	to	First signs of anoxaemia are that depth of breathing increases, pulse rate accelerates. There is reduced ability to maintain attention and think clearly. Muscular co-ordination is disturbed.
14% 10%	to	Still conscious but judgement faulty, may feel less pain from serious injury. Muscular effort leads to rapid fatigue. Emotions are disturbed – irritation and anger can appear.
10% 6%	to	Rate of breathing is doubled, may get nausea and vomiting. There is a loss of ability to perform vigorous muscle movements or even to move at all. There is a lack of awareness that anything is wrong. Legs may give way. Even if resuscitated may result in permanent brain damage.

Less than Respiration is in gasps with increasing gaps. Convulsions may occur.
6% Respiratory arrest then cardiac arrest within a few minutes

As with cold burns and frostbite any oxygen deficiencies must be reported to a first-aider for treatment.:

The victim may well not be aware of the asphyxia. If any of the following symptoms appear in situations where asphyxia is possible, immediately remove the affected person to the open air, following up with artificial respiration if necessary:

- (i) Rapid and gasping breathing.
- (ii) Rapid fatigue.
- (iii) Nausea.
- (iv) Vomiting.
- (v) Collapse or incapacity to move.
- (vi) Unusual behaviour.

1.3. Effect of Cold on the Lungs

Inhalation of cold vapour or gas can damage the lungs. Short exposures produce discomfort in breathing whilst prolonged exposure can cause more serious effects.

1.4. Oxygen Enrichment

The low temperature of Liquid Nitrogen can cause Oxygen to condense out of atmospheric air. This can occur around cold pipe work, valves and in open dewars. This Oxygen enrichment may result in increased flammability and explosion risk. Oxygen enriched liquid must not be allowed to come into contact with oil, grease or flammable materials as spontaneous combustion can occur.

1.5. Ice Plugs

Ice plugs may form in the neck of open dewar flasks and cause a build-up of pressure. As the pressure rises within the dewar, the ice plug may be expelled at high velocity or in extreme cases the pressure may build up sufficiently to rupture the vessel. Serious injury can result. If an ice plug be found extreme caution should be exercised and the area immediately vacated.

Advice on how to deal with an ice blockage should be sought from the gas supplier or dewar manufacturer.

Ensure that the manufacturer examines the dewar before returning it to service. Ice plugs can be prevented by diligent use of the correct dewar stopper.

1.6. Manual Handling

The Manual Handling Operations Regulations apply to the handling of liquid nitrogen dewars. Irrespective of the size or type of dewar, users shall carry out a manual handling assessment on the activities operators are required to perform. The Manual Handling Operations Regulations do not cover injury due to liquid spill. It is recommended that users include this in their risk assessments.

Under the Management of Health and Safety at Work Regulations employers are required to make a suitable and sufficient assessment of the risks to the health and safety of their employees while at work.

NOTE: Health and Safety Executive (HSE) guidance recommends that female workers should not lift loads greater than 16 kg.

2. Precautions

2.1. Safe Systems of Work & Risk Assessment

Equipment and systems of work should be designed, operated and maintained to reduce the risk of an accidental spillage. In the event of a spillage the quantity of Nitrogen that might be spilt should be minimised. To this end a risk assessment of the dangers posed must be undertaken in each area where Liquid Nitrogen is either used, transported or stored.

2.2. Personal Protective Equipment

The following Personal Protective Equipment must be worn when handling Liquid Nitrogen. Please note, all PPE must be CE marked.

Eyes: face visor (to protect both the eyes and face).

Hands: Cryogenic liquid handling gloves. Gauntlets are not recommended as liquid could collect in them.

Body: overalls, lab coat or similar are recommended. In order to avoid collection of liquid, such clothing should preferably not have pockets, and trousers should not be tucked into boots or have turn-ups. Open footwear must not be worn and legs should be covered.

2.3. Manual Handling

Keep the vessel upright at all times, except when pouring liquid from dewars specifically designed for that purpose.

Handle with care at all times as rough handling can cause serious damage to the dewar and spillage. Do not 'walk', roll or drag dewars. Always protect the vessel from severe jolting and impact. Do not allow the dewar to come into contact with chemicals or other substances which could promote corrosion.

Be careful to avoid spillage during handling. This could lead to cold burns or oxygen depletion. Even small spills will damage labelling.

2.4. Ventilation

Ventilation of Liquid Nitrogen storage areas depends on several factors e.g. volume of room, amount of Liquid Nitrogen stored and evaporation rates. For rooms above ground level with no special ventilation openings, natural ventilation will provide typically one air change per hour. With well-sealed windows eg double-glazing, this will be less. Basement rooms may only average 0.4 changes per hour.

For general handling of Liquid Nitrogen, vessels in locations at or above ground level, natural ventilation is generally sufficient provided the room is large enough. An indoor₅

location should have ventilation openings provided which are at least 1% of the floor area and positioned diagonally opposite with the main opening at ground level.

Cold Nitrogen gas is heavier than air and will accumulate at low level. Where possible Liquid Nitrogen should not be handled in basement rooms, rooms with ventilation at high level only, and rooms where the gas can be trapped in gullies, ducts or pits.

Rooms should be adequately ventilated to allow normal evaporation of vessels and evaporation during filling without the Oxygen concentration falling below 19.5%. In addition, the complete spillage of the contents of the largest vessel should not allow the Oxygen concentration fall below 18%. Oxygen monitors should be put in place.

2.5. Emergency Procedures

Emergency procedures should be prepared by the Manager, taking into account possible spillages and venting/leaking dewars.

2.5.1. Writing an Emergency Procedure

The following should be considered when formulating such a procedure:

- raising the alarm
- summoning help and emergency services.
- oxygen monitors should be used to check the atmosphere before occupation.
- isolating the source of leakage if appropriate and where it is safe to do so
- evacuation of persons from the danger area and preventing access. Remember persons in pits, basements, cellars, stairwells, lower floors etc
- ventilation of the area by opening exterior doors and windows, where safe to do so. This will allow Liquid Nitrogen to evaporate naturally. Do not try to clean it up.
- alerting neighbours to possible dangers from vapour clouds and evacuate where necessary
- preventing reoccupation of the area until all gas has dispersed.
- oxygen concentration should be checked before occupation.

Note: After the Liquid Nitrogen spillage has been isolated Oxygen deficiency checks should be carried out in any enclosed areas where the vapour cloud may have entered. This includes basements, pits and confined spaces. Staff likely to be involved must be clear about the actions required to minimise any adverse effects.

3. Training

All personnel handling Liquid Nitrogen and those directly involved in the commissioning, operation and maintenance of Liquid Nitrogen storage systems must be fully informed and trained regarding the hazards; in particular Oxygen deficient atmospheres, cold burns and emergency procedures. The training must be arranged to cover those aspects and potential hazards that the particular person is likely to encounter. Training should cover, but not necessarily be confined to, the following subjects for all personnel:

- potential hazards of Liquid Nitrogen
- site safety rules
- handling procedures e.g. method of dispensing, sample retrieval, transportation

- use of protective clothing/apparatus including breathing sets where applicable
- emergency procedures
- first aid treatment for cryogenic burns

All training must be formally recorded with refresher training undertaken periodically at least every 3 years.

4. Small Scale Use of Liquid Nitrogen (Up to 50 litres)

4.1. General guidance

Liquid Nitrogen is used in laboratories, clinics and health centres as a refrigerant and for the treatment of skin lesions by cryosurgery. Although used in smaller quantities the same hazards are present and the risks must be assessed.

4.1.1. Precautions during use (it is the responsibility of the ward/department using the dewar to ensure that it is safe for use)

The following precautions should be observed:

- Only proprietary insulated containers e.g. dewars, must be used for holding Liquid Nitrogen. They should be clearly and adequately labelled including basic safety information, transport labelling information and gas supplier contacts e.g.



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- Check first that the dewar is in good condition and do not fill if:
 - the dewar is damaged, including damage to seals
 - there is water or ice inside
 - there is excessive frosting around the neck
- Filling should be undertaken in a well ventilated area to prevent Oxygen depletion. Only dewars labelled for use with Liquid Nitrogen should be filled. Never fill a dewar labelled for another product. Glass dewars should be protected in a metal outer container with a secure, ventilated lid and a carrying handle.
- Never overfill dewars
- Pouring Liquid Nitrogen or immersing items should be done slowly to minimise boil off and splashing. Use tongs or similar tool when placing objects into or removing from Liquid Nitrogen.
- Treat dewars and insulated flasks with care. Even minor impacts may lead to slow or catastrophic loss of vacuum. Trolleys and tipping trolleys should be used for vessels of 25 litres and above.
- After the removal of samples from Liquid Nitrogen storage, be aware of the danger of sudden overpressure of the sample vial. This can occur when Liquid Nitrogen has entered the vial during storage and its rapid vaporisation when exposed to ambient temperature. Do not remove your face visor until the samples have thawed and you are sure that all the Nitrogen has evaporated.

- Leaving dewars and insulated flasks of Liquid Nitrogen open can allow Oxygen to condense and give rise to the risk of explosion/fire if allowed to contact flammable solvents, oil or grease.

4.1.2. Storage of Dewars

The precautions for the safe storage of dewars should apply whether they are full, part full or empty. The storage area should be dry, have adequate ventilation and be capable of being viewed from the outside ie through a window. Storage rooms with mechanical ventilation should have an alarm fitted outside the room to indicate failure. Unauthorised access should be prevented.

4.1.3. Transport

4.1.3.1. Transporting Around a Building

When transporting containers of Liquid Nitrogen care must be taken to ensure they are not left, even temporarily, in an enclosed space due to the risk of Oxygen depletion. Do not drag dewars along the floor. Trolleys should be used for vessels of 25 litres and above

4.1.3.2. Transporting In Passenger Lifts

Procedures must be in place to ensure that no-one travels in a lift with Liquid Nitrogen; the unexpected evaporation of relatively small quantities of Liquid Nitrogen can reduce the available Oxygen to a dangerous level in a standard size passenger lift.

Where lifts have to be used, either (i) use a lift which can be remotely controlled ie key controlled lifts; or (ii) one person places the dewar in the lift whilst another meets the lift at the designated floor (if this procedure is used a suitable qualified person must be at every floor if lift covers multiple floors to ensure no person can enter lift whilst Liquid Nitrogen is being transported). In both cases the dewar travels unaccompanied. This activity should be supervised by competent persons who are aware of the potential hazards and the appropriate emergency action.

4.1.3.3. Transporting In a Vehicle

Liquid Nitrogen should never be transported by car for the following reasons:

1. Spillage of Liquid Nitrogen in a car (or other unsuitable vehicle) could result in asphyxiation through Oxygen depletion.
2. Spillage can cause serious damage to the car's interior. For example contact with the spare wheel will make the tyre lethally dangerous if subsequently fitted to the car.
1. The driver will not be covered by their own or the NHS Lothian's insurance policy.

For carriage by vehicle the following precautions should always be adhered to:

- vehicles used for the transport of Liquid Nitrogen should be designed to prevent a build up of Nitrogen gas in the event of a leak or spill. This can be achieved by provision of adequate high and low level vents to encourage a free-flow of air through the load compartment and a bulkhead to prevent escaped gas reaching

the passenger compartment. They should be equipped with means of securing the dewar.

- dewar caps may come loose during transportation. A retaining device should be fitted which keeps the cap in place but does not seal the dewar e.g. a short piece of chain or wire.
- in the case of a road accident the emergency services must be advised that Liquid Nitrogen is being carried. Dewars should be labelled adequately before being transported by road.
- drivers must be adequately trained regarding the hazards of Liquid Nitrogen.

4.1.4. Maintenance of Dewars

The following checks to be carried out regularly; for dewars used infrequently this should be <6 monthly:

- condition of the cap
- damage to seals
- twisting or other damage to the neck
- damage to the dewar body, trolley and wheels
- interior is free of dirt or other contaminants; including insulating bungs which may have detached from the cap and fallen in
- liquid withdrawal devices free from damage

4.1.5. Disposal

Liquid Nitrogen should never be poured down a sink as waste pipes will crack offering the potential for gas leaks into occupied areas. Unwanted Liquid Nitrogen should be allowed to evaporate in well ventilated areas, preferably outside.

4.2. Specific Guidelines for Clinics and Health Centres

The quantities of Liquid Nitrogen used in clinics and health centres are generally small e.g. 2 litres per week, however appropriate delivery, storage and use of the Liquid Nitrogen is essential to safeguard staff and other persons who may be affected.

This guidance appreciates that there are storage limitations in this type of building and that due to changes in care facilities, areas which house dewars may from time to time change in their use and the dewars be located elsewhere.

It is the general expectation that dewars will be refilled every few months. In order to prevent unnecessary wastage through evaporation, the dewar should be fitted with a liquid withdrawal device. This will have the added benefit of ensuring that transfer of Liquid Nitrogen is easier and safer than pouring and ensuring that the dewar is unlikely to be knocked over causing spillage. This coupled with the supply of information, instruction, training and supervision to staff will ensure a safe system of work is implemented.

In order to meet most of the criteria in buildings where Liquid Nitrogen is stored and used, the following minimum recommendations have been identified and careful consideration made regarding these when identifying a storage area:

- dewars need to be filled in an area external to the building to avoid the risk of Oxygen depletion
- a dewar of a minimum capacity 25 litres, to aid stability, with a liquid withdrawal device and roller base should be used
- the dewar must be stored on the ground floor to avoid transporting up stairs

- secure access to the area in which the dewar is stored is necessary
- appropriate Personal Protective Equipment must be provided (see Section 2.2)
- staff with access to the storage area must be trained in the hazards posed by Liquid Nitrogen
- staff involved in the use of Liquid Nitrogen must be aware of the hazards and the appropriate method of decanting, including the wearing of appropriate face protection, gloves and clothing as a minimum level of Personal Protective Equipment
- after decanting, two members of staff should ensure that the valves on the liquid withdrawal device are properly closed
- the storage area must be labelled appropriately (see Section 4.1.1). The storage area must be capable of being viewed from the outside
- ventilation openings must be provided which are at least 1% of the floor area and positioned diagonally opposite with the main opening at ground level
- a maintenance regime for the dewars is implemented and documented (see Section 4.1.4)

By following these guidelines the risk of cryogenic burns and /or asphyxiation will be minimised.

5.0. Bulk Storage on Liquid Nitrogen

Where bulk storage of Liquid Nitrogen takes place, the installation must conform to the British Compressed Gases Association's Code of Practice CP36.

5.1. Siting of Liquid Nitrogen Bulk Storage Facilities

Storage installations should be situated in the open air in a well-ventilated position and where there is no risk of damage by passing vehicles. Storage tanks should be at the same level as the tanker parking area to enable the operator/driver to control the transfer operations.

Tanks below 2,000 litres may be installed internally but always following all the requirements of the Code of Practice CP36.

The storage tank shall be clearly labelled "LIQUID NITROGEN"

Operating and emergency instructions shall be provided by the gas supplier and shall be available and understood by the user before commissioning the installation. These instructions shall be kept up-to-date.

Consideration shall also be given to the use of oxygen monitors where ventilation arrangements are poor and it is not practical to increase natural ventilation or install forced ventilation.

5.2. Operation

The following must be observed:

- The installation shall be so designed that authorised persons shall have easy access to and exit from the operating area of the installation at all times. Warning notices shall support this.
- Only authorised persons shall be allowed to operate the installation.
- Operating instructions shall be supplied to operating personnel. The instructions shall define the safe operating limits of the system and include the necessary

safety information relating to the product and the installation. In general such instructions should be written and presented in a clear concise. Risk assessments must be carried out and recorded.

- For the convenience of the operator the supplier may colour code or identify by other means the hand wheels of these valves which are to be shut in an emergency.
- If during the operation of the installation an excursion occurs outside the safe operating limits of the system (e.g. overpressure, rapid temperature change), or mechanical damage, this shall be reported immediately to the gas supplier and/or tank owner so that a decision about the continued use of the tank can be made and a programme of inspection drawn up by a competent person and implemented. Any operating difficulty or emergency, concerning the installation that does not respond to measures covered by the instructions, shall be referred to the gas supplier.
- All personnel involved shall be fully informed regarding the hazards associated with cryogenic gases and properly trained as applicable to operate or maintain the equipment. Training shall be arranged to cover those aspects and potential hazards that the particular operator is likely to encounter. It is recommended that the training be carried out under a formalised system and that records be kept of the training given. The training programme should make provision for refresher courses on a periodic basis.
- Any modifications made to the installation must be agreed with the Nitrogen supplier prior to implementation.
- Warning signs must be displayed e.g see below



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5.3. Permit to Work

Before maintenance or pressure testing is carried out on the installation, a written Permit to Work for the particular type of work (i.e. cold work, hot work, entry of vessel, pressure test, electrical work etc.) should be issued by an authorised person to the individual(s) carrying out the work.

5.4. Periodic Inspection and Maintenance

All aspects of in service inspections and maintenance are addressed in the British Compressed Gases Association's Code of Practice CP39 and the details for cryogenic systems are contained in the British Compressed Gases Association's Code of Practice CP39, Module 1, *In-service requirements of cryogenic storage system at user premises*. Storage tanks are required to be rigorously inspected and approved by the Competent Person during manufacture and thereafter be periodically endorsed by the Competent Person as being fit for continued service.

The facility should be inspected regularly to ensure that it is maintained in a proper condition. Periodic and planned maintenance of the installed equipment must be carried out by a competent person. This work should include:

- External vessels and pipe work
- Inner vessel
- Vapourisers
- Pressure relief devices
- Ancillary equipment
- Isolation valves

All inspection and maintenance work should be recorded.

5.5. Emergency procedure

Emergency procedures shall be prepared by the user to cover the eventuality of a spillage of liquid cryogenic gases so that persons likely to be affected shall know the actions required to minimise the adverse effects of such spillage.

Consideration should be given to the carrying out of practical exercises.

The following are guidelines which may be used for formulating emergency procedures:

- (i) Raise the alarm.
- (ii) Summon help and emergency services.
- (iii) Oxygen monitor should be used to check the atmosphere before occupation.

- (iv) Notify the gas supplier.
- (v) Isolate the source of gases, if appropriate and where safely possible.
- (vi) Evacuate all persons from the affected area and seal it off.
- (vii) Alert the public to possible hazards from vapour clouds and evacuate when necessary.
- (viii) oxygen concentration should be checked before occupation.

After the liquid spillage has been isolated, oxygen enrichment / depletion checks should be carried out in any enclosed areas where the vapour cloud may have entered. This includes basements and confined spaces.

6.0 References

- The Health and Safety at Work Act 1974
- The Control of Substance Hazardous to Health Regulations 2002
- The Provision and Use of Work Equipment Regulations 1998
- The Manual Handling Operations Regulations 1992
- Health and Safety (Training for Employment) Regulations 1990
- Personal Protective Equipment at Work Regulations 1992
- European Regulation (EC) No 1272/2008 on classification, labelling and packaging substances and mixtures
- NHS Lothian Adverse Event Management Policy and Operational Procedure
- Risk Assessment. A brief guidance to controlling risks in the workplace HSE.INDG 163 (rev. 4)
- British Compressed Gases Association's Code of Practice CP30 - "The Safe Use of Liquid Nitrogen Dewars up To 50 Litres", rev 2, 2013.
- British Compressed Gases Association's Code of Practice CP36 - "Bulk cryogenic liquid storage at user premises", rev 2, 2013.
- British Compressed Gases Association's Code of Practice CP39 –module 1 "In-service requirements of cryogenic storage system at user premises", rev 1, 2016.