

Laboratory Gas Services Design Standards



MACQUARIE
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Laboratory Gas Services Design Standards

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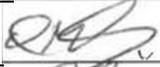
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1.1.PURPOSE

The Macquarie University Property - Laboratory Services Standard sets out Macquarie University's minimum requirements for the design, construction and maintenance of laboratory gas services and infra structure. It ensures new and refurbished laboratory gas systems are fit-for-purpose, provide secure, efficient, safe and reliable distribution of laboratory gas, are made from durable good-quality materials, are cost efficient to operate and maintain.

Applicable requirements documented in Australian and New Zealand Standards (AS/NZS), Australian National Construction Code (NCC), Workplace Health and Safety legislation and other relevant statutory requirements are minimum for compliance and are considered mandatory. The minimum relevant AS/NZS documents are provided in Section 11 of this standard. Where any ambiguity exists between this standard and the aforementioned mandatory requirements then:

- a. the highest performance requirements must apply
- b. applicable requirements must follow this order of precedence:
 - i. This standard
 - ii. Australian & New Zealand Standards (AS/NZS)
 - iii. Workplace Health and Safety legislation and other relevant statutory requirements
 - iv. National Construction Code (NCC)

1.2. SCOPE

This standard describes minimum requirements for design, purchase, construction, operation and maintenance of laboratory gas services fittings, plant, equipment and infrastructure for buildings and spaces owned, operated, maintained and/or managed by the Macquarie University. It applies to:

- a. new building construction
- b. refurbishment projects for University-owned spaces
- c. refurbishments of spaces that form part of a broader medium-term (less than five years) programme/plan of progressive upgrades to a University-owned building
- d. refurbishment projects for long-term University-leased
- e. facilities maintenance services

The standard covers provision of laboratory gas services for all University-projects. It covers:

- Reticulated pipework installations
- Gas Supply Monitor Installations
- Gas Leak Detection System Installations
- Automatic Gas Manifold Installations
- High Pressure Point Valve Installations
- Laboratory Air Plant Item Installations
- Laboratory Vacuum Plant Installations
- Nitrogen Generation Plant Installations
- Service and Maintenance
- Testing
- Commissioning
- Witness testing

It does not cover:

- Bottled gas supply and requirements. Refer to the manufactures specifications.
- Any other laboratory item supplied by Macquarie University or others. (i.e. incubators, mass spectrometers etc.)

Where specific applications are not explicitly covered or ambiguity exists, the intent of the design standard must be satisfied. In such cases a return design brief must be provided for review and approval by the issuer of this standard or their appointed delegate who must have relevant technical competence in the subject matter.

The standard applies to planners, project managers, consultants, contractors, sub-contractors, tenants, managing agents, University staff and others involved in the design, construction, installation, operation and maintenance of existing, new and proposed University buildings and facilities.

Laboratory gas products and services provided or specified by designers, consultants, staff and contractors must conform to this standard.

1.3. GLOSSARY OF TERMS

Unless the context otherwise requires, the following definitions apply:

ACA	Australian Communications Authority
ACB	Air circuit breaker
AS/NZS	Australian/ New Zealand Standard
BCA	Building Code of Australia
MU PROPERTY	Macquarie University Property Department
NATA	National Association
NCC	National Construction Code
ADG	Australian Dangerous Goods Code
DB	Distribution Switchboard
O.D.	Outside Diameter
V	Volt
mm	millimetre
m	metre
Ltr	Litre
AFFL	Above fixed floor level
VB	Isolation Valve Box
GPO	General Purpose Outlet

Authorities & Responsibilities

The design standard is owned by MU PROPERTY. It is approved and signed-off by the Director MU PROPERTY.

The MUP Asset Management Unit is responsible for reviewing and maintaining the standard and keeping it up-to-date.

The standard must be reviewed and kept up-to-date at least biennially.

1.4. SPECIFIC SCOPE OF WORKS FOR DESIGN AND CONSTRUCTION

These specific requirements must be included in the scope of works specification for design and construction of laboratory gas services:

Laboratory gas services must be detailed and designed by qualified professional engineers covered by professional indemnity and public liability insurances. Insured Values must be in accordance with the contract.

Maintain reliability and availability of laboratory gas systems of buildings during and after construction. Provide temporary laboratory gas supply systems as required to meet the affected user's requirements, and liaise with the users and project manager to determine these requirements.

Provide warranty for all new equipment and services.

Maintenance requirements during the Defects Liability period.

Compliance with BCA including Section J, Local Authorities" regulations and all relevant Australian and New Zealand Standards (AS/NZS).

Allow for any University work and restriction periods during the construction period.

Provision of laboratory gas maximum flow/ pressure demand calculations in editable spreadsheet format, and to satisfy the Supply Authority and to AS 2896-2011 as a minimum.

Supply of statutory design certifications and certification of compliance to the University standards.

Design drawings in AutoCAD 2D format including plans, schematics and single line diagrams.

Testing and commissioning schedules, certification and programme.

Contractors must visit project sites to determine limitations to installing laboratory gas services and include sufficient allowances in the tender price to cover these issues.

Ensure that spatial and building general construction details are satisfactory and equipment can physically be installed within the building.

Additional work items identified during tender inspections, but which may not be documented in the original scope of works.

Early notification of adverse latent conditions and liaison with the University's Superintendent to resolve the issues and agree additional costs before proceeding with the works.

Decommissioning and demolition of all redundant laboratory gas services and infrastructure in the works area.

Provide a detailed project description including the project drivers, the existing conditions and the final project use

Provide a section listing any major deviations from this standard and summarising the reason

1.5. LABORATORY GAS RETICULATION SCOPE OF WORKS

A project specific scope of works must be prepared by the designer. It must cover all major laboratory systems specifically, and all minor systems generally.

It must detail the design requirements for design and construct projects, including references to the project definition documents.

It must consider and specify any staging and temporary laboratory gas provisions.

The codes listed below are suggested as reference documents, but not limited to:

- Australian standards AS 2896
- Welding and brazing - Filler metals AS/NZS 1167
- Identification of the contents of pipes, conduits and ducts AS 1345
- Flanges for pipes, valves and fittings AS 2129
- The storage and handling of non-flammable cryogenic and refrigerated liquids AS 1894
- Safety and health in workrooms of educational establishments AS 1485
- Safety in Laboratories AS/NZS 2243
- Valves for compressed gas cylinders AS 2473.1

- Valves for compressed gas cylinders - Outlet connections (Threaded) and stem (inlet) threads AS 2473.2
- Safe working in a confined space AS/NZS 2865
- Laboratory design and construction AS2982
- The Storage and handling of gases in cylinders AS 4332
- Wiring Rules AS/NZS 3000
- Pressure vessels AS 1210
- Methods for fire tests on building materials, components and structures - Combustibility test for materials AS1530.1
- Methods for fire tests on building materials, component and structures - simultaneous determination of ignitability, flame propagation, heat release and smoke release AS/NZS 1530.3
- Copper and copper alloys - Seamless tubes for engineering purposes AS1572
- Pipe threads of Whitworth form - Sealing pipe threads AS1722.1
- Flanges for pipes, valves and fittings AS 2129
- Classification of hazardous area's AS2430*
- Pressure piping AS4041
- Building Code of Australia Volume 1 Class 2 to Class 9 Building Section E - Services and Equipment
- Oxygen and Acetylene gas reticulation systems in section 02.02 Standards AS 4289
- Bourdon tube pressure and vacuum gauges AS 1349
- Pressure gauges for regulators used with compressed gas cylinders AS 4706
- The storage and handling of flammable and combustible liquids AS 1940
- The storage and handling of toxic substances AS 4452

1.6. GAS PIPING

Pipes and fittings shall be selected to suit the user requirements of hazardous class, gas type, gas purity and pressure. As a minimum requirement welded copper tube type 'B' Oxygen cleaned shall be used. Compression, and crimp jointed copper or stainless-steel piping systems shall not be used unless specifically reviewed and approved by Macquarie University technical services. All valves, fittings, supports, gauges, manifolds to be supplied by the laboratory gas contractor. Pipework to be compact, neat and occupy minimum space required.

1.7. RETICULATED COPPER TUBING

All copper tubing to be installed on the Macquarie University campus is to be of the medical grade table 'B' oxygen cleaned for medical use type. The installation is to conform to the requirements of the medical gas standard AS 2896-2011. All copper tubing used throughout the installations shall be manufactured and cleaned in accordance with AS 1432 and AS 1571 and shall be suitable for the use with medical grade gases.

Purging with Nitrogen or Carbon Dioxide shall be carried out continuously during welding or any process requiring heat being applied to the tube. Should any contamination be found in the tube after installation that is considered unacceptable, the complete installation or those parts designated by the 'Engineering Consultant' shall be flushed in accordance with AS 2896-2011.

During installation, hacksaws and angle grinders shall **NOT** be used for the cutting of the copper tube. Any tubing found to have been cut using the tools mentioned above, shall be removed from the system for a horizontal distance of 2 metres in either direction from the cut or branch and all pipe below and 1 metre above vertically will be replaced.

Copper tube stored on site and or any opened ends shall be capped at all times to avoid contaminating the inside of the copper tube.

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As some sizes, may be unobtainable in a pre-cleaned condition it may be necessary to have the pipe cleaned prior to delivery to site, all pipe shall be cleaned and capped before delivery.

The removal of redundant existing gas tubing will need to be completed in a safe manor and making sure there is no distribution to the existing or new gas supplies.

Copper tube stored on site and or any opened ends shall be capped at all times to avoid contaminating the inside of the copper tube.

As some sizes, may be unobtainable in a pre-cleaned condition it may be necessary to have the pipe cleaned prior to delivery to site, all pipe shall be cleaned and capped before delivery.

Copper tube bracketing shall be in accordance with AS 2896-2011 as follows for maximum distances between:

Tube Diameter	Horizontal (metres)	Vertical (metres)
6mm	0.7	0.7
15mm	1.5	1.8
20mm	1.5	2.0
25mm	2.0	2.5
32mm	2.5	2.5
40mm	2.5	3.0
50mm	3.0	3.0
65mm	3.0	3.5
80mm	3.0	3.5
100mm	3.0	4.0
150mm	3.0	4.0
200mm	3.0	4.0
250mm	3.0	4.0

Table 1- Pipe Bracketing Spacing Requirements

1.8. RETICULATED STAINLESS STEEL TUBING

All stainless-steel tubing to be installed on the Macquarie University campus is to be of the medical grade oxygen cleaned for medical use type. The installation is to conform to the requirements of the medical gas standard AS 2896- 2011. All stainless-steel tubing used throughout the installations shall be manufactured and cleaned in accordance with AS 1432 and AS 1571 and shall be suitable for the use with medical grade gases. This is obviously dependent on the type of installation and requirement per project. E.g. an Ultra high purity (99.999) system will require stainless steel tubing to be double bagged at all times during the delivery and installation on site. House purity (99.5) system would require tubing to be capped at all times.

Purging with Argon shall be carried out continuously during orbital welding. Should any contamination be found in the tube after installation that is considered unacceptable, the complete installation or those parts designated by the 'Engineering Consultant' shall be removed from site and replaced with a new item.

During installation, hacksaws and angle grinders shall **NOT** be used for the cutting of the copper tube. Any tubing found to have been cut using the tools mentioned above, shall be removed from the system entirely and replaced with a new tubing.

Stainless steel tube stored on site and or any opened ends shall be capped at all times to avoid contaminating the inside of the copper tube.

As some sizes, may be unobtainable in a pre-cleaned condition it may be necessary to have the pipe cleaned prior to delivery to site, all pipe shall be cleaned and capped before delivery.

Stainless steel tube bracketing shall be in accordance with AS 2896-2011 as follows for maximum distances between:

Tube Diameter	Horizontal (metres)	Vertical (metres)
6mm	0.7	0.7
15mm	1.5	1.8
20mm	1.5	2.0
25mm	2.0	2.5
32mm	2.5	2.5
40mm	2.5	3.0
50mm	3.0	3.0
65mm	3.0	3.5
80mm	3.0	3.5
100mm	3.0	4.0
150mm	3.0	4.0
200mm	3.0	4.0
250mm	3.0	4.0

Table 1- Pipe Bracketing Spacing Requirements

1.9. RETICULATED TUBE LABELLING

All reticulated tubing to be labelled according to the service it is distributing. Labelling to be clearly visible. Colour coding as per the Australian standard colour coding for gas cylinders. This colour would be the background while the name of the gas will be in white lettering.

Tube to be labelled at intervals not exceeding 3 metres in length and clearly indicate the direction of flow.

1.10. RETICULATED TUBE PAINTING

All reticulated tubing to be painted upon the service it is distributing. Colour coding as per the Australian standard colour coding for gas cylinders. This is only required for new installations and not connecting into existing services of refurbished laboratories.

This will be assessed on a project by project basis. This must be approved by the Project Manager with consultation from the relevant Faculty and Technical Services Property Team.

1.11. RETICULATED TUBE BRACKETING

All bracketing of the reticulated gas lines must be a minimum of 50mm away from any other existing or newly installed service. barrier strips and powder coated tube clips must be used to avoid any dissimilar metal getting in contact.

1.12. ISOLATION BALL VALVE

Isolation ball valves used throughout the Macquarie University campus shall be cleaned and ungreased for medical use, full bore type.

The intended installation location must be in a place that is easily accessible and be able to operate without any obstruction. Unions to be installed so the isolation ball valve can be removed easily for replacement or servicing without cutting the laboratory gas mainline.

The isolation ball valves must be kept double bagged and kept capped until such time that they are installed. If they are installed at the end of a distribution main line, then the valves must be plugged for future use.

1.13. CHECK VALVES

Check valves used throughout the Macquarie University campus shall be cleaned and ungreased for medical use and spring check type.

The intended installation location must be in a place that is easily accessible and be able to operate without any obstruction. Unions to be installed so the isolation ball valve can be removed easily for replacement or servicing without cutting the laboratory gas mainline.

The check valves must be kept double bagged and kept capped until such time that they are installed.

1.14. GAS SUPPLY MONITOR

Gas Supply Monitors must be installed for each gas system (unless otherwise specifically advised by MU Property Technical Services). The gas supply monitors must be installed in a location confirmed by Macquarie University. They must be installed in an area that will be occupied regularly. The gas supply monitor will need to have a BMS output for connection to the Macquarie University BMS system. The gas supply monitor must be installed 1500mm A.F.F.L. and in clear view of person(s) working in the area. The gas supply monitor will be the ASCON type alarm panel. The normal message on the screen when there are no alarms will state 'ALL GAS SUPPLIES NORMAL'.

Alarm volumes and alarm messaging types to be confirmed by Macquarie University.

All installations and wiring connections must be by a licensed electrician.

1.15. GAS LEAK DETECTION SYSTEM

The gas leak detection system must be reviewed by Macquarie University prior to installation on site.

The system is to be set up in a way that is fail safe. If there is a dangerous level of Inert gas in a laboratory, the oxygen depletion sensor in this laboratory will send a signal to the control panel thus setting off the flashing light/audible alarms and at the same time sending a signal to close the solenoid valve dedicated to the inert gas supply to this Laboratory only. The gas leak detection system will need to have a BMS output for connection to the Macquarie University BMS system.

Where there are bottle gases used in the laboratory, special care will need to be taken into account as the alarm will not stop until the contents of the gas bottle are empty and the oxygen is at a safe level before you may enter the laboratory.

Upon low levels of oxygen, the flashing light and audible alarm are activated, and the solenoid valve cuts gas supply to that laboratory only (where gases have been reticulated).

The following typical installation heights for the gas leak detection system items to be as per below:

Gas sensors

Hydrogen sensor 200mm below ceiling or floor slab (if no ceiling).

Oxygen depletion sensor 1500mm to 1600mm A.F.F.L.

Carbon Dioxide, Carbon Monoxide, Oxygen depletion for liquid nitrogen rooms 300mm A.F.F.L.

Nitric Oxide sensor 1600mm to 1800mm A.F.F.L.

Flashing light and Audible Alarms

Either side above the entry door(s) and within the space being monitored to the laboratory or zone. Macquarie University to approve type. (360-degree beacon or wall mounted 180-degree types). A flashing light and audible alarm must be fitted to every gas leak detection system installed. The flashing light must be RED in colour.

Control panel

1500mm to 1600mm A.F.F.L. outside upon entry to the monitored laboratory or zone. Location to be approved by Macquarie University. Must have a BMS output for connection to the Macquarie University BMS system.

Signage

Signage and warning signs must be installed in the appropriate place per system. Signage inside the monitored laboratory is to read 'DANGER GAS LEAK DETECTED VACATE IMMEDIATELY'. Signage outside of the monitored laboratory to read 'DANGER GAS LEAK DETECTED DO NOT ENTER'.

1.16. AUTOMATIC CHANGE OVER MANIFOLD

Installation of the automatic manifolds must be installed 1500mm A.F.F.L. In a location, clear of any obstruction to allow easy access of replacement of bottles and must also indicate which laboratory(s) it supplies. Flash back arrestors to be installed on all flammable, Oxidising and explosive gas manifolds. Manufacturer to be approved by Macquarie University.

The manifold must be clearly labelled which laboratory gas service it is supplying. Pressures and gas purity must be confirmed by Macquarie University prior to installation. Make an allowance for connection to gas supply monitor. Appropriate gas bottle signage to be placed upon entry to the manifold store in a visible position.

1.17. HIGH PRESSURE POINT VALVE

Installation of the high-pressure point valve must be installed 1500mm A.F.F.L. In a location, clear of any obstruction to allow easy access of replacement of bottles.

The high-pressure point valve must be clearly labelled which laboratory gas service it is supplying and must also indicate which laboratory(s) it supplies. Pressures and gas purity must be confirmed by Macquarie University prior to installation. Make an allowance for connection to gas supply monitor. Flash back arrestors to be installed on all flammable, Oxidising and explosive gas manifolds. Manufacturer to be approved by Macquarie University

Appropriate gas bottle signage to be placed upon entry to the manifold store in a visible position.

1.18. GAS BOTTLE RESTRAINTS

Installation of the gas bottle restraints are to be the rail and strap type. 'G' size cylinder to have two restraints per cylinder. One at 1000mm A.F.F.L. and the other at 300mm A.F.F.L. All restraints to be fixed securely and with enough room to unstrap the gas bottles without obstruction to gas bottles or other bottle restraints. Confirmation of bottle sizes to be checked with Macquarie University prior to installation. (smaller size gas bottles will have a different size diameters).

1.19. SOLENOID VALVES

Solenoid valves will be the 24volt DC normally closed type. The intended installation location must be in a place that is easily assessable and be able to operate without any obstruction. Unions to be installed so the isolation ball valve can be removed easily for replacement or servicing without cutting the laboratory gas mainline.

Each solenoid valve will need to be selected for the correct intending gas service and application.

1.20. WALL MOUNTED PRESSURE REDUCING REGULATORS AT POINT OF USE

Wall mounted pressure reducing regulator valves to be the dual stage scientific type. Regulators to have isolation ball valve upstream to allow for gas shut off and removal of regulators if need be. Regulators to be mounted 1350mm A.F.F.L. this will need to be co-ordinated with the existing or new fixtures in the laboratory and also installed in a way that minimises the risk of pressurised gas being directed at the user. Regulators shall be installed for the appropriate intended gas use and also for the correct rated pressure.

Both the upstream and downstream pressure gauges will need to be supplied depending on the pressure of each application.

Each pressure reducing regulating valve will need to be selected for the correct intending gas service and application.

1.21. COMPRESSED AIR PLANT SYSTEM

Compressed air plant system will need to be sized, filtered, dry and installed for the correct intending use. All floor mounted plant items will need to be fixed to a 100mm high concrete plinth, with rubber mats placed between concrete plinth and plant item feet. Each plant item will need to be located in such a way that any item could be replaced without obstruction from another plant item and also keep in mind special requirements for the servicing of the compressed air plant.

Compressed air plant system must be installed in a clean environment.

All plant items must be fitted with stainless steel flexible hosing and or unions to allow removal if needed with cutting laboratory mainlines.

All air receivers will need to be DYNA bolted to the plantroom floor to avoid tipping. All plant alarms to be available for connection to the Macquarie University BMS system.

All condensate drains must be drained to a dedicated tundish or floor waste within the plantroom. If oil injected compressor is installed an oil/ water separator must be installed to **NOT** allow oil to go down floor waste.

Care must be taken in relation to the noise the air compressor plant may produce. Noise levels will need to be approved by Macquarie University prior to installation on site.

The proposed compressor must be approved by MQ Property prior to purchase and installation

1.22. VACUUM PLANT SYSTEM

Vacuum plant system will need to be sized and installed for the correct intending use. All floor mounted plant items will need to be fixed to a 100mm high concrete plinth, with rubber mats placed between concrete plinth and plant item feet. Each plant item will need to be located in such a way that any item could be replaced without obstruction from another plant item and also keep in mind special requirements for the servicing of the vacuum plant items.

All plant items must be fitted with stainless steel flexible hosing and or unions to allow removal if needed without cutting laboratory mainlines.

Exhaust pipes from the vacuum pumps will need to be vented to atmosphere complete with goose neck to stop rain entering and mesh welded onto the end to deter any vermin.

All vacuum receivers will need to be DYNA bolted to the plantroom floor to avoid tipping. All plant alarms to be available for connection to the Macquarie University BMS system.

Care must be taken in relation to the noise the vacuum pumps may produce. Noise levels will need to be approved by Macquarie University prior to installation on site.

The proposed vacuum plant system must be approved by MQ Property prior to purchase and installation

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1.23. NITROGEN GENERATOR PLANT SYSTEM

Nitrogen generator plant system will need to be sized and installed for the correct intending use e.g. purity etc. All floor mounted plant items will need to be fixed to a 100mm high concrete plinth, with rubber mats placed between concrete plinth and plant item feet. Each plant item will need to be located in such a way that any item could be replaced without obstruction from another plant item and also keep in mind special requirements for the servicing of the nitrogen generator plant.

Nitrogen generator plant system must be installed in a clean environment.

All generator items must be fitted with stainless steel flexible hosing and or unions to allow removal if needed without cutting laboratory mainlines.

All air receivers will need to be DYNA bolted to the plantroom floor to avoid tipping . All plant alarms to be available for connection to the Macquarie University BMS system.

All condensate drains must be drained to a dedicated tundish or floor waste within the plantroom. If oil injected compressor is installed an oil/ water separator must be installed to **NOT** allow oil to go down floor waste.

Care must be taken in relation to the noise the Nitrogen generator plant may produce. Noise levels will need to be approved by Macquarie University prior to installation onsite.

The Nitrogen Generator System must be interfaced with the building BMS system including graphics and alarm monitoring as agreed with MQ Property

The main contractor is to provide a list of all consumables for the proposed system including filters and recommended spares

1.24. SERVICE AND MAINTENANCE

The service and maintenance of laboratory gas system shall be of the following periods:

All plant equipment- twice a year minor and major servicing.

Gas manifold (Automatic, manual and High-pressure point valve)- Once a year.

Gas leak detection system - twice a year minor and major servicing.

Special requirements and permits to be organised with Macquarie University before proceeding with a service especially if a shutdown is required. A report must be submitted to Macquarie University upon completion of every service.

1.25. TESTING

The laboratory gas system shall be tested as per the AS2896-2011 and the Macquarie University laboratory gas standard. The gas system shall be sealed with all items of plant equipment liable to damage (e.g. gauges) at test pressure removed from the system. All defects disclosed during the testing shall be rectified immediately. A new test is to be undertaken upon completion of any rectification works and must be witnessed by a Macquarie university technical services representative.

1.26. COMMISSIONING AND WITNESS TESTING

The laboratory gas system shall be commissioned and tested as per the AS2896-2011 and the Macquarie University laboratory gases standard. Once the system is ready for witness testing the laboratory gas contractor must give Macquarie University enough notice to witness test the newly installed system. Documentation will need to be provided by the laboratory gas contractor to enable the checking of every laboratory item to be signed off. This will include flows, pressures, cross connection checks and alarms. Once completed a copy of this documentation will need to be submitted to Macquarie University and also included in the operation and maintenance manual.

1.27. WORKSHOP AND AS-BUILT DRAWINGS

The following drawings must be submitted for approval before commencing installation work for relevant laboratory gas services:

- Laboratory gases cover sheet
- Floor plan showing the as installed laboratory pipe routes, laboratory gas plantroom room equipment details and schematics
- Gas supply monitor details (including messages and wiring schematic details)

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- Gas leak detection system details (including flashing light/ audible alarm locations and wiring schematic details)
- Liquid plant supply system details and schematic details
- Isolation valve box details drawing and schedule
- Site excavation plan, including survey of obstructions and existing services
- In-ground valve pit and trench locations
- Valve pit and trench construction details and sections
- Switchboard Workshop drawings and schematics
- Switchboard cupboard layouts including risers

Update existing site services drawings

As-built drawings must reflect the complete laboratory gas installation and show dimensions, types and location of equipment, pipe supports, pipework, and principal items of plant and equipment. Show "as-installed" locations of building elements, plant and equipment in relation to permanent site features and other underground services. As-built drawings must show changes made during commissioning and the maintenance period.

As-Built drawings must be provided in full size and CD ROM with latest AutoCAD drawing files including a copy in pdf.

1.28. DEFECTS LIABILITY PERIOD MAINTENANCE

The following activities must be carried out during the Defects Liability Maintenance Period:

- Periodic inspections and maintenance procedures at frequencies according to the Manufacturer's requirements and Australian Standards AS 2896.
- Leak testing of point of use outlets, plant and reticulation systems.
- Alarm panel testing and calibration
- Gas leak detection system testing and calibration
- Fault rectification and replacement of faulty materials, equipment and accessories with new.
- Replace filters quarterly during the DLP and at the end of DLP
- Prompt emergency response when required.
- At the end of the Maintenance Period, contractors must make a final service visit to certify the installation is operating correctly.

1.29. OPERATION AND MAINTENANCE MANUALS

Provide electronic online operation and maintenance (O&M) manuals and two hardcover loose leaf copies. Documents and information that must be provided are described below.

1.29.1. OPERATOR'S MANUAL

All O&M manuals must be received and approved for final re-issue prior to Practical Completion. Authors and compilers of the manual must be experienced in the maintenance and operation of the installed equipment and systems.

The operator's manual must include:

- General description.
- Detailed description.
- Suppliers listing.

Laboratory Gas Services Design Standards

- Equipment brochures.
- Equipment maintenance.
- Test reports.
- As Installed Drawings.

1.29.2. GENERAL DESCRIPTION

General descriptions must include:

- An introduction on who is involved with the project. i.e. what department/ building, who is the managing builder and who is the Macquarie University representative for the project etc.

1.29.3. DETAILED DESCRIPTION

Detailed descriptions must include:

- A detailed description of the entire installation per gas supply and system. i.e. where the gas supplies come from, the locations of all laboratory gas item installed and any isolation valves that are installed for future expansion and the use and operation of alarms, control panels. etc.

1.29.4. SUPPLIERS LISTING

Suppliers listing must include:

- All contact details of the manufactured items supplied on the project.

1.29.5. EQUIPMENT BROCHURES

Equipment brochures must include:

- All information of the laboratory gas items installed on the project highlighting the exact model and part number of the installed item.

1.29.6. EQUIPMENT MAINTENANCE

Equipment maintenance must include:

- Details of the periodic service and maintenance of all laboratory gas items included any spare parts needed, installed on the project.

1.29.7. TEST REPORTS

Test reports must include:

- All commissioning, witness testing, training registers and installed and plant items certification of all laboratory gas items installed on the project.

1.29.8. AS INSTALLED DRAWINGS

As Installed drawings, must include:

- All shop drawings to be amended to show per the as installed systems on site. These are to be in full scale in DWG and PDF format.

1.30. APPROVAL OF MATERIALS AND COMPONENTS SAMPLES

Designers must request samples of all accessories, fittings and apparatus proposed for use in the works must be submitted for approval. Only those items that are accepted may be installed on site. Submit the manufacturer's product data for proprietary equipment, including:

- Technical specifications and drawings.
- Type test reports.
- Performance and rating tables.
- Recommendations for installation and maintenance.
- Schedule of proposed major products that are not specified as proprietary items.
- Product certification.

1.31. FIRE RATED SEALING OF PENETRATIONS

The copper tube that is penetrating the fire wall will need to be sleeved with a copper tube 2 times the size (15mm gas service to be sleeved with a 25mm copper tube). The sleeve must protrude each side of the fire wall. A suitable fire rated mastic must be applied between the sleeve and the gas service. Fire mastic must be applied between the sleeve and the fire wall to seal the penetration. Must comply with BCA requirements.

1.32. UNDERGROUND SERVICES

1.32.1. TRENCHING

Underground gas main lines to be a minimum of 600mm underground pipework will need to be sleeved in a PVC conduit and surrounded in sand around the PVC sleeve. Warning tape needs to be laid on top of backfilled sand to warn potential excavating in the future. Tube main lines will need to be pressure tested and signed off prior to back filling the trench.

1.32.2. TRENCHING & BACKFILLING

Trenching and backfilling operations must consider:

- **SITE SERVICES PLAN:** Obtain the University site services plan for the area concerned.
UNIVERSITY STANDARD: Comply with the University standard specification for underground trench excavation and backfilling.

DETAILED HAND EXCAVATION: Allow for detailed hand excavation where the University Site services plan indicates significant or dangerous existing in ground conditions, or carry out a specialist site survey where the survey plan is not available or clear. Allow for detailed hand excavation through all three zones to minimise damage to the tree roots in the drip zones.