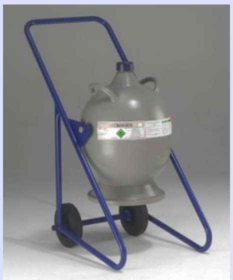
Safety Services Guidance



Guidance on storage and handling of cryogenic materials

Key word(s):	Cryogenic, liquid nitrogen, liquid helium, cardice, solid carbon dioxide, oxygen deficiency, cold burns, asphyxiation, liquid nitrogen traps (avoidance of).
Target audience:	Staff and students using cryogenic materials; those dispensing cryogenic materials or transporting vessels containing cryogenic materials.

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Introduction

1. Cryogenic materials are very cold liquid or solid substances used in a wide variety of processes in the University, and there are certain hazards associated with their use, such as cold burns, explosion and asphyxiation, for which specific guidance is appropriate and is provided below.

2. All Schools/areas in the University using these materials will need to ensure, so far as reasonably practicable, that risks are controlled, all persons handling them are fully trained in their use and that no-one is exposed to danger as a result of the School's activities.

Properties of cryogenic materials

3. Cryogenic liquids are liquids that exist between -66°C and -266°C. The most common cryogens used in the laboratory and research environment are liquid nitrogen, liquid helium, and solid carbon dioxide (dry ice), although there are others including liquid oxygen, liquid hydrogen and liquid argon. Some physical properties of these gases are given in the table below

Property	Oxygen (O_2)	Nitrogen (N_2)	Argon (Ar)	Helium (He)	Hydrogen (H_2)	Carbon dioxide (CO_2)
Molecular weight	32	28	40	4	2	44
Colour of gas	None	None	None	None	None	None
Colour of liquid	Light blue	None	None	None	None	None
Toxic	No	No	No	No	No	Mildly
Explosive/fire danger	Yes	No	No	No	Yes	No
Normal boiling point at P_{atm} (°C)	-183	-196	-186	-269	-253	-78.5 (sublimes)
Relative density of gas at P_{atm} (Air = 1)	1.105	0.967	1.380	0.138	0.09	1.48
Gas factor (*fg*) expansion ratio of liquid state to gaseous state	842	682	822	738	851	845 (solid)
P_{atm} = atmospheric pressure = 101.3kPa T_b = normal boiling point						

Risk assessment

4. All facilities where cryogenic materials are stored or handled must be subject to an initial risk assessment in which the potential depletion in oxygen concentration from the largest foreseeable spillage is calculated. The calculation is shown below.

5. If the calculation indicates that the oxygen concentration would fall below 19% consider if any of the following actions can be taken to reduce the quantity of gas held in the laboratory/room before considering fixed atmospheric monitoring equipment:

   - Use externally sited, bulk, compressed gas supplies with dedicated low-pressure pipework where available.
   - Relocate gas cylinders to an external, ventilated, secure storage area with gases piped into the building at the requisite pressure and flow. This is practical for ground and first floor rooms but is not a realistic option above the first floor due to difficulties gaining access for controlling flows for individual research work. Also cylinders located in areas with public access may be vulnerable to tampering.
   - Avoid keeping "spare" cylinders inside laboratories.
   - Avoid locating cylinders in small laboratories or rooms - keep processes requiring compressed or cryogenic gases in large rooms with good ventilation.
   - Where large gas cylinders are used infrequently or last a considerable length of time in practice, or could create an asphyxiating atmosphere in a small room then consider using smaller cylinders of gas.
   - Consider replacing Nitrogen cylinders by Nitrogen gas generators where applicable, which can be used to supply more than one item of equipment requiring Nitrogen.
   - Consider replacing Hydrogen or Helium cylinders (where Helium is used in preference to Hydrogen because of its inert characteristics) by Hydrogen gas generators where applicable, as the small volumes of gas produced by hydrogen generators pose no significant risk of fire or explosion in ventilated laboratories.
   - Cryogenic gases produce large volumes of gas per litre of liquid and spillages have the potential to create a deficiency of oxygen in a confined space, so minimise the volumes of cryogen taken for the work.

6. If, even after implementation of volume reduction measures, a risk of asphyxiation continues to exists, then the following options should be considered and the most appropriate implemented:

- Oxygen deficiency monitoring should be installed in those rooms containing compressed or cryogenic gases.
- Centralise gas cylinders and cryogen dewars in dedicated, well-ventilated rooms (or enclosures in rooms) containing oxygen deficiency monitoring equipment, and pipe compressed gas at the requisite pressure and flow to adjacent laboratories and equipment. Also decant cryogens to smaller vessels for use in unmonitored laboratories.

7. Risk assessments, written operating procedures and training are needed to cover the full range of hazards associated with storage and use of cryogenic materials, detailed guidance is given below.

Type and location of oxygen deficiency monitoring equipment

8. Where the risk assessment shows that mechanical ventilation and oxygen alarms are needed (i.e. oxygen levels could fall below 19%) there should be consultation with your University Safety Co-ordinator and Estates before any action is taken. The correct location for siting the monitor must be determined.

9. Where low oxygen alarms are installed:

- They should be mains powered (preferably with battery back-up), the control box located outside the door of the relevant laboratory/room, and warning siren and/or lights should warn both the room occupants and those outside the room of the hazard within. The sensor should be mounted in the room in an appropriate location for the type and location of gas. Hand-held oxygen deficiency monitors are not suitable for permanent monitoring installations
- They should not be set to activate at less than 19% oxygen.
- Written instructions of the action to take in the event of monitor activation must be prepared and displayed outside the facility.

10. However, fixed oxygen deficiency monitoring equipment is mains supplied and unlikely to have a battery back-up, so be aware that the equipment is unlikely to work during a failure of the electricity supply. Electrical supplies to oxygen deficiency monitoring equipment should be protected from accidental or malicious isolation as to do so could expose workers in laboratories to potentially asphyxiating conditions.

11. Oxygen deficiency monitoring equipment should be calibrated to alarm when oxygen concentrations fall below 19% (low level alarm) or exceed 23% (high level alarm) and should automatically reset (no alarm) when between these two values.

Maintenance of equipment

12. The manufacturer's instructions should be checked to determine the frequency of maintenance and oxygen deficiency sensor or battery replacement for the make and type of equipment you have. However, the oxygen deficiency sensor is likely to have a life expectancy of 12 - 18 months. To ensure that sensors are always operational they should be replaced every 12 months by a trained technician. Sensors should be purchased immediately before they are installed as they will deteriorate in storage.

13. Write the date the sensor was last replaced on a sticky label and affix it to the control unit outside the room, so that in the event of an alarm, the age of the sensor can easily be determined and hence the possibility of sensor failure being the cause of the alarm.

Oxygen deficiency and asphyxiation

14. The most significant risk of cryogenic liquids is death by asphyxiation where a spill or leakage depletes the atmospheric oxygen locally. If the oxygen concentration falls below 18% adverse effects will occur resulting in loss of mental alertness and performance combined with distortion of judgement. In atmospheres containing less than 10% oxygen death by asphyxiation is rapid: just two breaths of oxygen-free air kills.

15. If someone is discovered unconscious in a cryogenic handling or storage area there is also a serious risk of asphyxiation to the rescuers if they enter the facility. In such circumstances **do not enter** the room, but raise the alarm to evacuate the area and call the emergency services who are trained in entry into such spaces. **Do not open the door** to ventilate the room.

16. For cryogenic liquids other than oxygen the resulting oxygen concentration following a spill can be determined using the following equation:

$$Cox = \frac{100 \times Vo}{Vr}$$

where:

C*ox* = resulting oxygen concentration %
Vo = volume of oxygen, m^3
Vr = room volume, m^3
x = multiply

An example of the oxygen depletion resulting from a spill of the entire contents of a 50 litre Dewar of Liquid N2 in a room 5m x 10m x 3m is calculated below:

here

$$Vo = 0.21\left(Vr - \left(\frac{Vd \times fg}{1000}\right)\right)$$

where:
V*d* = volume of Dewar, litres
fg = gas factor (see table above)
0.21 = the normal concentration of oxygen in air, 21%
other symbols are as above

therefore

$$Cox = \frac{100 \times 0.21\left(Vr - \left(\frac{Vd \times fg}{1000}\right)\right)}{Vr}$$

$$Cox = \frac{100 \times 0.21\left(150 - \left(\frac{50 \times 682}{1000}\right)\right)}{150}$$

$$Cox = \frac{100 \times 0.21 \times 115.9}{150}$$

$Cox = 16.2\%$ This represents a hazardous atmosphere.

17. Note that in order to use such a simple calculation, significant assumptions have to be made that may not apply in practice. The most important of these are:

- that there is no removal of gas by natural or forced ventilation. Clearly, there will be some removal mechanisms in most cases, but quantification is difficult and unreliable. The calculation represents a worst case scenario.
- that there is efficient mixing of the gas. In practice, this will not be the case, and the assessor must be aware that pockets of higher concentrations (lower oxygen) will exist particularly in the early stages after release.

Note: To calculate the oxygen concentration when oxygen is the cryogenic liquid,

$$Vo = 0.21\left(Vr - \left(\frac{Vd \times fg}{1000}\right)\right) + \left(\frac{Vd \times fg}{1000}\right)$$

Cold burns, frostbite and hypothermia

18. Contact of the skin with cryogenic liquids (or even cold gas) can cause severe cryogenic burns; the tissue damage that results is similar to that caused by frost bite or thermal burns. While the cold itself can reduce the feeling of pain, the subsequent thawing of tissue can cause intense pain.

19. Contact with non-insulated and even insulated parts of equipment or vessels containing cryogenic liquids can produce similar damage e. g. cold pipework and other surfaces. Unprotected parts of the skin may stick to low-temperature surfaces and flesh may be torn upon removal. These risks should be controlled be separation or guarding, or if necessary, personal protective equipment.

20. Inhalation of cold vapour can cause damage to the lungs and may trigger an asthma attack in susceptible individuals.

21. Hypothermia is a risk due to the low temperatures arising from the proximity of cryogenic liquids. Risk is dependent upon the length of exposure, the atmospheric temperature and the individual; those exposed for prolonged periods should be warmly clothed.

Oxygen enrichment

22. Although oxygen itself is not flammable, when it is present in higher concentrations than in air it can significantly increase the chance of fire or an explosion.

23. 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 use where oxygen enrichment may occur.

24. For this reason, the risk assessment should address the question of whether a liquid nitrogen trap is really necessary, or whether the desired effect can be achieved with solid carbon dioxide.

Pressurisation and explosion

25. Cryogenic liquids vaporise with a volume change ratio of 700-900 and can thus cause violent changes in pressure, particularly if this occurs in a confined space.

This in turn can result in an explosion. Vent systems must be in place to allow gas to escape from confined spaces.

26. Pressurisation can occur due to the following:

- Ice forming on the venting tube, plugging it and preventing gas release
- Damaged equipment resulting in cryogenic fluids leaking into small areas, upon vaporisation the cryogenic liquid vaporises and causes pressure build up
- Loss of vacuum inside a cryostat or Dewar
- If a liquid helium-cooled superconducting magnet "quenches" (changes spontaneously from a superconducting state to a normal state)
- Liquid nitrogen having permeated through sealed cryotubes containing samples which then return to room temperature
- Direct contact of the cryogenic liquid with water in a tube results in rapid vaporisation of the cryogenic liquid and can cause the tube to explode

Damage to equipment and materials

27. The very cold temperatures of cryogenic liquids can damage equipment and materials, which can result in danger.

- Spilled liquid nitrogen can crack tiles and damage flooring such as vinyl. Special flooring is available.
- Rubber tubing may become brittle and crack during use.
- Condensation of water around electrical cables may result in an electrical shock hazard.

28. When carrying out refurbishment and new building projects careful choice of suitable flooring is required. For existing facilities the use of protective mats should be considered.

Flammable gas – hydrogen

29. Hydrogen is extremely flammable and should be treated with extreme caution. Areas of use should be restricted, clearly marked and well ventilated. No naked flames, electrical ignition sources, sources of static electricity, or potentially combustible materials should be allowed within the restricted area as any of these could result in an explosion if gas has escaped. An assessment under the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) will be required.

30. Liquid hydrogen can condense and solidify air resulting in an explosion hazard. For this reason closed hydrogen systems should be used to prevent backflow of air.

Manual handling of cryogenic storage vessels

31. The Manual Handling Operations Regulations 1992 apply to the handling of liquid nitrogen Dewars. Irrespective of the size or type of Dewar, users should carry out a manual handling assessment on the activities they are required to perform.

32. The following should be followed when moving Dewars:

- 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.
- Do not attempt to lift or move large, heavy vessels without assistance. Trolleys and tipping trolleys should be considered and are recommended for Dewars of 25 litres and above.

Emergency procedures

33. As part of the risk assessments for storage and use of cryogenic materials, each School should have written emergency procedures to deal with spillages, accidents and other unforeseen events, what action to take if the low oxygen alarm sounds and where to evacuate to. These will form part of the Local Rules and must be displayed in the area and made known to all users. Incidents resulting in injuries, and “near miss” events should be reported to Safety Services on the appropriate forms.

34. As a general rule, when the low oxygen alarm sounds, no-one should enter the room to investigate, and no-one should attempt to silence the alarm before the oxygen level recovers. The only exception to this is if they are wearing self-contained breathing apparatus, and this option will normally be available only to the emergency services.

35. In many circumstances, it will be adequate to allow the building ventilation system to raise the oxygen concentration to a safe level, without opening the door(s), and after this time, to try to reset the alarm. Re-entry into the room may be attempted with caution. No-one should attempt to re-enter alone; back up assistance should always be available. Hand held monitors should be used to check the automatic system indicators, and for the presence of any pockets of oxygen deficient air.

36. Information should be visible outside the room regarding emergency action, relevant contact details and action to take if people discover a problem or an alarm sounds ‘out of hours’.

Protective clothing

37. Personal protective equipment (PPE) must be worn when handling cryogenics. However, it is only there to prevent injury resulting from accidental spillage, splashes, contact with cold surfaces and explosion risks. Therefore working methods should be adopted which reduce the risk of spillage occurring. PPE IS NOT DESIGNED TO WITHSTAND IMMERSION IN CRYOGENIC LIQUIDS!

The equipment in the following table should be worn when handling cryogenic materials:

Face Shield	This should have a chin and brow guard to protect the user’s face and eyes against splashes
Gloves	Must conform to BS EN 511 (Cold Protection). For example, non-absorbent, insulated gloves, made from a suitable material such as leather that gives a good grip while handling and does not increase the chance of spillage. Two types are commonly available which should be loose fitting for easy removal: a) gloves with ribbed cuffs and b) gauntlet style. The latter are not recommended by the British Compressed Gases Association. Where possible sleeves should cover the ends of the gloves to prevent liquid splashing into them.
Body protection	Laboratory coats, overalls or similar type clothing should be worn. They should be made preferably without open pockets or turn-ups where liquid could collect. Trousers should be worn outside boots for the same reason. A splash resistant plastic apron may be appropriate.
Shoes	Should be top-sealed and preferably with sewn-in tongues. Open sandals or other loose-fitting shoes (or unlaced shoes) offer no protection in the event of spillage and should not be worn. If boots are worn, trousers should be worn over them to prevent spills running inside the boots.

General	Sleeves and trousers should be worn outside gloves and boots. All metallic jewellery should be removed because metal will quickly spread the cold from any contact with the cryogenic material possibly extending burns.

Tips on handling cryogenic liquids

- Ensure the vessel is dry and pour cryogenic liquids slowly into the receiving vessel to minimise splashing, spillage and thermal shock to the vessel
- Use tongs when placing objects into or removing them from cryogenic liquids
- Avoid use of wide-necked, shallow vessels to prevent excessive evaporation and the possibility of oxygen enrichment
- To check the level of the cryogenic liquid in a Dewar use the rule supplied with it. A garden cane is a suitable alternative
- When removing cell-line cages from storage use a hook to locate the handle and raise the cage
- Never overfill or use an un-vented Dewar
- Always fill small containers from an un-pressurised Dewar

Spillage procedures and notification

38. Minor spillage (< 1 litre)

- Allow liquid to evaporate, ensuring adequate ventilation
- Following return to room temperature, inspect area where spillage has occurred
- If there is any damage to the floors, benches or walls, report it to Estates using your School reporting mechanism
- If any equipment has been damaged following the spillage, inform the relevant person
- Always notify the School Safety Advisor and complete a University Incident Report form

39. Major spillage (> 1 litre)

- Shut off all sources of ignition
- Evacuate area of all personnel
- Inform named person(s) in School safety arrangements

- DO NOT return to the area until it has been declared safe by the School Safety Advisor or other competent person
- Notify Safety Services immediately Tel 64004 or Security (out of hours) 69966

Disposal

40. Care needs to be taken when disposing of cryogenic liquids.

- DO NOT pour cryogenic liquids down the sink - they will crack some sinks and waste pipes causing potentially dangerous leaks
- DO NOT pour cryogenic liquids across floors – it will damage floor covering and sub-floor
- DO NOT store cryogenic substances or allow them to vaporise in enclosed areas, including: fridges, cold rooms, sealed rooms and basements
- DO ensure that the area in which the cryogenic liquid is left to vaporise is well ventilated. Preferably do this in a fume cupboard.

First aid

41. Cold burns

- Remove any restrictive clothing - but not any that is frozen to the tissue
- Flush area with tepid water (not above 40°C) to return tissue to normal body temperature
- DO NOT apply any direct heat or rub affected area
- Cover with a loose, sterile dressing and keep patient warm
- Obtain medical assistance from a First Aider or Ambulance service.

42. Anoxia

- DO NOT attempt to rescue anyone from a confined space if they were working with cryogenic materials and have lost consciousness - raise the alarm and call the Fire Brigade and Ambulance service Tel: 9-999. Do not open the door.
- If someone has been exposed to an oxygen depleted atmosphere move them to a well-ventilated area immediately
- Seek medical help from a First Aider or Ambulance service as appropriate
- If breathing stops commence artificial respiration
- Keep them warm and at rest

43. Explosions

- If a tube or Dewar explodes injuring someone, seek immediate medical attention and notify Safety Services, Tel 64003/4

Installation

44. For typical lab usage follow requirements set out in British Compressed Gases Association (BCGA) Code of Practice 4. This covers systems carrying oxygen, argon, nitrogen, helium, carbon dioxide, hydrogen, methane, LPG and mixtures of these gases.

45. The checklist in Appendix 1 gives the requirements for a cryogenic storage area. Areas should be secure from unauthorised access.

46. Schools should keep a record of their cryogenic facilities including: Room No & Building; Room size; Type of cryogenic materials stored; Quantities e.g. 2 x 50litres, 3 x 20litres; Nature of associated hazards; Details of any O2 (or other) monitoring system present; Emergency contact information (Names & Tel Nos.)

Storage Vessels

47. Vessels for storage must be chosen carefully as the properties of many things change at very low temperatures. While most metals become stronger, other materials such as carbon steel, plastics and rubber become brittle or even stress fracture at such low temperatures. The vessel must be able to withstand both the temperatures and pressures that it will be exposed to.

48. Equipment and systems must be kept scrupulously clean to avoid contamination with materials that could be combustible should oxygen enrichment occur.

Dewars

49. Purpose designed, non-pressurised vacuum flasks used to store smaller quantities (ca.1-50 litres) of cryogenic liquids. They have loose fitting stoppers to allow boil-off. If any part of a Dewar is glass, it should be taped to prevent shattering should an explosion occur. While smaller Dewars may be hand-carried, larger ones are moved by purpose designed trolleys.

50. The risk assessment associated with small volume use should also:

- include the storage location – ensure cryogenic material is not allowed to evaporate in enclosed areas e.g. fridges, cold rooms, sealed rooms, basements

- take account of the transport route between storage location and point of use e.g. use of lifts, stairs
- give action to take following accidental spillage
- give details of any specific PPE required

51. **Note:** Transport of frozen samples within and between buildings should be done in dry ice whenever possible or using a dry shipper.

Pressurised vacuum-insulated vessels (PVIVs)

52. These are liquid storage vessels usually used for quantities greater than 50 litres and are self-pressurised. Each is individually marked on the shoulder to identify it and its test history. They vary in size, material composition, mass, stability etc.

- The PVIV must have an identifying label and a warning sign to indicate the nature of the contents
- Each vessel must be listed on the register of pressure vessels for inspection by a competent person
- A maintenance record must be kept for each PVIV. Maintenance checks should be carried out on a regular basis by the owner of the PVIV in accordance with BCGA Code of Practice 4
- Be aware of the safe working life for each item - they will need to be replaced at prescribed intervals

See also the University Safety Services toolkit on Pressure Systems.

Bulk storage and dispensing areas

53. Hazard-warning signs should be displayed to alert people to the presence of cryogenic liquids e.g. yellow/black warning triangle in all locations. Where flammable gas is present a prohibition notice showing No smoking, No naked flames and No combustible materials, must also be used.

54. These areas should also:

- Be restricted to the relevant personnel only
- Be no-smoking and no naked flame areas
- Be well ventilated, including make-up air
- Where identified following risk assessment, have an atmospheric oxygen monitor to detect for and warn about oxygen enrichment or deficiency
- Have a safe escape route and/or a means of rescue using breathing apparatus by suitably trained staff (Fire Brigade)

- Be designed specifically for use (bulk storage areas)

Further information on the storage of cylinders is provided in the BCGA Code of Practice 28.

Transportation

55. When transporting Dewars during day-to-day activities the following should be taken into consideration:

    - The correct personal protective equipment to be worn
    - Is the dewar free of damage?
    - Is the correct cap fitted to prevent spillage?
    - Is the destination ready to accept it?
    - Does the route take you through populated work areas, outside the building etc.?
    - Is there any slip or trip hazards (including stairs) which could result in spillage?
    - If transported on a trolley, is the route passable (steps, kerbs)?
    - Is the Dewar base/wheels suitable to prevent tipping?
    - Is the Dewar going to be transported in a lift? (see below)
    - Is there a contingency plan in case of spillage?

56. Transportation of liquid helium requires special attention, as the containers in which it is transported are specialised and relatively fragile.

Transportation by Lift

57. A lift is a confined space and should leakage of the cryogenic substance occur, anoxia or asphyxiation are potential dangers. Therefore:

    - DO NOT travel in the lift with the Dewar
    - One person should place the Dewar in the lift while another waits to receive the Dewar from the lift once the journey is complete
    - Use key controlled lifts whenever possible
    - Make sure that there is a clearly visible sign on the Dewar warning others not to enter the lift with the Dewar (sign available in Appendix 2).

Vehicular Transportation of Cryogenic Materials

58. Cryogenic materials are classed as Dangerous Goods for transport purposes and must not be transported in private vehicles. Transport must be performed by a courier if required. The appropriate packaging and labelling must be used and information must be provided as to what is being carried and its associated hazards in the documentation.

Training Requirements

59. Training should be given in all aspects of the use and handling of cryogenic materials. A combination of on-the-job skills, instructions and information covering the following areas provides a minimum standard to which all users must be trained.

- Understanding of the Safety Data Sheet (SDS), the risks involved and where to obtain information
- Understanding the risks and effects of oxygen depleted atmospheres
- Carrying out a risk assessment (including COSHH)
- Use of PPE
- Handling cryogenic materials
- Moving containers of cryogenic materials (>1 litre)
- Emergency procedures
- Spillage procedures

And, if necessary

- Manual handling of larger storage vessels
- Dispensing bulk quantities (> 1 litre)

60. Much of the training will be carried out as on the job training. This should be done by a named competent person and an individual training record must be kept for each person handling cryogenic substances.

61. Courses in Compressed & Cryogenic Gases and Manual Handling are also provided by the STDU. Contact Tel 52525.

Periodic inspections

62. Most large storage vessels will require periodic examination under the Pressure Systems and Work Equipment Regulations.

63. Schools should incorporate routine and regular inspections of cryogenic storage facilities and use of cryogenic materials into their programme of local inspections and checks.

References

The legislation below applies to the handling, storage and use of cryogenic materials and can be obtained using the Occupational Health and Safety Information Service (OHSIS) website via John Ryland's Library or Safety Services:

The Pressure Systems Safety Regulations (2000)
The Manual Handling Operation Regulations (1992)
The Control of Substances Hazardous to Health (COSHH) Regulations (2002)
The Confined Spaces Regulations (1997)
The Transportable Pressure Vessels Regulations (2001)
The Personal Protective Equipment (PPE) Regulations (1992)
The Management of Health and Safety at Work Regulations (1999)
The Carriage of Dangerous Goods by Road Regulations (1996)
The Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996
The Provision and Use of Work Equipment Regulations (1998)
The Dangerous Substances and Explosive Atmospheres Regulations (2002)

Cryogenic vessels - Cleanliness for cryogenic service BS EN 12300, BSI 1999, ISBN 0-5803-0386-1
Chemical Warehousing: the Storage of Packaged Dangerous Substances HS(G)71, HSE 2009, ISBN 9780717662371
"Safety of pressure systems" - Pressure Systems Safety Regulations 2000 and Approved Code of Practice L122 HSE 2000, ISBN 9780717617678
Manual Handling - Manual Handling Operations Regulations 1992 (as amended) - Guidance on Regulations L 23, HSE 2004, ISBN 9780717628230
Safe Work in Confined Spaces-Approved Code of Practice, Regulations and Guidance - Confined Spaces Regulations 1997 L101 HSC 2009, ISBN 9780717662333

Further Information

University Guidance on the use of Pressure Vessels and Systems

British Compressed Gas Association website http://www.bcga.co.uk. Their documents are also available via the OHSIS link above.

Appendix 1

Cryogenic Storage Facility Checklist

This checklist is provided as an aid for Schools to use when monitoring each location where bulk quantities of cryogenic materials are stored. Should the answer to any of the questions be NO, an action plan is required to address any short comings. For further advice, please contact your University Safety Coordinator or Safety Services (ext. 64003/4).

For each type of cryogenic material in each storage location:

Does the room have mandatory safety warning signs on the door?

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

Has the oxygen depletion following maximum spillage been determined?

Is there a warning device in case of:

a) oxygen enrichment/deficiency

b) failure of ventilation

Is there a written emergency protocol?

Is there a designated contact person in the case of emergencies?

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?

Is suitable PPE provided for handling the cryogenic materials?

Are there maintenance arrangements and records for the:

a) storage equipment (i.e. vessels, regulators)

b) ventilation equipment?

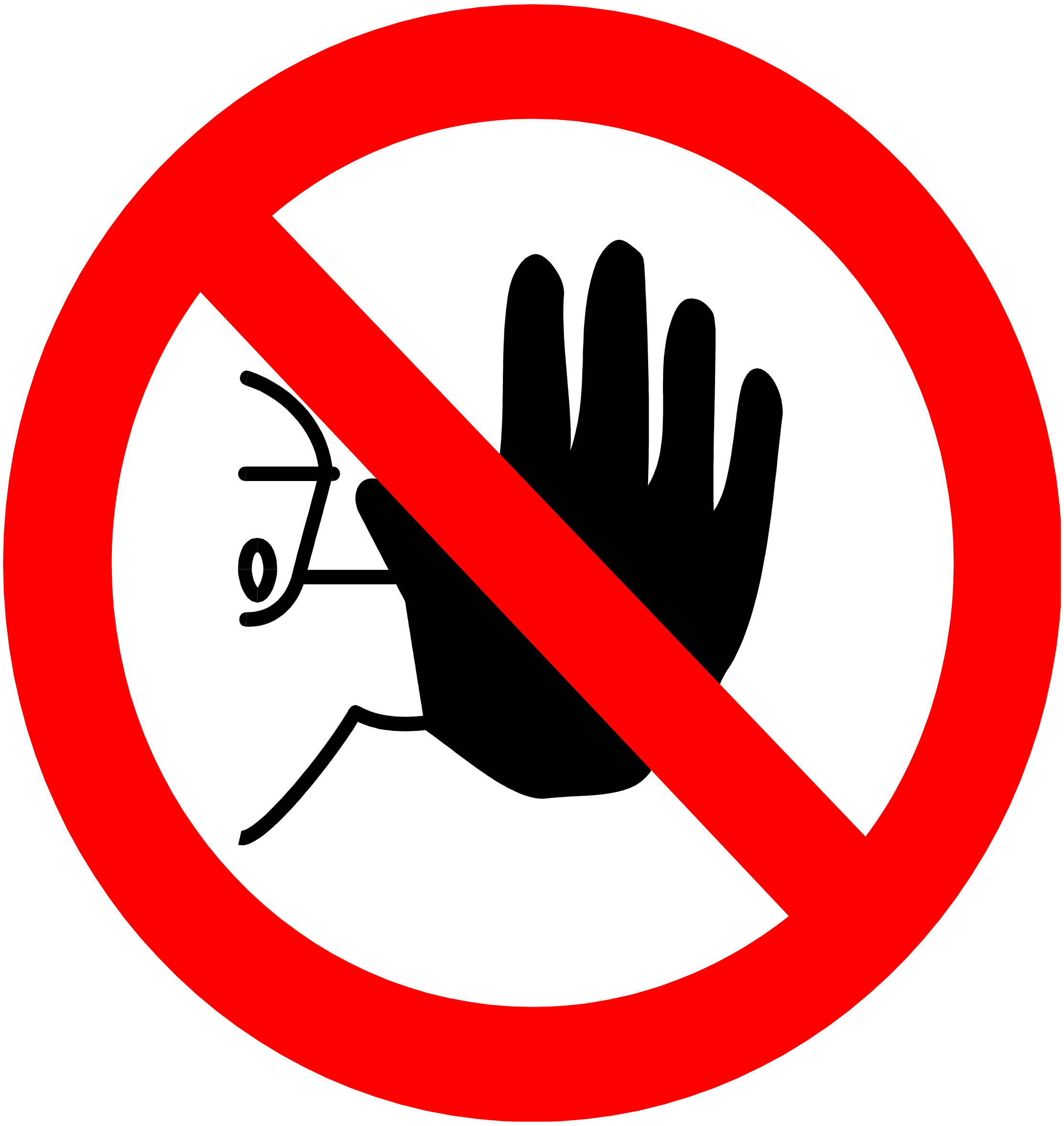
c) PPE?

Appendix 2

Safety Sign for Use When Transporting Liquid Nitrogen in Lifts.

The sign on the following page is suitable for use in these situations.

It must be printed in colour, and can be laminated to strengthen and protect during use.



No Entry
Liquid Nitrogen
in transit

Document control box	
Title	Guidance on storage and handling of cryogenic materials
Link to Policy or Chapter	University Health & Safety Arrangements Chapter 9 Health & Safety Risk Management and Risk Assessment – key principles.
Date first issued:	Mar 2006
Issued by:	Safety Services
Implementation date:	Mar 2006
Version:	1.6 (June 2017) personnel update 1.5 (April 2017) personnel update 1.4 (Aug 2016) personnel update 1.3 Apr 2015 1.2 March 2012 1.1 Jan 2008 1.0 Mar 2006 (as a code of practice)
Next review date:	On significant change
Owner of this document:	Head of Safety Services
Lead contact:	Safety Services