CODE OF PRACTICE 30

THE SAFE USE OF LIQUID NITROGEN DEWARS

REVISION 3: 2019

British Compressed Gases Association

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ISSN 2398-9440

PREFACE

The British Compressed Gases Association (BCGA) was established in l971, formed out of the British Acetylene Association, which existed since l901. BCGA members include gas producers, suppliers of gas handling equipment and users operating in the compressed gas field.

The main objectives of the Association are to further technology, to promote safe practice and to prioritise environmental protection in the supply, use, storage, transportation and handling of industrial, food and medical gases, and we produce a host of publications to this end. BCGA also provides advice and makes representations on behalf of its Members to regulatory bodies, including the UK Government.

Policy is determined by a Council elected from Member Companies, with detailed technical studies being undertaken by a Technical Committee and its specialist Sub-Committees appointed for this purpose.

BCGA makes strenuous efforts to ensure the accuracy and current relevance of its publications, which are intended for use by technically competent persons. However this does not remove the need for technical and managerial judgement in practical situations. Nor do they confer any immunity or exemption from relevant legal requirements, including by-laws.

For the assistance of users, references are given, either in the text or Appendices, to publications such as British, European and International Standards and Codes of Practice, and current legislation that may be applicable but no representation or warranty can be given that these references are complete or current.

BCGA publications are reviewed, and revised if necessary, at five-yearly intervals, or sooner where the need is recognised. Readers are advised to check the Association's website to ensure that the copy in their possession is the current version.

This document has been prepared by BCGA Technical Sub-Committee 6. This document replaces BCGA Code of Practice 30, Revision 2: 2013. It was approved for publication at BCGA Technical Committee 160. This document was first published on 23/07/2019. For comments on this document contact the Association via the website www.bcga.co.uk.

CONTENTS

* Throughout this publication the numbers in [ ] brackets refer to references in Section 15. Documents referenced are the edition current at the time of publication, unless otherwise stated.

TERMINOLOGY AND DEFINITIONS

Asphyxia	A fatal condition caused by a lack of oxygen. It may be accompanied by an excess of carbon dioxide in the blood (hypercapnia). Produced by interference with respiration or insufficient oxygen in the air.
Storage tank	The storage container from which the liquid nitrogen is transferred into the dewar.
Dewar	For the purposes of this Code of Practice the term *dewar* shall mean a mobile thermally insulated receptacle for refrigerated liquefied gases that operates below 0.5 bar pressure.
Inner vessel	The vessel containing the liquid nitrogen.
May	Indicates an option available to the user of this Code of Practice.
Mobile	Refers to the movement of an item within the confines of a site (as opposed to carriage on the public highway).
Outer vessel	The insulation container.
Pressure receptacle	A collective term that includes cylinders, tubes, pressure drums, closed cryogenic receptacles, metal hydride storage systems, bundles of cylinders and salvage pressure receptacles.
Shall	Indicates a mandatory requirement for compliance with this Code of Practice and may also indicate a mandatory requirement within UK law.
Should	Indicates a preferred requirement but is not mandatory for compliance with this Code of Practice.
Transport	Refers to the carriage of an item on the public highway.

CODE OF PRACTICE 30

THE SAFE USE OF LIQUID NITROGEN DEWARS

1. INTRODUCTION

This Code of Practice is intended for the guidance of users of liquid nitrogen dewars. All individuals involved in the handling, storage, filling, use or maintenance of liquid nitrogen dewars should have a knowledge of, and comply with, the requirements of this Code of Practice.

The objective of this Code of Practice is to promote safety by providing guidance and best practice for the handling, storage and use of dewars.

The *Management of Health and Safety at Work Regulations* [5] require all employers to assess risk, to implement control measures where necessary and to reduce the risk to an acceptable level. As such, safety management focuses on prevention.

Premise owners and users of gaseous equipment should ensure they have adequate insurance to cover their activities and that they use their gases and look after their gas equipment in a safe and responsible way. They should ensure their insurer is aware that there are gases on-site.

This code of practice is intended for use in conjunction with current guidance and information produced by the Health and Safety Executive (HSE) and other related bodies and trade associations.

2. SCOPE

This Code of Practice is for the safe storage, handling and use of dewars containing liquid nitrogen.

This code of practice only applies to the use of dewars and their contents, which are filled and used on site. Additional Regulations apply if the dewar and its contents are placed on the market.

For vessels that operate above 0.5 bar pressure refer to BCGA CP 27 [16] *Transportable vacuum insulated containers of not more than 1000 litres volume*.

Where dewars are used for the storage of samples, for example, biological, for additional information refer to BCGA GN 19 [21], *Cryogenic sample storage systems (biostores). Guidance on design and operation*.

Other cryogenic liquids, such as helium, oxygen and argon, are excluded from this code of practice, however, where they are contained in a dewar many of the same principles will apply, the specific properties of the individual gas should be assessed before its use. You

should always check with a competent person. As required, seek the advice of your gas supplier.

3. PROPERTIES AND HAZARDS OF NITROGEN

Each dewar shall have a label attached providing information on the product and basic safety advice, refer to Section 6.

It is a legal requirement that the supplier provides a Safety Data Sheet to the customer whenever a product is supplied for the first time. The Safety Data Sheet provides detailed information on the properties as well as advice on handling, storage and emergency procedures. These documents should be made available for the user of the gas.

Legislation requires that employers assess all safety and health risks and take appropriate measures to control hazards and risks. For liquid nitrogen this will include extreme cold and asphyxiation, refer to Section 3.2 and 3.3.

For additional advice on the hazard created by asphyxiant gases refer to HSE EH 40 [11], *Workplace exposure limits*, and BCGA GN 11 [20], *The management of risk when using gases in enclosed workspaces*.

The British Cryogenics Council, *Cryogenics Safety Manual* [24], provides additional information on the properties and hazards of cryogenic liquids.

3.1 Properties

Nitrogen gas is colourless, odourless and tasteless. It constitutes approximately 78 % of normal, atmospheric air. It is classified as non-toxic and does not support life or combustion. Some useful physical properties are detailed in Table 1.

Gas density at standard atmospheric conditions (1.013 bar(a) & 15 °C)	1.19 kg/m^3
Liquid temperature at standard atmospheric pressure (1.013 bar(a))	-196 °C
Liquid density at standard atmospheric pressure (1.013 bar(a))	0.8 kg/litre
Expansion ratio from liquid state to gaseous state (1.013 bar(a) and 15 °C)	1 : 683

Table 1: Nitrogen. Physical properties.

Nitrogen gas is heavier than air, especially when cold, and will tend to accumulate at low level. Nitrogen gas can accumulate in pits, ducts or trenches and will find its way down to lower levels, for example, a basement.

3.2 Potential changes to the local atmosphere resulting in asphyxiation

Excessive levels of nitrogen can produce local oxygen-deficient atmospheres.

This will result from:

- natural evaporation of liquid nitrogen. This is a continuous process;
- transfer of liquid nitrogen;
- disturbance of liquid nitrogen within the dewar;
- spillage.

Figure 1: Example of a sign warning of the risk of asphyxiation

If the oxygen concentration in the atmosphere decreases there is an increased risk of asphyxiation. This is especially true in areas of poor ventilation with little or no air movement, or in areas classified as confined spaces.

The normal level of oxygen is approximately 21 %. Any changes to this level will impact on people breathing the air, but it should be appreciated that the reactions of individuals can be very different. As a minimum the HSE recommend that the oxygen concentration in the workplace should be maintained above 19.5 %.

Asphyxia due to oxygen deficiency is often rapid with no prior warning to the victim. A general indication of what is liable to happen is given in Appendix 1.

For first aid treatment for asphyxia due to oxygen deficiency, refer to Appendix 1.

For guidance on conducting risk assessments and managing asphyxia risks, refer to BCGA GN 11 [20].

3.3 Cold (cryogenic) burns

Severe damage to skin may be caused by contact with liquid or cold gaseous nitrogen. This may also occur through contact with items that have been used with liquid nitrogen. The risk of direct contact of liquid nitrogen and human skin shall be managed.

For further information and first aid treatment for cold burns, refer to Appendix 2.

4. CONTROL MEASURES

The work activity risk assessment shall determine the hazard and risk controls.

Each work area is unique and will require a specific risk assessment to determine the risks and the most appropriate control measures.

Controls should be considered such as:

- equipment and process selection, refer to Section 4.1;
- engineering controls, including maintenance, refer to Section 4.2;

- adequate ventilation, refer to Section 4.3;
- minimising the overall inventory, refer to Section 4.4;
- minimising the potential for spillage and splashing, refer to Section 4.5;
- provision of information, instruction and training, refer to BCGA GN 23 [22], *Gas safety. Information instruction and training*;
- competence of personnel, refer to BCGA GN 23 [22];
- controlling access to storage and work areas;
- personal protective equipment, refer to Section 4.6.

4.1 Equipment and process selection

Through the careful initial selection of equipment and processes and periodic review, the risks from liquid nitrogen dewars may be eliminated. For example, a fixed system can be implemented that removes some of the risks from using a dewar.

4.2 Engineering controls, including maintenance

Alternatives to the process of filling and decanting liquid nitrogen are available and should be considered. For example, automated or remote liquid nitrogen dispense and withdrawal equipment. Consider options to separate people from the hazards, for example, screens.

4.3 Adequate ventilation

Storage and work areas shall be adequately ventilated to prevent the accumulation of nitrogen gas. Where there is residual risk then the use of atmospheric monitoring equipment should be considered. Further information is available in BCGA GN 11 [20].

4.4 Minimising the inventory

Only store sufficient stock to meet immediate needs. Ensure an adequate supply arrangement with the gas supplier. Use the smallest size of container to minimise the amount of liquid nitrogen being handled. At the point of use only fill the dewar with the minimum volume necessary to complete the current job.

4.5 Minimising the potential for spillage and splashing

Carefully consider the arrangement of the working area. Avoid unnecessary handling and use appropriate equipment for manual handling, decanting and pouring.

4.6 Personal protective equipment

A work activity risk assessment shall determine the requirement for the use of hazard controls, including, where necessary, for personal protective equipment (PPE). PPE may only be considered as a control to achieve an acceptable level of residual risk after higher levels of control have been addressed but found not to reduce the risk to a low level as is reasonably practical, for example, elimination, substitution, etc. Where PPE is required a PPE Assessment shall be carried out by a competent person. PPE

shall be provided as required by the *Personal Protective Equipment Regulations* [7]. The PPE shall be selected for a particular task and location and shall be appropriate and chosen to effectively manage any residual risk. Thus there are different PPE requirements for differing products, for different tasks, for different situations and for different personnel. Due regard should be given to any recommendations from relevant legislation, equipment publications, manufacturers information and the product Safety Data Sheet.

HSE L25 [13], *Personal Protective Equipment at Work*, provides guidance on the *Personal Protective Equipment Regulations* [7]. European Industrial Gases Association (EIGA) Document 136 [15], *Selection of personal protective equipment*, provides guidance for selecting and using PPE at work.

When conducting the risk assessment consider the wearing of portable oxygen monitors that will alert operators to the presence of an oxygen depleted atmosphere.

Protection of the following areas should be considered:

- head, face and eyes, refer to Section 4.6.1;
- hands, refer to Section 4.6.2;
- feet, refer to Section 4.6.3;
- body, refer to Section 4.6.4.

4.6.1 Head, face and eye protection

Protection of the head, face and eyes from liquid splashing, spraying or a pressure release.

- dependent on the direction a liquid may travel head protection may be required;
- safety glasses will only provide a limited level of protection to the eyes;
- goggles will provide protection to the eyes but not the face;
- a face shield will protect the whole face but they may allow splashes to come under the visor.

A combination of the above may need to be selected.

4.6.2 Hand protection

Protection of the hands from cold contact.

- CE marked hand protection for use at cryogenic temperatures is not available. BS EN 511 [10], *Protective gloves against cold*, provides a standard for use in cold environments, but only down to temperatures of –20 °C;

- hand protection shall be suitable for the task, i.e. it provides protection, thermal insulation, water resistance and dexterity;

- hand protection should be sized to allow rapid removal, for example, in the event of being soaked in liquid nitrogen;

- dependent on the direction a liquid may travel, gloves or gauntlets may be appropriate. Consider whether sleeves should cover the ends of the gloves or gauntlets, or be tucked in.

4.6.3 Foot protection

Protection of the feet from cold, spillages, slippage and mechanical impact.

- foot protection shall be suitable for the task and be comfortable to wear;

- provide protection against liquid soaking and penetrating the outer footwear, for example, through the material, through openings (such as lace holes), or from travelling down the leg;

- provide thermal protection (including socks);

- provide mechanical protection for toes and metatarsals, but be aware of reducing thermal protection;

- dependent on the direction a liquid may travel, different types of footwear, for example, long boots, ankle boots, shoes, etc. may be appropriate. Consider how any clothing may fit over or under the footwear;

- provide grip and protection against slipping.

4.6.4 Body protection

Protection of the body from cold and spillages.

- clothing designed such that liquid will not collect, for example, no open pockets or turn-ups;

- all areas of the skin should be covered, for example, long sleeves, full leg cover, neck cover, etc.;

- provide thermal and splash protection, for example, clothing that does not soak-up and retain liquid nitrogen;

NOTE: A splash resistant apron offers only limited protection, it may allow liquid to become trapped between the apron and the body.

- ensure clothing will be compatible with footwear and handwear, for example, how boots and gloves may be tucked in or over clothing.

5. DEWARS

5.1 Types of dewar

There are two types of dewar in general use.

The first type are dewars which are used for the storage and movement of liquid. These dewars are typically narrow necked to facilitate pouring. Refer to Figure 2.

Figure 2: Example of a dewar for storage and transport

Where they are used for moving liquid nitrogen the openings of this type of dewar shall be fitted with a free venting protective cap which allows the gas to escape. Refer to Figure 3.

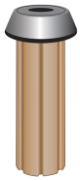

Figure 3: A protective cap

Some designs can be fitted with a liquid withdrawal device, as described in Section 5.3, to allow the liquid to be removed without tipping.

The second type of dewar has a wider open top (with a lid) and is generally used for cooling items by immersion in liquid nitrogen. These sometimes come with internal storage racks or compartments, which can be removed. Refer to Figure 4.

Figure 4: Example of an open top dewar

This type of dewar is not suitable for use with a liquid withdrawal device.

5.2 Dewar construction

The user shall ensure the dewar is suitably constructed to allow its use with liquid nitrogen.

Where they are used to transport liquid nitrogen they shall comply with the *Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations* [8]. These regulations implement the *European Agreement Concerning the International Carriage of Dangerous Goods by Road* (ADR) [9], which details the requirements for the packaging and labelling of dangerous goods. Dewars shall conform to the relevant requirements for open cryogenic receptacles given in ADR [9], P203 and ADR [9], Section 4.1.6.

Figure 5 shows the construction of a typical dewar. A vacuum is formed between the inner and outer vessel.

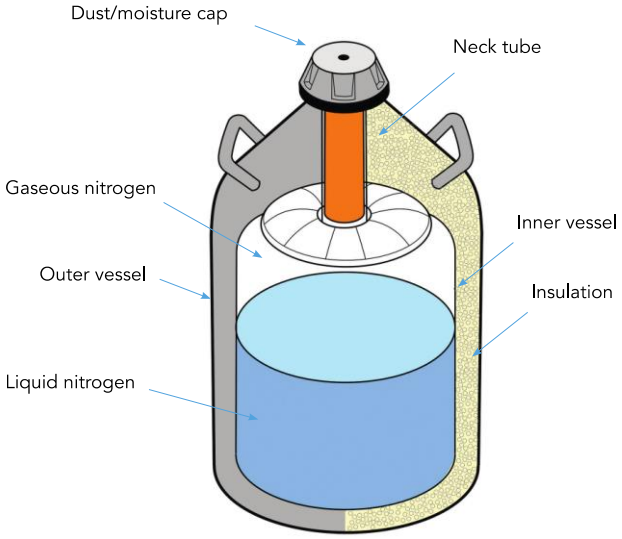

Figure 5: Typical dewar construction

5.3 Liquid withdrawal devices

Liquid withdrawal devices are available and may be a useful way to manage the safe withdrawal of liquid rather than pouring direct from the dewar.

Figure 6 shows an example of a typical liquid withdrawal device.

The liquid withdrawal devices shall be approved for use with the dewar by the dewar manufacturer (this will ensure that the requirements of the *Provision and Use of Work Equipment Regulations* [4] are met).

The use of a liquid withdrawal device will increase the pressure inside the dewar to enable liquid to be withdrawn. The internal pressure should be kept to the minimum necessary. The liquid withdrawal devices shall be fitted with a pressure relief device(s) that will ensure the internal pressure does not rise above 0.5 bar or prevent the internal pressure exceeding the design limit of the dewar or other critical components.

Figure 6:
An example of a typical liquid withdrawal device.

NOTE: If the pressure exceeds 0.5 bar then the *Pressure Systems Safety Regulations* [6] will apply.

The liquid withdrawal device shall only be fitted or removed by a competent person in-line with the manufacturer's instructions.

The liquid withdrawal device shall be removed prior to filling the dewar. It shall not be used for filling the dewar to which it is attached.

Liquid withdrawal devices are normally attached to the dewar via a clamping device. The device shall have a secondary retaining measure, for example, a retaining wire, to restrain the liquid withdrawal device in the case of clamp failure.

The dewar shall be secured such that it cannot move during the liquid withdrawal process.

For maintenance requirements refer to Section 7.

6. LABELLING

Liquid nitrogen dewars shall be clearly and correctly labelled.

All activities that require the use of liquid nitrogen shall have been subject to a risk assessment. As such the containers will only be made available for specific work activities where a safe system of work is in place. The safe system of work will determine the labelling requirements.

Typically the label requirements provide an indication that hazard(s) exist which are associated with the product. A label should include:

- the product name;
- a warning sign(s).

Figure 7 shows an example of a labelled warning sign.

Figure 7: An example of a labelled warning sign.

Where there is a requirement to transport the containers then the marking and labelling requirements shall comply with the requirements of ADR [9], refer to Section 12.

7. INSPECTION AND MAINTENANCE

The *Provision and Use of Work Equipment Regulations* [4] requires that work equipment should not result in health and safety risks, regardless of its age, condition or origin. They require that the employer carries out appropriate maintenance, inspection, identifies any specific risks and provides suitable information, instructions and training.

The employer shall appoint a competent person to identify and document the inspection and maintenance requirements taking account of the manufacturer's instructions. The employer shall ensure the inspection and maintenance of the equipment is carried out in accordance with this regime by a competent person.

Each dewar shall be subject to:

- a periodic inspection, refer to Section 7.1;

- a '*before use'* safety check, refer to Section 7.2;

- an '*after use'* safety check, refer to Section 7.3.

Where any maintenance is required written records shall be kept. Maintenance shall be in accordance with the manufacturer's instructions. If a repair is carried out on a dewar it shall be done to the original manufacturing specification.

NOTE: Repairs are likely to only be feasible on peripheral items, such as replacing bungs, nuts, bolts, wheels, pressure relief devices, hoses, etc.

Any dewar or liquid withdrawal device which is beyond repair shall be disposed.

7.1 Periodic inspection

To be carried out by the owner. The dewar and the liquid withdrawal device shall be inspected on a periodic basis. Following this inspection, the dewar and the liquid withdrawal device shall be marked with the next date for the next periodic inspection.

Dewar. The periodic inspection and maintenance may include:

- a visual check for damage. Ensure that there is no neck damage or twisting;

- a check for cleanliness, for example, oil, grease or other contamination, including moisture. As necessary, clean;

- a check that the protective cap is in good condition and is fitted. As necessary, replace it with a protective cap of appropriate specification;

- a check of the security of the handles or other handling devices which, if they failed, would allow the dewar to spill its contents;

- a check that the dewar is appropriately labelled, refer to Section 6;

- a check for vacuum condition.

Liquid withdrawal device. Periodic inspection may include a check that the liquid withdrawal device is in good condition, including the retaining wire, gauges, securing collar and / or clamp or valves and correct operation of valve. If damaged, then the relevant items shall be replaced.

The pressure relief device(s) shall be replaced at a suitable frequency. BCGA CP 39 [18], *In-service requirements of pressure equipment (Gas storage and gas distribution systems)*, provides general guidance on the inspection of pressure relief device(s).

7.2 Before use safety check

To be carried out by the user prior to use. The purpose being to check the equipment is serviceable, safe and ready for use.

The before use safety check shall consist of:

- a visual check for damage. Ensure that there is no neck damage or twisting;

- a check for cleanliness, for example, oil, grease or other contamination, including moisture. As necessary, clean;

- a check that the protective cap is in good condition and is fitted. Ensure that the insulating bung under the protective cap has not detached. As necessary, replace it with a protective cap of appropriate specification. Do not fill a dewar where the bung has fallen inside;

- a check of the security of the handles or other handling devices which, if they failed, would allow the dewar to spill its contents;

- a check that the dewar is appropriately labelled, refer to Section 6.

Where a liquid withdrawal device is fitted, check:

- the liquid withdrawal device is correctly fitted;

- that the liquid withdrawal device is in good condition. If the retaining wire, securing collar and / or clamp or valves are damaged, then the device shall be replaced;

- the pressure relief device.

Where a dewar is mounted on wheels, in a trolley or on a tipping device:

- check all components and the assembly for any damage, especially where stability may be affected. For example, damage to the support trunnion for the tipping trolley, the stand or the wheels.

Any damaged or contaminated equipment shall not be used.

7.3 After use safety check

To be carried out by the user on completion of use. The purpose being to check that any faults that occur in-service are rectified or reported / recorded.

The after use safety check shall consist of a check for:

- damage;

- cleanliness, as necessary, clean;

- vacuum integrity, displayed as in-service frosting on the external surfaces.

On completion of use the dewar should be returned to its designated storage area, refer to Section 10.

8. THE SAFE MOVEMENT OF DEWARS

The movement of a dewar refers only to the transfer of an item within the confines of a site (for transport on the public highway refer to Section 12).

The movement of dewars will introduce a number of hazards, such as:

- manual handling, refer to Section 8.1;

- spillage of the liquid;

  Liquid nitrogen which comes into contact with skin may cause cold burns;

  The extreme cold of liquid nitrogen can cause embrittlement and subsequent failure of certain materials, for example, carbon steel;

  NOTE: If liquid nitrogen is spilled, any objects or materials that were in contact with the liquid nitrogen should be checked for damage.

- movement through an area, such as a confined space, where a hazard may be introduced through the spillage of the liquid and where others not directly involved in using the dewar may be affected, refer to Section 8.2;

- the potential for injuries caused by contact with the dewar or its contents.

The actions to be taken in the event of an incident, for example, a spillage, should be assessed and a written procedure produced.

8.1 Manual handling

The *Manual Handling Operations Regulations* [2] apply to all aspects of manual handling, including the handling of liquid nitrogen dewars.

BCGA GN 3 [19], *Safe cylinder handling and the application of the manual handling operations regulations to gas cylinders*, and BCGA TIS 17 [23], *Model risk assessment for manual handling activities in the industrial gas industry*, provide guidance and assistance with risk assessment on manual handling activities. For additional guidance refer to HSE L23 [12], *Manual handling. Guidance on regulations*, and HSE INDG 143 [14], *Manual handling at work. A brief guide*. Advice is also available from The Ergonomics Society.

Figure 8: Dewar mounted on a trolley

Irrespective of the size or type of dewar, the employer shall carry out a manual handling risk assessment on the activities that operators are required to perform.

Figure 8 shows an example of a dewar mounted on a trolley.

When manual handling the following actions should be considered:

- selection of an appropriate route;
- selection of appropriate mechanical handling devices, for example, a tipping trolley;
- keeping the load within the capabilities of the operator;
- keeping the dewar upright at all times;
- protecting the dewar from jolting and impact;
- where fitted, determine if it is safe to move with a liquid withdrawal device attached. If in doubt, check with the liquid withdrawal device manufacturer.

Always handle a dewar with care; do not trundle shuffle or drag dewars.

8.2 Moving dewars in an enclosed space

The movement of liquid nitrogen in an enclosed space introduces hazards and may require compliance with the *Confined Spaces Regulations* [3]. Examples include the release of an asphyxiant gas from normal venting of the dewar, or a spillage. This may change the local atmosphere by increasing the nitrogen content and therefore reducing the oxygen content, refer to BCGA GN 11 [20];

Operators should avoid moving dewars in enclosed spaces, for example, on enclosed stairs, steps or in lifts, refer to Section 8.3 and Section 8.4. Where it is necessary to move a dewar in an enclosed space then this should be specifically included in the risk assessment.

Do not move a dewar that is visually venting gas (except to a safe place), for example, immediately after a fill.

8.3 Stairs and doorways

Stairs present an increased tripping hazard and a manual handling challenge and should be avoided. If the negotiation of stairs is unavoidable, then:

- specifically risk assess the process of movement on stairs. There is an increased risk of spillage of product. Take appropriate control measures, refer to Section 4;
- use mechanical handling aids which are designed to move dewars on stairs, for example, consideration should be given to the use of a stair lift;
- control access to the stairway whilst the dewar is being moved. Only those involved in the movement should be on the stairway.

Where movement through a doorway is required, then:

- ensure a clear pathway through the door;

- control access to the doorway whilst the dewar is being moved;

- keep the door open during the transition. Keeping the door open shall not to be carried out by the person moving the dewar.

8.4. Movement using lifts

The movement of dewars containing liquid nitrogen in a lift is hazardous and should be avoided.

Before movement in a lift takes place a detailed risk assessment in accordance with the *Management of Health and Safety at Work Regulations* [5] and the *Confined Spaces Regulations* [3] shall be carried out and suitable control measures with safe procedures established. The majority of lifts have a small internal volume and will become classified as a confined space when the dewar is placed in the lift. The release of nitrogen gas and the subsequent reduction in oxygen, has the potential to reduce the local atmosphere to an unsafe level to support life, refer to BCGA GN 11 [20].

Where it is unavoidable to move a dewar containing liquid nitrogen in a lift then take into account the following:

- the suitability of the lift, for example, weight capacity, compatibility with the extreme cold generated by liquid nitrogen;

- ventilation and extraction; for example, that vapours vent to a safe place;

- avoidance of people accompanying the dewar and others entering the lift, for example, through signage, the use of key control;

- the quantity of liquid nitrogen being moved;

- the stability and security of the dewar;

- movement with a liquid withdrawal device fitted;

- atmospheric testing of the lift or any area where nitrogen vapour may accumulate. BCGA GN 11 [20] provides guidance on safe atmospheres and atmospheric monitoring equipment;

- post movement actions, for example, a safe atmosphere (inside the lift) and management of any spillage;

- an emergency plan.

9. FILLING DEWARS

If the supply vessel is a bulk storage vessel it shall conform to and be sited in accordance with BCGA CP 36 [17], *Cryogenic liquid storage at users' premises*.

If the supply vessel is a transportable container it shall conform to and be located in accordance with BCGA CP 27 [16].

Decanting equipment shall be designed, manufactured and constructed by a competent person(s). Decanting equipment should incorporate adequate pressure relief and comprise of materials compatible with liquid nitrogen, including the temperature and pressure.

The activity, including its location, shall be risk assessed. As a minimum this should consider:

- competence of personnel;
- the properties of the product;
- adequate ventilation which prevents the local accumulation of nitrogen gas, refer to BCGA GN 11 [20];
- the floor surface, which should be flat, made of material compatible with the activity, with adequate load bearing strength, including for the supply tank and all decanting equipment. To include the location of drains and / or excess water control measures;
- two-way segregation from other work activities and local hazards, including environmental considerations, traffic, etc.;
- control of access into the filing area, for example, (temporary) barriers around the filling location;
- suitable safety signs and warning notices;
- lighting conditions;
- the adequacy of emergency arrangements, for example a spillage, cold burns, emergency egress routes, etc., refer to Section 13;
- a safe system of work, including scheduling of the activity to minimise the risk alongside other activities;
- requirements for personal protective equipment, refer to Section 4;
- ergonomics and human factors;
- associated equipment.

Dewar filling shall be carried out by competent personnel following a safe system of work. The filling procedure shall include:

- a pre-fill safety check, refer to Section 9.1;
- a safe system of filling, refer to Section 9.2.
- a post-fill check, refer to Section 9.3.

When filling dewars that are for sample storage, there is a risk of cross-contamination of the samples via the fill hose. If this is a possibility, a method for preventing cross-contamination shall be included in the filling procedure. Refer to BCGA GN 19 [21].

9.1 Pre-fill checks

Ensure the conditions meet the requirements of the safe system of work. For example:

- carry out the '*before use safety check'*, refer to Section 7.2;

NOTE: Where a liquid withdrawal device is fitted, this should be removed. Refer to Section 5.3;

- check the condition of the supply tank, for example, serviceability, product, pressure, quantity, etc.;
- check the condition of the filling equipment, for example, that it is clean and free from damage;
- check the operating environment.

Do not attempt to use blocked or damaged equipment.

9.2 Filling

The safe system of work should include, as a minimum, the following:

- instructions on filling both warm and cold dewars;
- attendance, the fill shall be attended at all times;
- ensuring the hose(s) and the dewar are kept under control throughout the filling process;
- purging of the hose(s) from the supply tank to clear any atmospheric moisture, other contaminants or gas (to a safe place);

Figure 9:
Decanting liquid nitrogen

- filling the dewar in accordance with the manufacturer's instructions;

WARNING: Never overfill a dewar.

- as appropriate, replace the protective cap on completion of filling;

- consider any requirements for fitting a liquid withdrawal device, refer to Section 5.3.

9.3 Post-fill check

On completion of filling ensure the conditions meet the requirements of the safe system of work, for example:

- conduct a post-fill check, as appropriate refer to the '*after use safety check*' in Section 7.3;

- check supply tank is left in a safe condition;

- check the filling area is left in a safe condition, for example, no ice patches, trip hazards, equipment stored, etc.;

- locate the filled dewar in a safe place ready for use.

10. THE USE AND STORAGE OF DEWARS

Except when pouring or when a liquid withdrawal device is fitted, the protective cap shall be fitted. The protective cap shall be in good condition with the insulating bung in place.

There should be a designated storage area for a dewar which is prepared and filled ready for use. This storage area shall be subject to a risk assessment to ensure safety and should consider the points raised within the filling risk assessment identified in Section 9. Implement the appropriate control measures, refer to Section 4.

If dewars are used in areas other than the designated storage area, each area shall also be risk assessed alongside the dispense activity.

A safe system of work shall be established for all dispense and use activities.

Storage and use location considerations:

- dewars should be sited in a dry, sheltered, but well-ventilated location;

- outdoors there is an increased risk of ice plugs forming in the dewar neck due to condensation of atmospheric moisture or rain freezing. Refer to Section 11.

- dewars containing liquid nitrogen will constantly vent gas. Indoors there is an increased risk from the release of nitrogen gas and the potential depletion of oxygen levels, resulting in an asphyxiation hazard, refer to Section 3 and Section 4.

On completion of the work activity the dewar shall be placed in its designated storage area.

Disposal of waste or residual liquid nitrogen is to be carried out in a safe and responsible way, in a well-ventilated area away from ducts, drains and other low-lying areas.

11. ICE PLUGS

Ice will form from atmospheric moisture, for example, from mist, rain, snow, etc., which comes into contact with the cold temperatures found in the neck or the top of the opening into the dewar. An ice plug may form if left unchecked. An ice plug can form a seal which will prevent the release of gas. Once the seal has formed this will lead to an increase in internal pressure, which if not removed will lead to the ice plug ejecting at high velocity and / or the catastrophic failure of the dewar.

Operators shall implement an inspection regime to check for the formation of ice near the dewar opening including taking action at the first sign of ice formation. If ice is found:

- empty the dewar and remove from service;
- allow the dewar to warm to ambient temperature;
- remove all moisture from inside the dewar;
- purge the dewar and carry out an '*after-use safety check'*, refer to Section 7.3.
- if serviceable, return to service;
- investigate the causes of ice formation and review the operating procedures to prevent a re-occurrence.

To help prevent ice formation, always replace the protective cap after each withdrawal or leave the liquid withdrawal device in place, then return the dewar to the designated storage area (this area is sheltered and dry).

Wherever practical, completely empty the dewar immediately after each use and replace the protective cap.

11.1 Actions to be undertaken in the event of an ice plug forming

Extreme caution shall be exercised if an ice plug is found. It may not be known how long an ice plug has been formed and consequently what the pressure may be inside the dewar. An increase in internal pressure may lead to projectiles and / or the rupture of the dewar.

There should be emergency operating procedures in place to manage the action to be taken once an ice plug has been identified. This shall be based upon technical information for the equipment and a suitable and sufficient risk assessment.

The emergency operating procedure should include the following considerations:

- exclusion of all personnel from the area;
- the advice of the manufacturer of the dewar;
- informing and seeking the advice of the owner of the dewar;
- calling a specialist action team and / or the emergency services.

Do not:

- approach the dewar;
- attempt to move the dewar;
- build a safety barrier around the dewar.

Once the ice has cleared and the dewar has reverted to a normal condition, any remaining liquid nitrogen should be removed.

The increased pressure may have damaged the inner wall of the dewar. The dewar shall be inspected by a competent person to determine if it is serviceable for return to service.

Investigate the causes of the ice plug and review operating procedures to prevent a re-occurrence before further use of a dewar.

12. TRANSPORTATION OF DEWARS

The transport of a dewar refers only to the carriage beyond a site boundary, for example, on the public highway (for movement of a dewar within the confines of a site refer to Section 8).

Liquid nitrogen is classified as Class 2 dangerous goods. The carriage of a load on a vehicle requires compliance with the *Road Traffic Act* [1]. Specifically, compliance is required with the *Carriage of Dangerous Goods and Use of Transportable Pressure Receptacles Regulations* [8]. These Regulations implement ADR [9].

Before any transportation takes place, as part of a suitable and sufficient risk assessment, the following shall be addressed:

- suitability of the vehicle, refer to Section 12.1;
- suitability of the dewar, refer to Section 12.2;
- vehicle crew requirements, refer to Section 12.3;
- documentation, refer to Section 12.4.

Dependent on the type and quantity of dangerous goods being transported, there may be additional specific requirements for the vehicle, the placarding of the vehicle, the requirements for vehicle crew training and documentation.

A qualified Dangerous Goods Safety Advisor shall be consulted to ensure compliance.

12.1 Vehicle

The vehicle used to transport a dewar shall be well ventilated, that is, an open or flatbed truck, or a trailer.

Whilst ADR [9] permits the carriage of gases within a closed vehicle there are safety reasons why this type of vehicle should not be used for the transport of liquid nitrogen. These reasons include:

- a dewar will constantly produce gas, this is an asphyxiation hazard (refer to Section 3);
- any liquid spill, for example, following a road traffic incident, will create large volumes of gas which has the potential to rapidly asphyxiate any person(s) exposed;
- in a closed vehicle this gas is contained, it will remain in the vehicle for a considerable time and will only disperse slowly;
- for closed vehicles, specific safety requirements apply, refer to a Dangerous Goods Safety Advisor.

NOTES:

1) Whilst some vehicles may be fitted with bulkheads to separate the driver's compartment from the storage area, these bulkheads are not reliably gas tight and they are not suitable to protect the vehicle crew from the hazard created.

2) Atmospheric monitoring equipment will provide a warning but may not give sufficient time to safely stop and evacuate a vehicle.

Gas suppliers may decline to provide liquid nitrogen if a closed vehicle is intended to be used.

ADR [9] mandates that a fire extinguisher is carried on all vehicles transporting dangerous goods. A dry powder fire extinguisher with a capacity of 2 kg is the minimum requirement.

12.2 Dewar

Only dewars which meets the requirements of ADR [9], P203, shall be used when transporting liquid nitrogen.

Dewars which do not conform to ADR [9] shall not be used to transport liquid nitrogen.

Before transport:

- remove the liquid withdrawal device, if fitted;

- ensure a protective cap is fitted. Use only a free venting protective cap designed for the dewar type. The protective cap shall not be secured down unless the securing methods are integral to the manufacturer's design of the protective cap;

- carry out a safety check for any damage and for vacuum integrity, displayed as in-service frosting on the external surfaces;

- transport only the minimum necessary. Ensure the dewar is not over-filled;

- secure the dewar, in a vertical position, to prevent movement during transport;

- ensure the dewar is correctly marked and labelled, in accordance with ADR [9], with the correct text size, as containing liquid nitrogen, with a product label that is legible and undamaged. The label shall contain as a minimum:

    - UN Number:
      UN 1977

    - Proper Shipping Name:
      Nitrogen, refrigerated liquid

    - Class 2 hazard diamond label:
      Label model No. 2.2

Figure 10:
Label 2.2

Additional safety information may be included on the label. Figure 11 shows a label which includes additional safety information.

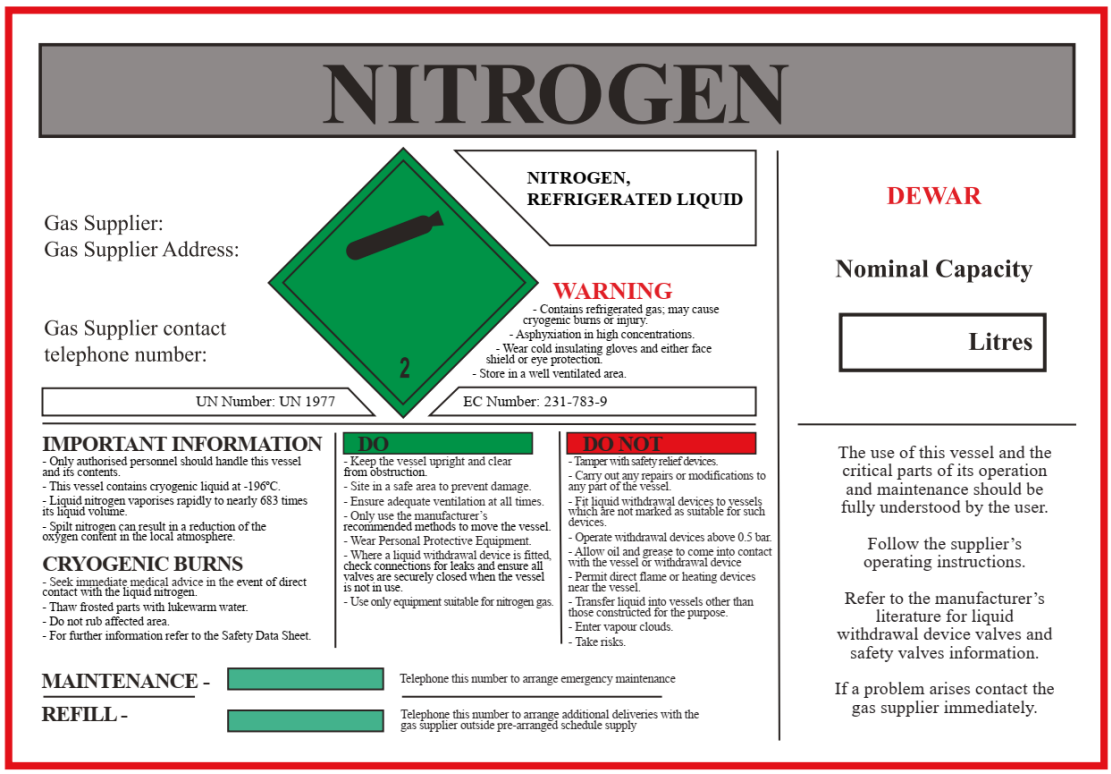

Figure 11: Example of a transport label.

12.3 Vehicle crew

At all times the driver of the vehicle remains responsible for the load being carried.

The vehicle crew shall receive appropriate information, instruction and training. To include:

- the properties and hazards of liquid nitrogen;
- the safe handling of dewars;
- actions to take in the event of an emergency, for example a road traffic incident or a spillage of liquid nitrogen;
- the correct use of fire-fighting appliances;
- the correct use of personal protective equipment.

NOTE: For guidance on training refer to BCGA GN 23 [22].

12.4 Safety documentation

As a minimum, consider carrying on the vehicle a copy of:

- the Transport Document, refer to ADR [9], Chapter 5.4. This provides an inventory of all dangerous goods being carried;

- Instructions in Writing, refer to ADR [9], Chapter 5.4.3. These provide advice on the actions to be carried out in an emergency;

- the liquid nitrogen Safety Data Sheet. This provides information on the properties of liquid nitrogen.

13. EMERGENCY ACTIONS

Employers should identify foreseeable emergency scenarios and develop appropriate emergency operating procedures. These scenarios will vary and be dependent on location and the work activity, they may include:

- spillage. Any spillage will result in very cold liquid being released. This has the potential to cause cold burns to persons and / or cause material damage through embrittlement. A large volume of gas, vapour and mist will be created. The large volume of gas will increase the risk of asphyxiation;

- creation of an asphyxiant atmosphere. An asphyxiant atmosphere may be created in poorly ventilated storage and / or use areas, and following a spillage. Refer to Section 3.2.

- excessive pressure. Excessive pressure can be created through:

    - the failure of a pressure relief device fitted to a liquid withdrawal device;

    - the creation of an ice plug in the neck of a dewar, refer to Section 11.

Considerations for emergency operating procedures

When developing emergency operating procedures consider the following:

- evacuation procedures for personnel from the area(s) likely to be affected;

- rescue procedures;

NOTE: Attempts to rescue affected persons from areas where an asphyxiant atmosphere may be present should only be made by persons trained in the use of breathing apparatus, rescue techniques and confined space entry procedures.

- availability and suitability of first aid provision, refer to Appendix 2 which describes the nature of such injuries and gives information about first-aid treatment appropriate in such cases;

- a transport related incident;

- escalation of the incident;

    - avoiding contact with spilled liquid and articles affected by the extreme cold;

- the places where escaped gas or liquid may flow or accumulate. Cold gas will collect in low lying areas, particularly, for example, pits, basements, cellars, stairwells, drains, etc.;

- preventing the liquid flowing along the ground into such areas, for example, by closing doors, the use of drain blockers, etc.;

- taking appropriate action to ensure that the ventilation system(s) does not spread (excessive levels of) the nitrogen gas to other areas;

- the use of emergency ventilation.

- Post incident actions:

  - restrictions on entering the area or approaching a vehicle until (excessive levels of) nitrogen gas have dispersed and that the air is safe to breathe. Refer to BCGA GN 11 [20];

  - allowing time for the liquid to evaporate naturally;

  - carrying out a mechanical assessment of items potentially affected by the extreme cold;

  - appropriate incident investigation and a review of control measures.

14. SECURITY

Dewars containing liquid nitrogen are hazardous. At all times, access to dewars should be restricted to authorised personnel and dewars should be kept secured. For storage refer to Section 10.

When dewars are supplied under a rental agreement and are no longer required they should be returned to the supplier at the earliest opportunity.

When a dewar reaches the end of its operational life, the owner should render the dewar beyond use and take disposal action in an environmentally sensitive way.

Additional advice is available from your gas supplier, equipment manufacturer and / or supplier and the BCGA.

15. REFERENCES

	Document Number	Title
1.		The Road Traffic Act 1988.
2.	SI 1992 No. 2793	The Manual Handling Operations Regulations 1992 (as amended).
3.	SI 1997: No. 1713	The Confined Spaces Regulations 1997.
4.	SI 1998: No. 2306	The Provision and Use of Work Equipment Regulations 1998 (PUWER).
5.	SI 1999 No 3242	Management of Health and Safety at Work Regulations 1999.
6.	SI 2000 No 128	Pressure Systems Safety Regulations 2000 (PSSR).
7.	SI 2002 No. 1144	The Personal Protective Equipment Regulations 2002.
8.	SI 2009 No. 1348	The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (as amended).
9.	ECE/TRANS/275	European Agreement concerning the international carriage of dangerous goods by road (ADR) (as amended).
10.	BS EN 511	Protective gloves against cold.
11.	HSE EH 40	Workplace exposure limits.
12.	HSE L23	Manual Handling. Manual Handling Operations Regulations 1992 (as amended). Guidance on Regulations.
13.	HSE L25	Personal Protective Equipment at Work.
14.	HSE INDG 143	Manual handling at work. A brief guide.
15.	EIGA Document 136	Selection of personal protective equipment.
16.	BCGA Code of Practice 27	Transportable vacuum insulated containers of not more than 1000 litres volume.
17.	BCGA Code of Practice 36	Cryogenic liquid storage at users' premises.
18.	BCGA Code of Practice 39	In-service requirements of pressure equipment (Gas storage and gas distribution systems).
19.	BCGA Guidance Note 3	Safe cylinder handling and the application of the manual handling operations regulations to gas cylinders.

20.	BCGA Guidance Note 11	The management of risk when using gases in enclosed workspaces.
21.	BCGA Guidance Note 19	Cryogenic sample storage systems (biostores). Guidance on design and operation.
22.	BCGA Guidance Note 23	Gas safety. Information instruction and training.
23.	BCGA Technical Information Sheet 17	Model risk assessment for manual handling activities in the industrial gas industry.
24.	British Cryogenics Council	Cryogenics safety manual.

Further information can be obtained from:

UK Legislation	www.legislation.gov.uk
Health and Safety Executive (HSE)	www.hse.gov.uk
British Standards Institute (BSI)	www.bsigroup.co.uk
European Industrial Gases Association (EIGA)	www.eiga.eu
British Compressed Gases Association (BCGA)	www.bcga.co.uk
British Cryogenics Council (BCC)	http://bcryo.org.uk
The Ergonomics Society	www.ergonomics.org.uk

PHYSIOLOGICAL EFFECTS OF ASPHYXIA

Asphyxia due to oxygen deficiency is often rapid with no prior warning to the victim. A general indication of what is liable to happen is given below but it should be appreciated that the reactions of some individuals can be very different from those shown. Further information is available in BCGA GN 11 [20].

Sudden asphyxia
In sudden and acute asphyxia, such as from inhalation of pure nitrogen, unconsciousness is almost immediate (seconds). A person will fall as if struck down by a blow on the head and may die in a few minutes, unless immediate curative action is taken.

Gradual asphyxia
Sudden asphyxia is the most common form encountered in practice but degrees of asphyxia will occur when the atmosphere contains less than 20.9 % (volume) of oxygen.

There are four stages of asphyxia, however it should be appreciated that the concentrations given are rough guides only and may vary with individuals and ambient conditions.

1st Stage - Oxygen reduced to 14 %.

The first perceptible signs of anoxaemia (oxygen deficiency) develop. The volume of breathing increases and the pulse rate is accelerated. The ability to maintain attention and think clearly is diminished, a fact that may not be noticed by the individual. Muscular co-ordination is somewhat disturbed.

2nd Stage - Oxygen reduced to between 14 % and 10 %.

Consciousness continues, but judgement becomes impaired. Severe injuries may cause no pain. Muscular efforts lead to rapid fatigue. Emotions are heightened, particularly ill-temper.

3rd Stage - Oxygen reduced to between 10 % and 6 %

Nausea and vomiting may appear. Victim loses ability to perform any vigorous muscular movements or even to move at all. Up to or during this stage, the victim may be wholly unaware that anything is wrong. Then the legs give way, leaving the victim unable to stand, walk or even crawl. This is often the first and only warning, and it comes too late. The victim may realise that death is imminent, but does not greatly care. No pain will be experienced. Even if resuscitation is possible, permanent damage to the brain may result.

4th Stage - Oxygen reduced below 6 %

Respiration consists of gasps, separated by periods of increasing duration. Convulsive movement may occur. Breathing then stops, but the heart may continue to beat for a few minutes longer.

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

- rapid and gasping breathing;
- rapid fatigue;
- nausea;
- vomiting;
- collapse or incapacity to move;
- unusual behaviour.

If medical attention is not immediately available, arrange for the casualty to be transported to a hospital without delay. Ensure that the ambulance crew and the hospital are advised of details of the accident and of the first aid treatment already administered.

HAZARDS FROM VERY COLD LIQUIDS OR GASES

A summary, reproduced with permission of the British Cryogenics Council, from their *Cryogenics safety manual* [24] which identifies the hazard from cryogenic burns and frostbite which can arise when handling cryogenic liquids, very cold gas or equipment at very low temperatures, and the appropriate first aid treatment. The hazards arise when handling any cryogenic product including liquid nitrogen.

Comply with the control measures detailed in Section 4 before handling any cryogenic liquid.

General cold exposure (hypothermia)
Hypothermia occurs due to the body being unable to maintain its normal temperature due to prolonged exposure to low temperatures. The dangers of hypothermia may be present at temperatures below 10 °C (283 K).

Individuals not suitable protected against low ambient temperatures may be adversely affected so far as their reactions and capabilities are concerned.

Persons apparently suffering from the effects of hypothermia should be removed from the cold area to a warm environment, (about 22 °C, 295 K). As appropriate, seek medical assistance.

Cryogenic burns and frostbite
Exposure of the skin to low temperature can produce effects on the skin similar to a burn. These will vary in severity with temperature and the time of exposure.

Naked, or insufficiently protected, parts of the body coming into contact with very cold, un-insulated pipes or vessels may stick fast by virtue of the freezing of available moisture and the flesh may be torn on removal.

The use of wet gloves shall be avoided under all circumstances. The low viscosity of cryogenic liquids means that they will penetrate woven or other porous clothing materials much faster than other liquids, for example, water.

Prolonged exposure to cold can result in frostbite. There may well be insufficient warning through localised pain while the freezing action is taking place. All cold burns should be checked by a first-aider to confirm the extent of damage and by a medical expert if there is any concern other the injuries.

Prolonged inhalation of cold vapour or gas can damage the lungs. Under no circumstances should cryogens be ingested. Cryogenic liquids and vapour can also damage the eyes.

First aid (cryogenic burns)
Flush the affected areas of skin with copious quantities of tepid water, but do not apply any form of direct heat, for example, hot water, room heaters, etc. Move the casualty to a warm place (about 22 °C / 295 K). If medical attention is not immediately available, arrange for the casualty to be transported to hospital without delay. Treatment for shock may be necessary.

While waiting for transport:

- Loosen any restrictive clothing;
- Continue to flush the affected areas of skin with copious quantities of tepid water;
- Protect frozen parts with bulky, dry, sterile dressings. Do not apply too tightly so as to cause restriction of blood circulation;
- Keep the patient warm and at rest;
- The patient can be given medical oxygen if available;
- Ensure that the ambulance crew or the hospital is advised of details of the accident and first aid treatment already administered;
- Smoking and alcoholic beverages reduce the blood supply to the affected part and should be avoided.

British Compressed Gases Association

www.bcga.co.uk