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Health and Safety

Policy

Gas Safety (including Compressed Gases and Cryogenic Liquids)

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Health and Safety Department

Approved Document

SAF-POL-GAS

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Health and Safety Equality, Diversity and Inclusion Statement

The Health and Safety Department and University Health and Safety Community strongly support the university's commitment to Equality Diversity and Inclusion (EDI). When creating university Health and Safety Policy, university requirements for EDI will always be taken into consideration. Whilst health and safety legislation will often take precedence, we will always seek to ensure that our systems and policies do not cause detrimental effects to any of the protected characteristics.

Contents

Implementation Process Map – Summary for each stage

Requirements by Stage	Documentation / Records	Who Is involved
Specification of new or modified system	Risk Assessment and detailed specification recorded for activities and process	BU stakeholders in conjunction with users
Design of new or modified system	Detailed design recorded	BU/Estates appoints Competent Designer
Installation of new or modified system	RAMS	BU/Estates appoints Competent Installer
Commissioning & Handover of new or modified system	Commissioning and user training documentation to	BU/Estates appoints Competent Installer or other competent party
Systems in Use	Risk Assessment, SOPs, Training & Competency	BU managers ensure safe use of sytems, supported by documentation, training and competency of users
Statutory Examination, Inspection, & Maintenance	Schedule produced by BU Records obtained from examiners/inspectors and maintained by BU	BU uses competent persons for inspection & maintenance. BU ensures Statutory Examination undertaken via UoN insurer
Emergency Response & Incident Reporting	Risk Assessment, SOPs, Training & Competency	Management and User SOPs, training and drills

Gas and Cryogen Safety

1. Introduction

University policies establish standards and expectations for health and safety across the organisation and set the minimum standards expected.

University policies establish standards and expectations for health and safety across the organisation and sets the minimum requirements. This policy covers the safe and effective management of gases across all university activities, including off campus where we have the management control.

The Health and Safety Department has established a University Health and Safety Management System (HSMS). The system is detailed in Health and Safety Management Systems Framework (MAN1.1) alongside the University Health and Safety Policy (P2) and creates a framework for the organisational management of health and safety at the university. All university policies and guidance are written to account for and implement these arrangements.

Each working unit, which may be a Faculty, Department, Site, Institute or School and will be referred to as a Business Unit in this policy. Any standard(s) imposed at a local level must meet all requirements set out in this policy. Where there is a discrepancy, the university policy takes precedence.

2. Scope

This policy applies to all those Business Units that manage processes and activities involving gas systems (including compressed gases / gases under pressure) and cryogens. It includes all aspects from storage, use, handling, monitoring, through to emergency procedures and waste to the point of use. In terms of the facilities and equipment associated with gas/cryogen handling and storage, it includes design, installation, testing, inspection and maintenance requirements,

The use of gas and cryogenic liquids in equipment and for experiments is not specifically covered by this policy and should be covered by a task risk assessment. Use of Swagelok or equivalent / in-house designed systems downstream of the regulator / point of use should only be carried out by a competent and trained person and subject to task / project risk assessment.

3. Policy statement

The University Health and Safety Policy (P2), alongside the Vice-Chancellors Vision Statement (P1) sets out the university's drive and ambition for health and safety, including defining our principal aims for health and safety. These aims are to ensure legal compliance established as a baseline and that everyone strives for best practice.

4. Regulatory background

- Legal duties to adopt and maintain safe methods of working are placed on both employers and employees by general health and safety legislation, principally by the **Management of Health and Safety at Work Regulations 1999** and the requirement contained with these Regulations for Risk Assessment.
- **PSSR (Pressure Systems Safety Regulations) 2000** which cover the safe design and use of pressure systems (separate H&S Policy)
- **Provision and Use of Work Equipment Regulations (PUWER) 1988**
- **The Control of Substance Hazardous to Health (COSHH) Regulations 2002** which require assessment of hazardous substances, how they can cause harm and how the risk of harm can be minimised
- Construction Design and Management Regulations 2015 -
- **BCGA** (British Compress Gas Association)**:** various codes of practice and guidance notes that apply to the University. The main ones applying to the university:
    - CP4 - Industrial gas cylinder manifolds and gas distribution pipe work: excluding acetylene, Rev 5: 2020
    - CP22 - Bulk liquid argon or nitrogen storage at production sites, Rev 1: 2022
    - CP26 - Bulk liquid carbon dioxide storage at users' premises, Rev 3: 2012
    - CP27 - Transportable vacuum insulated containers of not more than 1000 litres volume, Rev 1: 2004
    - CP30 – The safe use of liquid nitrogen dewars, Rev 3: 2019
    - CP34 - The application of the Pressure Equipment Regulations to customer sites, Rev 1: 2014
    - CP36 - Cryogenic liquid storage at users' premises, Rev 2: 2013
    - CP39 – In-service requirements of pressure equipment (gas storage and gas distribution systems), Rev 2: 2017
    - CP44 – Storage of Gas cylinders, Rev 3: 2020
    - CP47 – Safe use of individual portable or mobile cylinder gas supply equipment, Rev 1: 2018
    - GN11 – Management of risk when using gases in enclosed workplaces, Rev 4: 2018 – risk assessment and gas safety calculations, Rev 4: 2018
    - GN23 - Gas safety. Information, Instruction and Training, Rev 2: 2023
    - GN25 - Guidance on assessing the competency of personnel undertaking periodic inspection and testing of gas cylinders, Rev 1: 2021
- **DSEAR – Dangerous Substances and Explosive Atmospheres Regulations 2002** (separate H&S policy)
- **Supply of Machinery (Safety) Regulations 2008 (Amended 2011)** covering the design, construction and supply of safe products which would include gas and cryogenic installations.

5. Definitions

5.1 Gas system

A typical gas system is divided into distinct areas:

- **the gas source** (e.g. cryogenic storage tank/pressure receptacle such as a gas cylinder/ delivered by a pipeline or on-site manufacture)
- **the supply pipework** – connects the gas source to the control system (first regulator)

• **the control system** – required where the source supply conditions at the outlet point do not match what the user needs at the experiment end. The control system changes and controls the gas output to what is required by the user.
• **the distribution system** – transfers the gas to the point of use (sometimes via secondary control systems)

5.2 Gas equipment/apparatus

Gas Pressure system equipment can be broken down loosely into 3 groups:

1. Pressure Regulators: (see BCGA CP47 Ch 8.5 for further detail)
    a. Shall not be used with any gas other than that it is intended for.
    b. Shall be kept free of dust, debris, oil, grease, solvents, or other contaminants.
    c. Shall not be attached to a cylinder or vessel with the aid of PTFE (plumbers) tape.
    d. Damaged or expired regulators should not be used and should be removed from service.
    e. Should be labelled clearly with the max inlet pressure, max outlet pressure, name of manufacturer/supplier and the date of manufacture or when it is due to be replaced (as per manufacturers guidance)
2. Hoses or tubing:
    a. Connects properly fitted to equipment and tested and retained by suitable clips. Reusable worm-drive clamps shall not be used.
    b. Hoses with excessive contamination, damage or wear shall not be used and should be replaced immediately.
    c. Hoses should be joined together with an appropriate clip, and not taped together.
    d. Length of the hose should be kept as short as possible. Alternatively, consider a fixed, piped system
    e. Copper pipes and fittings shall not be used within hose assemblies for acetylene.
    f. Plastic tubing should be avoided.
3. Safety Devices (examples given below, but list not exhaustive – see BCGA references given above for further details)
    a. When safety devices are being fitted, all threads and seats should be in good condition, and the device should be fitted in accordance with the manufacturer/ supplier's instructions.
    b. Liquid withdrawal systems (for cryogenic vessels) should be in good condition, and should be replaced if the retaining wire, securing collar or clamp/valves are damaged. Shall be checked for visual damage and cleanliness (oil, dust, grease, etc.) before each use.
    c. Non returns valves shall be used when more than one gas is used simultaneously or, optionally, when oxygen or flammable gases are used as individual gases. They should be tested periodically to ensure they do not allow reverse flow.
    d. Flame arrestors should be used with oxygen and other flammable gases and should be marked with the direction of gas flow and an inspection/ replacement date.

5.3 Gas accessories

Examples: Flashback arresters, anti-whip restraining wire, cylinder restraints

5.4 Cryogenic system

Cryogenic systems are set-ups/equipment that are able to maintain very cold (cryogenic) temperatures in order to preserve liquefied gases and other substances. These include systems such as a cryogenic pump, cryogenic storage systems, cryogenic piping, a cryogenic chiller or a cryogenic dewar.

6. Roles and responsibilities

General roles and responsibilities for health and safety are defined in the University Health and Safety Management System (HSMS) (MAN1.2 - Roles and Responsibilities). Specific responsibilities are detailed below and are considered to be in addition. It is an expectation of the university to understand ownership and accountability. Roles identified below should be reflected in performance reviews to ensure safety is considered alongside scientific endeavours.

University Council will

- Receive annual assurance reports from the Health and Safety Committee on compliance with this policy
- Receive a copy of this policy from the University Health and Safety Committee once approved.

The University Health and Safety Committee will

- Be the formal oversight and compliance committee for the university and will provide assurance to University Council and University Executive Board (UEB)
- Provide University Council and UEB with copy of this policy once approved
- Promote good practice among university staff and students in relation to the management of gases identified in this policy
- Consider and advise on university policy and arrangements
- Be notified of any significant incident or enforcement action and ensure appropriate action is taken
- Receive report of audits and/or assurance monitoring.

University Executive Board (UEB) will

- Receive copy of this policy from the University Health and Safety Committee once approved
- Seek assurances that all mandatory requirements for gases and cryogens are met
- Seek assurances that all health and safety arrangements for gases and cryogens are adequately resourced
- Seek assurance that identified risk control measures are in place and are being acted upon
- Seek assurances that those with responsibilities for gas and cryogen systems are adequately trained and competent
- Seek assurance that there is a process for auditing health and safety performance for gas and cryogen arrangements
- Seek assurance that competent health and safety advice is available to assist in managing and assessing risks from activities involving gases and cryogens
- Be notified of any significant incident or enforcement action and ensure appropriate action is taken

- Receive report of audits and/or assurance monitoring from the Health and Safety Department.

University Health and Safety Department will

- Provide and keep updated, policy, arrangements and guidance to ensure any statutory requirements are met
- Provide competent advice and support on gases and cryogens to the university
- Ensure appropriate oversight for compliance with this Policy and provide reports to University Safety Committee and UEB
- Have oversight of training required for safe use of gases and cryogens and ensure adequacy through routine review
- Report investigation findings following incidents or non-conformities to the University Health and Safety Committee and UEB
- Lead on and coordinate visits by external agencies, including the Health and Safety Executive
- Receive annual assurance reports from Business Units on gas and cryogen safety
- Monitor Business Units are adhering to the university policy by carrying out audits (see University Health and Safety Monitoring Policy SAF-MAN3.1).

Heads of Business Unit will

- Appoint a Gas/Cryogen Safety Coordinator to coordinate the business unit's compliance with this policy
- Ensure relevant resources are in place to manage gases and cryogens
- Ensure that following any significant incident or enforcement action that an appropriate investigation is undertaken and any findings implemented
- Provide opportunities to hear and discuss any concerns raised within their Business Unit
- Ensure arrangements for effective cooperation and co-ordination between all relevant parties to ensure safety.

Principal Investigators / Line Managers will

- Comply with all policy, arrangements and guidance both at a university and local level
- Ensure that suitable and sufficient risk assessments for activities involving gases and cryogens are in place for their area of responsibility
- Ensure that adequate resources are in place to manage gas and cryogen safety
- Ensure their staff receive relevant training and that this is recorded robustly
- Ensure suitable levels of supervision are in place for gas and cryogen activities
- Report any shortcoming or defect in the current control measures.
- Ensure all incidents (including near misses) relating to their activities are appropriately reported and investigated
- Ensure suitable monitoring activities are followed and any actions are completed
- Where monitoring activities identify significant compromises of health and safety, suspend the activity pending implementation of appropriate actions.

Gas/Cryogen Safety Coordinator (GCSC) will

- Ensure there are suitable arrangements for managing gas/cryogen safety in the BU, in line with this policy
- Ensure an inventory of all gas/cryogen systems and related assets is maintained for all facilities and equipment involving gases and cryogens
- Oversee the specification process for any new or modified gas/cryogen systems
- Ensure competent persons are appointed for design, installation, commissioning and testing of gas and cryogen systems where systems are installed by their Business Unit
- Ensure that a written scheme of examination is in place for all gas and cryogen systems that require it
- Ensure that safe systems of work (SOPs) are in place
- Ensure that users have been provided with appropriate training in line with this policy
- Ensure any routine inspections, tests and maintenance required by legislation and/or this policy are being carried out, remedial actions taken, and records kept
- Ensure any gas/cryogen systems or equipment, that has failed an inspection and/or compromises health and safety, is immediately taken out of use
- Support with any incident investigation related to accidents or near misses involving gases or cryogens
- Ensure decommissioning data is obtained for any gas/cryogen system taken out of use

Individuals (staff, students or other employees) at the University will

- Comply with all policy, arrangements and guidance at university and Business Unit level
- Undertake activities in a safe manner
- Report any shortcomings or defects to their line manager / supervisor
- Take appropriate action in the event of an emergency as per local procedures

Those designing Gas Systems and Cryogen installations

- Will be competent for undertaking the design phase of new or modified gas or cryo systems and therefore will be external contractors to the University unless there are competent internal staff
- Will collaborate with the gas/cryogen system owner and Gas/Cryogen Safety Coordinator to ensure the specification is taken into account
- Will take into account interfaces with other systems, including pressure systems, as well as any specific local design or environmental features that have been incorporated
- Ensure that the design complies with the requirements of applicable legislation and shall base it on the requirements of applicable industry standards.

Reference: The Duties of the Designer – BCGA CP4 Section 5

Those Installing / Supplying Gas Systems and Cryogen Installations

- Will be competent for undertaking the installation phase of new or modified gas and cryogen systems
- Ensure that the gas or cryogen systems are installed in accordance with the design specification and any other applicable legislation or requirements (see list in CP4). Any proposed deviations must be discussed with the Designer
- Will be required to collaborate with the Gas/Cryogen Safety Coordinator to ensure the agreed design is followed

- Clarify with the Designer, any aspects of the design that they identify as missing, incorrect or inadequate.
- Ensure all documents, certificates, operating instructions, etc associated with individual components and equipment are provided to the User.
- On completion of the installation, ensure pressure systems are tested in preparation for commissioning.

Reference: *The Duties of the Installer – BCGA CP4 Section 6*
Selecting a suitable supplier for gas installation – HSE INDG408

Those carrying out testing and commissioning

- The commissioning of the system/equipment involves checking it is fully serviceable, it meets the design specification and it is in working order in preparation for handover to the User.
- Those conduction the commissioning activities shall be competent to do so.
- The person responsible for carrying the commissioning shall ensure
    - there is a written document that defines the commissioning regime
    - that commissioning is as specified by the Designer
    - that the related risk assessment(s) have been carried out
    - that all required control measures are implemented.

Reference: Testing – BCGA CP4 Section 7; Commissioning and Handover, - BCGA CP4 Section 8

Those carrying out thorough examinations, formal inspections and maintenance

- Those suppliers selected for undertaking the thorough examination, relating to a written scheme of examination under the pressure systems safety regulations, must be competent to do so and therefore will be external contractors to the University.
- Those selected to carry formal inspections and maintenance of gas systems and associated equipment / accessories must be competent to do so.

7. Appointment of Duty Holders

Each BU operating gas systems and equipment must appoint a Gas / Cryogen Safety Coordinator, deemed a safety critical role at the University. The appointment must be formally made by the Head of the Business Unit in accordance with the UoN Safety Critical Role Arrangement (SAF-MAN2.1).

8. Risk assessment and Control Measures

All potentially hazardous processes/activities involving gases and/or cryogens must be subject to suitable and sufficient assessment of the risks (see SAF-MAN-2.3).

Each BU is expected to use the university's standard risk assessment forms for recording their risk assessments and to ensure, where appropriate, that standard operating procedures are developed for users to be trained to work to.

Aspects that will require a risk assessment include:

8.1 Hazards associated with gases and cryogenic liquids

Liquid Nitrogen (LN2), and other cryogens shall be risk assessed in a similar way to compressed gases. The risk assessment should take into account all the physical hazards of the gas, including not only skin contact, but also inhalation and asphyxiation risks.

Reference to BCGA GN 11 (for gases) and BCGA CP30 (for cryogens) should be made to provide an idea of which types of hazards must be considered, and how one can suitably assess, quantify and mitigate the risks related to the scenario.

Key Hazards:

8.1.1 Asphyxiation / toxic gas exposure

Gas cylinder/cryogen vessel contents present a wide variety of hazards, depending on the nature of the gas. For non-toxic cases, minor air composition changes can result in hazardous working environments and asphyxiation, thus the risks should always be assessed numerically prior to initial use.

Other compressed gases may be oxidisers, corrosive or toxic – these should also be risk assessed adequately, with precautionary controls in place, prior to first use.

Gas detection (required for both compressed gases and cryogenic gases), where identified in the risk assessment, should be planned and installed by a suitable competent person. Consideration should be given to the location of the detectors and the location of the control panel. The alarm panel should be both legible and be able to be disarmed from a safe location i.e., a user should not have to enter the direct vicinity of the incident to either read or disarm the alarm.

The gas detection / ventilation system(s) shall be subject to a formally planned and recorded maintenance programme that includes calibration, periodic functional and end-to-end testing, (often known as ‘bump testing’), alarm and interlock checks, lamp (bulb) checks for visual alarms or annunciators and the periodic replacement of critical or wearing components, etc.

Alarm warnings, for example, flashing lights, audible alarms, etc, shall be clearly visible and shall be duplicated / repeated both outside (i.e., at all access points) and inside the workspace.

Appropriate, clear and legible warning signs shall be provided (for example, ‘Do not enter unless monitoring system shows no fault/safe to enter condition’, ‘Evacuate the area in the event of gas alarm’, etc.), located suitably and, where of potential benefit, repeated in several locations.

Training must also be supplied to workers so that they are aware of the emergency procedures in the event that an alarm sounds.

Such gas detection systems must be suitable for the scenario and must be installed by a competent person who will ensure appropriate location of detectors. A servicing plan must be in place, with the detection maintained in line with the manufacturer’s instructions.

In addition to detection, the process for allowing safe dissipation of the oxygen-depleting gas or the toxic gas must be identified and controls such as auto-shut off devices and automatic or mechanical means of increasing ventilation must be considered. Any such controls must be capable of being operated from outside the lab. Reliance on natural ventilation may not be a sufficiently robust control.

8.2 Manual handling (BCGA CP44 Ch8)

Workers who routinely handle gas cylinders and the larger cryogen containers (moving, replacing, etc.) are at potential risk of muscular skeletal injuries and control measures include using the correct equipment, appropriate handling aids, be trained in the correct techniques to move and position the cylinders and be provided with, and wear, suitable PPE (protective footwear, eye protection and protective gloves). Cylinders and cryogen containers should not be moved if connected to any pressure system equipment.

8.3 Storage

8.3.1 Gas Cylinders (BCGA CP44 Ch5)

The risk assessment should consider the location of compressed gas cylinders. **External positioning with piping into buildings to the point of use is strongly advised, and location in a building must be justified, cost would not be considered a reasonably practicable justification.**

All cylinder stores should be in an external area with good natural ventilation away from designated emergency exits and escape routes. The area should have good lighting and appropriate safety signage. Internal storage of cylinders should be discouraged, and a robust justification should be in the risk assessment if this cannot be avoided

Cylinder storage areas should be kept away from other stores, such as chemical stores, and kept at ground level. The storage area should allow for enough space to safely move around and handle the cylinders, and the store should be suitably secured to prevent theft, tampering, and unauthorised access. Cylinders should be correctly stored and secured within the storage area.

Gas cylinders must be singly and robustly restrained to minimise the risk of them toppling.

External storage locations must be secure from tampering and theft and consideration given to the risk of gas release and thereby suitable gas detection.

All receptacles must be suitably stored and this should be in a designated external store when not in use. Accumulation of compressed gas and cryogen receptacles in buildings must be avoided. Internal storage, for instance in a lab or other room, that has not been designed for the purpose, must not be used.

Segregation of gas cylinders of different hazard types must be in place and their proximity to fire exits, vehicle movements and other site features (air intake, drains, etc.) must be considered.

The cylinders should be arranged in such a way to maintain minimum recommended separation distances.

8.4 Signage (BCGA CP4 Appendix 8)

The following scenarios must have appropriate safety signs and notices displayed:

- Storage cages and cupboards (internal and external), include standard hazard symbols
- Gas pipelines – labelling with contents along length a regular interval and showing direction of gas flow
- Gas containers / Cryo tanks and vessels labelling (by container owner whether supplier or university)

- Gas detection installations – within room containing gas or cryogen systems and at entry to warn people not to enter when gas alarm sounding
- Point of use – any hazard warning signage relevant to the equipment or process

Signs shall comply with The Health and Safety (Safety Signs and Signals) Regulations 1996 and with BS 5378 “Safety Signs and Colours” Parts 1, 2 and 3.

8.5 Gas Lines and Pipework (BCGA CP4, Appendix 3)

All gas lines containing compressed gases or cryogenic gases should be fitted, labelled and maintained as per the guidance in BCGA CP4, with specific guidance given in Appendix 8.

All pipework shall be designed and fitted by a competent person to BCGA CP4 standards (BCGA CP18 for Special gases). Pipework to be maintained and inspected under a Written Scheme of Examination as per BCGA CP39. Any modifications made to the gas supply system should be performed by a competent person, where consideration should be given to gas velocity and pressure drops as a result of changes to the piping network. Additionally, ensure annual pressure drop-testing is in place as a means of testing for weaknesses or leaks in pipework.

The pipelines and all relevant safety critical features should be clearly identifiable along the whole trail, with specific instruction for the operation of safety critical features to be affixed locally. Where there are multiple pipes for different gases, it is recommended that each gas is identified at the same location. All pictograms used for labelling should be consistent with both the Safety Signs and Signals and Classification and Packaging of Chemicals Regulations.

The condition of the hose is of vital importance to safety. Correct hose connections, properly fitted and tested and retained by suitable non reusable clips or ferrules, are also essential. Re-usable worm-drive clamps (e.g. Jubilee clips) should not be used.

Low pressure hoses shall be:

- Capable of safely handling gas pressure applied.
- Made of a material which has been proved to be compatible with the gas used.
- Protected from excess heat.
- Kept as short as possible.
- Not allowed to become contaminated with grease or other materials.
- Fastened with appropriate fastenings.
- Where multiple low pressure hoses are used in close proximity, a unique marker to include the gas name should be used to identify each end of each hose.
- A fire in a coiled hose is difficult to extinguish; oxygen or fuel gas hoses should not be coiled around the cylinders, regulators or cylinder trolley during operation.
- Discarded when worn or damaged.

Hoses and hose assemblies shall conform to the following standards:

- BS EN 1327 Thermoplastic hoses.
- BS EN 559 Rubber hoses.
- BS EN ISO 14113 Rubber and plastic hose assemblies (450 bar).
- Hoses to BS EN 559 shall be assembled and tested in accordance with BS EN 1256.
- Hose connections shall conform to BS EN 560.
- Quick action couplings shall conform to BS EN 561.

8.6 Cryogenic Vessels (BCGA CP30 Ch10, BCGA CP36)

Handling (physical and hazardous exposure): Workers who routinely operate and move cryogenic vessels are regularly exposed to physical hazards such as manual handling and spillage of liquids leading to cryogenic burns or asphyxiation. When moving a dewar, consideration shall be given to the route and the correct movement techniques and equipment shall be used (with training provided). Workers should avoid moving vessels through enclosed spaces, such as lifts, up/downstairs and through busy thoroughfares; this shall be risk assessed and justified if absolutely vital. PPE should be available and used when decanting from or moving vessels, this may include protective, non-absorbent, insulated gloves, face visors, safety specs, lab coat, full length trousers, cryogenic spill aprons and safety shoes with a built-in tongue to avoid cryogens seeping through lace holes. Ahead of each use, the dewar should undergo a visual inspection with particular focus on looking for visual damage, checking for cleanliness (oil, grease and moisture contamination), protective cap fitted and in good condition, security of the handles of the dewar, suitable labelling of the dewar and checking if the vacuum condition is correct.

A designated storage area for a dewar should be available whereby the dewar should be sited in a dry, sheltered location which is well ventilated. If the dewar is located outside, ice plugs may form due to condensation of the moisture in the atmosphere or rain freezing. As such, the dewar should be sheltered and the protective cap refitted when the system is not in use. For LN2 dewars that are located indoors, they will constantly vent gas, this depletion of oxygen levels shall be considered, and gas detection fitted if identified in risk assessment (see “Assessment of working environment” above).

If decanting of liquid cryogens takes place outside, weatherproofing must be considered.

9. Specification and Design of Gas Systems (BCGA CP4)

9.1 Specification

A typical gas or cryogen system has the following aspects:

- the source (gas or cryogen)
- the supply pipework
- the control system
- the distribution system

The specification must take into account the following:

- purpose of the system/equipment
- compatibility to process equipment
- desired location of equipment, including the storage of cylinders and the routing of pipework
- identification of hazards associated with the gases and consideration of how these will be controlled, e.g. LEV, gas detection.

9.2 Design

The design of a gas system must be completed by a competent person and consider the requirements of the user specification.
BCGA CP4, Ch 5 outlines in detail the design considerations of gas systems and the roles and responsibilities of the designer. BCGA CP4 must be complied with when selecting a designer for gas systems at UoN.

10. Installation and Commissioning

Installation of a new or modified gas system or gas cylinder system or a cryogen installation must be undertaken by a competent person.

Prior to first use by workers, the installation must be commissioned and tested to ensure it is operating as per the design. The stages of commissioning are:

- Installation
- Technical / Performance checks
- Assessment of any safety controls such as protective devices and gas detection
- Production of a Written Scheme of Examination (WSE) where required
- Examination in cases where a WSE is in place
- Record of the commissioning process

All associated paperwork must be provided to the system owner and/or GCSC.

All pipework must be clearly labelled with its contents and clearly identifiable by the gas source to which it is connected (*Reference BCGA CP4 Appendix 8*). For external pipelines, suitable weatherproofed labels should be affixed and checked regularly for damage.

All components installed for isolation or for use in emergencies should be clearly identified by a sign indicating the purpose of the fixture and how it can be operated in the event of an emergency.

Handover after commissioning

Handover is the point when all installation, testing and commissioning activities are complete and the system/equipment is ready to be put into service, either for the first time or following completion of modification or additions. There should be user training on the system and safety working procedures / instructions provided.

There is a requirement within the Pressure Systems Safety Regulations 2000 (PSSR) that laboratory gas cylinder manifolds are properly:

- Designed, installed, tested, commissioned, and handed over prior to first use. Also, those using such systems should be trained and understand how to operate the system safely and correctly and undergo emergency contingency training prior to using the system.

For pressure systems, the system owner must ensure a Written Scheme of Examination is in place and, if applicable the initial examination completed. If PSSR Reg 9 (see section 12.1 below) is not applicable, a documented inspection and maintenance regime must be in in place in accordance with PUWER Reg 9.

Reference: BCGA CP4 Section 8 – documents that should be part of the handover

11. Statutory Examinations, Inspections, Servicing, Maintenance and User Checks

All gas manifolds and cryogenic systems at the University of Nottingham shall be subject to a programme of regular examinations, inspection and maintenance. This programme should be documented and compliance with it reviewed at the BU H&S Committee.

It is the responsibility of the user to ensure that inspections are carried out periodically and appropriately such that detection of deterioration can be acknowledged and remedied as necessary (BCGA CP39 Ch 4.4).

All examination, inspection and maintenance of pressure equipment shall consider the manufacturer/ supplier's recommendations. All equipment, including regulators, safety devices and hose assemblies should be inspected at assembly, before use, after use and at least annually thereafter. An inventory of replaceable/serviceable equipment should be kept, and all equipment should be replaced or refurbished as per the manufacturer's instructions and should not be refurbished in-house by users who lack the competence to perform this task. (BCGA CP47 Ch 5)

See Appendix 3 concerning the components that must be checked / replaced with recommended frequencies. (BCGA CP47 Appendix 1)

11.1 Written Schemes of Examination (Pressure Systems Safety Regulations)

Elements of piped compressed gas systems attached to pressure cylinder installations fall within the scope of the Pressure Systems Safety Regulations 2000 (PSSR). Key requirements are for a Written Scheme of Examination (WSE) to be in place prior to the system being used and for the system to be examined in line with the WSE with any actions arising, remedied or the equipment taken out of use.

The frequency of examinations is specified in the WSE. Typically, a Written Scheme will cover the examination of protective devices, high pressure regulators, high pressure hoses and pigtails and pipework, which, in the event of failure could give rise to danger.

Systems subject to a WSE should be marked whether the system has passed or failed after each examination. **Failed systems must be taken out of use.**

11.2 Inspection of specific parts of a gas system (BCGA CP39 Ch4.4)

In addition, there is a requirement for regular inspection / maintenance checks (including annual pressure drop-testing) that technically fall outside the requirements of the Written Scheme of Examination, see Appendix 1 and 2. These may be undertaken by a trained and competent member of staff or the BU must contract the services of a competent third party.

11.3 Servicing and Maintenance (BCGA CP47 Ch5)

Gas systems and equipment must be serviced and maintained in accordance with manufacturer's instructions. The Business Unit must keep records of this.

11.4 Routine In-house Checks (BCGA CP47 Ch5)

Monthly visual checks of all gas manifolds and cryogenic vessels, with all attached equipment must be carried out and recorded by a competent member of staff.

Users are expected to carry out visual checks of any gas system or cryogenic equipment (including safety devices, connections, hoses, lines, connectors and pipework) they use, ahead of each use. The condition of any PPE should also be checked before using. Pre-use checks should be stated in the SOP.

12. Training, competency and supervision

The university will ensure that all staff who have responsibilities for gas and cryogens safety will receive the appropriate level of training detailed below.

The university has a duty to ensure users/workers are competent to carry out their work tasks and where competency has not been attained, appropriate supervision must be in place. The user's line manager is responsible for managing this.

This section defines specific requirements that are in addition to those in the Health and Safety Management System (see the SAF-MAN-2.5 – Training and Competency and MAN2.1 – Appointment of Safety Critical Roles).

Table 1: Training Requirements

Role	Expected minimum experience and training	Supervised / supported by
Auditor (for Technical Auditing)	Evidence of experience in gas safety management	N/A
H&S Advisors providing Gas / Cryogens Safety Advice	Undertaken and passed Safe Use and Handling eLearning (separate courses for gases and cryogens) Attended Inspection and Maintenance Course for gases Undertaken relevant CPD activities to maintain up-to-date knowledge base.	H&S Director and competent third parties as required
BU Gas / Cryogens Safety Coordinator (GCSC)	Undertaken and passed Safe Use and Handling eLearning courses (separate courses for gases and cryogens) Undertaken practical training as relevant to the BU Attended and passed Inspection and Maintenance Course for gases Instructed on duties as GCSC	Direct reporting to BU management Supported by H&S Advisors and BU HSC
User / Worker	Attended and passed Safe Use and Handling course (separate eLearning available for gases and cryogens.) Undertaken practical training relevant to their specific work (either within BU in line with SOPs and/or other training provision as specified locally) Deemed competent or supervised as relevant to the task and their current level of experience, knowledge and skills	Line Manager / Supervisor
Worker undertaking component inspections (alternatively use an external competent person)	Attended and passed Inspection and Maintenance course Deemed competent or supervised as relevant to the task and their current level of experience, knowledge and skills	BU Gas / Cryo Safety Coordinator

Worker undertaking design and construction	Completed and passed relevant external training/ qualifications for the level of design and construction to be undertaken. Deemed competent in accordance with BCGA CP4.	BU Gas / Cryo Safety Coordinator

Records of all training and instruction must be kept at university level (by Health and Safety Department) for HSD staff training and at Business Unit level for Gas/Cryogen Safety Coordinators, and users/workers.

BCGA references regarding training requirements

- Day-to-day operations and emergency procedures involving gases: Users should receive suitable training on day-to-day working with the cylinders. Consideration should also be given to the arrangements and actions one should follow in the event of an emergency (cylinder falling, failure of bursting discs/ valve etc); this shall be documented.

  Reference BCGA CP44 Ch 7. *Further guidance on what should be included in training can be found in BCGA GN23*

- Day-to-day operations and emergency procedures involving cryogens: Users should receive suitable training on day-to-day working with the cryogenic vessels, including decanting from vessels and moving vessels, if necessary. Consideration should also be given to the arrangements and actions one should follow in the event of an emergency (ice plug formation, excess venting, pressure build-up, cold burns); this shall be documented.

  Reference: Further guidance can be found in BCGA GN23 and GN25

- Before initial use of gas cylinders, cryogenic vessels, any attached related hoses, and safety devices the user should receive adequate training and should be competent to carry out each task (details of expected training in BCGA GN23). The users should receive training on how to act in the event of an emergency, such as a pressure system failing.

  Reference: BCGA CP47 Ch 8

- **Use and Handling:** The user should have access to, and use, the correct PPE, and should only use pressure system equipment as per the manufacturer's guidance; the user should not perform tasks outside of their training.

  Reference: BCGA CP47 Ch 6 and Ch 7.1, BCGA CP30 Ch 7 and Ch 10

Competence of Third Parties (Designers, Installers, Commissioners, Examiners)

All persons involved in the design, installation, commissioning and testing of pressure systems shall be competent in the work they are undertaking. Competence requires that personnel have the appropriate level of skills, knowledge and experience.

When the university appoints contractors to work on university systems, due diligence checks must be carried out of the contractors' competence, e.g. they must evidence risk assessments and method statements relevant to the activity they are undertaking and that they hold valid, adequate public liability insurance.

Reference: BCGA CP4 Section 3.2: Competence

13. Monitoring

To ensure high standards of health and safety are maintained, the university policy is to carry out monitoring and inspection in all areas in accordance with the university's Monitoring of Health and Safety Performance (MAN3.1). Monitoring must be carried out at both Business Unit and university levels; records of monitoring must be kept robustly, and the responsible person must ensure that actions are being followed up and completed with support from the GCSC.

Specific monitoring of gas / cryogen systems must be undertaken periodically by the BU, a Gas / Cryo Safety Mini-audit question set is available.

Aspects of gas safety must also be part of the standard inspection checklist applied in BUs that operate gas systems and equipment.

Table for Assurance Reporting (KPIs)			
Description of Report	**By**	**To**	**Frequency**
BU Annual Review and Plan includes Gas and Cryo safety	HSC	HoBU and BU H&S Committee	Annual
Gas/Cryo Safety Mini-Audit	BU	BU H&S Committee & H&S Department	3 – 5 Years
BU Report of UoN KPIs, e.g.: ▪ % workers trained ▪ % RAs up to date including SOPs ▪ % of systems with completed inspections/examinations/checks ▪ Incident reports reported and reviewed	GCSC	BU H&S Committee H&S Department (latter will collate data for reports to UoN H&S Committee)	Annual / when requested

14. Emergency procedures

Each Business Unit that has gas and / or cryogen systems must have business arrangements for dealing with emergencies.

Emergency arrangements must be documented, in writing and workers trained in the action to be taken, e.g. dealing with unexpected release of gas (asphyxiation or ill-health effects).

Everyone working with or exposed to gases and cryogenic liquids must receive sufficient training for them to understand the procedures to be instigated in the case of an emergency.

Anyone responding (referred to as Emergency Responders) to a release must be fully trained and competent. They must be provided with the following training in addition to basic awareness training:

- Training on the types of gas/cryo emergency likely to happen in the Business Unit (delivered locally to an SOP)
- Training on dealing with these types of emergencies, including the use of PPE and spill kits that are required in the BU (delivered locally to an SOP)
- Annual drills and release response practice (delivered locally to an SOP)

Priority must be given to keeping workers safe over equipment and premises and it may be necessary to cease the work and shut down the process to avoid any further risk of exposure.

15. Incident reporting

The Health and Safety Management System defines the university process for Incident Reporting, Investigation and Trend Analysis (see MAN3.02)

All incidents, including near misses relating to the use, handling or storage of gases or cryogens must be reported on the university's online incident reporting system. Any university person may report an incident on the system; the responsible manager must report otherwise.

Any incident reported must then be investigated to determine remedial actions to prevent reoccurrence. Any lessons learnt must be shared as relevant across the BU and university.

Appendix 1: Business Unit Gas/Cryo Review Checklist

A. Inspection, testing and maintenance regime for Gas Manifolds and Cryogenic Systems:

Actions required:

1. Check all relevant systems covered by a suitable written scheme of examination.
2. Check that all examinations of gas systems are up to date with any noted actions completed.
3. Monthly visual checks of all gas manifolds and cryogenic vessels, with all attached equipment to undergo inspection. Checks to be documented.

B. Assessment of working environment: asphyxiants/toxics/flammables, enrichment, and depletion appropriate to the gases being used.

Actions required:

1. Risk assessment, including calculations, to be carried out for worst case scenario of gas depletion from cylinders or piped frameworks, or cryogenic loss/expansion from vessels in every lab area. Evidence of calculations to be provided in risk assessment and documented. (Reference to BCGA GN11 Ch 2 and Ch 5). Consideration to be given to control measures such as auto-shut off and increased ventilation.

C. Implementation on gas detection, maintenance and inspection and training

Actions required:

1. Where identified in the risk assessment, suitable gas detection to be installed.
2. Detection servicing plan in place, with detection maintained in line with manufacturer instructions.
3. Appropriate signage and notices in place to inform what workers or visitors should do in the event of the alarm sounding/flashing.
4. Workers trained in response to alarms sounding, and records of training to be kept.

D. Handling of gas cylinders, training, and storage requirements for cylinders not in use (i.e. not connected to equipment)

Actions required:

1. Correct equipment required to manoeuvre cylinders should be available, and suitable PPE to be available to all workers accessing cylinder stores.
2. All cylinder store workers to be suitably trained in gas cylinder safety and emergency procedures.
3. All cylinder stores to be located, operated, and maintained as per guidance found in BCGA CP44 Ch 5.

E. Handling of cryogenic dewars, training and storage requirements:

Actions required:

1. Correct equipment required to manoeuvre vessels should be available, and suitable PPE to be available to all workers decanting or moving vessels.

2. All workers using cryogenic vessels shall receive suitable training related to the tasks they will be undertaking – this must also cover the actions the user must undertake during an emergency.
3. Weather-proofing to be considered for all areas in which decanting of LN2 into portable dewars occurs.
4. Visual checks performed on dewar ahead of each use

F. Training, use, handling, and maintenance of gas delivery systems (safety devices and hoses) attached to in-use gas cylinders or cryogenic vessels.

Actions required:

1. All users of safety devices to be suitably trained, with evidence of training kept locally.
2. Visual checks to be performed on safety devices/ hoses attached to cryogenic vessels and gas cylinders/manifolds ahead of each use.
3. PPE to be provided, used, and maintained in situations which require it (such as when modifying pressure systems or replacing components).
4. Inventory of pressure system devices to be kept with all components replaced, serviced, and documented as and when required.

G. Piped gas lines and labelling:

Actions required:

1. All pipework to be clearly labelled with its contents and clearly identifiable by the gas source to which it is connected, as per BCGA CP4 Appendix 8.
2. Annual pressure drop-testing in place and recorded.
3. All components installed for isolation or for use in emergencies should be clearly identified by a sign indicating the purpose of the fixture and how it can be operated in the event of an emergency.
4. For external pipelines, suitable weatherproofed labels should be affixed and checked regularly for damage.

Appendix 2: Hints and Tips

Good lab practices:

- Regulators are different for different types of gas so it is crucial to ensure the correct type is being used
- Regulators may be top or side-mounted depending on the type of cylinder, ensure the correct orientation is used
- So users can promptly turn of the gas from a cylinder, ensure the correct keys are in position on the cylinder, or at the very least attached
- Provide leak detection spray in the vicinity of cylinders to enable users to easily check for leaks
- Ensure workers do not modify equipment without appropriate design criteria and risk assessment.

Low pressure hoses used in association with piped compressed gas systems and gas cylinders

The condition of the hose is of vital importance to safety. Correct hose connections, properly fitted and tested and retained by suitable non reusable clips or ferrules, are also essential. Re-usable worm-drive clamps (e.g. Jubilee clips) should not be used.

Low pressure hoses shall be:

- Capable of safely handling gas pressure applied.
- Made of a material which has been proved to be compatible with the gas used.
- Protected from excess heat.
- Kept as short as possible.
- Not allowed to become contaminated with grease or other materials.
- Fastened with appropriate fastenings.
- Where multiple low pressure hoses are used in close proximity, a unique marker to include the gas name should be used to identify each end of each hose.
- A fire in a coiled hose is difficult to extinguish; oxygen or fuel gas hoses should not be coiled around the cylinders, regulators or cylinder trolley during operation.
- Discarded when worn or damaged.

Hoses and hose assemblies shall conform to the following standards:

- BS EN 1327 Thermoplastic hoses.
- BS EN 559 Rubber hoses.
- BS EN ISO 14113 Rubber and plastic hose assemblies (450 bar).
- Hoses to BS EN 559 shall be assembled and tested in accordance with BS EN 1256.
- Hose connections shall conform to BS EN 560.
- Quick action couplings shall conform to BS EN 561.

Creep Test

Regulator creep is a phenomenon in which delivery pressure rises above the set point. Creep can occur in two ways. The first is due to inconsistencies in the motion of the regulator springs when gas flow is stopped. When flow has stopped, the springs should move to a new position of equilibrium, if this does not happen correctly, it can cause a slight increase in delivery pressure. The second cause of regulator creep is debris entering the regulator, impeding its normal operation.

To carry out a creep test -

a) Isolate the downstream side of the gas regulator by closing the regulator outlet valve, instrument valve or process isolation valve.
b) Close the regulator until it reaches stop or rotates freely.
c) Slowly turn on the gas supply, when the regulator inlet gauge registers full cylinder delivery pressure, shut off the gas supply.
d) Turn the regulator adjusting knob clockwise until delivery pressure gauge reads approximately half of scale (i.e. 50 psi on a 100 psi gauge).
e) Close the gas regulator by turning the adjustment knob counterclockwise until it rotates freely or reaches the stop. Note the reading on delivery pressure gauge.
f) Wait 15 minutes and recheck the setting on delivery pressure gauge.
g) If any rise in delivery pressure is detected during this time, the regulator is defective and should be replaced.
h) Return system to normal operating status.
i) Record & file results of test.

Drop test (gas tightness test)

Procedure to follow for carrying out a drop test:

a) Isolate all gas consuming equipment from the low pressure gas distribution system and ensure that all distribution valves are open.
b) Isolate the downstream side of the gas regulator by closing the regulator outlet valve, instrument valve or process isolation valve.
c) Close the regulator by turning the adjustment knob counterclockwise until it reaches stop or rotates freely.
d) Slowly turn on the gas supply until the regulator inlet gauge registers full cylinder delivery pressure.
e) Turn the regulator adjusting knob clockwise until delivery pressure gauge reads normal system operating pressure.
f) Switch off gas supply. Note the reading on delivery pressure gauge.
g) Wait 15 minutes and recheck the setting on delivery pressure gauge. If any drop in delivery pressure is detected during this time, the low pressure delivery pipe work should be tested for leaks using an approved leak detecting solution and any leaks repaired as required.
h) Return system to normal operating status
i) Record and file test results.

Appendix 3: Guidelines for the inspection and maintenance of high- and low-pressure components associated with piped compressed gas systems attached to compressed gas cylinders

Table for inspection and maintenance of piped compressed gas systems					
Equipment	**Intervals**				
	At Assembly	**Before Use**	**After Use**	**Annual**	**Replacement / refurbishment intervals**
REGULATORS and their integral protective devices Section 6.1, 8.5.	Check compatible with the gas. Ensure within life for use. Check the regulator inlet pressure is compatible with the maximum cylinder pressure. Ensure the Pressure Adjustment control is firmly fixed to the body and operates freely. Check the inlet and outlet connections sit square to the regulator's body. Check condition of threads and sealing surfaces. Ensure no signs of PTFE tape. Check both gauges on regulator naturally face the front and are undamaged. Ensure both gauge needles reset to zero.	Check body for any signs of soot, oil, grease or other contamination. Check compatible with the gas. Ensure the Pressure Adjustment control is firmly fixed to the body and operate freely. Ensure the regulator gauges start at zero prior to use. Ensure the pressure rises on the high pressure gauge when opening the cylinder outlet valve. Check the low pressure gauge rises smoothly when setting the gas pressure. Leak test all joints at working pressure.	Check for any damage, contamination, defects or faults. Check that gauges return to zero during the venting process.	Full visual inspection. Check life dates. Functional tests to ensure correct operation. Typically this will include a creep test to ensure regulator integrity.	5 years from date of manufacture or manufacturer's recommendations. Replace with a new, or refurbished unit NOTE 1. NOTE 2.

	No oil, grease or other contamination. Leak test all joints at working pressure.				
FLAME ARRESTORS and their integral cut off valves. Section 6.3.	Check correct type fitted. Check manufacturing standard. Ensure within life for use. Check condition of threads and sealing surfaces. Check the Direction of Flow is correct. No oil, grease or other contamination. Leak test all joints at working pressure. Check the Pressure sensitive cut-off valve button is not restricted / damaged / tied down.	Ensure flame arrestors are fitted. Leak test all joints at working pressure.	Check for any damage, contamination, defects or faults.	Check unit for leaks, flow restrictions and reverse flow to ensure correct operation of non-return valves. Where pressure sensitive cut off valves are fitted, they shall operate at a pressure of no greater than 1.2 bar. If of a pressure sensitive type, check shut-off in the tripped condition in the direction of flow. Check life dates.	5 years from date of manufacture or manufacturer's recommendations. Replace with a new, or refurbished unit. NOTE 1. NOTE 2.
HOSE ASSEMBLIES (including NON-RETURN VALVES) Section 6.2, 6.3, 8.7.	Check the manufacturing standard. Check suitability of hose colour, internal bore size and length Check threads and sealing surfaces. Check hoses condition for damage (e.g. kinking twisting or cracking).	Ensure all the gas hose is unwound from gas cylinder trolley prior to use. Check hoses condition for damage (e.g. kinking twisting or cracking). Leak test of all joints at working pressure.	Check for any damage, contamination, defects or faults.	Reverse hose to ensure the correct operation of non-return valve where fitted. Bend hose in a tight radius to ensure reinforcement is not visible and there is no sign of collapse or distortion.	Determined by local operating conditions. Replace as required. NOTE 2

	Ensure HCV and Nut & Tails are fitted using correct ferrules and are located in the correct place. Leak test of all joints at working pressure.				

NOTE 1: Components such as elastomers, seals and diaphragms, will wear and deteriorate from their date of manufacture whether in gas service or not. Items stored out of gas service for one year or over should receive checks in accordance with the annual requirements.

NOTE 2: Some equipment is marked to either identify the date it was manufactured or the date when it needs replacement or refurbishment. Refer to BCGA TIS 18 [50], Date marking of gas accessories.