Australia's National
Science Agency

Reticulated Gas Installations and Maintenance Technical Guide

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1 Introduction

This document provides information on the necessary components of, and establishes mandatory minimum requirements for, laboratory gas installations and maintenance across CSIRO in accordance with Australian Standards. This guideline is intended to apply to all new gas installations, or to any modifications of gas installations from 1 January 2020. Any current installation which does not meet these guidelines must conduct a comprehensive risk assessment to ensure work in the area is being conducted safely and current controls are sufficient to mitigate the risks. This risk assessment must be reviewed by HSE and any relevant subject matter experts.

This document does not cover the design and installation of bulk gas, bulk cryogenic (i.e., greater than a single container water capacity of 500 L or kg as per the Commonwealth *Work Health and Safety Regulations 2011*), medical gas installations, or town gas installations (i.e., mains reticulated gas supply/systems which can differ from place to place but is generally natural gas (methane) and sometimes LPG in regional towns). Such installations must be designed by a professional engineer and subject to local regulatory requirements.

If there is any uncertainty regarding an installation, professional advice should be sought. All gas installations/modifications/maintenance should be undertaken by a qualified and experienced trade person.

Note: Any modification to building systems, services or integration with infrastructure services (e.g. linking gas alarm to BMS) must be undertaken in consultation with CBIS.

2 Laboratory and Pipework Design

2.1 General Requirements

All laboratory designs must incorporate the following items:

- Clear signage on entry doors to identify gas classes reticulated to or contained within the laboratory.
- Ventilation compliant with the requirements of AS 2982, AS 2243 series and AS 1668.2.
  - All pipework is to be solid and fixed. Flexible tubing lengths may only be used to connect a gas outlet to equipment within the laboratory and must be kept to a minimum length[1]. Flexible tubing is not to be used for pipework penetrations of any nature[2].
  - Installed pipework must be accessible but should be provided protection from physical damage[3].
  - Pipe material is to be compatible with the gas that is contained within it. Welded pipework is required for flammable (Class 2.1) or toxic (Class 2.3) gases and is generally recommended as the ideal installation. However, Swagelok fittings are accepted for non-toxic non-flammable gases (Class 2.2) if the system pressures are within the rating of the Swagelok system.

  Note: Sections of pipework that are readily accessible for visual inspection are suitable for Swagelok fittings, but pipework that is within a concealed space that is not readily accessible must be solid pipe/welded construction.
  - Penetrations for gas pipework are to be sealed and maintain the integrity of any fire walls that they penetrate[4].
  - Gases must be reticulated at the lowest practicable pressure[5].
  - Reticulated gas pipework must be labelled with the contents and direction of flow in visible locations, as per Table 1[6].
  - Isolation valves must be installed in a place that is easily accessible and have clear and labelled OPEN/CLOSED positions. Preferably these should be two-position valves, not screw valves.
  - All pipework is to be pressure tested in accordance with AS 4041.

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[1] AS 2243.6–1990: Safety in laboratories—Mechanical aspects, Section 4.2.3. Where there is a risk of damage to the flexible tube, flexible braided metal hose should be used.

[2] AS 2982–2010: Laboratory design and construction, Section 3.7.2

[3] AS 2982–2010: Laboratory design and construction, Section 3.7.3

[4] Building Code of Australia – Specification C3.15

[5] AS 2982–2010: Laboratory design and construction, Section 3.7.2

[6] AS 2982–2010: Laboratory design and construction, Section 3.7

- Any areas of reticulation where there is a risk of gas release are to be identified. Risk assessments are to be documented to determine if gas detection is required for leak detection in the associated areas.

- Gas outlets must be provided with the following:
  - Gas flow regulators
  - Clear indication of the gas source location and gas type
  - Clear indication of ON/OFF positions
- In general, all installations are to be considered as permanent and are to be installed by a qualified person with proven experience. Where a temporary set-up is necessary for operational reasons, it must comply with these standards, be risk assessed and reviewed by HSE and, where relevant, other specialists.

Table 1 : Gas pipework labelling requirements

Pipework Diameter	Minimum Height	Base Identification Colours piping	Base Identification Colour Specifications	Example pipe marking (refer to Table 2 of AS 1345)
<40mm	≥4mm upper case letters, repeated such that the label is visible from all viewing directions.	yellow-ochre for gases (i.e., fuel/ process/ liquefied gases under pressure, exhaust gases and fumes, medical gases) excluding air/highly acidic or alkaline gases violet for acids/alkaline - all corrosive gases light blue for compressed/ instrument/ vacuum/ ventilation/ pneumatic conveyor air as the base colour	Black text on sand for yellow-ochre gases Black text on Lilac for violet gases Black text on Aqua for light blue gases	
40mm to 75mm	25mm			
>75mm	50mm			

2.2 Storage of Cylinders

- An empty gas cylinder shall be treated as full since empty containers retain residual gas under pressure.
- Wherever possible, the location of compressed gas cylinders within a laboratory should be avoided. Cylinders may be kept connected for use inside a laboratory only if an outdoor location is not practicable. This may be for reasons of gas purity, pressure drop, special temperature stability requirements or other specific reasons particular to the application. A risk assessment should be carried out that documents the reasons for the cylinders being located in the laboratory and the controls put in place to manage the additional risk.

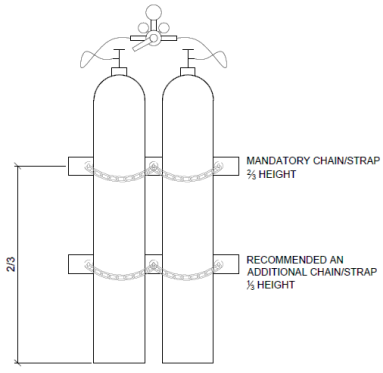

Figure 1: Recommended restraints

- Cylinders in use in a laboratory must be <70 L water capacity. The smallest practicable cylinder size must be used.[7]
- Cylinders not in use must be relocated to a dedicated gas cylinder store[8]. All in-use cylinders within a laboratory must be fitted with a regulator and pressure relief device which must vent to a safe space that does not present an asphyxiation risk[9].
- All gas cylinders must be restrained while in use or while being stored, in a vertical position unless specifically designed for horizontal storage. Cylinders with a capacity >2.5 L must be restrained in a vertical position (e.g., against a wall or bench) using purpose-built cylinder restraints at ~2/3 the cylinder height. See Figure 1 (above) for details on positioning of cylinder restraints[10], noting that the inclusion of the second strap at 1/3 height is recommended but not required.

2.3 Emergency Shut-Offs and Ventilation Systems in Rooms with Reticulated Gas

- Gases that are reticulated from a source external to the laboratory must be provided with an emergency gas shut-off device. The gas shut-off button must be located on the path of egress, clearly labelled and preferably near the laboratory exit, co-located with other emergency shut-off buttons[11].
    - All pressurised gas supplies shall be isolated through activation of double block (fail-safe) solenoid valves fitted to each area for each gas service.[12]
- Where gas detection systems are installed, gas shut-off devices (solenoid valves) must be interlocked with this system.
- Solenoids must also be interlocked with mechanical ventilation systems, where ventilation systems have been identified as a key control for mitigating the potential consequences of a gas leak (e.g. toxic gas exposure standards exceeded if ventilation were to fail).
- Indication devices such as strobes must be provided to alert occupants of a failure of mechanical ventilation. The devices must be clearly labelled.
- Ventilation must be adequate to ensure the laboratory is kept below exposure standard levels, LELs and within a safe oxygen concentration (19.5%-23.5%).[13] Ventilation must be configured to prevent the accumulation of gases. This may require exhaust intakes at high level for lighter than air gases, and intakes at low level for heavier than air gases.

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[7] AS 2243.2 – 2021 Safety in laboratories—Chemical aspects and storage, Section 7.7.4

[8] AS/NZS 2243.1–2005: Safety in laboratories - Planning and operational aspects, Section 4.5.7

[9] AS 2243.6–1990: Safety in laboratories—Mechanical aspects, Section 4.2.4

[10] AS 2243.6–1990: Safety in laboratories—Mechanical aspects, Section 4.3

[11] AS 2982–2010: *Laboratory design and construction*, Section 3.4

[12] 4.5.1(k) CSIRO Design and Common Requirements

[13] AS 4332 – 2004 The storage and handling of gases in cylinders, Section 2.5 (b); WHS Regulations 2011 Cth Clause 5, definition of Safe Oxygen Level.

Note 1: Gas shut-off solenoids should be located external to the laboratory, preferably located within the gas store adjacent to the manifold.

Note 2: Ventilation configuration should be assessed (and where necessary, modified) on a case-by-case basis where general room ventilation is inadequate. Consider, for example, an installation where both lighter-than-air (e.g., hydrogen) and heavier-than-air gases (e.g., carbon dioxide) are used; this configuration could require the installation of multiple intakes to account for the different behaviour of each gas.

2.4 Gas Detection Systems

For all gases other than compressed air, an Activity Risk Assessment must be documented to determine if there is risk of creating a hazardous atmosphere in the event of a gas leak. This assessment may be aided by use of the Spontaneous and Gradual Release Gas Risk Assessment Tool. Hazardous atmospheres include where:

- the oxygen concentration in the air becomes deficient or enriched (i.e., less than 19.5 % or greater than 23.5 %)
- the concentration of flammable gas exceeds 5% of the gas' lower explosive limit (LEL), or
- the concentration of a toxic gas exceeds its exposure standard, represented as either an 8-hour Time Weighted Average (TWA) or Short-Term Exposure Limit (STEL), whichever is lower.

Warning: Oxygen detectors must never be used to indicate displacement by carbon dioxide. Reliance on them to monitor the presence of carbon dioxide has led to fatalities.

If the assessment determines that a hazardous atmosphere is possible, a gas detection system must be installed and comply with the following criteria:

- The detectors must be located in a configuration that considers the behaviour of the gas and potential points of release. Lighter than air flammable gas detectors should be at high level (approximately 200mm below ceiling or slab), heavier than air detectors should be mounted at low level (approximately 300mm above floor level), detectors for gases that have a similar density to air must be mounted between 1600-1800mm above floor level.[14]
- A gas concentration readout panel must be provided external to the space. Where possible, this should be incorporated in the gas detection control panel.
- Detection systems must be calibrated at a frequency specified by the manufacturer. Calibration dates and due dates must be shown on the panel and each of the detectors connected to the system.

[14] AS/NZS 60079.29.2:2016: *Gas detectors - selection, installation, use and maintenance of detectors for flammable gases and oxygen*, Section 8.3.2

- Audible and visible alarms must be installed in conjunction with all gas detection systems. An audible and visible alarm must be provided within the laboratory and one or more additional alarms must be provided in the adjacent space(s) to alert occupants of a hazardous environment from outside of the laboratory.
- The alarm points must be set as per the following criteria:

– Oxygen depletion / enrichment – 19.5 % or 23.5 % oxygen by volume

– Flammable gases and vapours – low alarm set at 5 % of the LEL; high alarm set at 10 % of the LEL

– Toxic gases and vapours – high and low alarm set point for toxic gases set at the STEL or TWA, whichever is lower. These values are listed by Safe Work Australia's Hazardous Chemicals Information System. Where possible, it is best practice to set the detector alarm points to a lower value, such as 50% (or less) of the STEL or TWA.

Table 2, below, provides a list of common laboratory gases and the recommended maximum alarm set points. Be aware that gases may present multiple hazards (i.e., a gas may be asphyxiating, toxic and flammable), and alarms/other control measures should be selected to address the lowest concentration which presents a risk.

Table 2: PROPERTIES OF COMMON GASES AND RECOMMENDED GAS ALARM SET POINTS

Class	**Type of Gas**	**Density Relative to Air**	**Low Alarm Set Point**		**High Alarm Set Point**	
2.2	Argon	Heavier	O_2 alarm set to 19.5%		O_2 alarm set to 23.5%	
2.2	Helium	Lighter	O_2 alarm set to 19.5%		O_2 alarm set to 23.5%	
2.2	Nitrogen	Similar	O_2 alarm set to 19.5%		O_2 alarm set to 23.5%	
Class	**Type of Gas**	**Density Relative to Air**	**Low Alarm Set Point (5% LEL)**		**High Alarm Set Point (10% LEL)**	
2.1	Acetylene	Similar	1200 ppm or 0.12 %		2400 ppm or 0.24 %	
2.1	Butane	Heavier	700 ppm or 0.07 %		1400 ppm or 0.14 %	
2.1	Ethylene	Similar	1200 ppm or 0.12 %		2400 ppm or 0.24 %	
2.1	Hydrogen	Lighter	2000 ppm or 0.20 %		4000 ppm or 0.40 %	
2.1	Methane	Lighter	2200 ppm or 0.22 %		4400 ppm or 0.44 %	
2.1	Propane	Heavier	900 ppm or 0.09 %		1800 ppm or 0.18 %	
Class	**Type of Gas**	**Density Relative to Air**	**Low Alarm Set Point**		**High Alarm Set Point**	
			TWA	**Recommended**	**STEL**	**Recommended**
2.3	Ammonia	Lighter	25 ppm or 0.0035 %	25 ppm or 0.0025 %	35 ppm or 0.0025 %	25 ppm or 0.0025 %
2.2	Carbon Dioxide	Heavier	5000 ppm or 0.5 %	5000 ppm or 0.5 %	30000 ppm or 3 %	10000 ppm or 1 %
2.3	Carbon Monoxide	Similar	30 ppm or 0.003 %	15 ppm or 0.0015 %	-	-
2.3	Chlorine	Heavier	-	-	1 ppm or 0.0001 %	0.5 ppm or 0.00005 %
2.3	Sulphur Dioxide	Heavier	2 ppm or 0.0002 %	1 ppm or 0.0001 %	5 ppm or 0.0005%	2.5 ppm or 0.00025%

2.5 Specific Requirements for Flammable Gases (Class 2.1)

- Pipe material must be compatible with the gas that is contained within it. Pipework for flammable gases must be of steel construction (carbon or stainless)[15], except for natural gas and LPG, which may be copper. As per section 2.1, pipework must be welded.
- Flammable gases may produce a potentially explosive atmosphere in a laboratory if released and as such a hazardous area may exist within the laboratory. This will require consideration of the need for hazardous area zoning and the location of potential ignition sources within the hazardous area. Different gases will represent different hazards and zoning requirements due to their properties (e.g., heavier or lighter than air). If ignition sources cannot be located outside the hazardous area, the ignition source (e.g., electrical equipment) must be suitably hazardous area rated[16].

Note 1: Flammable gas installations must include the installation of flashback arrestors, unless an assessment is made detailing alternative controls to mitigate the risks of ignition of gas in the pipework. For acetylene used in oxy-fuel systems, flashback arrestors are mandatory - see 2.7 below.

Note 2: Gas safety regulations require certain gas appliances (Type A or Type B appliances) to be installed and verified by specially trained gas fitters. Type B appliance installations (including appliances with gas consumption ≥ 10MJ/h such as gas fired heaters, incinerators, or boilers) may have requirements that supersede the controls listed in this guide. Exact requirements vary from state to state; engage suitable qualified personnel to design, install and certify these appliance installations.

2.6 Specific Requirements for Toxic Gases (Class 2.3) or Gases with an Exposure Standard

- Access to areas that contain or use toxic gases (Class 2.3) must be limited to staff with necessary induction and training.
- Generally, reticulation of toxic gas systems is to be of stainless-steel construction. Alternative materials may only be considered that are proven to be resistant to reticulated gases in accordance with AS 2982 Section 3.7. Pipework must be welded, as per section 2.1.

[15] AS2982–2010: *Laboratory design and construction*, Section 3.7

[16] Refer to the CSIRO *Managing Hazardous Areas (HA) Technical Guide* for further information.

2.7 Specific Requirements for Oxygen and Acetylene Gas Reticulation Systems

- Flashback arrestors are to be installed at any oxygen gas outlets that will be used in conjunction with a fuel gas to supply an oxy-fuel application[17].
- Flashback arrestors and isolation valves must be installed at acetylene gas outlets that will be used to supply oxy-fuel applications[18].

Note: Flashback arrestors must comply with AS 4603 and be tested (or replaced) yearly and marked permanently with the most recent test date. If annual testing in accordance with AS 4603, Section 3, is not cost effective, then the flashback arrestor must be replaced by a competent installer at the same frequency.

[17] AS 4289-1995 (R2016): *Oxygen and acetylene gas reticulation systems*, Section 2.6

[18] AS 4289-1995 (R2016): *Oxygen and acetylene gas reticulation systems*, Section 3.5

3 Gas Store Design

3.1 General

In addition to the above requirements for Laboratory and Pipework Design (Section 2), there are further requirements for dedicated storage areas of gas cylinders, depending on whether the store is classified as *Minor* or *Greater than Minor Storage (e.g., placarding, manifest, or fire protection quantities).*

This classification is determined by the type of gas and aggregate quantity of gas stored within it.

3.2 Signage

Storage areas of gas cylinders must include clear signage on entry doors to identify chemical classes contained within the area. Where quantities of chemicals stored in the work area **do not** exceed the Placard Quantity for any category of chemicals listed in Schedule 11 of the WHS Regulations, this can be a simple poster. See Appendix B for an example CSIRO area hazard poster which contains details of chemical classes stored in an area.

Where the quantities of hazardous chemicals in the area **do** exceed the Placard Quantity for any hazard class listed in Schedule 11 of the WHS Regulations, placards which meet Schedule 13 of the WHS Regulations must be displayed on workplace entrance(s), the building entrance(s) and the storage area entrance(s).

3.3 Classification of Storage Areas

Storage of gases in cylinders in quantities not exceeding those in Table 3, may be classified as *Minor Storage*. For reference, typical gas cylinder water capacities are provided in Table 4.

Table 3: MAXIMUM QUANTITIES OF GASES PERMISSIBLE FOR CLASSIFICATION OF MINOR STORAGE[19]

Class of Gas	**2.1**	**2.2**	**2.2 (5.1)**	**2.3**
Type	Flammable gas	Non-flammable, non-toxic gases	Non-flammable, oxidising gases	Toxic gases
DG Class Symbol				
Maximum Aggregate Water Capacity	500 L	2000 L	1000 L	50 L
Maximum No. of G-Size Cylinders	10	40	20	1

[19] AS 4332–2004 (R2016): *The storage and handling of gases in cylinders*, Table 2.1

Note: Where gases of mixed classes are stored, the aggregate quantity of all gases must not exceed 2000 L and the quantity of each class must not exceed that given in Table 3.

If a **proposed gas store** exceeds the above quantities, it is classified as a *Greater than Minor Storage* area and professional advice to assist with the design must be sought. Additionally, if proposed modifications to an **existing gas store** exceed the threshold of *Minor Storage*, professional advice to support the design must be sought. Exceeding the above quantities may also trigger manifest reporting requirements to the relevant state or national work health and safety regulator.

If a proposed installation is within an existing store, the compliance of the existing store is to be investigated and confirmed prior to the installation commencing.

Table 4: APPROXIMATE WATER CAPACITIES OF CYLINDERS FOR HIGH PRESSURE INDUSTRIAL GASES

Cylinder Size	C	D	E	F	G
Water Capacity (L)	2-3	9-10	22-24	34	48-50

3.4 Requirements for Minor Stores

All Minor Store areas must comply with the following requirements[20]:

- The gas store is to be secure from unauthorised access (i.e., non-authorised staff and members of the public).
- Adequate ventilation must be provided at all times by means of natural or mechanical ventilation. This must include ventilation at high and low level. Fully enclosed non-ventilated cabinets are not acceptable. For mechanically ventilated gas stores where lighter than air gases are present, the ventilation openings (including exhaust intakes) are to be located at the highest point of the gas store.
- The floor is to be flat, solid, and constructed of non-combustible materials.

Note: it is recommended that minor gas stores are located externally and consist of a lockable metal cage with a solid sheet metal roof and mounted on a concrete plinth. If the gas store is located in an area with the potential of damage by vehicles, it should be protected with heavy construction barriers or bollards.

- The store must be kept clear of other dangerous goods stores, combustible materials, vegetation, or leaf litter by a distance of at least 3 m. Indoor minor stores must be separated from other minor stores of gases or other dangerous goods stores by at least 5 m.
- All manifolds must be clearly labelled with the type of gas and areas served (e.g., Laboratory or Room Numbers).

[20] AS4332–2004 (R2016): *The storage and handling of gases in cylinders*, Section 2

- All manifolds are to include a regulator and the gas is to be reticulated at the lowest practicable pressure[21] and within the design limits of the system[22].
- All pipework must include a pressure relief device which is to vent to a safe space and be maintained as per the manufacturer's requirements[23]. The installation date and the due date for replacement are to be permanently marked on all pressure relief devices[24].
- Fire-fighting equipment must be provided in accordance with Table 5:

Table 5: FIRE PROTECTION REQUIREMENTS FOR MINOR STORES OF GASES IN CYLINDERS[25]

Aggregate Capacity (L)	Requirements
< 1000	Water hose connection and hose of sufficient length to deposit water on any part of the store.
1000 to 2000	One hose reel; or one 2A 60B(E) (4.5kg Dry Powder Type) fire extinguisher, a water hose connection, and hose of sufficient length to reach the entire store.

- The store must not be located near to any artificial sources of heat such as radiators, boilers, or steam pipes except where there has been prior consultation with the cylinder supplier for the particular circumstance.
- Stores are to be located a minimum of 1 m from any window, door, duct opening, or air vent.
- The store must not be located in a basement for Class 2.1 and 2.3 gases. Class 2.2 gases which have no subsidiary risks may be stored in a basement (nevertheless, the storage of compressed gas cylinders in a basement should be avoided if there is a practicable alternative).
- Classes of incompatible gases shall be segregated in minor storage (it is recommended to segregate incompatible gases in minor storage in accordance with AS 4332 Clause 4.4.3 as good practice, where practicable).
- The total capacity of gases in indoor minor gas stores must not exceed one minor storage quantity per 200 m^2 of floor area.

3.5 Segregation Distances for Different Classes of Gases

- Flammable (Class 2.1) and Oxidising (Class 2.2/5.1) must be segregated from each other by at least 3 metres. This distance may be used for the storage of Class 2.2 gases (Non-Flammable Non-Toxic).
- Toxic (Class 2.3) must be segregated from gases of other classes by at least 3 metres.

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[21] AS/NZS 2982–2010: Laboratory design and construction, Section 3.7.2

[22] AS 4041–2006 (R2016): Pressure Piping, Section 7.2

[23] AS 4041–2006 (R2016): *Pressure Piping*, Section 7.3

[24] AS/NZS 3788–2006 (R2017): *Pressure equipment - In-service inspection*, Section 4.7

[25] AS4332–2004 (R2016): *The storage and handling of gases in cylinders*, Table 2.2

- The segregation distance between Flammable and Oxidising gases may be measured in a horizontal plane around an intervening screen wall having a fire rating level (FRL) of at least 120/120/120, provided that the wall extends at least 0.5 m above the tallest cylinder within the store.

3.6 Specific Requirements for Flammable Gases (Class 2.1) in Minor Stores

- If flammable gases are present, all pipework within the store is to be earthed in accordance with AS 1020 by a suitably qualified person.

3.7 Specific Requirements for Toxic Gases (Class 2.3) in Minor Stores

- The gas supplier must be contacted to ascertain the additional precautions necessary for the particular toxic gases proposed. Reference must also be made to the relevant SDS, Workplace Exposure Standards and Confined Space Codes or Standards.

4 Cryogenic Considerations

4.1 Bulk Cryogenic Tanks (>500 L)

- Cryogenic tanks that are at risk of vehicular damage are to be protected by means of heavy construction bollards or barriers[26].
- Pressure relief valves on cryogenic vessels and pipework are to be maintained in accordance with AS 3788 Section 4.7.4[27].
- A water source is to be provided near all bulk cryogenic vessels and handling points for the purpose of first aid and de-icing valves.
- Additional requirements for bulk cryogenic installations can be found in AS 1894.

Note: It is recommended that an additional first aid shower/eye wash station is provided which may be portable[28].

4.2 Reticulation

In addition to the above requirements for Laboratory and Pipework Design (Sections 2.1 and 2.3), further requirements for reticulation of cryogenic liquids are:

- Pipework shall be designed in accordance with AS 4041 and shall be able to cope with thermal contraction and expansion.
- Any section of pipework that can cause fluid entrapment and can be closed off at each end shall be fitted with a pressure relief system. Pipework must be labelled in accordance with AS 1319[29].

4.3 Handling and Storage of Portable Vessels (Dewars)

- Only vessels designed for the storage of cryogenic materials should be used to store and transport cryogenic liquids and gases. Vessels should not be sealed unless they are fitted with appropriate pressure release valves.
- All vessels must be treated as full for the purpose of risk assessments and determining control measures.
- Any area that contains cryogenic vessels is to have access control[30].

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[26] AS 1894–1997: *The storage and handling of non-flammable cryogenic and refrigerated liquids*, Section 3.5.2

[27] AS/NZS 3788–2006 (R2017): *Pressure equipment - In-service inspection*, Section 4.7

[28] AS4332–2004 (R2016): *The storage and handling of gases in cylinders*, Section 5.5

[29] AS 1894–1997: *The storage and handling of non-flammable cryogenic and refrigerated liquids*, Section 3.10.2

[30] AS 1894–1997: *The storage and handling of non-flammable cryogenic and refrigerated liquids*, Section 6.3.5

- All vessels >50 L water capacity are to be located in a designated cryogenic storage area. If vessels >50 L (or multiple vessels with an aggregate volume of >50 L) are required to be stored internally, then:
  - The space must comply with the requirements of AS 1894 for internal cryogenic storage.
  - Hazard placarding is to be provided to indicate the classes of gases that may be present in the event of a leak.
  - A risk assessment must be conducted to determine if there is a risk of creating an oxygen depleted or enriched atmosphere within the area or neighbouring areas in the event of a leak/spill. This assessment must include consideration of ventilation rates, safety shut-off systems, rate of release, and gas volume relative to the laboratory. If a risk is determined, a gas detection system must be installed as described above (Section 2.4).
- Oxidising cryogenic fluids (such as liquid oxygen or liquefied nitrous oxide) must not be stored indoors[31].
- Staff must not travel in elevators/lifts with vessels containing cryogenic liquids or solids. Where possible, vessels containing cryogenic materials should be transported between floors in a lift without occupants, with a staff member meeting it on the designated floor. The lift should include a chain with signage indicating that the lift is not to be occupied while the cryogenic materials are being transported. Where possible, lock-off functionality should be provided to the lift controls so that the lift will not stop on other floors until it reaches its destination.
- Cryogenic materials used off-site must be transported in a trailer or vehicle tray, not in an enclosed vehicle cab.

[31] AS 1894–1997: *The storage and handling of non-flammable cryogenic and refrigerated liquids*, Section 3.5.4

5 Ongoing maintenance of reticulated systems

5.1 General Requirements

All reticulated gas installations must undergo regular review and maintenance to identify and rectify safety issues, as well as to prolong the longevity of the reticulated system.

- Staff who use reticulated gas systems must have a maintenance schedule in place for their gas system and monitoring equipment.
- The minimum general maintenance requirements for reticulated gas systems and monitors are listed in Tables 6-9.
- Each reticulated installation or gas monitoring equipment may have additional or different maintenance requirements or timelines provided by the manufacturer, which must be followed in preference to the below tables.
- Where reticulated gas systems carry flammable, toxic or corrosive gases, more regular inspection and maintenance may be necessary.

Table 6: Pressure regulators, where independent from a reticulated gas manifold

When	What	Who
Before each use or at least weekly	• Visual inspection: ○ Regulator and gauge appear to be undamaged and functional ○ Threads and sealing surfaces are in good condition, including O-rings (where applicable – replace if necessary) ○ No oil, grease, or dust contamination	Staff member responsible for regulator or staff member about to use the regulator
Annually	• Test that regulator is free from leaks, gauges are working, and regulator is operating correctly	Inspection by qualified technician.
5 years, or less if recommended by the manufacturer	• Refurbishment or replacement	Refurbishment by a trained gas technician

Table 7: Flashback arrestors

When	What	Who
Annually	• Proper functioning of flashback arrestors and non-return valves tested by Gas Technician (see AS4603 Section 3). Means of identifying test date marked in a permanent fashion on the arrestor • Alternatively, replacement of full Flashback Arrestor if testing not possible	Qualified technician

Table 8: Gas sensors and alarm systems

When	What	Who
Before each use or at least weekly	• For portable detectors, check that the device has zeroed and initialised correctly • For detectors utilizing battery power, check that the battery is still charged	Staff member using gas detector
Monthly	• Visually inspect gas sensors and alarm system for damage or obvious defects	Staff member responsible for gas detector
Six-monthly	• Inspection by qualified technician, which may include re-calibration	Qualified technician

Table 9: Gas reticulation manifolds and other pipework

When	What	Who
During cylinder changeover, or at least monthly	• Visual inspection of reticulated gas manifold and accessible pipework for damage or leaks and to ensure all connections are tight, clean and in good condition ○ Immediately replace any damaged components identified • Check system is operating as expected, with no unusual increases or drops in pressure	Staff member changing over cylinder or staff member responsible for gas manifold/pipework
Monthly	• Leak test all accessible joints at working pressure • Check valves shut off and open correctly	Staff member responsible for gas manifold/pipework

Annually	• Gas supply system inspected for leaks or other damage, including:
	  ○ Regulators
	  ○ Pressure relief valves
	  ○ One-way check valves
	  ○ Flexible hosing
	• Review gas storage location to ensure it remains compliant with storage requirements in Sections 2 and 3 of this Guide. This may include:
	  ○ Cylinder restraints remain in good working order
	  ○ Store is not over capacity and used or old cylinders are being returned to the supplier
	  ○ No changes to surrounding area which may impact, or be impacted by the gas storage and pipework
	  ○ Storage area is clean and free of combustible materials to a radius of 3 m
	  ○ Signage, placarding and labelling of pipelines are up-to-date and legible
		Inspection by qualified gas technician.
		
		Staff member responsible for gas manifold/pipework should make visual review of area

5 years, or less if recommended by the manufacturer	• Replacement of flexible hoses, pressure relief valves and check valves, if not maintained annually • Copper piping should be tested every 2 years	Qualified gas technician

5.2 Maintenance of gas cylinders

The maintenance of individual gas cylinders is generally the responsibility of the supplier. Where an issue is identified with a cylinder, immediately cease use, and contact the supplier for advice.

This includes cylinders which:

- Have illegible labels
- Show visible signs of damage
- Have been dropped or forcefully impacted while in use or storage
- Have been exposed to potentially damaging environments such as excess heat

Gas cylinders which are filled in-house with gases or gas mixtures must be maintained and tested in accordance with the AS 2030 series. For a cylinder with a test date more than 10 years old, the contained gas can be used (provided there are no signs of damage) however the cylinder must be re-tested before being filled again.

Gas cylinders must **not** be refilled in-house with a different gas or gas mixture than is displayed on the cylinder label, or otherwise repurposed to contain any other substance.

NEVER use oil, grease or other flammable lubricants on gas cylinders, valves, fittings, or regulators.

Appendix A – Codes, Standards and other Information Sources

The following Australian Standards and Codes of Practice are referenced in this document:

- AS 1319:1994 – Safety signs for the occupational environment
- AS 1345:1995 – Identification of the Contents of Pipes, Conduits, and Ducts
- AS 1894:1997 – The Storage and Handling of Non-Flammable Cryogenic and Refrigerated Liquids
- AS 2243.1:2005 – Safety in Laboratories – Planning and Operational Aspects
- AS 2243.2:2021 – Safety in Laboratories – Chemical Aspects and Storage
- AS 2243.6:2010 – Safety in Laboratories – Plant and Equipment Aspects
- AS 2982:2010 – Laboratory Design and Construction
- AS 3788:2006_R2017 – Pressure Equipment – In-service Inspection
- AS 4041:2006_R2016 – Pressure Piping
- AS 4289:1995_R2016 – Oxygen and Acetylene Gas Reticulation Systems
- AS 4332:2004_R2016 – The Storage and Handling of Gases in Cylinders
- AS 4603:1999_R2016 – Flashback Arresters – Safety Devices for Use with Fuel Gases and Oxygen or Compressed Air
- AS 60079.29.2:2016 – Gas Detectors – Selection, Installation, Use and Maintenance of Detectors for Flammable Gases and Oxygen
- AS 60079.29.3:2016 – Gas Detectors – Guidance on Functional Safety of Fixed Gas Detection Systems
- Australian Dangerous Goods Code – Edition 7.7
- National Construction Code 2019 – Building Code of Australia

Appendix B – Example CSIRO Area Hazard Poster

HAZARDS
in this Work Area

Precautionary Measures Required

Building 001 Room 101 – Gas lab	Name	Out of Hours Contact Number
Area Custodian	A. Custodian	(00) 9899 1234 0424 123 456
Other	B. Custodian	(00) 9899 4321 0456 987 654

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