CryoService Limited / MRC (Medical Research Council)

Standards for Liquid Nitrogen Supply Systems in Life Science Applications

Contents

Part 1. Introduction

1.1 Purpose and structure of document

This document provides guidance on the standards required by MRC and/or CryoService Limited in respect of liquid nitrogen supply systems for life-science applications. It considers options selected on the basis of the findings of preliminary and substantial risk assessments, primarily focusing on the possible effects of oxygen depletion.

The guidance also seeks to address ergonomic concerns with liquid nitrogen and sample handling and considers other hazards of working with liquid nitrogen.

With respect to planning a new or modified liquid nitrogen storage facility, Part 2 provides guidance on the detailed risk assessment process, which is a mandatory first step. Worked examples are found in the associated Appendix.

Part 3 outlines the various types of tanks and storage vessels available and Part 4 gives examples of installation schemes founded on relevant risk assessments.

1.2 Properties of liquid nitrogen

Major hazards

The major hazards associated with the use of liquid nitrogen are potential exposure to oxygen deficient atmosphere, direct skin contact with extremely cold liquid and sudden pressure release. These can result in asphyxiation, cold burns and physical trauma.

Properties

Liquid nitrogen is colourless, odourless, exists at –196ºC (at atmospheric pressure), and is widely employed in cold storage applications (such as preservation of biological samples).

An increase in temperature through spillage, release or even simple exposure to surrounding air causes the liquid to boil and nitrogen to return to the gaseous phase. A large expansion in volume accompanies this change in physical state; one litre of liquid producing approximately 680 litres of gas.

If nitrogen gas accumulates in an area, air will be displaced, resulting in a reduced oxygen level. This presents a high risk of asphyxiation to any personnel present.

The extreme temperature can also damage human tissue, and any contact with the liquid or equipment exposed to the product, may result in cold burns.

If the liquid is contained in a storage tank or pipework, pressure builds with any change to the gaseous state, and there is potential for harm from any subsequent release of energy.

Liquid nitrogen storage and supply facilities, within life science applications, must therefore be planned, with the health and safety of laboratory, delivery, maintenance and other personnel paramount.

1.3 Installation Management

Applications

Scientific processes require the use of liquid nitrogen in a number of applications.

Techniques such as nuclear magnetic resonance (NMR) utilise liquid Nitrogen as a coolant.

Medical research may require anaerobic or semi-anaerobic atmospheres.

Small-scale distribution and handling may also be necessary to support sample transfers and manipulation in experimentation.

Supply System and Preliminary Risk Assessment

The essential first step in determining the appropriate supply system for any particular installation is to undertake a preliminary risk assessment. Issues to be considered will include:

- Maximum volume of nitrogen required to be held at point of use
- Maximum volume of nitrogen required to be held in storage tanks
- Maximum number of samples to be stored
- Type and quantity of sample storage vessels to be used (including back-up systems)
- Operations to be performed at point of use
- Location or options for location (if there is more than one possibility)
- Manual handling and ergonomic considerations
- Maintenance of plant.

The importance of undertaking this preliminary risk assessment cannot be overstated with the objective being elimination or, where this is not reasonably practicable, minimisation of risk through appropriate engineering control measures.

The nature and complexity of the supply system will depend upon the application(s) and the layout of the building/premises, volume/pressure/flow requirements, options on tank location, distance from storage point to point of use, etc.

The cryogenic storage vessels may take a variety of forms and sizes, ranging from large static tanks for bulk liquid storage, through small/medium mobile tanks for limited volume/increased flexibility applications, to Dewars for small-scale work.

In this context a Dewar is defined as a non-pressurised vessel used for the storage of liquid nitrogen. It can be used for sample storage or for holding small stocks of cryogenic liquid.

Siting/Installation

Where the initial assessment identifies the need for a liquid nitrogen storage tank to be located on site, a survey must always be undertaken prior to planning the installation to assess a suitable location for the tank and the risks involved.

The site chosen for the tank must, as an absolute minimum, take into account the following factors:

- Amount of product being stored in the tank
- Access requirements for installing the tank
- Access requirements for filling/maintaining the tank
- Safety distances/precautions required to protect against build-up of unsafe atmospheres and the potential for cryogenic burns resulting from product release
- Safety measures required to protect the tank from fire and impact damage (from vehicles and other objects)
- Security arrangements to prevent access to the tank by unauthorised personnel.

The British Compressed Gases Association (BCGA) Codes of Practice provide guidance and a framework to assist with fulfilling the legal duties and achieving best practice (see References). Failure to carry out the proper siting and installation of the tank/equipment may lead to unsafe operation and breach of legislation.

External tanks must have sufficient clearance on all sides to comply with BCGA CP28 (tanks up to 1000 litres water capacity) or CP36 (tanks over 1000 litres water capacity).

The siting and installation of the tank/equipment should be carried out by a trained and competent person, in line with the findings of the risk assessment. It is the responsibility of the person carrying out the siting and installation of the tank to ensure that the work is carried out in accordance with the appropriate regulations/codes of practice, and that all parts/components used are safe and suitable for the intended application.

The user should consult their own Health & Safety regulations to ensure full compliance with local requirements and that site emergency and evacuation procedures are taken into account. These formal requirements will need to be reviewed by any external contractors involved in filling and maintenance operations.

Part 2. Risk Assessment for Oxygen Depletion

Competent personnel must assess the risks arising from storage and use of liquid nitrogen in the workplace, including:

- Oxygen depletion
- Cold burns
- Pressure release
- Manual handling/ergonomic issues.

Appropriate and adequate preventative and risk control measures must be identified, established and maintained. This section focuses on assessing and managing the risks associated with oxygen depletion.

2.1 Introduction

Nitrogen gas may enter the workplace by various means, for example during:

- Product transfer operations
- Sample handling and removal from storage vessels
- Venting of excess pressure
- Spillage or leakage leading to “boil-off” of liquid
- Leaks in the system pipework.

These could result in a reduction of the normal oxygen concentration in the air that we breathe. Any depletion of the oxygen level in the air (below 21%) must be treated with concern. As a minimum, the concentration in the workplace should be maintained above 19.5%.

Atmospheres containing less than 18% oxygen are potentially dangerous, and entry into such areas should be prohibited unless suitable and sufficient measures are adopted (for example the use of breathing apparatus).

Effects of Sudden Asphyxia

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

Effects of Gradual Asphyxia

Sudden asphyxia is the most common form encountered, but gradual asphyxia can also occur as the oxygen levels in the atmosphere decrease slowly over time.

One possible cause for the gradual lowering of the oxygen levels would be nitrogen vapour escaping from liquid nitrogen storage Dewars in an enclosed space.

The signs and symptoms likely to be exhibited by persons inhaling different levels of oxygen in the atmosphere are shown in the Table 1 below.

Table 1 - Asphyxia Symptoms for Low Oxygen Levels

Oxygen Content of Air	Signs and Symptoms of Asphyxia
18% - 19.5%	May affect physical and intellectual performance without person's knowledge.
15% - 18%	Decreased ability to work strenuously. May impair co-ordination and may induce symptoms in persons with coronary, pulmonary, or circulatory problems.
12% - 15%	Respiration deeper, increased pulse rate, and impaired co-ordination, perception and judgement.
10% - 12%	Further increase in rate and depth of respiration, further increase in pulse rate, performance failure, giddiness, poor judgement, blue lips.
8% - 10%	Mental failure, nausea, vomiting, fainting, ashen face, blue lips.
6% - 8%	Loss of consciousness within a few minutes, resuscitation possible if carried out immediately.
0% - 6%	Loss of consciousness almost immediate, death ensues, brain damage even if rescued.

The potential for an oxygen deficient atmosphere is dependent upon many factors including:

- The volume of gas released into the workplace
- The rate at which the gas is released
- The volume of free air within the workplace
- The nature and level of the ventilation
- The potential for localised accumulation of gas.

2.2. Principles of risk assessment

Calculation of oxygen levels as part of risk assessment

Once the parameters outlined in the preliminary risk assessment are defined, it is essential that detailed risk assessments are made to cover all of the possible scenarios that would or could result in nitrogen gas being released into the facility with the consequent potential for oxygen depletion.

Calculations are required for possible sudden release of gas, as well as release through evaporation, leakage and spillage.

Details of the calculations required, together with worked examples, can be found in **Appendix 1**.

2.3. Risk control

The results of the full risk assessment for potential oxygen depletion are used to determine the control measures required to eliminate or minimise the possibility of being exposed to oxygen depleted atmospheres. The selection of control measures and models of installation systems can be found in **Part 4**.

Part 3: Liquid nitrogen storage tanks/Equipment

3.1 Tank Overview

The storage tank is designed for storing liquid nitrogen at pressures above atmospheric, and the tank must not be used for storing any other type of product. The type of product stored (i.e. liquid nitrogen) must be clearly indicated on the tank,

The net volume of the tank is typically 90-95% of the gross volume, providing a space at the top of the tank to allow for liquid expansion.

The storage tank is usually used for dispensing liquid nitrogen, but the product can be dispensed from the tank as a gas instead if required. On some tank installations, the tank may be able to perform both liquid and gas dispensing functions as required.

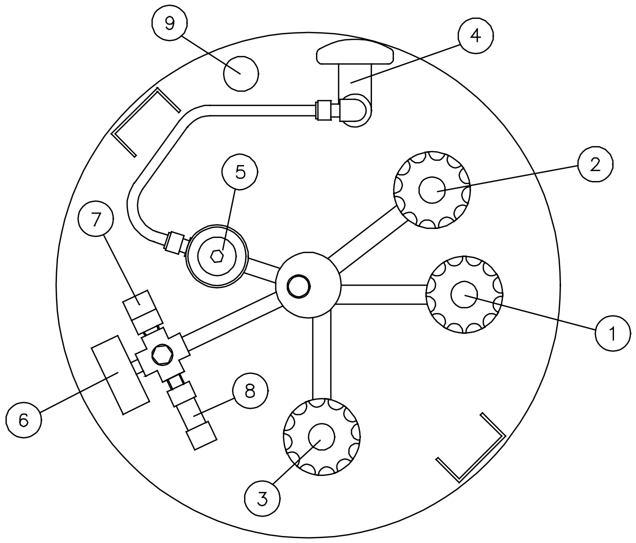
The tank is fitted with a liquid gas fill point to enable re-filling of the tank from a delivery tanker without interrupting the user's operations. The tank fill point may be located either directly on the tank itself if it is sited outdoors, or can be moved outdoors for filling purposes, or at a remote outdoor location away from the tank and connected to the tank via a liquid fill pipeline. On some installations the safety vent pipeline from the tank may also vent externally via the tank fill point.

The tank is usually fitted with a dispense pipeline system to dispense the nitrogen in either liquid or gaseous form (or both) to the end use applications (e.g. cold storage). Liquid dispense pipelines are always insulated to reduce product losses caused by vaporisation of the liquid. The insulation may take the form of conventional lagging or the use of super insulated vacuum lines (SIVL).

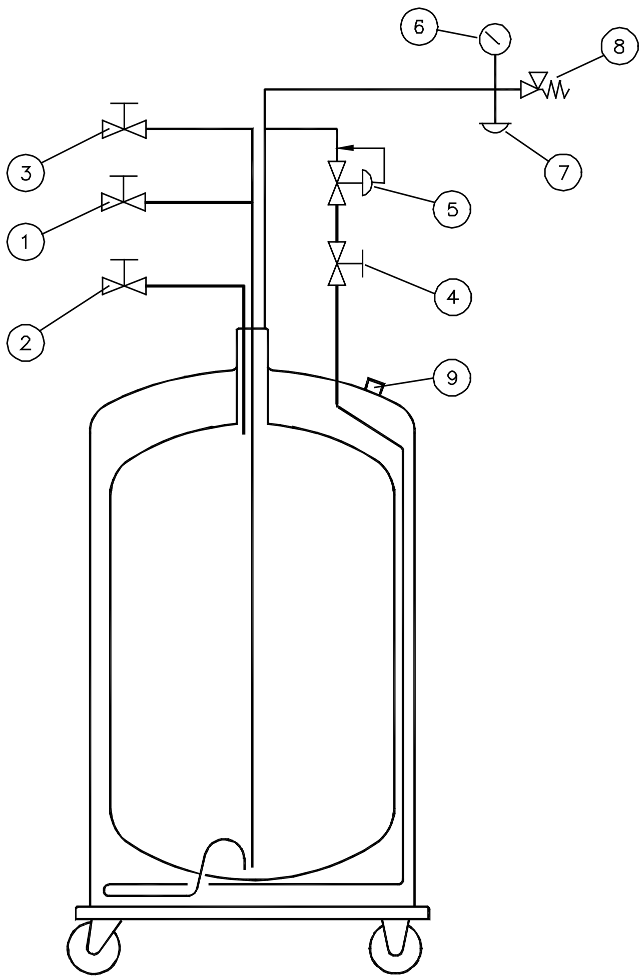
Note: The manufacturer's plate on the tank provides information on the date of manufacture, design codes/standards, tank capacity and maximum working pressure.

Typical Schematic Tank Diagrams

Dispensing Manifold



General Vessel Layout



Key.

1. **Liquid Fill / Decant .**
2. **Trycock / Vent (Gas Use).**
3. **Liquid Fill / Decant.**
4. **Pressure Build.**
5. **Pressure Regulator.**
6. **Pressure Gauge.**
7. **Burst Disc.**
8. **Relief Valve.**
9. **Evacuation Port Cover.**

3.2 Types of Tank Installation

Depending upon where the tank is to be sited or used, it may be installed as either:

- A static tank
- A mobile to fill tank
- A mobile tank.

Some mobile to fill/mobile tanks can be supplied fitted with wheels for ease of movement, whilst others can only be moved using a special trolley. The manual handling considerations (e.g. stairs) for filling and using a mobile to fill/mobile tank should be considered when deciding upon the type of tank to be installed.

Static Tank

Mobile Tank on Wheels

Mobile Tank on Trolley

Static Tank

A static tank is installed in a fixed location, with the tank fill pipeline (remote fill tanks only), safety vent pipeline and dispense pipeline(s) all permanently connected to the tank. The tank remote fill point (where fitted) and vent outlet are piped to fixed safe outdoor locations. Depending upon the height of the tank and the prevailing wind conditions, some of the larger static tanks may be bolted to a concrete base.

For reasons of security, the enclosure of the tank within an open fence (e.g. heavy wire) should be considered.

Mobile to Fill Tank

A mobile to fill tank is normally connected to the dispense pipeline(s), but is disconnected and moved to a safe outdoor location for filling. A facility should be provided at the normally installed position for connecting the tank safety vent pipeline outlet to a vent system which discharges in a fixed safe outdoor location.

Mobile Tank

A mobile tank may be used in various locations, but is moved to a safe outdoor location for filling. A designated tank storage position should normally be allocated which is provided with a facility for connecting the tank safety vent pipeline outlet to a vent system which discharges in a fixed safe outdoor location.

3.3 Tank Construction

The tank comprises of an inner pressure vessel containing the liquid nitrogen, enclosed by a larger outer vessel, and the inter-space between the two vessels is insulated to keep the liquid nitrogen refrigerated. On most tanks the inter-space between the two vessels is evacuated to provide a high vacuum insulation for the inner vessel, and insulating material is also usually used to back up the vacuum insulation to ensure that the heat leak to the inner vessel is kept to the minimum.

Some of the larger static tanks are not vacuum insulated, and instead rely purely on high efficiency insulating material between the two vessels to keep the liquid nitrogen in the inner vessel refrigerated. Some of these larger static tanks may also be fitted with an external refrigeration system to provide additional cooling for the tank.

For safety, the outer vessel on the tank is protected against over-pressurisation by means of a simple pressure relief device that will vent the inter-space between the two vessels in the event of leakage from the inner pressure vessel. The pressure relief device fitted to protect the outer vessel may be either a plug held in place by the atmospheric pressure acting upon the outer vessel that will simply fall out to relieve any excess pressure in the inter-space, or a bursting disc that is designed to rupture in the event of excessive pressure in the inter-space.

3.4 Ancillary Tank Equipment

The installed equipment must comply with The Pressure Systems Safety Regulations. Robust engineering and procedural controls must be used in support of appropriately specified and maintained cryogenic equipment.

Tank Pressure Relief Devices

For safety, the tank is fitted with two independent pressure relief devices to protect the inner pressure vessel from over-pressurisation. The primary safety protection is always provided by means of a spring-loaded pressure relief valve which opens to release pressure if the pressure in the tank exceeds the load exerted by the spring, and closes to stop releasing pressure as the pressure in the tank drops below the spring's load rating.

The secondary safety protection may be provided by means of either a second pressure relief valve, or one or two bursting discs that are designed to rupture in the event of primary pressure relief valve failure. If the tank is located inside a building, the pressure relief valve exhaust ports are normally connected to a vent pipeline which discharges in a fixed safe outdoor location.

Tank Pressure Gauge and Contents Gauge

The tank is fitted with a pressure gauge to indicate the internal pressure in the tank, and a separate contents gauge to indicate the liquid level in the tank. The contents (liquid level) gauge fitted to the tank may be either a capacitance type, differential pressure type or float type gauge as shown below.

Push button to read liquid level in tank

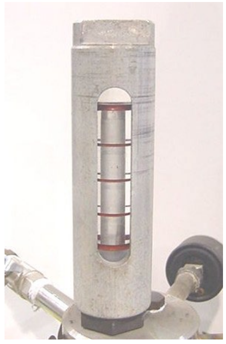
Pressure Gauge

Capacitance Gauge

Differential Pressure Gauge (1)

Differential Pressure Gauge (2)

Float Gauge (1)



Float Gauge (2)

Tank Manually Operated Valves

The tank is normally fitted with manually operated shut-off valves for isolating the liquid fill line into the tank and the liquid and/or gas dispense line out of the tank (as appropriate). In some cases an additional 3-way valve is also fitted in the liquid fill/dispense line for changeover from liquid filling to liquid decanting purposes.

In addition the tank is normally fitted with a manually operated trycock/vent valve or trycock valve and vent valve and, where appropriate, a 3-way valve for change-over from the primary pressure relief device to the secondary pressure relief device. If the tank is fitted with a pressure build system, the tank will also be fitted with a pressure build valve.

Tank Fill Line Thermal Relief Valves

For safety, where the tank is filled via a remote fill point, the liquid fill line between the fill point and the tank may be fitted with a thermal relief valve or valves to protect the system against over-pressure if there is any risk of liquid being trapped at any point.

3.5 Tank Dispense Equipment

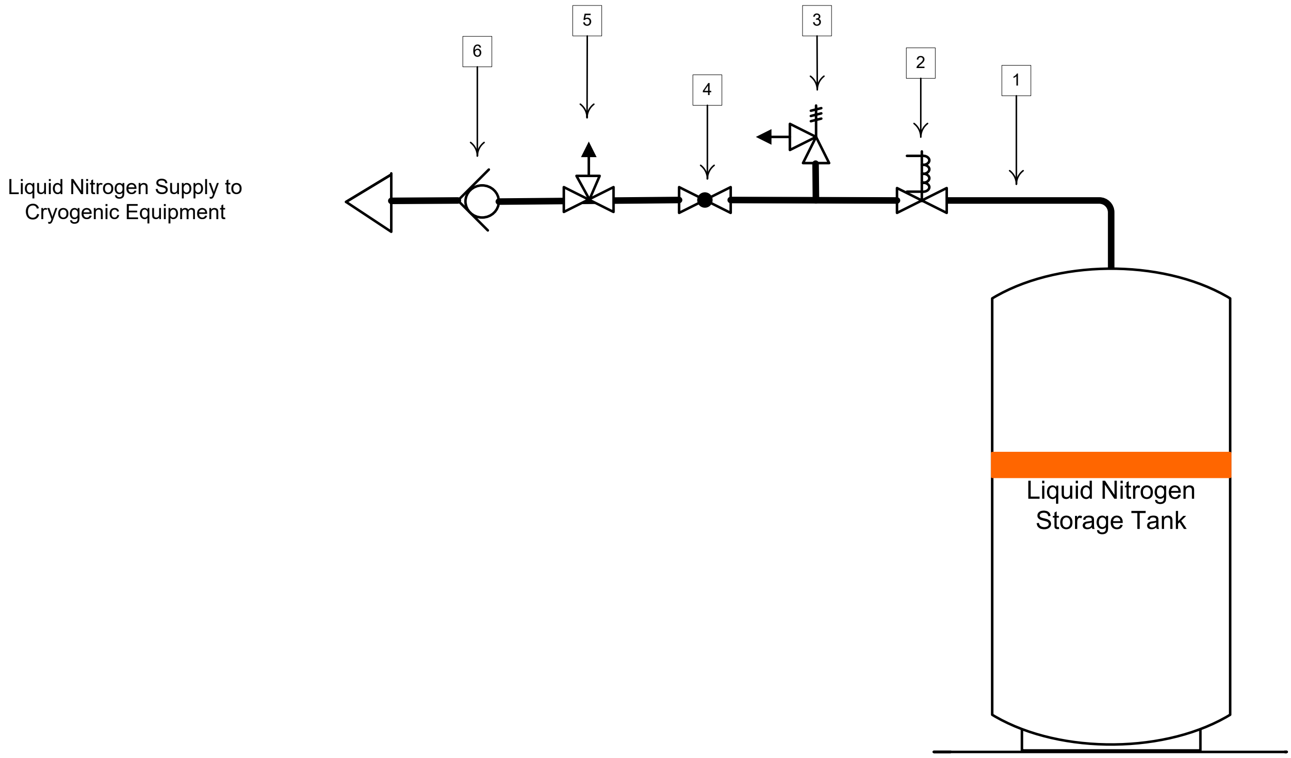
Design Considerations

The tank dispense pipeline/equipment must be specifically designed to suit the application. This design must take account of the product dispensed (i.e. liquid nitrogen or nitrogen gas), pressure, temperature, flow, and environmental requirements as a minimum.

The tank dispense pipeline/equipment must therefore not be altered, tampered with, removed or replaced without a comprehensive review of the design parameters by a trained/competent person to ensure the continued safe operation of that system.

Typical Tank Liquid Nitrogen Dispense Pipeline/Equipment (Where Applicable)

The diagram below shows the typical equipment that **may** be fitted in a liquid nitrogen dispense pipeline from a storage tank.



Item 1 - Super Insulated Vacuum Line (SIVL)

A super insulated vacuum line (SIVL) is used to convey liquid nitrogen from the storage tank to the cryogenic equipment; this SIVL may be either a ‘dry’ or a ‘wet’ system.

Item 2 - Solenoid Operated Shut-Off Valve

A solenoid operated shut-off valve is fitted to enable automatic isolation of the liquid nitrogen supply to the cryogenic equipment.

Item 3 - Thermal Relief Valve

A thermal relief valve is fitted to provide protection against over-pressure if there is any risk of liquid nitrogen being trapped at any point (e.g. between two valves).

Item 4 - Hand Operated Shut-Off Valve

A hand operated shut-off valve is fitted to enable manual isolation of the liquid nitrogen supply to the cryogenic equipment.

Item 5 - Automatic Phase Separator

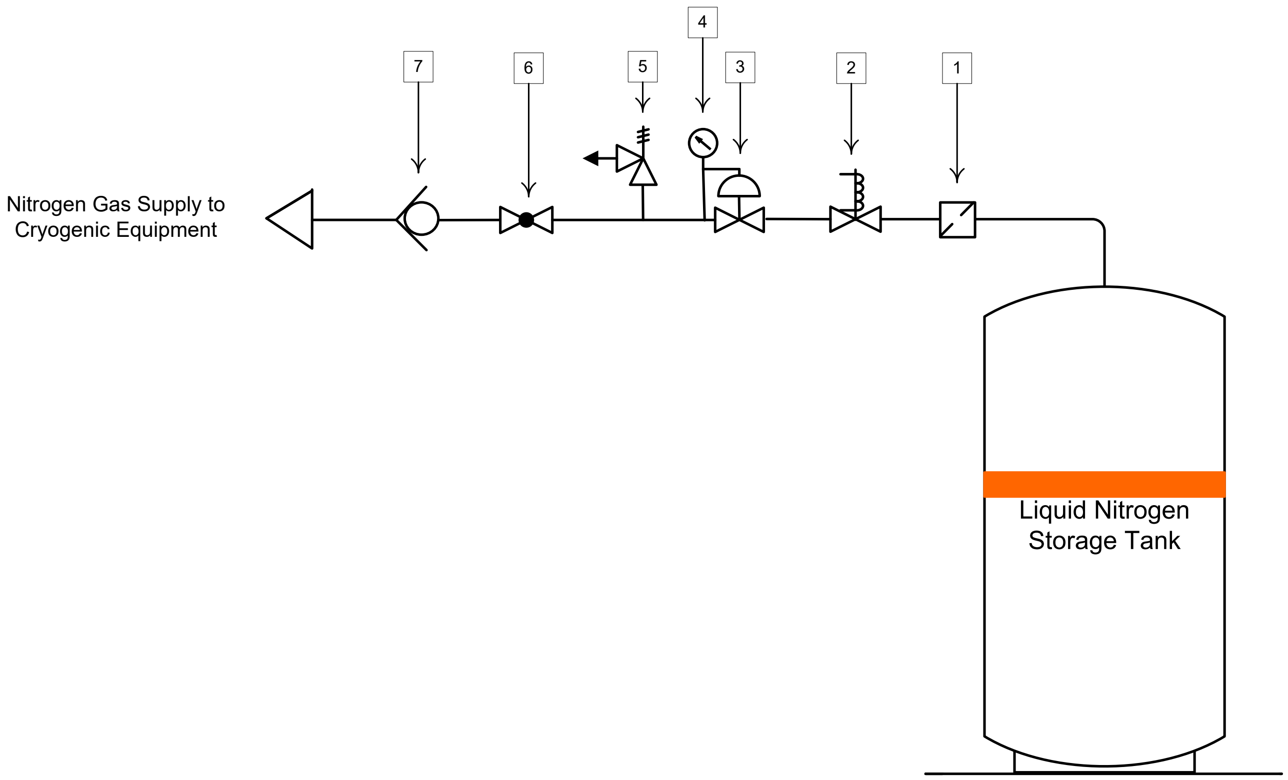
A phase separator is fitted to automatically vent any nitrogen gas in the pipeline to atmosphere, and thus ensure that only liquid nitrogen is supplied to the cryogenic equipment.

Item 6 - Non-Return Valve

A non-return valve is fitted to prevent any back-feed into the storage tank from the cryogenic equipment or other connected storage tanks.

Typical Tank Nitrogen Gas Dispense Pipeline/Equipment (Where Applicable)

The diagram below shows the typical equipment that **may** be fitted in a nitrogen gas dispense pipeline from a storage tank:



Item 1 - Filter

A filter is fitted to prevent any contamination of the nitrogen gas supply to the cryogenic equipment.

Item 2 - Solenoid Operated Shut-Off Valve

A solenoid operated shut-off valve is fitted to enable automatic isolation of the nitrogen gas supply to the cryogenic equipment.

Item 3 - Pressure Regulating Valve

A pressure-regulating valve is fitted to control the nitrogen gas supply pressure from the tank.

Item 4 - Pressure Gauge

A pressure gauge is fitted to indicate the nitrogen gas supply pressure from the tank.

Item 5 - Pressure Relief Valve

A pressure relief valve is fitted immediately downstream of the nitrogen gas pressure regulating valve to provide protection against over-pressure in the event of a fault on the pressure regulating valve.

Item 6 - Hand Operated Shut-Off Valve

A hand operated shut-off valve is fitted to enable manual isolation of the nitrogen gas supply to the cryogenic equipment.

Item 7 - Non-Return Valve

A non-return valve is fitted to prevent any back-feed into the storage tank from the cryogenic equipment or other connected storage tanks.

3.6 Dewars, Freezers and Other Storage Containers

There are many different types of Dewars, freezers and other storage containers available, and a few examples of these are shown below.

The selection of a suitable sample storage vessel is important. There are issues of safety and economy to be considered, as well as issues of good management and sample record keeping.

Samples are stored either in direct contact with the liquid or vapour or through the use of vessels that hold the nitrogen enclosed in a jacket. The option of holding the samples in the vapour phase has become increasingly popular given the associated benefits in terms of reduced product consumption, sample tube damage and potential for cross-contamination.

The option of using jacketed vessels has its own advantages for the operator, who does not come into direct contact with the liquid nitrogen. Their use should therefore be considered on safety grounds and nitrogen consumption is approximately the same as that of vapour phase vessels.

Part 4 Installation systems

4.1. Selection of Control Measures

Control measures should be put in place to eliminate or reduce the possibility of an asphyxiating atmosphere developing. These may include all or a combination of the following as appropriate to the level of risk:

Installation:

- Ensure a safe location for the cryogenic tanks/equipment - where possible site storage tanks/cylinders outside and pipe the liquid nitrogen into the workplace
- Nitrogen storage tanks of 500 litre capacity and above must be located outside in a location acceptable to the supplier, and designated a "No Parking" area
- Where necessary secure the storage tanks/cylinders against accidental impact damage by the installation of suitable safety rails or bollards
- Ensure safe external venting of all gas exhausts/pressure relief lines from the cryogenic tanks/equipment
- Ensure the correct specification, installation, use, inspection and maintenance of the cryogenic tanks/equipment
- Ensure ergonomic design of the work area to minimise or eliminate movement of the tanks/equipment and manual handling requirements.

Ventilation:

- Adequate ventilation is necessary to avoid or minimise the accumulation of nitrogen gas in the workplace
- For rooms above ground level with no special ventilation openings, natural ventilation will provide typically one air change per hour. With well sealed windows (e.g. double glazing), this will be less. Basement rooms only average 0.4 air changes per hour.
- For general handling of transportable cryogenic vessels in locations at or above ground level, natural ventilation is generally sufficient provided the room is large enough or the outdoor area is not enclosed by walls.
- An indoor location should have ventilation openings with a total area of at least 1% of the floor area. The openings should be at low level (e.g., 0.5 – 1.0 metre from floor) and be positioned diagonally across the room.
- Cold nitrogen gas is heavier than air and will accumulate at low level. Where possible liquid nitrogen should not be handled in basement rooms, rooms with ventilation at high level only and rooms where the gas can be trapped in pits or gulleys.
- Either natural ventilation (air vents, windows etc.) or forced ventilation (mechanical extraction system) may be used depending upon the number of air changes needed per hour; a forced ventilation system is usually necessary for more than 2 air changes per hour.
- Consideration must be given to the use of oxygen level meters and alarm systems in areas where the ventilation is poor.

Additional control measures may also be necessary to warn of the development of an unsafe atmosphere and/or assist in ensuring people do not remain in an unsafe area where an asphyxiating atmosphere may exist. These may include any of the following:

Oxygen Monitoring and System Interlocks:

- Oxygen depletion monitors must be fitted wherever the risk assessment indicates that oxygen levels may be depleted to less than **19.5%**.
- The monitors are installed to test the atmosphere in the workplace before entry and during occupancy.
- The alarm should activate at 19.5% and produce a visible and audible alarm signal.
- Any activation of the alarm should give rise to concern and action. It is strongly recommended that whenever the alarm is activated at 19.5%, any person inside the room should leave immediately.
- Where the risk assessment indicates that oxygen levels could be depleted to below 18.5%, there should be two levels of alarm, at **19.5%** and **18.5%**.
- The second alarm should produce a distinct visual and audible alarm signal.
- Fixed monitors are preferable to personal monitors as they protect all personnel in the workplace rather than just an individual person, and the monitors should normally be positioned near to the potential nitrogen exposure points, at a height of between 1 metre and 1.2 metres above the ground.
- External alarm repeaters linked to the fixed monitors should also be installed where necessary, and sited so that they are clearly visible and audible to personnel before entering the workplace.
- All monitors and alarms must be regularly tested, calibrated and maintained in accordance with a planned schedule.
- The oxygen depletion monitors may also be used to initiate any the following actions **on reaching the second action level of 18.5%**:

  - To activate a solenoid operated safety shut-off valve to isolate the liquid nitrogen supply from the tank.

  - To raise the air extraction rate (typically from 10-15 air changes per hour to 20-30 air changes per hour).

  - To activate a door interlock system to prevent access (but allow escape).

- Where a mechanical extraction system is used and if the ventilation fails for any reason, the system can also be linked to a solenoid operated safety shut-off valve system to isolate the liquid supply from the tank.

Restoration of normal operation following an emergency shut-down following oxygen depletion to below 18.5% should only be by secure key operation carried out by a competent authorised person. Key operation must be located outside the work area. Key operation is not required where only the first action level has been reached. Where the oxygen levels do not go below 18.5%, automatic alarm reset is permitted.

Other Safety Measures:

- There should be good visibility into and within the work place.
- Where the risk assessment identifies the need and appropriateness, a 'buddy' system may be used, whereby a second person is employed on watch duty outside of the work area ready to raise the alarm and commence rescue work in the event of an incident.
- An Emergency Evacuation and Rescue Procedure should be prepared and regularly practised by all personnel involved.
- If self-contained breathing apparatus is provided, then all personnel must be properly trained to ensure that it is used correctly.

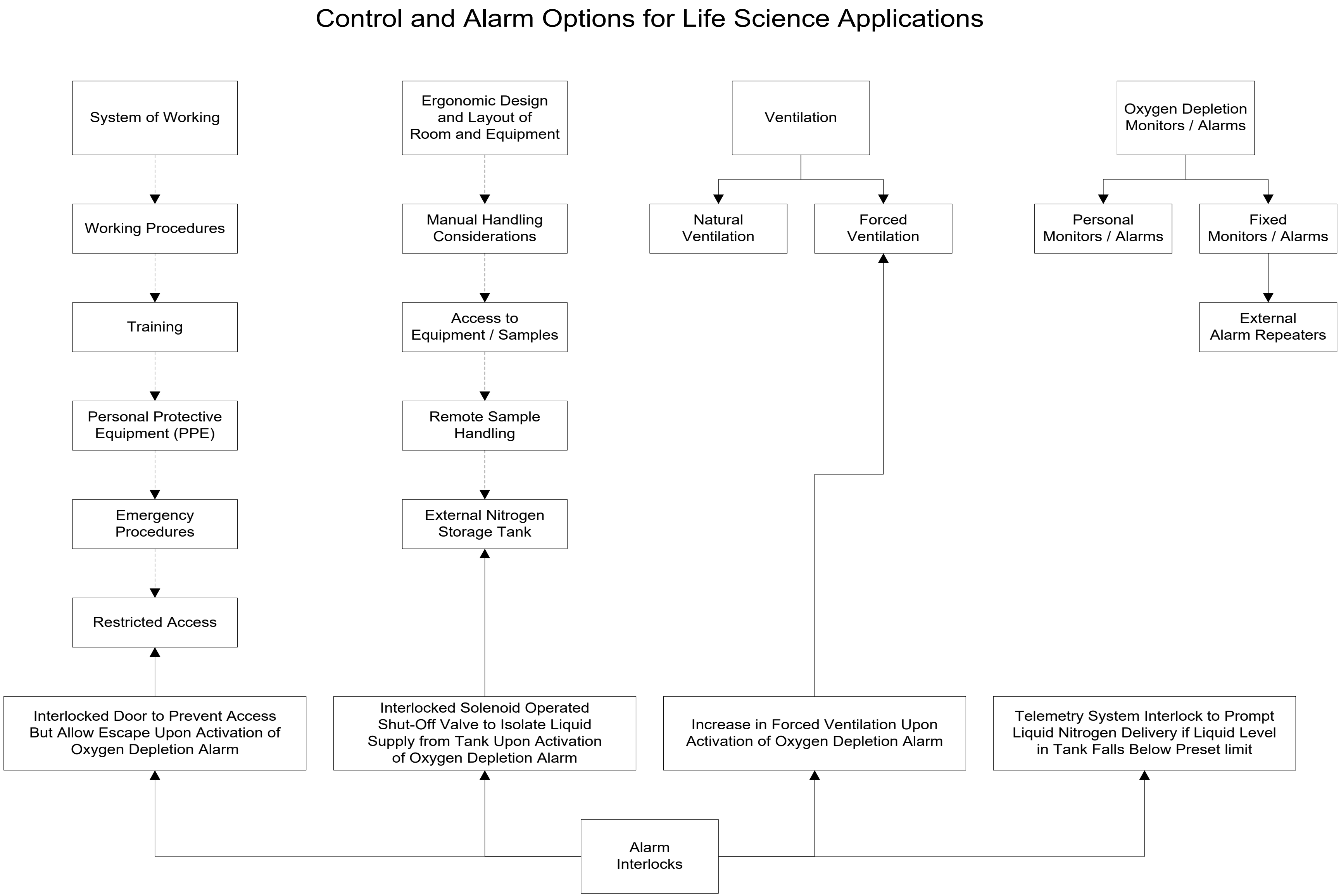
Procedures:

- Access to the nitrogen storage facilities should be restricted to authorised personnel only.
- Standard Operating Procedures (SOP's) must be written and all operatives trained in their use.
- SOP's should:
  - be clear and concise;
  - define safe operating limits;
  - include the risk assessment relevant to the procedure.
- All valve handles or hand wheels should be colour coded, or be easily and quickly identifiable by other means (to aid emergency operation).

Sample management

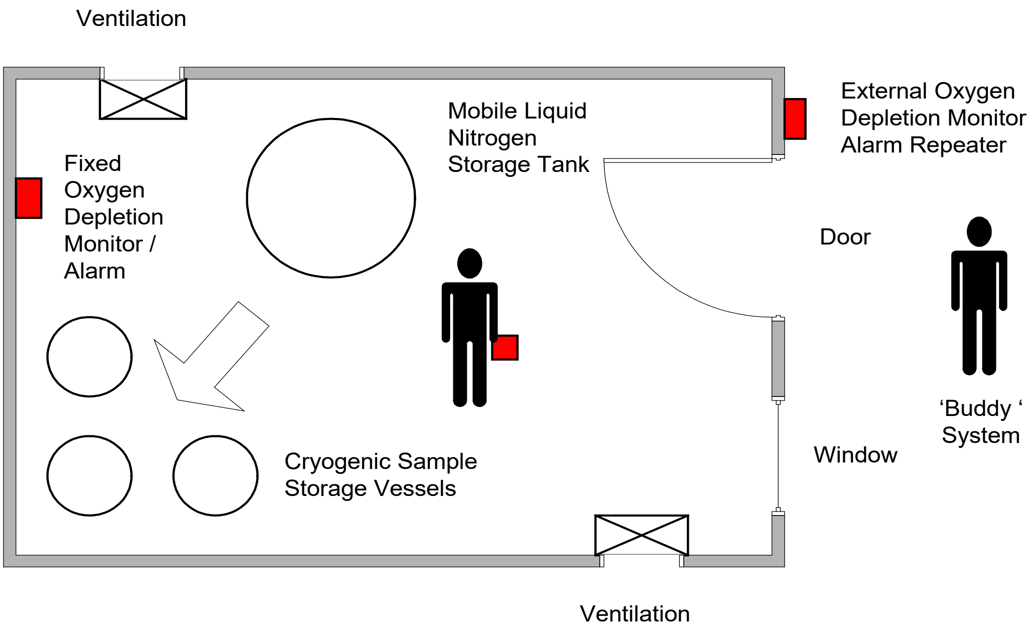
Good sample management through a computerised inventory system should be in place. This has safety implications because recovering a sample from a known location will take less time than searching and thus reduce the time for potential exposure.

4.2 System, Control and Alarm Options (schematic)



4.3. Examples of Good Working Practice

Example 1 – Manual System



Features:-

- Mobile tank(s) for liquid Nitrogen storage / supply
- Natural or forced ventilation (dependant upon Risk Assessment)
- Personal Oxygen depletion monitor / alarm (with associated 'Buddy' system) and/or Fixed (wall mounted) Oxygen depletion monitor / alarm with external alarm repeater.

Requirements:-

- Well rehearsed Emergency Evacuation and Rescue Procedures.
- Good visibility into and within the room.
- Audible Alarms.

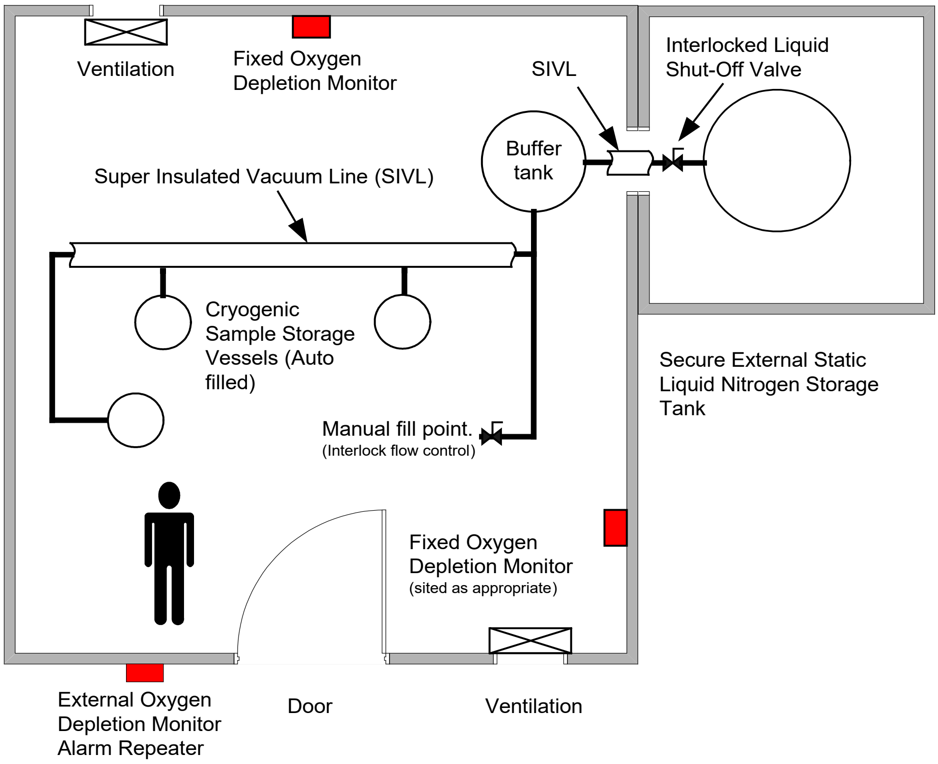
Pro's:-

- Re-assurance – perception of control over liquid Nitrogen availability / sample storage
- Flexibility – from mobile tank use in a number of locations and / or in sample storage location.
- Simplicity

Con's:-

- Manual handling – weight, distance, environmental issues
- Potential for liquid transfer between different floor levels – lift use, key controlled access requirements etc…
- High level of manual interaction – increased potential for product exposure
- Labour intensive
- Potential for abuse of or errors in normal operating procedure
- Limited control over unauthorised access to product

Example 2 – Semi-Automated System



Features:-

- Static tank for liquid Nitrogen storage / supply
- Natural or Forced ventilation system (dependant upon risk assessment)
- Fixed (wall mounted) Oxygen depletion monitor(s) with external alarm repeater
- Auto fill of cryogenic sample storage vessels (via solenoid valves) from liquid Nitrogen storage tank – with integral high / low level sensors and alarms
- Manual fill point for open necked non-pressurised vessels
- Interlocked solenoid operated shut-off valve to isolate liquid supply from tank upon activation of Oxygen depletion alarm
- Nitrogen Buffer storage vessel to prevent direct filling from external Bulk Tank

Requirements:-

- Clear understanding of system requirements / operation.

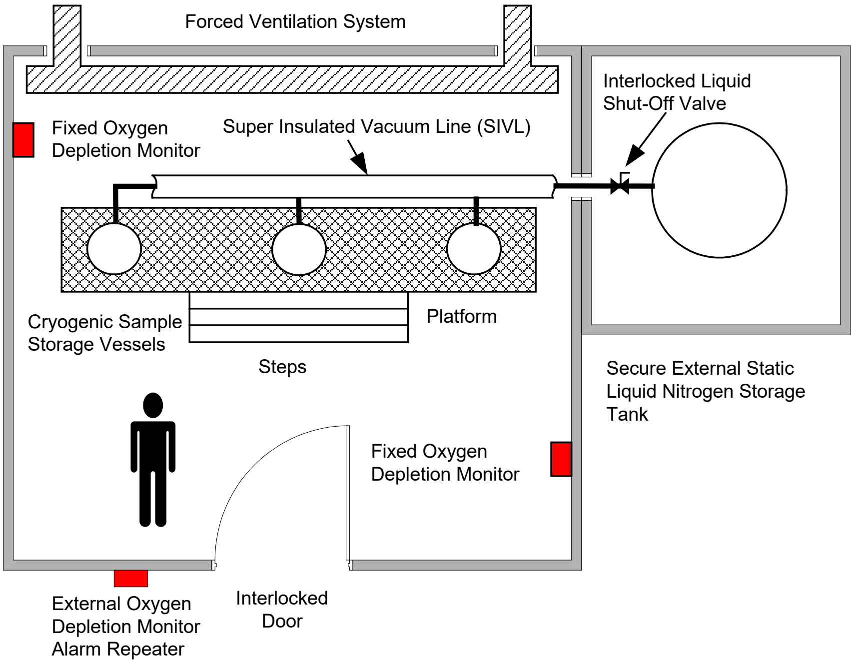
Pro's:-

- Re-assurance – perception of control over liquid Nitrogen availability / sample storage
- Manual handling eliminated

Con's:-

- Level of manual exposure to product retained
- Potential for abuse of or errors in normal operating procedure
- Continued potential for unauthorised access to product / samples

Example 3 – Fully Automated System



Features:-

- Static tank for liquid Nitrogen Storage / supply – linked to remote telemetry system
- Forced ventilation system – with capture inlets at low level to ensure Nitrogen vapour removal
- Fixed (wall mounted) Oxygen depletion monitor(s) with external alarm repeater – linked to ventilation system for increased Nitrogen vapour extraction in alarm mode
- Auto fill of cryogenic sample storage vessels (via solenoid valves) from liquid Nitrogen storage tank – with integral high / low level sensors and alarms
- Interlocked solenoid operated shut-off valve to isolate liquid supply from tank upon activation of Oxygen depletion alarm
- Interlocked door to prevent access (but allowing escape) – upon activation of Oxygen depletion alarm
- Internal rotating carousel within sample storage vessels

Requirements:-

- Clear understanding of system requirements / operation.
- System maintenance

Pro's:-

- Reduced need for system access – reduced exposure
- Increased confidence of product availability – optimised deliveries due to remote telemetry system
- Improved security
- Reduce potential for downtime
- Minimised gas accumulations
- Improved ergonomics

Con's:-

- High initial cost
- Reduced perception of control

5.1 Oxygen depletion – other issues

Use of Lifts

Vessels containing liquid nitrogen should not be transported by lift; a simple calculation can provide good reasons why. Using the formula on Page 9 for sudden asphyxia; the calculation shows that if just one litre of liquid nitrogen was spilt in a small lift of dimensions 1.5 m x 1.5 m x 2.3 m, assuming just one air change per hour and using 2 m height for calculation purposes, the oxygen concentration in the lift could drop to 17.8%.

In exceptional circumstances where the transportation of a liquid nitrogen container in a lift is unavoidable, the following points must be observed:

- The transportation of a liquid nitrogen container within a building or in a lift can be hazardous and should only be undertaken using equipment designed for the purpose.
- The transportation of a liquid nitrogen container in an occupied lift can be especially hazardous and should be avoided wherever possible (the container should be secured where it is necessary to ensure that it cannot fall over whilst in the lift).
- A key controlled lift should always be used where available (which can be programmed to go directly to a predetermined floor and remain there without any person accompanying the container in the lift). A second person is required at the receiving floor to remove the container from the lift when it arrives.
- If a key controlled lift is not available, a goods only lift should be used in preference to a passenger lift where available, and no person other than the person transporting the container should be in the lift whilst the liquid nitrogen container remains in the lift.
- Where there is an unavoidable requirement for a person to transport a liquid nitrogen container in a lift, that person should notify a third party at the start and finish of the journey.
- Where the transportation of a liquid nitrogen container within a building or in a lift cannot be avoided, the container must be filled and transported in accordance with the following rules:
    - No tank or Dewar or cylinder containing liquid nitrogen shall be transported within a building or in a lift if it has any visible leaks or defects (always check the equipment first before entering the building or lift).
    - No manual venting of a tank or cylinder shall take place whilst the tank or cylinder is being transported within a building or in a lift.
    - If a tank is to be transported within a building, the pressure in the tank shall be reduced to at least 25% below the tank relief valve setting just prior to entering the building. In addition, if the tank is to be transported in a lift, the tank shall only be filled to a maximum of 95% of the tank's net capacity (as shown on the tank contents gauge).
    - A Dewar may be transported within a building provided that it has not been over-filled, and there is only a small amount of vapour escaping. In addition, if the Dewar is to be transported in a lift, the total quantity of liquid inside shall not exceed 100 litres and the Dewar shall be removed from any trolley and placed directly on the lift floor.

Entry into Confined Spaces

Extreme caution must be exercised when entering a confined space, e.g. a basement, unventilated room, tank or low area where nitrogen gas can accumulate.

No one must enter a confined space where nitrogen gas can accumulate without a written 'Permit to Work' issued by a competent authorised person, who has first undertaken a suitable risk assessment.

The risk assessment must take into account the following factors:

- The job to be carried out
- The working environment
- Working materials and tools
- Safety equipment (atmosphere testing, harnesses, breathing apparatus etc)
- Training and competence of those carrying out the work
- Emergency arrangements for rescue and first aid.

5.2 Cold Burns

Exposure of skin to very low temperatures can produce effects similar to a burn. The severity of the burn varies with temperature and exposure time. Prolonged exposure to cold can result in frost bite.

Cold burns can occur where physical contact is made with either the liquid nitrogen itself or with any article that has been in direct contact with the liquid.

All cold burns must be reported to a qualified first-aider and, where necessary, medical opinion sought. Detailed first-aid guidance can be found in Section 8.

Should an unprotected, or insufficiently protected, part of the body come into contact with very cold surfaces it may stick fast as the natural moisture in the skin is frozen. Extreme care must be taken as the flesh can be torn whilst trying to break free.

Inhalation of cold vapour or gas can damage the lungs. Contact with the eyes can cause permanent damage.

Control Measures

When considering the risks of cold burns associated with the manual handling of liquid nitrogen containers, the use of insulated piped liquid nitrogen supplies directly from a storage tank is strongly recommended. Where manual handling cannot be avoided, users should apply the following guidance.

Safe working practices, together with the use of suitable personal protective equipment (PPE), will provide protection against the incidence of harm caused by cold burns (please refer to Part 6 for Safe Working Practices).

5.3 Pressure Release

Pressure release can cause harm due to the release of energy. This may directly cause physical injury itself, or cause other materials and substances to inflict injury.

Control Measures

The use of correctly specified equipment and scheduled maintenance/examination routines, together with the use of suitable personal protective equipment (PPE), will provide protection against dangerous pressure releases. The specification and selection of appropriate protective devices should always be made by a competent person, e.g. a professional design engineer.

Equipment Specification and Maintenance:

- The pressure equipment must be fitted with suitable pressure relief devices to protect the equipment from excess pressure, and the pressure vent pipeline must discharge in a safe location.
- Ensure that all pressure equipment used is suitably rated for the maximum pressure and temperature limits of the system, and is maintained in good condition.

Safe working practices must also be applied (Part 6).

5.4 Manual Handling/Ergonomic Issues

The layout of the work area must be ergonomically designed to ensure a safe system of working and to minimise or eliminate manual handling requirements.

Control Measures

- Static storage tanks/equipment and piped liquid/gas supplies should be used in preference to mobile storage tanks/equipment wherever possible.
- Where mobile tanks/equipment are used, then it is essential that the handles and/or wheels on the tanks/equipment/trolleys are secure, and that all wheels turn freely.
- Wheels or platforms should be of adequate construction, and tested to withstand the weight of a full tank.
- To avoid impact damage to the tank, the base should be extended where possible to provide bumpers or similar protection.
- If any manual handling is required, this must be subject to an appropriate risk assessment to ensure it is carried out safely without any risk of personal injury (e.g. back strains, hernias, sprains, cuts or fractures).
- Safe working practices should also be applied.

Part 6 Safe systems

6.1 Safe Working Practices and the Use of PPE

Safe Working Practices:

- Wherever possible avoid transporting liquid nitrogen containers up or down slopes, steps or stairways;
- Wherever possible avoid transporting liquid nitrogen containers through densely populated areas;
- Wherever possible avoid transporting liquid nitrogen containers over uneven ground or in areas where there is poor lighting or any risk of slips, trips or falls;
- Wherever possible avoid transporting liquid nitrogen containers through doorways or other restrictive access ways;
- Wherever possible use a trolley to lift and move liquid nitrogen containers, and ensure that the protective cap, cover or liquid withdrawal device is properly fitted;
- Liquid nitrogen containers must be handled with care to avoid liquid spillage;
- Keep the liquid nitrogen container upright at all times, except where necessary to decant liquid;
- Always handle empty containers as if they are full; it may be that they still contain some residual liquid nitrogen;
- Liquid nitrogen containers must be regularly inspected to ensure they are in good condition (see Section 5 for further details).

If the use of a stairway to move a liquid nitrogen container is unavoidable then the following additional safety precautions should be considered:

- If the container is large or bulky, it is recommended that two people carry the container;
- Ensure that access to the stairway is restricted to only the people carrying the container;
- Consider wearing additional personal protection against spillage;
- Consider the installation of a stair lift where practicable.

Personal Protective Equipment (PPE):

- Suitable eye protection, such as safety glasses or a full face safety visor, is essential when working with liquid nitrogen to protect against unexpected liquid splashes;
- Hands must also be protected when working with liquid nitrogen to protect against possible liquid splashes, or equipment that has been in direct contact with the liquid - wear non-absorbent insulated safety gloves that fit closely around the wrist, but are a loose fit for easy removal;
- All parts of the body should be covered to protect against possible liquid nitrogen splashes, or equipment that has been in contact with the liquid - wear suitable overalls or clothing with long sleeves, trousers and closed shoes etc.;

- The clothing should be made without pockets or turn-ups where liquid can collect, and trousers should be worn outside boots for the same reason;
- Where liquid nitrogen is being used above floor level (e.g. on a bench or being carried up and down steps at chest height), consideration should also be given to wearing additional splash protection such as a splash-resistant apron;
- Open footwear such as sandals must not be worn, and neither should any footwear that will allow the liquid to penetrate its surface;
- All personal protective equipment worn must be manufactured to an appropriate standard, be in good condition, and be regularly inspected for any signs of wear or damage - defective personal protective equipment should be replaced immediately.

6.2 Operator Training

All personnel must receive appropriate information, instruction and training on the risks associated with the storage and use of liquid nitrogen in the workplace, and the safe use of the associated tanks/equipment provided for this purpose.

6.2.1 Liquid Nitrogen Storage Systems

All personnel directly involved in the commissioning, operation and maintenance of liquid nitrogen storage systems must be fully trained regarding the hazards of oxygen deficient atmospheres and cryogenic liquid and vapour burns.

Training must be arranged to cover those aspects and potential hazards that the particular operator is likely to encounter.

Training should cover, but not necessarily be confined to, the following subjects for all personnel:

- Potential hazards of nitrogen
- Site safety regulations
- Emergency procedures
- Use of personal protective equipment (PPE); including breathing sets where applicable
- First aid treatment for cryogenic burns
- Standard Operating Procedures.

All training must be formally recorded.

Refresher training should be undertaken annually, or when it is shown to be needed (e.g. after an incident).

6.2.2 Use of Liquid Nitrogen

Any staff involved in the use of liquid nitrogen (i.e. filling of containers, removal of samples etc.) must be properly trained. This training should include:

- The hazards associated with liquid nitrogen
- Method of dispensing/sample retrieval
- Use of personal protective equipment (PPE)
- Emergency procedures.

Refresher training should be arranged at appropriate intervals and records of this training should be kept.

6.2.3 Other Hazards

Oxygen Enrichment

Operators should be trained to recognise that the low temperature of liquid nitrogen can cause oxygen to condense out of atmospheric air. This can occur around cold pipework, valves and in open Dewars. This oxygen enrichment may result in increased flammability and explosion risk. Oxygen enriched liquid must not be allowed to come into contact with oils or grease or flammable materials as spontaneous combustion can occur.

Ice Plugs

Ice plugs may form in the neck of open Dewars and cause a build-up of pressure. As the pressure rises within the Dewar, the ice plug may be expelled at high velocity or in extreme cases the pressure may build up sufficiently to rupture the vessel.

Should an ice plug be found, extreme caution should be exercised and the area immediately vacated. Personnel dealing with the incident should do so from a safe position. The recommended method of dealing with an ice plug is to pierce a hole in it with a thin, hot L-shaped rod.

Ensure that the Dewar is examined by the manufacturer before returning it to service.

Ice plugs can be prevented by diligent use of the correct Dewar stopper.

Part 7. Emergency Procedures and First Aid

7.1 Emergency Evacuation and Rescue Procedure in the Event of a Serious Nitrogen Gas Leak or Spillage

It is the user's responsibility to develop their own Emergency Evacuation and Rescue Procedure to deal with any nitrogen gas leaks or spillage. The following information is for guidance only:

1. Raise the alarm.
2. Evacuate the area where the gas leak/spillage has occurred, and carry out a roll call to account for any missing personnel.
3. Ventilate the area to the outside and do not allow any persons to enter the area to search for missing personnel until it is safe to do so, unless they are equipped with and trained to use self-contained breathing apparatus.
4. Where appropriate and if safe to do so, close the isolation valve(s) on the liquid nitrogen storage facilities.

   Note: Oxygen depletion monitors, where fitted, will help to determine the safety of the areas in which they are located in relation to the build-up of nitrogen gas.
5. Continue to ventilate the area where the leak/spillage has occurred until it is confirmed as safe for persons to enter to identify the source of the leak/spillage.
6. Where appropriate, contact the appropriate service company for the equipment concerned to rectify the leak.
7. After the leak/spillage has been isolated, oxygen deficiency checks should be carried out in any enclosed areas where the vapour cloud may have entered; this includes basements, pits and confined spaces

The Emergency Evacuation and Rescue Instructions should be prominently displayed locally detailing the actions required, and the Emergency Evacuation and Rescue Procedure should be regularly practice by all personnel involved.

7.2 Operating Difficulty or Emergency

If during the operation of the installation the safe operating limits of the system are exceeded (e.g. over-pressure, rapid temperature change or physical damage), the nitrogen supplier must be informed immediately. This will allow a decision to be made about the continued use of the tank and a programme of inspection to be drawn up and implemented.

Operating difficulties regarding the installation not covered in operating instructions must be referred to the nitrogen supplier.

Any modifications made to the installation must be agreed with the nitrogen supplier prior to implementation.

7.3 First Aid Treatment

First Aid for Asphyxiation

If a person seems to become dizzy or loses consciousness while working with liquid nitrogen, remove the victim to a well-ventilated area immediately without risk to yourself.

Keep the victim warm and rested, summon medical aid and apply artificial respiration if breathing has stopped.

First Aid for Cryogenic / Cold Burns

Liquid nitrogen in contact with human tissue produce an effect very similar to frost bite and the same methods of treatment are applicable.

Immediate treatment is required. If the area is large, send for an ambulance. Continue treatment while waiting.

Remove any clothing that may constrict the circulation to the frozen area, but do not remove adherent clothing until thawed thoroughly.

As soon as possible, place the part of the body exposed to the cryogenic (cold) material in a water bath that has a temperature of 42 - 45°C (107 - 115°F). Never use dry heat.

If there has been massive exposure to the super-cold material so that the general body temperature is depressed (which is a highly unlikely possibility), the patient should be re-warmed by total immersion into a warm bath. Shock may occur during re-warming.

Frozen tissues are painless and appear waxy with a pallid yellowish colour. They become painful, swollen and prone to infection once thawed. Thawing may take from 15 to 20 minutes and should be continued until the colour of the skin turns from pallor to blue, and then to pink to red.

When the frozen part of the body has thawed, cover the area with dry sterile dressings with a large protective covering.

Alcoholic beverages and smoking decrease blood flow to the frozen tissue and should be avoided.

Medical help will be needed to combat pain, and to prevent infection.

Appendix 1

Calculations to estimate possible oxygen depletion

This appendix includes the formulae for calculating possible oxygen depletion as a consequence of

1. **Calculation of oxygen levels following sudden release of nitrogen**

The asphyxiation risk level can be calculated by assuming the immediate and uniform introduction of gas from the vessel of largest storage capacity within the workplace.

$$\textbf{Oxygen concentration} = \frac{V_o}{V_w} \times 100\%$$

Where:

V_o = volume of oxygen (m^3)

V_w = volume of available air (m^3)

$$V_o = 0.21 \times \{V_w - (V_t \times 683)\}$$

Where:

V_t = net tank capacity (m^3)

683 = expansion ratio of nitrogen (liquid to gas)

$$V_w = V_r - V_i$$

Where:

V_r = volume of workplace (obtained from room/area dimensions: length, width and height). If height > 2 m, then height should be taken as 2 m for the purpose of the calculation.

Vi = volume of objects/items/equipment within the workplace (e.g. sample storage vessels)

If the calculation shows the oxygen concentration in the workplace will be less than 19.5%, then an action plan will need to be developed to formulate suitable preventative and risk control measures.

Worked Example

A Dewar containing 100 litres of liquid nitrogen in a room 10 m by 10 m by 3 m. Calculate the resulting oxygen concentration if all the nitrogen was released into the room immediately and uniformly.

To calculate $\mathbf{V_w}$, we will use 2 m instead of 3 m as the maximum height. We will also assume that the equipment will occupy 10% of the residual space in the room.

Thus, $\mathbf{V_w = (200 - 20) = 180\ m^3}$

$$V_o = 0.21 \times \{180 - (0.1 \times 683)\} = 23.46$$ (Where 100 litres = 0.1 m^3)

$$\%O_2 = \frac{23.46}{180} \times 100\% = 13.03\%$$

Reference to Table 1 indicates that this oxygen level would have significant harmful effects on any person in the room at the time. Engineering control measures, principally through ventilation, must therefore, be installed.

2. Calculations of oxygen levels following a) gradual release of nitrogen from Dewars; b) losses during filling and c) loss from total spillage of largest container

a) Gradual release

In typical situations the concentration of nitrogen gas build-up in a room over prolonged periods may be calculated using the formula:

$$\mathbf{C_t = \frac{L}{Vn}}$$

Where:

C_t = gas concentration
V = room volume (m^3)
n = air changes per hour
L = gas release (m^3/hour)

Worked Example

A room 3 m x 4 m x 2.5 m dimensions at ground level having one air change per hour houses 8 x 25 litre nitrogen storage containers for which the manufacturer quotes 0.2 litre/24 hours evaporation rate for each. This evaporation rate is multiplied by 2 to allow for vacuum deterioration over time. The liquid to gas volume expansion ratio for nitrogen is 683.

$$\mathbf{L = \frac{(8 \times 0.2 \times 2) \times 683}{24 \times 1000} = 0.091\ m^3/hour}$$

$$\mathbf{V = 3 \times 4 \times 2 = 24\ m^3}$$

(Where 2 m is used instead of 2.5 m as the maximum height)

n = 1

Using the formula $\mathbf{C_t = \frac{L}{Vn}}$ Then, $\mathbf{C_t = \frac{0.091}{24 \times 1} = 0.0038 = 0.38\%}$

In this example, the evaporation effect concentrates the nitrogen in the room by 0.38%. This increase will result in an oxygen depletion of (0.38 x 0.21)%, or 0.08%.

This level of nitrogen enhancement in the room is small enough for forced air ventilation not to be required, but reduction in the size of room or increase in the number of Dewars would result in a greater potential enhancement. For example if Ct was calculated as 0.05 (or 5.0 percent) this would result in reduction in oxygen of 1%, which is very close to the safety margin recommended by BCGA.

b) Loss during filling

For a manual filling operation of a Dewar, it can be assumed that up to 10 percent can be lost.

Worked example

Using the same example, the largest container holds 25 litres of liquid nitrogen. Using the formula:

$$V_0 = 0.21\left(V_R - \frac{(0.1 \times V_D \times f_g)}{1000}\right)$$

we can calculate the volume of oxygen in the room, where:

V_D = capacity of Dewar
V_R = volume of room
f_g = expansion factor for nitrogen

In this case, we have

$$V_0 = 0.21\left(24 - \frac{(0.1 \times 25 \times 683)}{1000}\right)$$

$$= 4.68\ m^3$$

To calculate the oxygen level, this equals

$$\frac{100 \times 4.68}{24} = 19.5\%$$

This is the reduction where the BCGA recommend a first stage alarm to be fitted.

c) Losses through spillage and filling

The same formula can be used to calculate the final oxygen concentration following losses through spillage and filling of the Dewar, only this time a correction factor of 1.1 is used representing 100% loss of the content and 10% loss during a filling process. We have therefore:

$$V_0 = 0.21\left(24 - \frac{(1.1 \times 25 \times 683)}{1000}\right)$$

$$= 1.096\ m^3$$

To calculate the oxygen level, this equals

$$\frac{100 \times 1.096}{24} = 4.57\%$$

This level would be a severe hazard and full ventilation control would be indicated. A second stage alarm should be fitted.

Appendix 2 Tank Commissioning Fill

If the tank is a newly installed tank which has not previously been filled, or a previously filled tank which is now warm and empty, a commissioning fill of the tank will always be required first to 'condition' the tank prior to normal filling.

A suitably trained and competent person, possessing the necessary knowledge, experience, skills and equipment to complete the task in a safe manner, must carry out the commissioning fill of the tank. This will ensure that there is no damage caused to the tank and there is no risk of injury to personnel; which could otherwise result if the tank is filled/cooled too quickly.

The rate of liquid fill must be very carefully controlled to prevent thermal shock and excess pressure in the tank, and on some tanks (especially tanks above 1000 litres capacity) it may be necessary to purge/chill the tank with cold gas first before starting to fill the tank with liquid. The commissioning fill procedure should be developed in line with the findings of an appropriate risk assessment.

The filling of the tank should be carried out outside in the open air where there can be no accumulation of vented gas and the risk of asphyxiation is minimal. Wear safety glasses or goggles, ear defenders, insulated leather safety gloves, overalls with long sleeves and safety shoes when filling the tank.

All equipment used for filling the tank must be in good condition and be suitably rated for the pressure and temperature extremes of the system.

Just after filling, the tank pressure may increase rapidly due to the agitation of the liquid. Consideration should therefore be given to the possible release of gas through the tank safety pressure relief devices, especially if the tank is to be transported or stored in an enclosed space such as a building or lift. Precautions to be taken to prevent this occurring could include stabilising the tank at a reduced pressure/liquid level after filling. Under no circumstances should the safety pressure relief devices be sealed in any way to gas being released from the tank.

Appendix 3. Tank/Equipment Inspection and Maintenance

In order to ensure the continued safe operation of the cryogenic tank/equipment, it is necessary to carry out regular planned inspections, examinations and preventative maintenance.

The tank/equipment must be inspected, examined and maintained to a schedule compatible with the requirements of The Pressure Systems Safety Regulations and all relevant and current Health and Safety legislation as a minimum.

The British Compressed Gases Association (BCGA) Codes of Practice provide guidance and a framework to assist with fulfilling these legal duties and achieving best practise. Failure to carry out the necessary inspection and maintenance of the tank/equipment may lead to unsafe operation and breach of legislation.

Evidence of the necessary examination of the tank/equipment in accordance with a Written Scheme will be required by any competent liquid gas delivery business prior to carrying out any tank filling operations.

Inspection and Maintenance Requirements

Site

The site should be inspected regularly to ensure that it is maintained in a proper condition and that safety distances are maintained.

Tank Installation

Periodic and planned maintenance of the installed tank/equipment shall be carried out.

Tank External Vessel and Pipework

An annual external visual inspection should be carried out to confirm the satisfactory condition of the outer jacket, pipework, valves, controls, safety pressure relief devices and auxiliary equipment. A check on the vacuum shall be made whenever an abnormal pressure increase inside the inner vessel has occurred.

When the tank is taken out of service a Competent Person shall endorse the further use of the tank, taking into account the condition of the tank, the operating history and the degree and results of any previous examinations(s).

Tank Inner Vessel

The inner vessel shall have been approved and rigorously inspected during manufacture by a Competent Person. A Competent Person shall validate the vessel as fit for its purpose for a defined period prior to its first installation.

Thereafter the vessel integrity shall be endorsed periodically as fit for continued service; the requirements for this endorsement and the required frequency shall be defined by a Competent Person, taking into account a documentation assessment and an assessment of the condition of vessels constructed to a similar design.

NOTE:

A ‘Competent Person’ must possess:

a) The necessary academic qualifications, personal integrity and training to enable him/her to detect any actual or potential defects or weaknesses which it is the purpose of the examination to discover.

b) The necessary experience and skills to enable him/her to assess the importance of such defects or weaknesses in relation to the strength and safety of the system being examined.

c) If he/she is an individual within the owner/user’s own company, he/she must be given a written contract instructing him/her to carry out the duties of the ‘Competent Person’. This contract must clearly state that in carrying out these duties he/she is free from any commercial or other influences which could hinder his/her ability to carry out his/her duties.

A ‘Competent Person’ may be:

a) An individual within the owner/user’s own company provided he/she has the necessary personal qualities stated above, and a contract stating that he/she is free from any other influences.

b) An individual within an independent engineering inspection organisation offering this service.

c) An individual within a company or partnership offering this service as a consultancy.

Vaporisers

Vaporisers are ambient air or electrically heated heat exchangers which are used to receive liquid nitrogen from a storage tank and convert it to nitrogen gas (where applicable) for the application.

In cold weather, the operator should regularly check any ambient air vaporisers used for any excessive ice build-up. Any such ice build-up should be removed by the appropriate use of steam or water.

Pressure Relief Devices

There are two types of pressure relief device used; either a spring-loaded pressure relief valve which opens to release pressure, or a bursting disc which is designed to rupture and release pressure.

Regular visual inspections of all pressure relief devices must be carried out during normal operation to ensure they have not been damaged, or in the case of bursting discs ruptured.

A regular test of each pressure relief valve used must be carried out by a ‘Competent Person’ to demonstrate its fitness for a further period of service.

Bursting disc elements may deteriorate due to aggressive environments resulting in their relief pressure rating being reduced. It may, therefore, be necessary to replace the disc elements in such environments on a planned basis.

Ancillary Equipment

Other ancillary equipment (e.g. pressure/temperature gauges), should be regularly inspected and maintained in accordance with the manufacturer’s recommendations.

Isolation Valves

Isolation valves should be regularly checked for correct functional operation.

Permit to Work

Before any maintenance or pressure testing is carried out on the installation, a written ‘Permit to Work’ for the particular type of work being carried out (e.g. cold work. hot work, entry of vessel, pressure test, electrical work etc) must be issued to the individual(s) carrying out the work. The ‘Permit to Work’ must be issued by a competent authorised person, who has first undertaken a suitable risk assessment.

No hot work should be carried out in the vicinity of the installation without a written ‘Permit to Work’.

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