BRITISH COMPRESSED GASES ASSOCIATION
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CODE OF PRACTICE 30

The safe use of liquid nitrogen dewars.

Revision 4: 2024

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PREFACE

The British Compressed Gases Association (BCGA) was established in 1971, formed out of the British Acetylene Association, which existed since 1901. 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, 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, *The safe use of liquid nitrogen Dewars,* Revision 3: 2019 and BCGA Technical Information Sheet 27, *Risk assessment guidance for the safe use of liquid nitrogen Dewars*, Revision 1: 2020. It was approved for publication at BCGA Technical Committee 171. This document was first published on 19/12/2024. For comments on this document contact the Association via the website www.bcga.co.uk.

JOIN US: BECOME A BCGA MEMBER

The *British Compressed Gases Association* (**BCGA**) is the leading UK Trade Association representing the interests of the industrial, food and medical gases industries, whose members include manufacturers and suppliers of liquefied, dissolved and compressed gases in a wide variety of containers, including cylinders, tubes, tanks, etc., as well as the associated gaseous pressure systems, pipework, components and related equipment. Members also provide specialist safety, health, environment, quality, inspection and training services.

There are currently three categories of BCGA Membership designed to reflect the needs of the gases industry. These are:

Full Membership

For companies or individuals who have any practical involvement in the manufacture, mixing, handling, sales, distribution, storage or transportation of industrial, food and medical related gases or equipment.

Associate Membership

For companies or individuals who have no practical involvement (as noted in Full Membership), and is therefore for designers, consultants, training providers, academics, interested individuals involved with the industry, other associations or simply those that regularly use gases in their work environment.

Start-up Scheme

The start-up scheme is designed to support young companies, who are in the early years of their business, working in the gases industry.

As a member you'll have access to a wide variety of benefits and services to help you develop your company including:

- Certificate of Membership;
- Information about all the latest news and updates in our industry;
- The opportunity to influence oncoming regulation and guidance produced by Government;
- The opportunity to be involved in developing standards (BS EN ISO) for our industry;
- The opportunity to shape the future direction of our industry;
- Technical advice;
- Interaction with other members;
- The right to attend any of our Technical Sub-Committees;
- Access to all BCGA publications;
- The opportunity to be involved in writing BCGA publications;
- Being able to attend the BCGA Conference at Member rates;
- Appropriate listings on the BCGA website;
- Use of BCGA logo.

Becoming a BCGA member couldn't be easier. Simply download and fill in the membership application and turnover declaration forms on our website, under '**Membership**'.

If you have any questions email: admin@bcga.co.uk

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* 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.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a website and webpage, and their contents, cannot be guaranteed. BCGA is not responsible for the content of referenced websites.

TERMINOLOGY AND DEFINITIONS

Asphyxia	An extreme 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.
Confined Space	Any place, including room, chamber, tank, vat, silo, pit, trench, pipe, sewer, flue, well, or other similar space in which, by virtue of its enclosed nature, there arises a reasonably foreseeable specified risk. It has two defining features: (i) It is a place which is substantially, (though not always entirely) enclosed. (ii) There will be a reasonably foreseeable risk of serious injury from; flammable or toxic atmosphere, oxygen deficient or enriched oxygen atmosphere. (as defined in the *Confined Spaces Regulations* [3])
Cryogenic Liquid	A liquid gas at a temperature below 120 K (-153 °C). This is deemed to be a cryogenic temperature.
Decanting	The dispensing of liquid nitrogen from a Dewar into another suitable receptacle, either by pouring or by using a liquid withdrawal device.
Dewar	For the purpose of this Code of Practice, the term Dewar shall mean a Mobile thermally insulated receptacle for refrigerated liquid nitrogen that operates below 0.5 bar pressure. This definition also includes dry shippers, industrial vacuum insulated flasks and portable cryogenic laboratory freezers.
Dewar Filling	The transfer of liquid from a pressurised source into a Dewar.
Hypoxia	A condition where the human body, or a region of the body, is deprived of adequate oxygen.
Inert Gas	A gas that is neither toxic nor flammable, but which does not support human life and which reacts scarcely or not at all with other substances.
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 a Dewar within the confines of a site (as opposed to carriage on the public highway).
Reduced Oxygen Atmosphere	An atmosphere where the level of oxygen is reduced (or depleted) below the normal concentration in air, that is, nominally 20.9 % measured by volume.

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.
Storage Vessel	The storage container which contains a stock of liquid nitrogen and from which the liquid nitrogen is transferred to the Dewar.
Transport	Refers to 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 for the guidance of users of Dewars containing liquid nitrogen. A Dewar is a mobile thermally insulated receptacle used to contain refrigerated liquid nitrogen that operates below 0.5 bar pressure.

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

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 industry associations.

2. SCOPE

This Code of Practice provides guidance and best practice for the transportation, storage, movement, handling and safe use of Dewars containing liquid nitrogen.

Other Cryogenic Liquids, such as helium and argon, are not included within this code of practice, however, many of the same principles will apply. The specific properties of the individual gas should be assessed before its use. Seek specialist advice, as required.

This document excludes the use of liquid oxygen.

For Storage Vessels that operate above 0.5 bar pressure, refer to:

- BCGA CP 27 [19] *Transportable vacuum insulated containers of not more than 1000 litres volume*.

- BCGA CP 36 [20], *Cryogenic liquid storage at Users' premises*.

For the long term storage of biological samples, refer to BCGA CP 45 [23], *Biomedical cryogenic storage systems. Design and operation*.

3. PROPERTIES OF LIQUID NITROGEN

Gas suppliers will ensure that each gas they supply is correctly identified.

Each Dewar shall have a label attached, providing information on liquid nitrogen as well as basic safety advice, refer to Section 6.

The gas supplier will provide more comprehensive information on a Safety Data Sheet. This will provide detailed information on the properties of liquid nitrogen, as well as advice on handling, storage and emergency procedures. For more specific safety information and advice contact the gas supplier.

Liquid nitrogen is used because it is an Inert Gas and for its cold properties. The cold temperatures are best maintained by keeping the stored liquid at either atmospheric or under low pressures. If the pressure is allowed to build the temperature will rise.

Liquid nitrogen has a relative density of 0.8 and a boiling point around -196 °C. Above this temperature the liquid will evaporate into a gas, expanding at a ratio of approximately 1 litre of liquid to 683 litres of gas.

Nitrogen gas is non-corrosive, colourless, odourless and tasteless. It constitutes approximately 78 % of normal, atmospheric air. It is classified as non-toxic and non-flammable. It does not support life and breathing in an atmosphere where there is reduced oxygen will result in Hypoxia (nitrogen is an asphyxiant).

Nitrogen gas, when cold, is heavier than air and may accumulate in low lying areas, for example, pits, ducts, trenches, etc., and find its way down to lower levels, for example, a basement. It will mix with the surrounding atmosphere as it warms and reaches ambient temperature.

Legislation mandates that employers assess all safety and health risks and take appropriate measures to identify the hazards and control the risks. For liquid nitrogen the hazards include asphyxiation and extreme cold, refer to Section 4.

The British Cryogenics Council, *Cryogenics Safety Manual* [30], provides additional information on Cryogenic Liquids.

4. RISK ASSESSMENT

The *Management of Health and Safety at Work Regulations* [5] require all employers to undertake risk assessment(s) to identify potential hazards, to assess risk and to implement control measures, where necessary, to reduce the risk to an acceptable level.

The risk assessment shall cover health and safety risks to personnel, to property and harm to the environment.

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

Only persons who are competent under the *Management of Health and Safety at Work Regulations* [5] shall undertake risk assessments. This competence includes sufficient knowledge of nitrogen, its properties and how it is to be used, associated activities and the specific workplace.

There are inherent risks with Dewars containing liquid nitrogen. Prospective users shall satisfy themselves through the application of the *Management of Health and Safety at Work Regulations* [5] that safer and better options are not reasonably practicable.

This section provides guidance when carrying out a risk assessment on the specific hazards associated with using Dewars containing liquid nitrogen. It does not constitute a comprehensive assessment of all workplace hazards as required under the *Management of Health and Safety at Work Regulations* [5] and additional specific risk assessments may be required, for example, for manual handling, slips, trips, falls, etc.

NOTE: The principles in this guidance can be applied to the use of other Cryogenic Liquids, such as helium, argon and oxygen, however, the specific properties of the individual

gas should be assessed before its use. As required, refer to the appropriate safety data sheet and seek specialist advice.

The storage and use of liquid nitrogen in a Storage Vessel is outside of the scope of this document. information is available in:

- BCGA CP 27 [19];
- BCGA CP 36 [20], *Cryogenic liquid storage at Users' premises*.

However, the process of operating the source Storage Vessel to fill a Dewar should be considered in the overall risk assessment.

For the properties of liquid nitrogen, refer to Section 3.

This document will assist in conducting a risk assessment. The HSE provide risk assessment guidance:

- https://www.hse.gov.uk/simple-health-safety/risk/index.htm
- HSE INDG 163 [16], *Risk assessment. A brief guide to controlling risks in the workplace*.

The basic principles of conducting a risk assessment require:

- identifying the potential hazards in the workplace. Refer to Section 4.1;
- identifying who might be harmed and how. Refer to Section 4.2;
- evaluating the risks and deciding on appropriate control measures, taking into account control measures already in place. Then implementing the required controls. Refer to Section 5;
- recording the risk assessment;
- reviewing and updating the risk assessment.

Section 4.3 provides a list of topics to be taken into account during the risk assessment.

4.1 Hazards associated with the storage, handling and use of Dewars containing liquid nitrogen

The specific hazards to be assessed are:

- asphyxiation;
- cold contact;
- pressure.

Additional hazards may include:

- reduced visibility;
- hypothermia;

- embrittlement.

Asphyxiation
If the oxygen concentration in the atmosphere decreases, there is an increased risk of asphyxiation. This is especially true in an area(s) of poor ventilation with little or no air movement, or in an area(s) classified as a Confined Space.

The normal level of atmospheric oxygen is 20.9 %. 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. Any difference in oxygen content from normal should be investigated. As a minimum the HSE recommend that the oxygen concentration in the workplace should be maintained above 19.5 %.

Any release of nitrogen can produce a local Reduced Oxygen Atmosphere. Nitrogen gas continuously evaporates from liquid nitrogen from a Dewar, irrespective of the activity. The following are examples of ways in which the rate of evaporation may increase:

- by liquid agitation, for example, during movement of a Dewar;
- during transfer, for example, from a Dewar to another container;
- following liquid spillage;
- pressure relief device operation (if fitted). Venting and the potential for inadvertent release of nitrogen;
- local external heating of the Dewar;
- uninsulated and poorly insulated components;
- placing articles into the liquid;
- type of and frequency of use;
- volume liquid in the Dewar.

The effect on humans of breathing in an asphyxiant gas can be rapid, and unconsciousness can occur in as little as two breaths. The individual affected will not be aware of Asphyxia occurring.

For guidance on conducting risk assessments and managing Asphyxia risks, refer to BCGA CP 52 [25], *The management of risks from gases in the workplace*.

Cold contact
Liquid nitrogen is extremely cold, at a temperature of -196 °C. Exposure to low temperatures can be harmful and may result in frostbite and / or cold burns, including damage to eyes, skin and internal tissue. Injuries may be immediate or long term. Severity will be dependent on the exposure time.

Contact between liquid nitrogen and humans shall be avoided.

Exposure can occur as a result of:

- direct contact with liquid nitrogen;

  Contact may result in frost bite and / or cold burns. A cold burn has similar effects to a burn caused by high temperatures, it can be more severe due to longer exposure times caused by numbing.

- inhaling cold nitrogen gas.

  As well as the hazard of asphyxiation, inhalation of cold nitrogen gas can damage the lungs and is likely to aggravate existing health conditions. The severity is dependent on the temperature and exposure time.

- ingesting liquid nitrogen.

  Ingestion of liquid nitrogen will cause severe damage to internal organs, it is likely to be fatal.

- indirect contact with liquid nitrogen.

  Including contact with items which have been cooled to liquid nitrogen temperatures, for example, items which have been immersed in liquid nitrogen. The material properties, size and thermal mass of the item and the degree of cold soaking will determine the length of time the cold hazard exists (until it reaches ambient temperatures). Contact may result in frost bite and / or cold burns.

- inhaling a cold atmosphere (where liquid nitrogen is present).

  Inhalation of a cold local atmosphere can damage the lungs and is likely to aggravate existing health conditions. The severity is dependent on the temperature and exposure time.

For guidance on managing the hazards and risks of working with Cryogenic Liquids, refer to BCGA CP 52 [25].

Pressure

Pressure is the stored energy of the gas and is related to the temperature of the gas and the volume of the container in which it is stored. Direct contact with a gas under pressure can cause damage to eyes, or contact and penetrate the body creating a gas embolism (bubbles in the blood circulatory system). Excess pressure can cause structural failure of the Dewar or rapid ejection of its fittings. A pressure release may create excessive noise.

Liquid nitrogen continuously evaporates. It will change from a liquid to a gas with an expansion ratio of approximately 1 : 683. This expansion will lead to an increase in pressure if it is not released.

Normally a properly designed and operated Dewar is open to the atmosphere, and is not a pressure vessel, therefore the risk of harm from an increase in pressure is low. However, excess pressure may build up in a Dewar if:

- an ice plug occurs in the opening;

  Ice will form from atmospheric moisture which comes into contact with the cold temperatures found in the neck or the top of the opening into the Dewar. An ice

plug is likely to form if a lid or cap is not fitted. An ice plug can form a seal which will prevent the release of gas. For more information, refer to Section 11.

- the rate of liquid nitrogen evaporation exceeds the rate by which it can release to atmosphere. This may be caused by:
    - lids or caps, which are too tight restricting the release of gas;
    - lids or caps which are too loose. This they may allow the formation of an ice plug;
    - any objects placed on a Dewar lid which may also restrict the release of gas;
    - a reduction in the efficiency of the Dewar insulation (for example, a loss of vacuum), or the location of a Dewar near a heat source.
- if an incompatible, unserviceable or incorrectly fitted liquid withdrawal device is fitted;
- if a Dewar is modified, misused or incorrectly maintained.

Reduced visibility
Mists and vapour clouds occur when the moisture condenses out of the atmosphere when in direct contact with liquid nitrogen, cold gas or cold soaked items. This has the potential to conceal workplace hazards.

When using Dewars, mist and vapour clouds may occur as a result of:

- a spillage of liquid nitrogen;
- replenishment;
- leaving the lid or cap off;
- Decanting of liquid nitrogen;
- the use of uninsulated containers;
- immersing warm objects into the liquid;
- cold soaked items regaining ambient temperature.

The size and extent of any mist or vapour cloud from liquid nitrogen is dependent on the activity, local environment conditions and the volume of liquid.

Hypothermia
Hypothermia occurs due to the body being unable to maintain its normal temperature due to prolonged exposure to low temperatures. All individuals will have different physiological outcomes. Symptoms may include pale, cold and dry skin, skin and lips may turn blue or grey (on black or brown skin this may be easier to see on the palms of the hands or the soles of the feet), shivering, drowsiness, confusion and in extreme cases fatality.

The NHS provide advice at: https://www.nhs.uk/conditions/hypothermia/

Where liquid nitrogen is used and stored, low workplace temperatures may be created. Hypothermia can occur as a result of:

- prolonged exposure to cold environments where liquid nitrogen is present;
- inadequate or inappropriate personal protective equipment.

Embrittlement
Embrittlement is loss of ductility in a material. Loss of ductility increases the likelihood of a brittle fracture. The extreme cold of liquid nitrogen prevents elasticity and can cause embrittlement and subsequent failure of certain materials, for example, carbon steels, plastics and polymers.

Due to the extreme cold temperature of liquid nitrogen, embrittlement can occur rapidly. For some items this may permanently change their properties.

Embrittlement of non-compatible materials may occur, for example:

- following a spillage;
- on immersion;
- during Decanting;
- through thermal transfer when objects are in close proximity.

4.2 Who is at risk

Any person who is:

- using a Dewar containing liquid nitrogen;
- present in an area where a Dewar containing liquid nitrogen is being transported, stored, moved or used (this includes any employee, contractor, visitor or member of the public),

is at risk.

NOTE: Contact with liquid nitrogen or changes to ambient gas concentrations may also affect machinery and animals, this may be a different effect to that experienced by humans.

4.3 Minimum considerations for a risk assessment

In addition to other workplace activity risk assessments, this risk assessment (covering Dewars containing liquid nitrogen) should take into account the following:

- activity and method (process and procedures);
- compatibility, size, type and suitability of equipment and materials;
- inspection and maintenance of equipment;
- volume of liquid nitrogen in storage and use;

- competency of personnel;
- the location of the Dewar (storage and use);
- transport and movement, refer to Section 9.
- management of the local area (housekeeping and adjacent activities);
- hazard exposure time;
- local environment, including ventilation;
- human factors and ergonomics;
- personal protective equipment;
- the potential for pressure build up;
- spillage(s) and splashing;
- emergency response (including ice plug, first aid, etc.);
- health effects, including on those with a pre-existing health condition;
- disposal, of excess liquid nitrogen and equipment.

On completion of the risk assessment, implement appropriate control measures, refer Section 5.

5. CONTROL MEASURES

The hierarchy of control, as described in the *Management of Health and Safety at Work Regulations* [5], Schedule 1, shall be applied.

Determine if the hazard can be eliminated or substituted, or if not, how the risk can be controlled so that harm is unlikely.

In terms of risk elimination, an installed gas supply and distribution system may be an option to remove some of the risks from using a Dewar. For further information refer to BCGA CP 4 [18], *Gas supply and distribution system (excluding acetylene).*

Where the hazards cannot be eliminated or substituted, then further controls shall be applied.

Common controls include:

- having only 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 activity;
- limiting access to storage and work areas to authorised personnel;
- that there are suitable operating procedures in place;

- that the activity is carried out by competent personnel. The competence of personnel, including the provision of information, instruction and training, is described in BCGA GN 23 [27], *Gas safety. Information instruction and training*.

- the use of appropriate personal protective equipment, refer to Section 5.1.

Hazard specific controls include:

- **asphyxiation**.

Storage and work areas shall be adequately ventilated to prevent the accumulation of nitrogen gas. Where there is the risk of accumulation then the use of suitable ventilation and atmospheric monitoring equipment should be considered. Further information is available in BCGA CP 52 [25].

- **cold contact**.

The use of automated or remote liquid nitrogen dispense and withdrawal equipment.

The use of remote handling equipment, for example, tools designed to handle items at cryogenic temperatures.

The use of properly rated equipment appropriate for Cryogenic Liquids.

Options to separate people from the hazards, for example, screens.

Segregation of cold items from personnel, until the items have reached ambient temperatures.

Ventilation systems to quickly remove cold nitrogen gas to a safe area, refer to BCGA CP 52 [25].

Removal of Dewars containing liquid nitrogen back to their storage area as soon as the task is complete.

- **pressure**.

The prevention of uncontrolled pressure in a Dewar.

The *Pressure Systems Safety Regulations* [6] (Regulation 15) requires that at all times a Dewar which is designed to be open to atmosphere, cannot become pressurised.

For Dewars open to the atmosphere, this is achieved through ensuring the correct protective cap is in place when not in use.

For Dewars fitted with a liquid withdrawal device, this is achieved through the correct type and compatibility of the liquid withdrawal device with its associated pressure relief valve(s), which follow an appropriate maintenance and inspection regime.

The operating procedures include keeping Dewars away from sources of heat, preventing ice plugs and preventing blockages of venting gas, for example, through objects being placed on the Dewar.

When filling a Dewar, operating procedures shall ensure that there is no build up of pressure. Refer to Section 10.

Dewars shall not be modified from the manufacturers specification without their approval.

- **reduced visibility**.

Adequate ventilation and management of humidity in the work area. Ventilation systems to quickly remove cold nitrogen gas to a safe area.

Replacement of protective caps and lids on completion of use;

Provision of a work area which minimises the potential for hazards, for example trips, slips and falls etc., in the event of any reduced visibility

Allow only the necessary personnel and activities to take place during replenishment or when liquid nitrogen is in use.

- **Hypothermia**.

Segregation of people away from any activity involving liquid nitrogen where they are not involved.

Minimising the length of time people are involved in an activity using liquid nitrogen.

- **embrittlement**.

Compatibility of equipment for use with liquid nitrogen.

Having suitable equipment available to manage or contain any spillages.

Segregate any cold-soaked items from incompatible materials until ambient temperatures are achieved.

5.1 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).

Only after all other levels of control have been determined to be ineffective in controlling risks to a reasonably practicable level, should PPE be considered as a control.

Even with PPE, if the risk is not reduced to as low a level as is reasonably practicable, then the activity shall not proceed.

HSE L25 [14], *Personal Protective Equipment at Work,* provides guidance on the *Personal Protective Equipment Regulations* [8]. *European Industrial Gases Association* (EIGA) 136 [17], *Selection of personal protective equipment*, provides guidance for selecting and using PPE at work.

Where PPE is required, a PPE assessment shall be carried out in accordance with the *Personal Protective Equipment Regulations* [8]. This shall be carried out by competent persons.

The selection of PPE shall be appropriate for the hazard, task, location and individuals.

PPE shall be provided by the employer, along with the necessary information, instruction, training and supervision for its use. The employer shall ensure that employees wear any PPE required.

Cleaning and maintenance (including its replacement) shall be included in the PPE management system. Suitable storage shall be provided for PPE when it is not in use.

The effectiveness of the PPE shall be reviewed periodically.

Emergency situations may require different or additional PPE.

Users shall take into account the requirements of other applicable Regulations, such as the *Control of Substances Hazardous to Health (COSHH) Regulations* [9], in relation to assessing risks, along with any relevant equipment publications, manufacturers information and the product(s) safety data sheet.

NOTE: Any equipment that has a personal protective function is classified as PPE, for example, a personal atmospheric monitor.

When conducting the risk assessment consider the wearing of portable oxygen monitors that will alert operators to the presence of a Reduced Oxygen Atmosphere.

The PPE assessment shall take into account any requirements for:

- head protection, including face, eye and ear protection;
- hand protection;
- foot protection and metatarsal protection;
- body protection.

6. DEWARS

There are various types of Dewar available for the storage and general use of liquid nitrogen.

WARNING: There are many insulated flasks available for domestic use, for example, for the short term storage of hot drinks. They do not provide adequate pressure protection. These flasks are not suitable for, and shall not be used for, Cryogenic Liquids.

Some Dewars are constructed of materials which are less robust, for example, those manufactured from glass. These Dewars are usually protected by a specially designed carrying case. Additional controls may be required to prevent damage.

The requirements for the design and construction of a Dewar for use with a Cryogenic Liquid are set out in Section 6.1.

Where a liquid withdrawal device is in use refer to Section 6.2.

The requirements for labelling a Dewar are set out in Section 6.3.

There are three principal models for an unpressurised Dewar. These are:

1) Dewars which are used for the storage and dispensing of Cryogenic Liquid. These Dewars are typically narrow necked to facilitate Decanting. Figure 1 shows an example.

Note the 'trunnions' welded to the side of the Dewar. These enable the Dewar to be fitted correctly into a tipping trolley. Refer to Section 9.1.

These Dewars are supplied with a purposely designed insulated protective cap. The protective cap prevents the ingress of heat and contaminants, including moisture, whilst allowing nitrogen gas to escape. This reduces the likelihood of moisture freezing in the neck (leading to an ice plug) and prevents the build-up of pressure inside the Dewar.

Figure 1:
A Dewar for storage and dispensing

The protective cap shall be fitted at all times (except when filling or Decanting). Figure 2 shows an example of a protective cap.

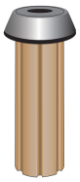

Figure 2:
A protective cap

Some Dewar designs can be fitted with a liquid withdrawal device, as described in Section 6.2. This allows the liquid to be removed without tipping.

2) A Dewar flask. This has a wide open top (usually provided with a lid).

They are used for the temporary storage of liquid nitrogen and are typically used for cooling items by immersion.

Figure 3 shows an example of a Dewar flask.

Figure 3:
An open top Dewar flask

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

3) A Dewar freezer. This has a wide neck and is used for the storage of samples at cryogenic temperatures. These Dewar freezers are supplied with a purposely designed insulated protective cap, which often have a security system incorporated.

These generally come with internal storage systems or compartments, which can be removed.

Figure 4 shows an example of a Dewar freezer.

Figure 4:
A Dewar freezer

Dewar freezers are not used for the Decanting of liquid.

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

There are many different types of Dewar freezers on the market, ranging from a simple manually filled container, to a fully instrumented automated system. These may range in size from a few litres, to several thousand litres volumetric capacity. Further information is available in BCGA CP 45 [23].

NOTE: A type of Dewar freezer is a 'Dry / Cryo Shipper'. These are designed to safely transport samples under cryogenic conditions (vapour phase storage). The liquid nitrogen is contained in an adsorbent material which prevents spillage in normal use. However, the other hazards associated with liquid nitrogen remain.

6.1 Dewar design and construction

There are no specific standards for the construction of an unpressurised Dewar. They are designed and manufactured using sound engineering practice.

A properly designed and manufactured Dewar will be manufactured from materials which are compatible with liquid nitrogen properties. The Dewar will have a protective cap or lid which shall be a loose or nominal fit that will allow gas to escape, but that prevents liquid splashing out.

Where a Dewar freezer is used for the storage of medical samples at cryogenic temperatures it is required to comply with medical legislation. Such a Dewar freezer is classified as a Class IIa medical device in compliance with the European *Medical Devices Directive* [12] (Annex IX, III. Classification, Rule 2).

NOTE: The *Medical Devices Directive* [12] states that:
"*All non-invasive devices intended for channelling or storing blood, body liquids or tissues, liquids or gases for the purpose of eventual infusion, administration or introduction into the body are in Class IIa:*

- if they may be connected to an active medical device in Class IIa or a higher class,
- if they are intended for use for storing or channelling blood or other body liquids or for storing organs, parts of organs or body tissues,

in all other cases they are in Class I."

Medical devices placed on the market in the UK shall comply with the *Medical Device Regulations* [7]. This requires that they shall be registered with the UK Regulator, the *Medicines and Healthcare products Regulatory Agency* (MHRA), and that conformity assessment shall be carried out by a UK Approved Body (including, if successful, being marked with a 'UKCA' mark).

For medical devices placed on the market in a European country, conformity assessment shall be carried out by a European Notified Body for compliance with the European *Medical Device Directive* [12] (including, if successful, being marked with a 'CE' mark).

Where they are used to transport liquid nitrogen, Dewars shall comply with the *Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations* [10]. These regulations implement the *Agreement Concerning the International Carriage of Dangerous Goods by Road* (ADR) [11], 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 [11], P203 and ADR [11], Section 4.1.6.

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

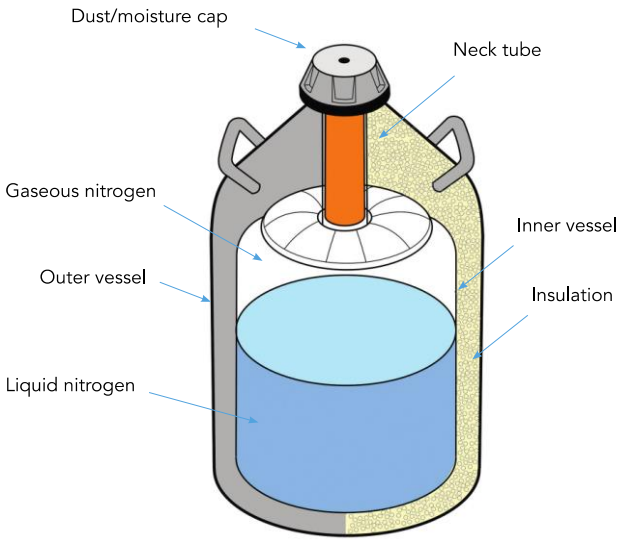

Figure 5: Typical Dewar construction

6.2 Liquid withdrawal devices

Liquid withdrawal devices are an option. Rather than pouring direct from the Dewar, they provide an alternative means to manage the safe withdrawal of liquid.

Figures 6, 7 and 8 show simplified examples of typical liquid withdrawal devices.

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).

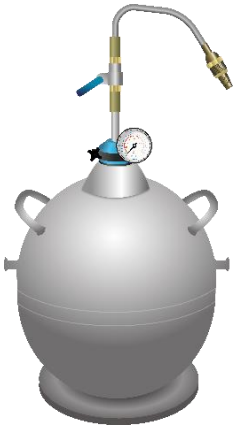

Figure 6:
An example of a liquid withdrawal device. It is secured in place with a clamp.

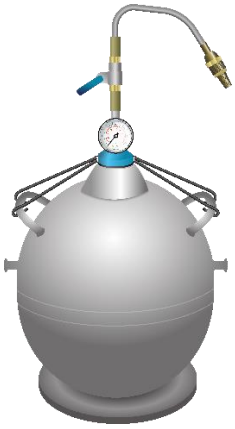

Figure 7:
An example of a liquid withdrawal device. Additional security provided using restraining springs.

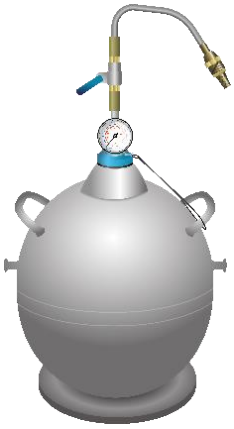

Figure 8:
An example of a liquid withdrawal device. Additional security provided with a restraining wire.

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. Each liquid withdrawal device shall be fitted with a pressure relief device(s)

that will ensure that the internal pressure does not exceed the design limit of the Dewar or other critical components.

Liquid withdrawal devices are attached to the Dewar, for example, using a clamping device. If a secondary retaining safety device is provided, it shall be used. Refer to Figure 6, Figure 7 and Figure 8.

NOTE: A secondary retaining safety device will help to restrain the liquid withdrawal device from being inadvertently released and potentially ejected.

If the pressure relief device set point exceeds 0.5 bar then the Dewar shall meet the requirements for a pressurised vessel and the *Pressure Systems Safety Regulations* [6].

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.

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

A Dewar containing liquid should not be moved when fitted with a liquid withdrawal device.

NOTE: Gas will continually vent to atmosphere when fitted with a liquid withdrawal device. The hazards identified in Section 4, including asphyxiation, require the appropriate controls detailed in Section 5 to be applied.

For maintenance requirements refer to Section 7.

6.3 Labelling

Dewars containing liquid nitrogen shall be clearly and correctly labelled.

The risk assessment 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;
- warning signs.

Figure 9: Examples of signs

Figure 9 shows examples of labelled warning signs.

Where there is a requirement to transport the containers then the marking and labelling requirements shall comply with the requirements for transport legislation, 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. The employer shall carry out appropriate maintenance, inspection, identify 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 and recorded.

Each Dewar shall be subject to:

- a '*before use'* safety check, refer to Section 7.1;
- an '*after use'* safety check, refer to Section 7.2.
- an in-storage safety check, refer to Section 7.3;
- an in-storage ice formation check, refer to Section 7.4;
- a periodic inspection, refer to Section 7.5.

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.

Disposal. Dewars and liquid withdrawal devices are maintained and kept in service 'on condition'. Any Dewar or liquid withdrawal device which is beyond repair shall be disposed.

Where Dewars are supplied under a rental agreement and are no longer required, they should be returned to the supplier at the earliest opportunity. The supplier is responsible for the disposal of their Dewars at the end of their service life.

When a Dewar or liquid withdrawal device reaches the end of its service life, the owner should render it beyond use and take disposal action in an environmentally sensitive way.

7.1 Before use safety check

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

If the Dewar is empty and requires filling, carry out the filling checks in Section 9.

The before use safety check shall consist of:

- a visual check for damage. Ensure that:
  - there is no neck damage or twisting;
  - there is no frosting on the external surfaces;
  - there are no excessive dents, scrapes, gouges, cuts, deformation, etc., which would affect the vacuum;
  - the trunnions or mounting spigots are serviceable and correctly located (if the Dewar is to be mounted).

Any damage shall be further investigated, for example, consult with the manufacturer;

- a check for cleanliness. The Dewar shall meet the cleanliness standards required for the service for which it is intended, for instance, medical or food use. Check for contaminants, for example, moisture, oil, grease, etc. As necessary, clean;

- an internal check for foreign articles. Do not fill a Dewar until all articles are removed;

- 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;

- a check of vacuum integrity. This may be displayed as moisture or frosting on the external surface, which may be noticeably colder than ambient temperature;

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

- a check that the Dewar is appropriately labelled, refer to Section 6.3.

Where a liquid withdrawal device is fitted, check:

- the liquid withdrawal device is correctly fitted;

- the pressure relief device is installed;

- that the liquid withdrawal device is in good condition and is serviceable. If the valve, gauge, pressure relief device, clamping device or a secondary retaining device are damaged, then the device shall be replaced;

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 on the tipping trolley, the stand, the wheels, etc.

Equipment with unacceptable damage or contamination shall not be used.

7.2 After use safety check

To be carried out by the user on completion of the activity. 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, this may be displayed as moisture or frosting on the external surface, which may be noticeably colder than ambient temperature.

The Dewar shall be returned to its designated storage area when no longer required, refer to Section 10.

If a Dewar is not going to be stored with liquid nitrogen inside, the after use check shall ensure the Dewar is empty, appropriate protective covers are fitted and it is labelled to show it is empty.

7.3 In-storage safety check

Dewars shall be stored in compliance with Section 10. When Dewars containing liquid nitrogen are in storage, an inspection regime shall be implemented to check:

- the storage facility ventilation, weather protection, Dewar stowage, house keeping and separation distances (refer to BCGA GN 41 [28], *Separation distances in the gases industry*) are maintained;
- the atmospheric monitoring equipment. All atmospheric monitoring equipment shall be operating correctly, with an inspection and maintenance regime in place, including calibration requirements;
- the Dewar vacuum integrity. This may be displayed as moisture or frosting on the external surface, which may be noticeably colder than ambient temperature;
- labelling. Each Dewar shall be appropriately labelled;
- protection of the opening. Each Dewar shall have a suitable protective cap or cover correctly fitted;
- the inventory. The storage facility liquid nitrogen inventory shall not exceed the limits identified in the risk assessment.
- for ice formation. Refer to Section 7.4.

7.4 In-storage safety check for ice formation

If an ‘ice plug’ has formed, refer to Section 11. If an ‘ice plug’ has not yet formed but there is excessive ice build-up, then:

- empty the Dewar and remove from service;
- allow the Dewar to warm to ambient temperature;
- remove all moisture from inside the Dewar;

- investigate the causes of ice formation and review operating procedures to prevent a re-occurrence.

The Dewar shall only be returned into service if the cause of the ice formation has been resolved.

7.5 Periodic inspection

To be carried out by the owner. Dewars and liquid withdrawal devices are maintained and kept in service 'on condition'. Each Dewar and liquid withdrawal device shall undergo a thorough inspection on a periodic basis. Following this inspection, the Dewar and the liquid withdrawal device shall be marked with the date for the next periodic inspection. The manufacturers recommendation on a service life should be observed.

Dewar. The periodic inspection and maintenance shall include:

- a visual check for damage. Ensure that:
  - there is no neck damage or twisting;
  - there are no excessive dents, scrapes, gouges, cuts, deformation, etc., which would affect the vacuum;
  - the trunnions or mounting spigots are serviceable and correctly located (if the Dewar is to be mounted).

  Any damage shall be further investigated, for example, consult with the manufacturer;

- a check for cleanliness. The Dewar shall meet the cleanliness standards required for the service for which it is intended, for instance, medical or food use. Check for contaminants, for example, moisture, oil, grease, etc. As necessary, clean in accordance with manufacturer's instructions;

- 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 6.3;

- a check for vacuum condition. A reduction in the vacuum integrity may be displayed as moisture or frosting on the external surface, which may be noticeably colder than ambient temperature.

Liquid withdrawal device. Periodic inspection shall include a check that the liquid withdrawal device is in good condition and is serviceable. If the valve, gauge, pressure relief device, clamping device or a secondary retaining device are damaged, then the liquid withdrawal device shall be replaced.

Where fitted, the liquid phase separator device is in good condition, is serviceable and operates correctly.

The pressure relief device shall be replaced at a suitable frequency. BCGA CP 39 [21], *In-service requirements of pressure equipment (Gas storage and gas distribution systems)*, provides general guidance on the inspection of pressure relief device(s).

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 may increase the risk associated with the hazards in Section 4.

Dewars shall only be moved in well-ventilated areas.

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

In addition to the use and storage locations, any workplaces and other areas where a Dewar may be moved shall also be assessed for the risks associated with a release of gas in accordance with BCGA CP 52 [25].

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

For guidance on manual handling, refer to:

- BCGA GN 3 [26], Gas *cylinder. Manual handling operations*;
- HSE L23 [13], *Manual handling. Guidance on regulations*, and
- HSE INDG 143 [15], *Manual handling at work. A brief guide*.
- The Ergonomics Society.

Figure 10:
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.

The movement of a Dewar containing liquid nitrogen should be minimal as far as is reasonably practicable. When a Dewar is being moved, there is an increased risk of spillage. The severity of the risk will increase dependant on the distance travelled, the surface conditions, local environment and the frequency of movement.

Always handle a Dewar with care; do not trundle, shuffle or drag Dewars. A Dewar should be moved using a purposely designed trolley. Usually this will allow movement by a single person. Figure 10 shows an example of a Dewar mounted on a trolley.

Examples of some common specific hazards associated with movement, include:

- movement though doors and the use of stairs. Refer to Section 8.1;
- movement using lifts. Refer to Section 8.2.

Inspection and maintenance. Where Dewars are mounted on equipment for movement on site, for example, trolleys, tipping trolleys, roller bases, etc., these shall be checked for their serviceability and fitness for continued use on a periodic basis. This activity shall be carried out by a competent person and recorded.

8.1 Stairs and doorways

Stairs present an increased tripping hazard and a manual handling challenge. They should be avoided. Stairs are usually regarded as being an enclosed space. 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 in the location of the stairway.

Where movement through a doorway is required, then:

- ensure a clear pathway through the door. Do not move a Dewar through a revolving 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.

8.2 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.

Where it is unavoidable, the requirements of BCGA CP 52 [25] shall be followed. BCGA CP 52 [25] provides guidance on safe atmospheres and atmospheric monitoring equipment, including within a Confined Space and movement within a lift.

9. FILLING DEWARS

Dewars are typically filled either from a pressurised Storage Vessel, or directly from a road delivery tanker. Where filling is from a Dewar to a Dewar, i.e. Decanting, refer to Section 10.

If the Storage Vessel is a pressurised vessel it shall conform to and be sited in accordance with BCGA CP 36 [20].

If the Storage Vessel is a transportable container it shall conform to and be located in accordance with BCGA CP 27 [19].

The pressure in the Storage Vessel shall be as low as is reasonably possible to minimise splashing and prevent jetting of the liquid. A pressure of 1 bar is sufficient for transferring liquid. Higher pressures should not be used as more product will convert to a gas and create a greater gas cloud.

The risk assessment for the filling process shall take into account the equipment, the specific liquid transfer method and the pressure involved.

Where the filling location is remote from the gas source:

- a gas supply and distribution system shall comply with BCGA CP 4 [18];
- the location assessment shall take into account the requirements for managing the risks from gases in the workspace detailed in BCGA CP 52 [25];
- the use of a fail-safe device should be assessed. A fail-safe device can set the process to a safe condition in the event that conscious manual intervention ceases during the filling process.

The Dewar Filling equipment (whether fitted directly to the Storage Vessel, delivery tanker or a distribution system) shall be designed, manufactured and constructed by a competent person(s). The Dewar Filling equipment shall incorporate adequate pressure relief and comprise of materials compatible with liquid nitrogen, including the temperature and pressure.

The Dewar Filling equipment, including the flexible hose, shall be designed to prevent liquid being trapped. If there is the potential for trapping liquid, a pressure relief device shall be installed.

NOTE: Examples of where liquid may become trapped include between two valves, due to an ice block or a failure to remove protective covers.

A phase separator shall be used. A phase separator helps to prevent jetting and reduce splashing, whilst assisting in the spread of liquid to cool the Dewar, making for a more efficient process.

The filling activity shall be risk assessed in accordance with Section 4.

In addition to the above, as a minimum the filling location shall incorporate:

- a non-porous floor surface. This should be flat, made of material compatible with the activity, with adequate load bearing strength for the Decanting equipment and Dewar(s);
- spill management infrastructure. Any spilled liquid shall be able to disperse or be contained within a safe area;
- two-way segregation from other work activities and local hazards, including environmental considerations, traffic, etc. For information on separation distances, refer to BCGA GN 41 [28];

- control of access into the filing area, for example, (temporary) barriers around the filling location;

- adequate lighting conditions;

- suitable safety signs and warning notices;

- ergonomics and human factors. Further information is available in BCGA TIS 44 [29], *Human factors*;

- 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 5.6;

- the adequacy of emergency arrangements, for example, a spillage, cold burns, emergency egress routes, etc., refer to Section 13.

The filling of Dewars 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 may be a risk of cross-contamination of the samples via the Dewar Filling equipment. If this is a possibility, a method for preventing cross-contamination shall be included in the filling procedure. Further information is available in BCGA CP 45 [23].

9.1 Pre-fill check

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

- carry out the Dewar '*before use safety check'*, refer to Section 7.1;

  Where a liquid withdrawal device is fitted, this shall be removed during filling. Refer to Section 6.2;

- check the condition of the gas supply source (the Storage Vessel, tanker or distribution system), for example, serviceability, product, pressure, quantity of gas available, etc.;

- check the condition of the Dewar Filling equipment, for example, that it is clean and free from damage. If serviceable, prepare the Dewar Filling equipment for use;

- check and prepare the operating environment in preparation for filling.

Do not attempt to use blocked or damaged equipment.

9.2 Filling

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

- operating procedures for filling both warm and cold Dewars. These shall take into account the manufacturer's instructions and the requirements for wearing personal protective equipment;

- attendance. The fill shall be attended at all times;

- quantity. Only fill the Dewar with the required quantity of liquid nitrogen necessary to complete the task. Excess liquid nitrogen should be avoided;

- purging of the Dewar Filling equipment to clear any atmospheric moisture, other contaminants or gas (to a safe place);

- ensuring the Dewar Filling equipment and the Dewar are kept under control throughout the filling process;

- actions to take in the event of an incident, for example, spillage, Dewar Filling equipment blockage, etc. Refer to Section 13;

Figure 11:
Filling a Dewar

WARNING: Never overfill a Dewar.

- on completion of filling, replace the protective cap.

9.3 Post-fill check

On completion of filling ensure the conditions meet the requirements of the safe system of work. To include:

- a post-fill check on the Dewar, refer to the '*after use safety check*' in Section 7.2;

- a check that a protective cap (of the correct specification) is fitted. Alternatively, if required for use, fit a liquid withdrawal device, refer to Section 6.2;

- a check the Dewar is correctly labelled for liquid nitrogen. Refer to Section 6.3;

- a check of the gas supply source (the Storage Vessel, tanker or distribution system), which shall be left in a safe condition;

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

- that the filled Dewar is located in a safe place, refer to Section 10.

10. THE STORAGE AND USE OF DEWARS

Storage. There shall be a designated storage area for each Dewar(s). The location and infrastructure used for storage shall be subject to a suitable and sufficient risk assessment.

Suitable storage shall be provided for Dewars which are empty.

Where the storage area is used to store a Dewar(s) which contains liquid nitrogen additional controls are required. The area shall:

- be well-ventilated;
- be outdoors, dry and sheltered (if a store is in any location other than outdoors, then additional controls are required);
- be secure, with access managed to allow only authorised and competent personnel. Refer to Section 14;
- meet the required separation distances. For further information, refer to BCGA GN 41 [28].

WARNINGS:

1) Dewars containing liquid nitrogen will constantly vent gas. There is a risk from the release of nitrogen gas and the potential for a Reduced Oxygen Atmosphere, resulting in an asphyxiation hazard, refer to Section 3 and Section 4.

2) 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.

In storage, whether they contain liquid nitrogen or not, each Dewar shall:

- be fitted with a suitable protective cap or cover. Alternatively, a liquid withdrawal device may be fitted where a Dewar is ready for use. The protective cap or cover shall correctly fit the Dewar and be in good condition, refer to Section 6.
- be labelled to identify if they are 'empty' or 'full'. If there is no label, Dewars shall be treated as if they are 'full', i.e. they contain liquid nitrogen.

Following a suitable and sufficient risk assessment, the storage area may also be used for the purpose of Decanting.

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

The use location and activity shall be subject to a suitable and sufficient risk assessment to ensure safety, taking into account the requirements of Section 4, Section 5 and Section 9.

Liquid nitrogen may be decanted by either pouring, or through the use of a liquid withdrawal device. All the receiving equipment shall be compatible with liquid nitrogen.

When pouring liquid nitrogen, suitable equipment to aid the pouring shall be used, for example, a tipping trolley, refer to Figure 10. This provides good control of the pouring process and reduces the potential for splashing, whilst minimising the requirement for manual handling.

When using a liquid withdrawal device, only small volumes may be decanted at a time. It may be necessary to allow a period of time for sufficient gas pressure to build up inside the Dewar before further Decanting can take place.

WARNING: Do not apply any additional sources of heat to a Dewar.

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

Disposal of liquid nitrogen. If the Dewar and the receiving equipment were correctly filled, there should be only the minimum amount of residual liquid nitrogen for disposal.

Where there is no further use for the liquid nitrogen then it should be disposed of in a safe way, for example, by pouring in a controlled method onto an outdoor, non-porous surface, meeting the location requirements detailed in Section 9 for filling. All disposal methods and the disposal location shall be subject to a suitable and sufficient risk assessment.

The use of a designated evaporation area, is an option for the disposal of waste liquid nitrogen.

Liquid nitrogen shall not be disposed of in a water drainage system.

WARNING: The release of liquid nitrogen has the potential to create several hazards, including vapour clouds, a Reduced Oxygen Atmosphere, cooling down any objects it contacts, damaging or killing any vegetation it covers, forming ice on the floor resulting in slippery surfaces, etc.

Section 4 and BCGA CP 52 [25] provide information on the hazards from Cryogenic Liquids.

11. ICE PLUGS

Ice will form from atmospheric moisture which comes into contact with the cold temperatures found in the opening into the Dewar. Overtime the ice will increase and will seal the opening to the Dewar. This is called an ice plug. An ice plug prevents the release of gas, this will result in an increase in internal pressure. An increase to the internal pressure will lead to either the ice plug being ejected at high velocity or the catastrophic failure of the Dewar.

Figure 12 shows an example of an ice plug forming.

Figure 12:
An example of an ice plug forming

If this code of practice is complied with, an ice plug should not occur, for example:

- correctly fitting a suitable protective cap or cover;
- carrying out the in-storage safety checks, refer to Section 7.3.
- only filling a Dewar with the quantity of liquid nitrogen required for the activity;
- disposing of surplus liquid nitrogen on completion of the activity.

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

WARNING: 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 either lead to the ice plug being ejected at high velocity or the catastrophic failure of the Dewar.

There shall be suitable and sufficient 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.

As a minimum 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.

Unless specifically trained, using appropriate equipment and taking the necessary safety controls, do not:

- approach the Dewar;
- attempt to move the Dewar;
- enclose the Dewar.

Once the ice has cleared and the Dewar has reverted to a safe condition, any remaining liquid nitrogen should be removed. Refer to Section 10.

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 further use.

The cause(s) of the ice plug shall be investigated and appropriate corrective and preventative actions taken to prevent a re-occurrence.

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).

The transportation of liquid nitrogen in Dewars is a hazardous operation and should be avoided where possible. As an alternative, arrange with the gas supplier to deliver the liquid nitrogen to the site where it is required.

The hazards of transporting liquid nitrogen include:

- a Dewar containing liquid nitrogen will constantly produce gas, this is an asphyxiation hazard (refer to Section 3). In an enclosed vehicle this gas may remain in the vehicle for a considerable time and may only disperse slowly;
- a liquid spill, (for example, caused by unsecured Dewars falling over, driving over potholes, following a road traffic incident, etc.) may result in:
    - a gas cloud, which has the potential to asphyxiate any person(s) exposed;

- the release of very cold liquid. This may impact on people, resulting in cold burns, and on the vehicle, for example, freezing tyres (and making them very brittle), or making surfaces extremely cold to touch.

Where the transportation of Dewars cannot be avoided, the carriage on a vehicle shall comply with the *Road Traffic Act* [1]. Liquid nitrogen is classified as Class 2 dangerous goods. Specifically, compliance is required with the *Carriage of Dangerous Goods and Use of Transportable Pressure Receptacles Regulations* [10]. These Regulations implement ADR [11].

NOTE: For sample transportation under cryogenic conditions (vapour phase storage), the use of a Dry / Cryo Shipper may be a safer option.

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

The principles detailed within BCGA CP 50 [24], *The carriage of gas cylinders on vehicles*, shall be followed. Whilst this document focusses on gas cylinders, the majority of the principles apply for the transportation of Dewars. Dewars shall meet the requirements of ADR [11], P203, for open cryogenic receptacles. Dewars which do not conform to ADR [11] shall not be used to transport liquid nitrogen.

Dewars containing liquid nitrogen should not be transported inside vehicles. They should only be transported on open vehicles or trailers. Where (against recommended advice) Dewars containing liquid nitrogen are carried inside a vehicle, in the same space as people, then a suitable and sufficient risk assessment and appropriate controls shall be implemented. Advice is available in BCGA CP 50 [24].

NOTES:

1. Whilst some vehicles may be fitted with bulkheads to separate the driver's compartment from the load area, these bulkheads are not generally designed to be gas tight and they may not be suitable as protection for the vehicle crew from the asphyxiation hazard created.

2. The use of atmospheric monitoring equipment will provide a warning of a decrease in local oxygen levels, but may not give sufficient time to safely stop and evacuate a vehicle before Asphyxia occurs.

Before transportation:

- 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 the before use safety check. Refer to Section 7.1;
- transport only the minimum volume of liquid nitrogen 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 [11], 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 diamond hazard label:
      Label model No. 2.2
      Refer to Figure 13

Figure 13:
Label 2.2

Additional safety information may be included on the label. Figure 14 shows an example of a label, it includes additional safety information.

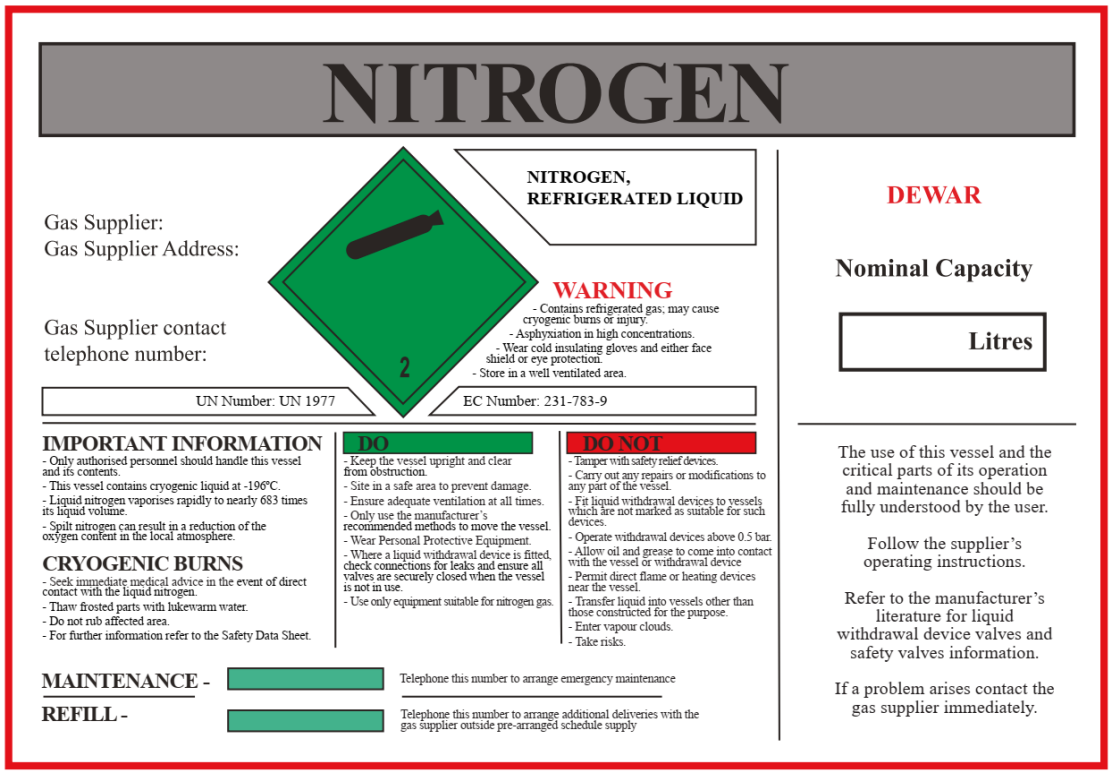

Figure 14: Example of a Dewar label incorporating transport information.

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, potentially creating an asphyxiant atmosphere;

- creation of an asphyxiant atmosphere, through oxygen depletion. An asphyxiant atmosphere may be created in poorly ventilated storage and / or use areas, and following a spillage.

- excessive pressure. Excessive pressure can be created through:

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

    - the use of a sealed (unvented) container where the pressure cannot be released;

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

- activation of alarms.

Emergency operating procedures

The emergency operating procedures shall include the following:

- response to alarms, including an understanding of the type of alarm and the actions required;

- 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 competent persons who are following suitable rescue techniques, including the use of breathing apparatus. Refer to BCGA CP 52 [25].

- availability, location and suitability of first aid provision;

- specific actions where a transport or movement related incident is foreseeable;

- specific actions where an ice plug forms, refer to Section 11.1.

- management of an incident. This may include:

    - escalation;

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

    - the identification of places where escaped gas or liquid may flow or accumulate, for example, pits, basements, cellars, stairwells, drains, etc.;

    NOTE: Cold gas will collect in low lying areas, but will mix with the surrounding atmosphere as it reaches ambient temperature.

    - where practical, preventing the liquid flowing along the ground into such areas, for example, by closing doors on exit, etc.;

- the appropriate actions to prevent the spread of (excessive levels of) the nitrogen gas to other areas through that the ventilation system(s);
- the use of emergency ventilation;
- allowing time for the liquid to evaporate naturally;
- management of the affected area(s) until the hazard is reduced and the area made safe. Refer to BCGA CP 52 [25].

- post incident actions:
  - review the emergency response taken to manage the incident;
  - carrying out a mechanical assessment of items potentially affected by the extreme cold;
  - conduct an incident investigation to identify the cause;
  - review the preventative control measures;
  - identify and implement any corrective actions.

14. SECURITY

All gases are hazardous substances. Appropriate security shall be provided during storage, movement and use.

A documented security vulnerability risk assessment (SVRA) shall be carried out at each location where Dewars (and other hazardous substances) are stored or are in use. Refer to BCGA CP 40 [22], *Security requirements for the industrial, medical and food gases industry*.

Access to, and the use of Dewars, shall only be by authorised and competent personnel.

Dewars being prepared for or during carriage, shall comply with the security provisions of ADR [11], Chapter 1.10. All persons engaged in the carriage of dangerous goods shall adhere to the security requirements of ADR [11] commensurate with their responsibilities.

Advice on security can be obtained from BCGA or from local crime prevention officers.

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	Confined Spaces Regulations 1997.

4.	SI 1998: No. 2306	The Provision and Use of Work Equipment Regulations 1998 (PUWER).
5.	SI 1999 No. 3242	The Management of Health and Safety at Work Regulations 1999.
6.	SI 2000 No 128	Pressure Systems Safety Regulations 2000.
7.	SI 2002 No. 618	The Medical Devices Regulations 2002 (as amended).
8.	SI 2002 No. 1144	The Personal Protective Equipment Regulations 2002
9.	SI 2002 No. 2677	The Control of Substances Hazardous to Health Regulations 2002 (COSHH).
10.	SI 2009 No. 1348	The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (as amended).
11.	UNECE	Agreement concerning the international carriage of dangerous goods by road (ADR) (as amended).
12.	European Directive 93/42/EEC	Council Directive 93/42/EEC of 14 June 1993 concerning medical devices. The Medical Devices Directive (MDD) (as amended).
13.	HSE L23	Manual Handling. Manual Handling Operations Regulations 1992 (as amended). Guidance on Regulations.
14.	HSE L25	Personal Protective Equipment at Work.
15.	HSE INDG 143	Manual handling at work. A brief guide.
16.	HSE INDG 163	Risk assessment. A brief guide to controlling risks in the workplace.
17.	EIGA 136	Selection of personal protective equipment.
18.	BCGA Code of Practice 4	Gas supply and distribution system (excluding acetylene).
19.	BCGA Code of Practice 27	Transportable vacuum insulated containers of not more than 1000 litres volume.
20.	BCGA Code of Practice 36	Cryogenic liquid storage at users' premises.
21.	BCGA Code of Practice 39	In-service requirements of pressure equipment (Gas storage and gas distribution systems).
22.	BCGA Code of Practice 40	Security requirements for the industrial, medical and food gases industry.
23.	BCGA Code of Practice 45	Biomedical cryogenic storage systems. Design and operation.

24.	BCGA Code of Practice 50	The carriage of gas cylinders on vehicles.
25.	BCGA Code of Practice 52	The management of risks from gases in the workplace.
26.	BCGA Guidance Note 3	Gas cylinder. Manual handling operations.
27.	BCGA Guidance Note 23	Gas safety. Information instruction and training.
28.	BCGA Guidance Note 41	Separation distances in the gases industry.
29.	BCGA Technical Information Sheet 44	Human factors.
30.	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
Medicines and Healthcare products Regulatory Agency (MHRA).	www.mhra.gov.uk
British Compressed Gases Association (BCGA)	www.bcga.co.uk
European Industrial Gases Association (EIGA)	www.eiga.eu
British Cryogenics Council (BCC)	http://bcryo.org.uk
The Ergonomics Society	www.ergonomics.org.uk

British Compressed Gases Association

www.bcga.co.uk