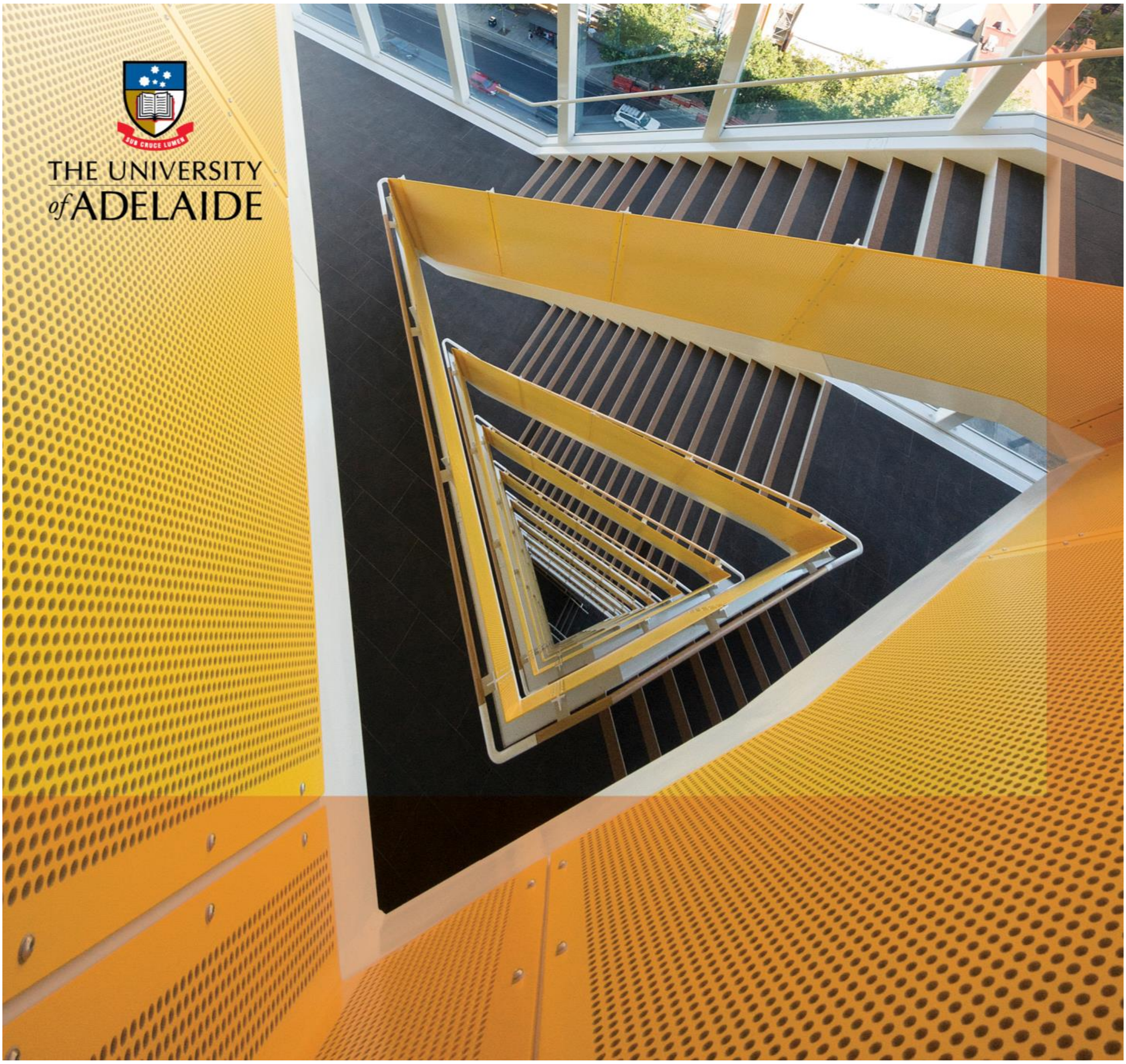


DESIGN STANDARD

C. Mechanical Services

Contents

Revision log

Current issue

C. Mechanical Services - UoA Design Standards. FINAL August 2018.

Previous issues

Version	Authors	Description	Revision	Date
1.0	Vicki Jacobs, Capital Projects Delivery, UoA	C. Mechanical Services – UoA Design Standards.	DRAFT Version 1	December 2017
2.0	Bruce Lawson, Service Delivery, UoA	C. Mechanical Services – UoA Design Standards.	DRAFT Version 2	December 2017
3.0	GHD	C. Mechanical Services – UoA Design Standards.	DRAFT Version 3	March 2018
4.0	Vicki Jacobs, Capital Projects Delivery, UoA/ GHD	C. Mechanical Services – UoA Design Standards.	FINAL Version 4	August 2018

List of revised items

Version	Authors	Revised items	Date

Revision management

It is envisaged that revisions to this document will be undertaken at intervals of not more than two (2) years.

Endorsement body

Director of Infrastructure

Owner

Associate Director, Capital Projects Delivery

Contact person

Associate Director, Capital Project Delivery

Authors and acknowledgements

The Standards have been developed by Capital Projects with the assistance of University of Adelaide staff, external consultants, contractors, and colleagues from other education institutions.

The University conveys its thanks to all parties who have participated in the development, assessment, and review of these Standards.

Abbreviations

AS/NZS	Australia or Australian/New Zealand Standards
BCA	Building Code of Australia
CPD	University of Adelaide- Capital Projects Delivery
DDA	Disability Discrimination Act
NCC	National Construction Code
OSH	Occupational Safety and Health
SEPP	State Environmental Planning Legislation
SiD	Safety in Design
UoA	University of Adelaide
WHS	Work, Health and Safety

1. Introduction

This section outlines the purpose, structure, related documents, and definitions for the University of Adelaide (UoA) Design Standards.

1.1 Purpose of the document

The UoA Design Standards (the Standards) respond to the strategic vision for the University, outlined in Beacon of Enlightenment 2016-2035, and the guiding planning principles contained in the UoA Masterplan 2016-2035. Prepared in recognition of the University's unique historical context, the Standards are guided by the aims of supporting physical, social and cultural connectivity, embracing diversity, equity and accessibility, and promoting sustainability and academic excellence.

The Standards specify the minimum, mandatory requirements for the design, construction and management of all University of Adelaide infrastructure projects. Requirements are specific to the University's needs, and are over and above minimum mandatory Authority requirements. They include:

- Methodological requirements for project delivery; and
- Technical requirements for the finished product.

The objective is to support the consistent delivery of a high quality product, while allowing sufficient scope for innovation, creativity and technological advancements.

The Standards must be used by any parties involved in the planning, design, construction, occupation management, maintenance and operation of UoA facilities. This includes external consultants and contractors, UoA planners, designers and project managers as well as professional and faculty staff, facility managers, maintenance contractors and other service providers – all of whom must be aware of the Standards as they apply to their project and scope of work.

1.2 Structure of UoA Design Standards

C. Mechanical. Services Design Standard (this document) is a part of the UoA Design Standards suite of documents (the Standards).

The Standards are divided into the following volumes for ease of use:

- A. Project Process Checklist (this document)
- B. Building and Architecture
- C. Mechanical Services
- D. Electrical Services
- E. Communication Services
- F. Hydraulic Services
- G. Fire Services
- H. Security Services
- I. Vertical Transport
- J. External Works
- K. Documentation

- L. Metering and Monitoring
- M. Audio Visual
- N. Signage and Wayfinding

The Standards must be considered in their entirety, regardless of the project's size, specific disciplines or responsibilities.

In particular, UoA staff and consultants using this volume must ensure familiarity with the mandatory project procurement obligations, detailed in A. Project Process Checklist.

Each volume within the Standards is structured into four parts:

- Part 1 – Introduction
- Part 2 – General requirements
- Part 3 – Technical requirements
- Part 4 – Schedules (as required)

1.3 Related documents and legislation

1.3.1 Documents

During the earliest strategic feasibility and planning stages of the project, review and analysis of the latest edition of the following UoA strategic planning documents must be carried out and outcomes of that review reflected in the Project Brief (refer to clause 1.4 – Definitions of this volume).

These documents should also be read in conjunction with the UoA Design Standards.

- UoA Masterplan 2016-2035
- UoA Strategic Plan - Beacon of Enlightenment, 2013-2035
- Disability Action Plan 2013-2019
- Campus/ Building-specific Disability Action Plans
- Dormwell Framework
- UoA Reconciliation Statements
- Campus/ Precinct/ Building-specific Masterplans (e.g. Waite Masterplan, Union House Masterplan)
- Campus/ Building-specific Conservation Management Plans
- Faculty Masterplans
- Technical discipline/ space-specific Masterplans, including:
  - ITS Strategy Masterplan
  - Mechanical Services Masterplan
  - SAMP
  - Teaching Spaces Masterplan
  - Labs Standards and Masterplan
  - Library of the Future Masterplan
  - Space Standards Guidelines
  - Deferred Maintenance Schedule
  - Bushfire Prevention Plans
  - Campus Water Management Plan
- Campus Sustainability Plan 2017 and associated documents, including:
  - The Carbon Neutral Adelaide Action Plan 2016-2021
  - Innovation Hub/ Smart Cities
  - Building Performance Rating System

1.3.2 Relevant legislation

The planning, design and construction of each UoA facility must fully comply with current legislation. Legislation includes but is not limited to:

- Australia or Australian/ New Zealand Standards (AS/NZS)
- National Construction Code (NCC)
- Building Code of Australia (BCA)
- Occupational Safety and Health (OSH) legislation
- Disability Discrimination Act (DDA)
- Accessibility Aspiration Design Factors
- State Environmental Planning Legislation (SEPP)
- Commonwealth and State Legislation
- Local Council and Authority requirements
- Relevant Heritage Acts (for both Places and Natural Resources)

1.4 Definitions

For the purpose of this document, the following definitions apply:

Must	Indicates that a statement is mandatory
Should/ shall	Indicates a recommendation
May/ can	Indicates the existence of an option
The Standard/s	The University of Adelaide Design Standards
Project Manager	University of Adelaide staff member responsible for delivering the building project
Strategic Project Brief	The strategic project brief developed by the University, during the project feasibility phase. Used to develop the consultants scope of works. Refer to clause 2.1 of this document for further discussion.
Return Brief/ Project Brief	The detailed brief prepared by the consultant/ design team at the end of the detailed briefing phase, and signed off by the Project Stakeholder/s, prior to commencement of Concept Design, against which mandatory milestone certification checkpoints are measured. Refer to clause 2.1 of this document for further discussion.

2. General requirements

This section outlines:

- General administrative requirements related to the use of the B. Building and Architecture, and the process for project delivery for all projects, including: project specific documentation; discrepancies; departures; certification of compliance; project procurement process; value management; safety in design; WHS; environmental management; independent building commissioning; manufacturer's specifications; and professional services requirements; and
- General design requirements related to the B. Building and Architecture, including the University policy on sustainable design as well as durability, economy and flexibility.

2.1 Project specific information

Project-specific information will be contained in project- specific documentation, such as Project Brief. The Standards will supplement any project-specific documentation. Refer below clause 2.2- Discrepancies for clarification of precedence, should a discrepancy between Project Specific Documentation and The Standard arise.

Extracts from the Standards may be incorporated in contract documentation specifications. However, the consultant and the contractor must fully investigate the needs of the University and produce designs and documents that are entirely fit for purpose, which meet the intent of the Project Brief.

2.1.1 The project brief

In accordance with A. Project Process Checklist and clause 2.4 Certification of Compliance, the Project Brief must be developed and signed-off in the following manner, and utilised as a measure, against which periodic certification must be carried out.

- The Pre-feasibility Statement and preliminary project brief contained therein, communicates proposed project objectives and scope, preliminary budget and any project- specific strategic targets (if known).

- The Strategic Project Brief is typically developed by the University during the feasibility phase of the project. This brief reflects outcomes of the strategic project investigations. The Strategic Project Brief must be interrogated and verified by the Project Delivery Unit, Project Manager and key strategic stakeholders, prior to proceeding to the next Detailed Briefing Phase of the project delivery process. It is from this verified Strategic Brief, that the consultants brief will be developed.

The Strategic Project Brief must:

a. identify project- specific sustainability targets, over and above the Standards, and associated reporting obligations;

b. identify proposed project budget and funding source. This must include:

— Capital Budget (separated into construction and university costs), and

— Operating Budget (reflecting project- specific sustainability targets);

c. identify other strategic targets associated with the project;

d. identify list of known Stakeholders with a preliminary engagement plan developed. This includes identification of key stakeholders with whom sign-off approvals obligations will sit. Refer below Clause 2.4 Certification of Compliance with the Standard;

e. identify general spatial and operational requirements of the end users;

f. identify decanting and relocations proposals associated with works;

g. identify a list of further investigations that are required (e.g. Heritage, DDA etc.);

h. identify an indicative project program for the delivery of works;

i. identify strategic risks associated with the project (Refer Clause 2.7 Risk Register);

j. communicate any safety in design risks identified to date (Refer Clause 2.8 Safety in Design);

- The Return Brief (also referred to as Project Brief) is typically prepared by the Consultant at the end of the detailed briefing phase, during which intensive stakeholder consultation has occurred. The Project Brief must be signed-off by key stakeholders prior to proceeding to the next Concept Design Phase of the project delivery process. It is against the signed- off Return Brief (also typically referred to as Project Brief), that the mandatory, milestone, compliance certifications will be measured. (Refer to clause 2.4 Certification of compliance, in this document). For very simple projects, compliance may be measured against the Strategic Project Brief, or equivalent, provided it meets all mandatory due diligence obligations, related to the development of a brief, listed in A – Project Process Checklist.

The Return Brief must:

- Meet the obligations of the Strategic Project Brief (including, but not limited to budget and sustainability targets);
- identify detailed operational and spatial requirements of the end users;
- include room data sheets for complex projects (refer to A. Project Process Checklist for clarification).

2.2 Discrepancies

The Standards outline the University's general requirements above and beyond mandatory authority requirements and legislation.

Where the Standards outline a standard higher than the relevant legislation, the Standards will take precedence.

If any discrepancies are found between any relevant legislation, the Standards, or project-specific documentation, these discrepancies must be highlighted in writing to the Associate Director, Capital Projects Delivery.

2.3 Departures

The intent of the Standards is to achieve consistency in the quality of the design and construction of the University's built forms.

In addition, University staff, consultants and contractors are expected to apply industry best-practice and strive for improvement and innovation in design and construction techniques wherever possible. In recognition of this expectation, application to depart from the Standards, must be made in writing to the Associate Director, Capital Projects Delivery via the UoA Project Manager, using the Alternative Design Solution Application Form. The application must include:

- Reference to the Standard clause under consideration
- Details of the departure and alternative proposal
- Impact of that departure on:
  - Compliance with the Project/ Return Brief
  - Project capital budget
  - Operating budget

Where a departure from the Standards is sought, dual-approval to proceed must be issued in writing by both the Associate Director, Capital Projects Delivery and the Director of Infrastructure. Until this approval is granted, the consultant is not authorised to proceed to the next project phase. Any departures made without written confirmation must be rectified at no cost to UoA.

At the completion of the project, all authorised Alternative Design Solution Application Forms must be submitted to the Associate Director, Capital Projects Delivery by the UoA Project Manager. Alternative Design solutions shall be monitored over time for success and may be considered for inclusion in subsequent versions of the Standards.

2.4 Certification of compliance

At regular intervals the consultant team must certify in writing that both the Standards, and the Project Brief, have been met.

This can be done using the templates provided in A- Project Process Checklist, or an equivalent, approved reporting tool.

Discrepancies and departures must be declared, with justification, at this time, in accordance with clauses 2.2 Discrepancies and 2.3 Departures of this document.

Approval must be granted prior to proceeding to the next project phase in accordance with the process outlined in A- Project Process Checklist.

It should be noted that The Standards, as they relate to this clause, refer to all Volumes of the Standard, including A- Project Process Checklist.

2.4.1 Frequency of certification

Frequency of certification is based on the size and complexity of the project. Refer to A. Project Process Checklist for frequency of certification requirements based on the complexity of the project.

For new all new building projects, (multi-disciplinary) projects, or projects with a value greater than $500,000, Certification must occur at the end of each of the following project phases:

- Concept Design Phase
- Design Development Phase
- 50% Complete Contract Documentation Phase
- 100% Complete Contract Documentation Phase
- Project Hand-Over Phase

For very small or simple (single discipline) projects, Building Standard Certification must occur at the following times:

- At an agreed point, prior to the end of the 50% Complete Documentation Phase
- At an agreed point prior to the end of the 100% Complete Contract Documentation Phase

2.4.2 Additional certification requirements

In addition to the above mandatory certification check-points, certification of compliance with the Design Standards and The Project Brief, must also occur as part of any Value Management Session, in accordance with clause 2.6. Value management of this document.

2.5 Project procurement process

All project team members must follow the project process outlined in A. Project Process Checklist. The checklist is a planning and tracking tool to be used by the project manager, consultants and contractors, to ensure adherence to the approved UoA process for project delivery and to ensure the Standards are achieved as a minimum on all projects.

A. Project Process Checklist Design Standard caters for different project complexity types. For clarification of the project complexity type, refer to Manager, Capital Projects Delivery.

A. Project Process Checklist Design Standard does not alleviate any responsibility to ensure familiarity and compliance with all aspects of the Design Standards. The checklist (or an approved, project specific version) must be maintained as an active document throughout the project, and must be submitted to the Manager, Capital Projects Delivery, via the UoA Project Manager at project completion.

A. Project Process Checklist Design Standard is divided into project delivery phases. While the order of actions listed can be varied to suit a project, all actions listed must be completed, and certified as complete, prior to proceeding to the next phase. Project-specific variations of the checklist involving alteration to the number of mandatory milestone certification checkpoints, or elimination of any action, must be treated as a departure from the Standards and submitted for approval to the Associate Director, Capital Project Delivery at the commencement of the project start-up phase.

Project managers, consultants and contractors must ensure that adequate time and resources are allocated to meet the requirements of A. Project Process Checklist Design Standard and, in particular:

- Mandatory milestone certification checkpoints and associated approvals processes (refer to clause 2.4 Certification of compliance)
- Engagement and consultation obligations with stakeholders

- DDA, Safety in Design, and Risk Management workshops
- UoA peer reviews
- Two-step value management process, refer to 2.6 Value- management

2.6 Value management

A mandatory two-step value management (VM) session must be carried out when the project has reached the 50% Complete Contract Documentation Phase (or at a time deemed appropriate by the UoA Project Manager). Additional value management sessions may be required and must follow the same process. Consultants and Project Managers must make appropriate allowance for resources and time to meet the requirements of this clause.

Any value management sessions must take the following two-step process:

1. Value management (VM) session; followed by
2. Written certification (in accordance with disclosure and approvals obligations set out in clause 2.4 Certification of compliance in this volume), that the proposed value managed solution:

- Meets the requirements of the Design Standard
- Meets the requirements of the Brief. This includes (but is not limited to) confirmation of the following:
  - Estimated order of cost for capital and operating budget; and
  - Project-specific sustainability objectives

2.7 Risk Register

The Risk Register records details of all the risks identified at the beginning and during the life of the project, their grading in terms of likelihood of occurring and seriousness of impact on the project, initial plans for mitigating each high-level risk, the costs and responsibilities of the prescribed mitigation strategies and subsequent results.

This Risk Register must be maintained for all projects, throughout the life of the project. Initial risk assessment must form part of the Project Feasibility Phase for the project. If strategic risks are identified, they must be recorded and managed separately to those that are related to worksplace health and safety. The preliminary register (or list of issues) must be communicated in the Strategic Project Brief.

The register must continue to be developed and maintained by the UoA Project Manager for all projects. Later the register will be maintained by the Managing Contractor, Service Delivery maintenance staff, and potentially end-users. The register will be updated regularly as existing risks are re-graded in the light of the effectiveness of the mitigation strategy, and new risks are identified. For larger projects a Risk Management Plan may be required also. In smaller projects, the Risk Register can be used as the Risk Management Plan.

Refer to clause 2.8 for further discussion about Safety in Design and the mandatory Safety in Design Risk Assessment Workshop.

Refer to A. Project Process Checklist for the Project Risk Register Template.

Refer to clause 2.8 Safety in Design/ workplace health and safety for discussion on cultural safety.

2.8 Safety in Design/ workplace health and safety

Safety in Design (SiD) aims to prevent injuries and disease by considering hazards as early as possible in the planning and design process. A safe design approach considers the safety of those who construct, operate, clean repair and demolish an asset (the building, structure, plant or equipment) as well as those who work in or with it. Designers are in a unique position to reduce the risks that arise during the life cycle of the asset during the design phase.

In accordance with Safety in Design/ WHS Legislation, at each phase of the design process, risk identification must take place with the view to eliminating the risk, or where this is not possible, reducing risk as low as reasonably practicable, through the implementation of control measures. Safety in Design Risk Assessments must be carried out throughout the job and reported on at regular team meetings, keeping the status of control measures and the residual risks at a current level. Refer to clause 2.7 Risk Register for further information about reporting obligations.

For all new building projects, complex refurbishment projects, or high-risk projects a mandatory Safety in Design Risk Assessment Workshop must be carried out no later than the 50% Documentation Phase. This should be led by a member of the consultant team and in addition to the contractor, the consultant team and relevant other parties such as fabricators/ operators specific to the project, the workshop must be attended by a UoA WHS Representative and the UoA End-User Representative.

The assessment should involve hazard identification, assessment of risk of harm for each hazard, and strategy for eliminating or controlling the risk. One outcome of the assessment may be that Safe Operating Procedures (SOP) need to be developed. The SOPs identified in the Safety in Design Risk Assessment Workshop must be incorporated into the End-User Building User Guide and Safety Induction.

As part of the Safety in Design Risk Assessment, confirm with the Associate Director Capital Projects Delivery, as to whether consultation with the Gender Equity and Diversity Committee (or delegate) is required, to establish risks associated with cultural and gender safety associated with the project.

2.9 Independent building commissioning

For all new buildings, or where the Project Brief requires it, an independent commissioning agent not involved with the design or construction of the project must be engaged.

Detailed testing and commissioning requirements must be specified for each project by the UoA-appointed consultant/designer.

Project hand over inspection and testing plans (ITPs) must be developed by the consultant/contractor to allow the system to be handed over to the University. Detailed testing and commissioning records must be provided for each system and each component, taking into account the requirements of the Standards. All such records must be witnessed and verified by the UoA-appointed project consultant/ designer.

2.10 Post-occupancy Building Services Performance Report

After one seasonal cycle of operation, an independent building services performance review must be carried out and report prepared. Refer to the Manager, Sustainability for details. This may be carried out internally, or by an external consultant. Requirements of the Post-Occupancy Building Services Performance Report will be established by the Manager of Sustainability.

2.11 Manufacturer specifications

All installation must be carried out in accordance with manufacturer specifications and data sheets to ensure product performance over its intended life and so as not to invalidate any warranties.

2.12 Sustainable design

The adoption of environmentally sustainable building philosophies must be considered a primary objective of all projects, regardless of size. Opportunity to implement responsible design and construction solutions must be considered as a matter of course during every phase of the project. Project specific sustainability initiatives and targets must be identified in the Project Brief along with associated reporting obligations relating to both:

a. the requirement for the designer to certify/ rate/ measure the proposed design solution prior to construction; and

b. the requirement for the designer to include physical equipment and processes for measuring the performance of the building throughout its life- cycle (refer Vol Metering and monitoring).

In the absence of the identification of project- specific sustainability targets, and in addition to sustainability considerations covered in the relevant Volumes, the following must be incorporated in all architectural and engineering services designs.

2.12.1 Energy demand and thermal comfort

To minimise energy demand and improve thermal comfort in buildings, the following must be considered:

a. Use of basements and underground parking areas and labyrinths to pre-cool intake fresh air in mechanical systems if viable and where excessive dehumidification is not required.

b. High levels of thermal insulation to roof, floors and walls.

c. Reflectance of external building materials.

d. Thermal and solar performance of glazing.

e. External shading of north, east and west facing windows and walls.

f. Building orientation and massing.

g. Design glazing to achieve optimal day lighting and solar heat gain and to minimise the need for mechanical heating or cooling.

h. Appropriate design for temperature, air velocity, fresh air ventilation rates, relative humidity for different functional spaces as required by C. Mechanical Services Design Standard.

2.12.2 Use of natural daylight

a. Design façades and windows to maximise natural daylight in usable floor areas and incorporate use of sky lights, light wells and internal atriums or courtyards where appropriate.

b. Avoid overshadowing and visual intrusion onto adjoining sites.

c. Design buildings to avoid undesirable glare impacts on pedestrians, motorists, people using open spaces and those in other buildings.

d. Minimise the impact of night lighting on adjacent sites and buildings.

2.12.3 Indoor environmental quality

a. Provide appropriate lighting to suit the use of the space in accordance with E. Electrical Design Standard. Record the as-designed lighting levels and controls per functional space within the post-construction As-built documentation package.

b. Use materials, fittings and furnishings with low-VOC content i.e. paints, adhesives, sealants, carpets, timber products and furniture to avoid and minimise off-gassing impacts on building occupants' health.

c. Design to minimise unacceptable noise.

d. Utilise natural cross ventilation of habitable rooms and corridors to minimize the requirement for mechanical air conditioning.

2.12.4 Energy efficiency

a. Electrical appliances with the highest Australian Government Energy Star Ratings must be used for the relevant capacity ranges of appliances. These appliances include but are not limited to refrigerators, freezers, clothes dryers, dishwashers, electric hot water boilers, televisions, computer monitors and air-conditioning units.

b. Preference must be given to locally manufactured products where multiple products have the highest energy rating.

c. Electrical equipment, including specialised laboratory equipment not covered by Energy Star Rating Scheme must include energy efficiency as part of the selection criteria and have controls to prevent unnecessary energy consumption.

d. All buildings must provide utility meters to monitor, electricity, gas and water in accordance with C. Mechanical Services Design Standard, D. Electrical Services Design Standard, F. Hydraulic Services Design Standard, and L. Metering and Monitoring Design Standard:

— Energy efficient lighting and lighting controls must be provided to meet minimum illumination requirements in accordance with the D. Electrical Services Design Standard.

— Buildings must incorporate technology to reduce peak power demand, i.e. use of thermal storage for cooling and heating, power factor correction devices, etc.

— Roof design must maximise orientation to the northwest to northeast to optimise potential for installing roof top solar energy systems.

2.12.5 Water use

a. Water sub-metering must be provided to monitor large water consuming processes in accordance with F. Hydraulic Services Design Standard and L. Metering and Monitoring Design Standard.

b. All sanitary fixtures and tap ware must achieve WELS ratings specified in F. Hydraulic Services Design Standard.

c. Rainwater harvesting and reuse (toilets, cooling towers, fire test water and landscape irrigation) must be considered for all projects and applied where feasible. Ensure system design allows for future upgrade and expansion. Opportunities to integrate 'demonstrator' education must be explored. Refer also to F. Hydraulic Services Design Standard.

2.12.6 Water sensitive urban design

University campuses must implement water sensitive urban design principles by:

a. Reducing potable water demand through water efficient appliances, hydraulic standard.

b. Capturing rainwater for beneficial reuse including irrigation, cooling water and toilet flushing.

c. Minimising wastewater generation and treatment of wastewater to a standard suitable for effluent re-use and or release to receiving waters.

d. Passively treating urban stormwater using bio-filtration and wetlands systems to meet water quality objectives for reuse and or discharge to surface waters.

e. Using stormwater in the urban landscape to maximise the visual and recreation amenity of developments.

f. Grey water must not be reused where expensive wastewater treatment involving significant inputs of energy, chemicals and high maintenance is required.

2.12.7 Materials

a. Materials must be selected to meet sustainability requirements specified in Section 12 of B. Architecture and Building Design Standard (this document).

b. Selection of construction materials must consider 'cradle-to-grave' environmental impacts which look at impacts associated with raw materials extraction, manufacture, use and re-use potential and disposal.

c. Preference must be given to construction materials with recycled content and reused materials where practical.

d. Life cycle costing principles must be considered in selection of materials and systems. This includes capital, operations and maintenance, and disposal costs.

e. Use recycled and recyclable content in building materials, where fit-for-purpose from a durability and performance perspective.

f. Use suitable demolition materials for on-site fill.

g. Rainforest timber and timber from Australian high conservation forests must not be used.

h. Consider appropriate design detailing for engineered products to avoid any off-gassing potential from volatile compounds used in manufacture.

2.12.8 Noise mitigation

a. During the planning process isolate noise generating activities to avoid impact on sensitive receptors and quiet activities.

b. Protect all occupied spaces from noise pollution from external and internal sources.

c. Plant and equipment located on roofs must have acoustic treatment if they generate excessive noise.

d. Plant locations and noisy equipment must be designed and situated to avoid noise impacts on sensitive receptors and local residents.

e. Minimise noise emitted from external equipment such as fans, air-conditioners, compressors, and from other noise generating sources.

f. Minimise noise transmission within multiple occupancy buildings.

2.12.9 Construction and demolition waste

Building contractors and designers must provide infrastructure for recovery of building, construction and demolition materials to minimise waste disposal to landfill. They must:

a. Prepare and implement a materials recycling and waste management plan in the construction phase for all construction and demolition waste as part of the project environmental management plan.

b. Identify the range of materials that will be collected for recycling and describe procedures, management practices and reporting.

c. Formally apply dimensional co-ordination where it will practically assist the efficiency of material use, preference for modular components and materials supplied in set sizes or dimensions.

d. Consider ease of disassembly and recycling of construction materials and components at the time of refurbishment or completion of a facility's life.

e. Ensure project planning, specification and programming for the recovery, storage and transfer of reusable materials from demolition works including their transport from site to recycling and re-use facilities.

f. Implement procedures for disposal or recycling of hazardous materials at properly licensed facilities.

2.13 Durability, economy and flexibility

The University's goal is to achieve the optimal balance between capital and operating costs, whilst providing occupants a high level of environmental quality and service throughout the lifetime of each building. A whole-of-life asset value-for-money solution must be sought.

The University's building elements, services and external spaces must be:

- Cost-effective to operate and maintain.
- Designed with consideration of capital as well as operating expenditure in mind.
- Robust and durable.
- Easily and safely cleaned and maintained.
- Standardised to minimise individual specialisation and customisation.
- Flexible in the design to allow for expansion or adaption to new uses.
- Designed with built-in flexibility of space, plant and equipment to reasonably accommodate future uses.

2.14 Building compartmentation and sealing

Building fire compartments (existing and proposed) must be clearly identified within the contract documentation package and within the post-construction package. All penetrations through the barrier must be fire treated. Provide motorized dampers connected to the fire alarm system for any fixed open louvers such as at elevator shafts. Provide damper and controls to all air intakes/ exhausts.

Building envelopes must be designed and constructed with a continuous air barrier to control air leakage into, or out of, the conditioned space. Clearly identify all air barrier components on construction documents and detail the joints, and penetrations of the air barrier. The air barrier must be durable to last the anticipated service life of the assembly. Do not install lighting fixtures with ventilation holes through the air barrier.

3. Technical requirements

This section outlines the specific technical requirements for C. Mechanical Services Design Standard.

The following functional requirements must be given special design consideration.

- Energy efficiency
- BMS to be designed to suit the project function. The University have implement a high functionality BMS, confirm BMS and control requirements for inclusion within the project.
- Accessibility, ease of operation, simple maintenance with minimal maintenance frequency
- Adequate space for installation and maintenance of machinery in designated plant rooms, ceiling spaces or other areas
- Access to plant rooms and equipment.

3.1 Coordination of services

Ensure co-ordination of the design and installation of mechanical services with other services to ensure adequate provisions are allowed for (e.g., electrical, water and sewer discharge connections) and to minimise conflict with other services (e.g., location of access hatches, ceiling space allowances, etc.).

Provide a minimum of 15% spare capacity for within switchboards, BMS panels and controllers for future expansion.

3.2 Access

Access to ridged roof plant rooms with mechanical equipment must be large enough to accommodate an attic ladder.

Fixed access platforms, walkways, stairs and ladders in accordance with AS 1657 are to be provided to allow for service/maintenance of equipment in ceiling spaces, roof spaces and on roofs. Walkways are to be integrated with ductwork, pipework and conduit layouts at the design stage so that all serviceable items of equipment can be accessed from the fixed walkway. Any external fixings are to be weatherproof.

Access for regular maintenance activities requiring fall arrest equipment, static lines, anchor points etc. is not acceptable

3.3 Heating, ventilation and air-conditioning (HVAC) systems

HVAC is to be provided to all new buildings or parts of buildings subject to major refurbishment. Where air-conditioning is provided, evaluate the use of ESD initiatives within the design including the use of natural ventilation via modulating louvres / windows controlled directly by the BMS.

Generally, chilled water systems are preferred, in particular, in areas which are in close proximity to existing or planned chilled water reticulation systems.

Consult the University masterplan in the selection and design of new HVAC systems.

Direct expansion (DX) systems may have a lower up-front capital cost, however, have higher life cycle cost due to lower efficiencies. Preference should be given the DX systems, where chilled water is not readily available to the site.

Preliminary system selection must be discussed with UOA prior to final design. System selection should be based on life cycle costing analyses of one or more options. During the design, option and concept phase engage with the University's incumbent BMS specialist to review the controls functionality with existing BMS systems. Consult with and look at the option to integrate the BMS into the Universities enterprise servers.

Innovative solutions for HVAC systems should be presented to UOA for consideration.

3.4 Specific design criteria

Population density can be taken from room data sheets, unless indicated otherwise.

Humidity will not be controlled, unless specifically required for critical processes.

Required outside air quantities should be in accordance with AS/NZS 1668.2.

Outside air economy cycle should be evaluated and considered for all new installations however must comply with the requirements of the National Construction Code.

Refer to the project schedules and relevant Australian standards in relation to Animal research facilities and laboratories. Pre-cooling of the outside air, using heat exchange equipment, must be considered and evaluated on the basis of life cycle cost analysis.

Toilet ventilation should provide as required by AS 1668.2, for high occupancy public areas and the like consider increased air extraction rates to suit the space function. Include within reports and submit to the University for review.

3.5 Air filtration

Air filters are to be carefully selected, located and installed to provide:

- Efficient removal of dust particles from the airstream

- Low resistance to air flow
- Maximum dust holding capacity, to minimise frequency of replacement
- Optimum accessibility for inspection and replacement
- Efficient perimeter sealing to eliminate bypass, and facilitate cell replacement without deterioration of the seal effectiveness.
- Filters to be based on disposable type.

Refer to Section 3.31 Air filtration systems of this document.

3.6 Acoustic requirements

Acoustic requirements will be detailed on a project by project basis. Generally, system noise must comply with AS/NZS 2107.

Acoustic analysis of air distribution may be required in the preliminary system selection. Particular care should be taken in assessing the acoustic impact of an air conditioning system on lecture theatres, seminar rooms, possible examination rooms, etc.

3.7 Vibration and seismic isolation

All rotating or reciprocating equipment must be equipped with vibration isolation mountings. Ductwork, piping, electrical conduit, etc. must be suspended with vibration isolating hangers, if required.

Plant located on Waffle Pad and secured to the floor will not be accepted. Ductwork, piping, electrical conduit, etc. must be suspended with vibration isolating hangers and couplings. Provide seismic restraints to suit installation.

3.8 Pipework and ductworks

Sheet metal ductwork and associated fittings must comply with AS 4254.

Pipework installed externally shall be within culverts. Any deviations must be submitted to the University for approval.

Ensure As Installed ductwork drawings include the location of the commissioning test points.

Refer to Section 3.30 Specifications of this document for ductwork specification.

Refer to Section 3.32 Mechanical pipework of this document for pipework specification.

3.8.1 Design

Pipework shall be sized for any future air conditioning requirements. Water velocities must not exceed good design practice and pressure drops must be kept to a minimum, bearing in mind the average differential pressure in the loop is 100kPa.

Piping and ducting systems must be sectionalised in such a way that scheduled or non-scheduled shutdowns will affect only a portion of the building. Additional valves and shut-off dampers must be installed for this purpose. Chilled water piping for a partially air conditioned building must be sized to have sufficient capacity to service the complete building at a future date.

3.8.2 Access

All components on the heating and chilled water lines, such as isolating valves, control valves, balancing valves, gauges and test points, must be readily accessible.

Ductwork access openings must be provided as detailed in Section 3.0 Specifications and Clause 3.30.9 Ductwork access openings of this document.

3.9 Duct dampers

Duct dampers must, in general, be opposed blade or butterfly type. Acoustic assessment should be carried out if opposed blade dampers are selected as the flow control mechanism for any sideblow registers. Volume control dampers must be installed in all branches to assist in air balancing during commissioning and when room layouts are altered. Ensure the volume control dampers is installed as far as possible from the terminal device.

3.10 Variable air volume system control

Variable air volume system control must be achieved through the use of variable frequency drive fan motor control, unless otherwise specified. Fans, motor drive units and controls must be selected to yield a minimum airflow turndown ratio of 3:1. Variable speed drives must be specified as from a Tier 1 provider, e.g. Schneider, Danfos, Seaman.

3.11 Variable air volume boxes

Variable air volume (VAV) boxes must be installed in such a way that the control box can be opened and the electronic controls accessed.

When using VAV boxes with reheat, the reheat coil should be sized to suit an air entry condition of 10°C and provide adequate capacity to offset the space heat loss at an external ambient of 3°C.

3.12 High efficiency motors

High efficiency motors must be specified and installed to comply with AS/NZ 1359.5.

All motors must comply with the Australian Government's Equipment Energy Efficiency Program (www.energyrating.gov.au/).

The highest efficiency motor should be selected for all applications.

3.13 Dedicated room air conditioning units

Dedicated air conditioning units (e.g., for constant or controlled temperature equipment, server or communications rooms, and laboratories requiring after hours operation) may be required when it is not economical to run the main system. These units should preferably be chilled water air handling units.

If other systems are proposed, it should be approved by UoA and a dedicated metered electrical supply, monitored and controlled by the Building Management and Control System, should be provided.

Standalone, fit for purpose, air conditioning units are to be provided for communications rooms and other equipment rooms which are intended to operate 24 hours a day. Domestic air conditioning units are not to be utilised for 24 hour operation.

3.14 Building management and control systems (BMCS)

Building management and control systems (BMCS) are utilised to:

- Reduce energy costs
- Enable instantaneous remote indication, monitoring and control of selected functions
- Provide selected malfunction reports to Central Plant
- Provide data to enable forecasting of energy requirements
- Provide load-shedding facility.
- Be integrated with the Universities other energy management and control systems (requires early project consultation with incumbent BMS / Controls specialist), for integration of:
- Data analysis and energy use
- All plant and equipment BACnet points to be visible
- Integration to University virtual servers

BMCS must:

- Enable Integration with Fault Detection Diagnostic programs
- Be Native Bacnet with software hosted on University maintained virtual or physical servers only
- Be integrated with the Campus enterprise networks – on Nth Terrace Campus systems to be Automated Logic WebCtrl
- Integrate with the University syllabus Plus room booking system to enable AC operation as per the Syllabus Plus schedules

Refer to Section 3.38 Building management and control systems of this document. UoA must be consulted regarding any connections to the BMCS.

3.15 Services metering

Mechanical services make-up water and gas supplies must be metered by pulse meters, confirm project requirements. The output from the pulse heads must be connected to the building BMCS. Electrical power supplies to mechanical services switchboards must be monitored by meters within the electrical services switchboards.

Flow measuring devices will be either Danfoss MAGFLO flow meters or ABB Kent Taylor MagMaster flow meters. Flow meters must operate at 75% of the design flow at a velocity of 1 - 2m/s. It is recommended the manufacturer of the flow meter check all selections.

3.16 Mechanical services switchboard (MSSB)

Mechanical services switchboards (MSSB) must have the facility to transmit alarms via the BMS. All alarms must be capable of being inputs to the BMS. All switchboard wiring must be numbered by appropriate ferrules and must conform to AS/NZS 3000.

Refer to D. Electrical Services Design Standard, for mechanical electrical requirements.

3.17 Low voltage wiring systems

Wiring systems should primarily be run to allow for future removal, modification or maintenance. The types of cabling and cable containment systems (for example, cable ladder, cable tray, trunking / duct, conduit and open fixed to permanent structure) should match the standards established for the electrical services installation for the project.

Allow 25% spare capacity within wiring circuits for future expansion

3.18 Chilled water systems

Where central thermal plant systems are installed chilled water systems must be designed so that they may be extended or interlinked with the existing systems as the thermal pipework network expands. This means that temperatures, pressures etc. should be compatible. All control valves must be two-way. Any bypass may be considered if required to maintain the minimum water flow in a particular location. .

3.19 Balancing valves

Commissioning and balancing valves must be installed on chilled or heating water systems to meet the design water flow.

Chilled and heating water coil flows through UoA's air handling units are controlled by the BMS and associated coil control valves to maintain leaving air temperatures to meet the cooling or heating demand. This is achieved by the provision of leaving air temperature sensors on all air handling and fan coil units.

3.20 Condensate

Condensate lines must be run to sewer . Condensate or waste water must not run on to roofs, into gutters or directly into downpipes.

3.21 Corrosion protection

The design consultant will ensure that all components in a system are fully protected against all forms of corrosion and conform to the relevant Australian Standards.

3.22 Air handling units

All air handling units that can be walked or crawled into must have internal lights. The light switch must be located outside the air handling unit and must meet IP 56 specifications and must have a red neon indicator light.

3.23 Valve selection

Valves to be selected to suit application and fluid.

Comply with relevant Australian Standard to suit application.

3.24 Make up water tanks

Make up water tanks must be closed pressure vessels specified and installed in compliance with AS/NZS3500 and the requirements of Water Corporation.

3.25 Heating water systems

Where central thermal plant systems are installed heating hot water systems must be designed so that they may be extended or interlinked with the existing systems as the thermal pipework network expands. This means that temperatures, pressures etc. should be compatible. All control valves must be two-way. Any bypass may be considered if required to maintain the minimum water flow in a particular location.

Heating water boilers where possible must be energy efficient condensing boilers. Where heating systems are less than 200kW multiple instantaneous natural gas heating water systems should be considered.

3.26 Labelling

After painting, all equipment, ducts and pipework must be identified with Safetyman labels in accordance with AS1345 "Rules for the Identification of Piping, Conduits and Ducts". Labels must be located at approximately 3m intervals in plantrooms and labels shall be provided at each service access opening into pipe shafts. Where pipes run together the labels shall be grouped together.

All apparatus shall be labelled as to its designation and status. Each label shall be conspicuous and manufactured from three layer rigid material engraved to approval, particularly in respect of size and lettering.

All plant room and concealed space components shall be identified with black traffolyte labels with white upper case lettering minimum size 20mm high glued securely to the equipment. Labels shall not be glued to equipment covers.

Traffolyte labels shall be fixed to ceiling T-bars or access panels indicating equipment access points to VAV boxes, valves, fire dampers and other equipment requiring periodic service or inspection. White traffolyte labels with black upper case lettering, minimum size 5 mm high shall be used where required in occupied spaces.

3.27 Mechanical plant rooms (refurbished and new)

All plant rooms, new or refurbished, shall have the following:

3.27.1 Drains

Drains are to be located as near as possible to the centre of the plant room. The waste line from the drain must run to a sewer line.

Drains or tundishes must be provided where possible adjacent to equipment. Where condensate lines from air conditioners are required to run across the plant room floor terminating at the drain condensate lines must be covered by an angled PGI cover painted with black and yellow hazard stripes at a 45° angle.

The plumbing contractor must be responsible for the drain charging line and solenoid valve. The BMS contractor must be responsible for connecting the solenoid to the BMS.

3.27.2 Lights

Light fittings must be located above or adjacent to the MSSB, BMCS controllers and FCU access hatches or doors. Emergency lighting must be located in the vicinity of MSSB and for egress.

3.27.3 Bunding

Where flooding is considered a risk, a 100mm high brick bund must be built across the plant room side of the entry door and sealed against water leakage. The bunding must be painted with black and yellow hazard stripes at a 45° angle. The joint between the wall and the floor must be sealed with a waterproof sealant with a view to making the plant room as watertight as possible.

Provide permanent ramps at access doors for the access of plant and equipment into and out of the plantrooms.

3.27.4 Plinth

All mechanical-electrical plant must be located on a plinth.

All rotating or reciprocating equipment must be mounted on vibration isolation mountings. Piping and ducting must be isolated from all rotating equipment with vibration isolators or flexible connections.

Galvanised steel edge surrounds must be supplied, positioned and fixed by the mechanical contractor. Surrounds shall be minimum 1.6mm thick galvanized sheet steel with bevelled edges fully welded and painted with cold galvanizing paint.

3.27.5 Outside air

All outside air intakes shall be fitted with a volume control damper and filters in accordance with Schedule 4.2 Laboratory and fume cupboard pipeline identification colours of this document.

3.27.6 Electrical power point

A double switched socket power outlet for general maintenance / utility use shall be located adjacent to or below the MSSB and BMS panel.

3.27.7 Plant room penetrations

Where services, ducting, pipe work and electrical conduits penetrate the plant room wall they must be sealed. Fire rate to suit the space classification and use.

3.27.8 Ducting

The opening for ducting must be sealed on both sides, then flashed with PGI in the plant room. If the ducting is visible outside the plant room, then it too must be flashed and painted.

3.27.9 Pipes

Pipes and electrical conduits passing through the plant room walls must be sealed and flashed to prevent damage. The sleeve must be sealed around the outer edge between the brick or concrete.

3.27.10 Painting

The floor, walls, ceilings and all other services must be painted as per Section 4.10 of this document.

3.28 Redundant services

All services made redundant (internal/external) must be removed and made good.

Cut and seal off services at the source of supply.

Existing branch valves must be removed and made good.

Existing redundant services exposed during excavation must be highlighted to UoA and removed where appropriate.

3.29 Testing and certification

Upon completion of the installation and before the Certificate of Practical Completion is issued, the plant must pass such tests as are deemed necessary by the design consultant. The tests must be carried out by the contractor in the presence of the consultant. UoA Campus Management may elect to be present.

Contractor to allow for system re-commission during the summer and winter seasons to comply with design requirements.

3.29.1 System balancing

System balancing is to be carried out by the mechanical services contractor as per commissioning requirements. A detailed description of procedures and a schedule of parameters (temperatures, flows, pressures, etc.) showing actual and design values are to be provided.

3.29.2 Cleaning

All equipment, piping, ductwork etc. are to be protected and kept in a clean condition prior to commissioning.

3.30 Specifications

3.30.1 Ductwork

Sheet metal ductwork and associated fittings must comply with AS 4254.

Round or oval sheet metal ductwork must be spiral wound grooved seam type.

Rectangular sheet metal ductwork must generally be cross-broken or beaded in accordance with AS 4254.

Where drawings show the sizes of the airway, actual duct size must be increased by the thickness of internal insulation or other internal treatment.

The cross sectional dimensions of the duct may be varied to obtain more economical sheet usage or to allow a better fit within the available space. Any such changes must be designed to achieve the same pressure drop as the design drawings.

Seal exhaust ductwork with duct sealant, mastic or gaskets to AS4254, at joints and seams to ensure that the duct is airtight and leak-proof.

3.30.2 Material

The material of sheet metal ductwork must be prime lock forming quality galvanised steel sheet. Grade G2 or G3 to AS 2338 with Z275 coating to AS 1397.

All angles used for supporting ductwork must be hot dipped galvanised.

Rivets for galvanised ductwork must be of aluminium alloy with 5% magnesium and of the expanding solid end type.

Rivets for stainless steel ductwork shall be of monel metal.

Bolts and nuts must conform to AS 1111, AS 1112 and AS 1275 as appropriate. Bolts and nuts shall be zinc plated with hexagon, heads and nuts, for protected locations.

3.30.3 Branch connections

Branch connections to rectangular ducts are detailed in AS4254 in accordance with the following:

- Straight tap branches may be used for connection to individual outlets.
- Parallel flow branches must be used for connections handling 30% or more of the air flow in the main duct and where indicated on the drawings.
- 45° entry branches must be used for other rectangular connections.

A splitter damper at parallel flow branches and a single or opposed blade damper in other branches are to be provided.

3.30.4 Spigots for flexible ducts

Spigots for connection of flexible ducts shall be circular or oval to suit the size shown on the drawings. The spigot shall be manufactured from spun aluminium or 0.8mm minimum thickness galvanised steel. Where required for air balancing, (e.g. take-offs from supply ducts) spigots shall be fitted with a butterfly damper. The damper blade shall be manufactured from 0.8mm minimum thickness galvanised steel. The damper shall be complete with a metal shaft securely fixed to the blade and a cast metal quadrant arm. The quadrant arm shall clearly indicate the damper position and must be secured to a cast metal quadrant by a wing nut. The quadrant must be mounted at least 70mm proud of the spigot.

3.30.5 Pressure classification

All return air ductwork, fresh air ductwork, exhaust air ductwork and supply air ductwork must be manufactured to a minimum AS4254 - 250 Static Pressure Classification.

Specialised ductwork systems subject to static pressures exceeding 250Pa must be manufactured to the classification exceeding the design pressure.

3.30.6 Exhaust ductwork

Splitters, turning vanes or internal stiffening tie rods must not be incorporated in unfiltered exhaust systems.

3.30.7 Duct supports

Duct supports must be from galvanised steel strap for small ducts, or galvanised steel angle, "Unistrut", or Millstrut" sections, galvanised with cadmium plated all thread rod and galvanised steel nuts for larger ducts. Ducts may be hung from joint angles or TDF flanges.

General hanger arrangements and spacing must conform to AS4254. Round spiral wound ductwork, exposed to view inside the building, must be internally reinforced to maintain the shape of the ductwork and to receive a hanger rod. The fastenings must not be visible from floor level.

3.30.8 Access opening

Access must be provided to all motorised dampers and fire dampers and where shown on drawings.

Panels installed in insulated ducts must be insulated.

Access openings must be of a size and location such that dampers can be reset and blades checked for tight closure.

3.30.9 Ductwork access openings

Ductwork access openings must be to the following minimum dimensions:

- Access Doors 1350 x 500 - walk in access.
- Stiffened to prevent distortion under normal use, hinged to open against air pressure, with clamp type latches and handles which can be opened from both inside and outside, sealed with mechanically fixed rubber or soft Neoprene Gaskets to make the door airtight.
- Co-ordinate all access hatches with the architect, electrical, hydraulic and fire contractor to ensure clear maintenance access to all services and ductwork in the vicinity of the access hatch. Size the access hatch to suit the type of maintenance activities likely to be undertaken on the plant and equipment. Minimum access hatch is 600 x 600mm.
- Double panel, deep formed, GSS. Insulated as ductwork or filled with minimum 25mm mineral wool with rigid matching G.S.S. frame securely attached to the duct and 4 off wedge type sash latches sealed as for access doors.
- Handholes 200 mm x 300 mm hand and sight access.
- Double panel, deep formed GSS as for manholes but with 2 only latches.

3.30.10 Flexible connections

Provide airtight flexible connections to isolate fans and/or conditioner casings from ductwork. Align openings before fitting flexible connections.

Arrange connections to permit renewal without moving ductwork or equipment. Provide each connection with an effective length of 75mm to 125mm between ductwork and equipment, with adequate (at least 25mm) slack in the material to ensure the movement and vibration isolation is achieved.

Incorporate folds in connection material joint seams to conceal raw edges. Match stitching thread to same material qualities or better. Seal seams with approved glue or mastic if necessary for airtightness. Stitch joint seams suitable for maximum potential service stress.

Ensure protrusion into the airway does not exceed 10mm by incorporating connections with metal collar frames or other features in connections subject to negative pressure internally.

For exposed connections use suitable weather resistant material or protect by weatherproof sheetmetal covers which do not compromise isolation.

Make connections to rectangular ductwork with continuous 16mm x 6mm x 1.2mm thick galvanised steel channel section or 25mm x 1.6mm galvanised steel bar flexible connection sandwiched between the channel and the duct. Fasten the channel section to the duct with pop rivets at not greater than 150mm centres for pressures below 500Pa and 75mm centres for pressures above 500Pa.

With flanged rectangular connections, hold the flexible joint in place by a matching flange with a backing plate.

With circular duct screw 25mm x 1.6mm draw bands at nominal 300mm centres (for pressures to 500Pa) and 150mm centres (for pressures above 500Pa).

Provide material types and usage to the requirements of AS 1668 Part 1 and AS 4254.

Use the following types:

- Heavy duty vinyl
- Neoprene fire retardant, waterproof (1.005kg/m2).
- Heavy duty PVC coated vinyl.
- Fibreglass reinforced PVC fabric.
- Neoprene coated glass fabric (1kg/m2).

- PVC coated fabric with cotton sateen backing (0.5kg/m2).
- Woven plastic material.

For fume cupboard exhaust systems provide acid resistant UPVC sheeting (long enough to accept duct movement due to expansion without moving fan mounting).

For kitchen exhaust systems provide woven ceramic fibre cloth with impervious lining.

For smoke, spill, stairwell pressurisation systems and spraybooths provide fabric to be able to withstand the test required by AS 1530, based on the Standard Time Temperature Curve for 2 hours.

Use non-combustible yarn and conceal and sew down raw edges.

3.30.11 Flexible ductwork

Material

To AS 1668 Part 1 in either of the following constructions:

- Corrugated aluminium, helically wound with lock seam capable of being bent or set by hand without spring back and without deforming the circular section.
- Single or multiple layers of aluminium strip formed into corrugations and wound in helical or annular form, without any obvious seam or joint.
- Tough, tear-resistant, airtight fabric liner and cover, enclosing a galvanised steel wire helix and reinforced with an outer helix of glass fibre cord.
- Tough, flexible, reinforced aluminium foil laminate, supported by a reinforcing helix of aluminium allow or steel.

Joints

Seal the joints with 50mm wide minimum PVC tape.

Collars to which the duct must be attached must be a minimum of 50mm in length.

Sleeves used for joining two sections of duct must be a minimum of 100mm in length.

Fastening

Secure the duct to the sleeve or collar using a wormscrew draw band.

Application

Flexible duct should only be used on final connections to diffusers in demountable ceilings or where partition layouts are subject to change.

Make duct runs as short and as straight as possible, not exceeding 3m with a bend centre line radius to duct diameter ratio of 1.5.

Do not make test holes to flexible ducts, or build flexible ducts into full height walls.

Flexible ducts must be connected to internally insulated rectangular sheetmetal ductwork with square to round connections on either side of full height walls to maintain acoustic separation. Sheetmetal ductwork must be acoustically sealed to both sides of the wall.

3.30.12 PVC ductwork

Material

Fabricate round PVC ductwork from PVC pipe. Fabricate plenums and transitions from UPVC sheet, minimum thickness 3mm.

Fittings

Form bends and tee pieces from the same material as the duct, and make an airtight joint to the duct by welding.

Fabricate "lobster back" bends with at least five segments, butt welded, and with a centreline radius not less than 1.5 x duct diameter.

Flexible Connections

Provide sleeve type PVC or neoprene flexible connections, capable of being removed without disturbing the ductwork or plant. Attach with 25mm x 0.6mm stainless steel straps.

Dampers

Construct all the parts within the duct from UPVC.

Supports

Provide galvanised steel straps or trapeze angles to AS 4254. Fit a 150mm wide x 5mm thick curved PVC sandwich between trapeze hangers and the duct. Do not fix self-tapping screws into the duct.

Spacing (maximum centres):

- Horizontal ducts: 1500mm.
- Vertical ducts: 2400mm.

Provide supports at the bases of vertical runs and guides at each floor penetration.

Welding

Continuously weld all joints, including seams, stiffeners, flanges, corners of fabricated bends and tees, and the like. Weld stiffeners on both sides. Back weld slip socket joints.

Butt welding: Vee type, using hot air equipment, as follows:

- In 3mm and 4mm material: 1 run of 3mm welding rod
- In material thicker than 4mm: Triple welding rod or 3 runs of 3mm rod.

Use a continuous PVC H-section jointing socket, heat formed for circular duct cross joints only in locations inaccessible for butt welding.

Bending

Immediately before bending sheet material, heat both sides to avoid thinning and high stress concentrations. Heat bend the corners of rectangular ductwork to an inside radius equal to the material thickness or 5mm, whichever is the greater.

Seams

Keep longitudinal seams to a minimum. Locate welded seams away from the corners, preferably in the middle of a short side.

Flanged Joints

Weld flanges to the ductwork, and connect by bolting at 25mm centres with 6mm diameter bolts. Provide soft plasticised PVC gaskets or non-setting compound appropriate to the application.

3.30.13 Cleaning

All ductwork must be stored under cover with open ends sealed with plastic sheeting before shipment to site. Plastic must remain in place up to the time of installation open ends of installed duct must also be protected from dust ingress by plastic sheeting and tape.

3.30.14 Flashings

Provide galvanised steel over flashing collars to ductwork penetrating roofs or external walls or where necessary for waterproofing.

3.30.15 Test points

Provide 12mm diameter holes, closed off with rubber grommets or other approved means suitable for the pressure classification of the ductwork, to allow testing with a velometer or pitot tub.

Locate holes in straight lengths of duct where air flow is most favourable for accurate measurement. Where practical allow 10 equivalent diameters of straight duct upstream and 1.5 equivalent diameters downstream.

Locate the holes in circular ducts at 0o and 90o relative to an axis of the duct. Locate holes in rectangular ducts, evenly spaced across the duct with a half space at each end, according to the list below.

- Up to 300mm 2 holes
- 301mm to 450mm 3 holes
- 451mm to 630mm 4 holes
- 631mm to 1220mm 5 holes
- Above 1220mm 6 holes

Provide holes in locations as necessary to check air balance, where directed and in the following locations:

- Downstream of each supply air take-off from the main riser
- Downstream of each main air handling unit

3.30.16 Dampers

General

Provide damper sets where specified and where necessary for balancing the system.

Careful assessment of possible acoustic problems must be made if opposed blade dampers are selected as the flow control mechanism for any sideblow registers. Volume control dampers must be installed in all branches to assist in air balancing during commissioning.

Construction

Dampers are to:

- Be free of rattles, fluttering or slack movement
- Be capable of adjustment over the desired range without excessive self-generated noise or the need for special tools
- Not have sharp edges
- Be sufficiently sized to eliminate movement when locked

Frames must be minimum 3mm thick GSS folded to channel sections or extruded aluminium sections not less than 1550mm wide and welded at corners, with Mullions minimum 1.6mm thick GSS or aluminium folded to channel sections and riveted into a box section, minimum in sheet metal ducts and UPVC in PVC ducts.

Blade material must be GSS, aluminium sheet, or stainless steel, in sheet metal ducts and UPVC in PVC ducts.

Fit mechanically fixed sealing strips where positive shut-off is required.

Bearings must be self-aligning type, either:

- Oil impregnated sintered bronze
- Oil impregnated plastic or
- Ball bearing.

Provide an adequate means of external lubrication where required.

Spindle materials must be cadmium plated steel.

Spindles may be of the stub type or run the full length of the blades with the ends machined to accept the operating mechanism without slip.

- For blade lengths up to 600mm, use 10mm diameter spindles
- For blade lengths from 601 to 1200mm, use13mm diameter spindles
- For blade lengths over 1200mm, use 13mm diameter spindles with intermediate bearing support.

Provide linkages which connect all blades so that they rotate equally and close tightly.

Linkage may be:

- Ball joints,
- Bright steel flat bar cadmium plated with brass link pins held in position by circlips; or
- Gear trains where opposed action is required.

Application

Single blade dampers:

- Manually adjustable at branch take-offs
- Manually adjustable at air outlets and grilles

Splitter dampers:

- Manually adjustable at branch connection to main duct and/or supply air registers
- Manually adjustable at air outlets and grilles

Multi-blade dampers:

Use opposed blade type for

- Throttling applications where flow is varied
- Size damper for wide open resistance between 3 to 6% of the total system resistance.

Use parallel blade type for

- Mixing applications such as outdoor air and return air dampers with constant pressure drop across the damper.
- Size damper for wide open resistance between 10 to 30% of total system resistance.

Dimensions

Clear face dimensions must be duct size unless otherwise shown on the drawings.

Operation

For manual operation; position operating mechanisms accessible for visual inspection, maintenance and adjustment, a means of providing damper adjustment and locking in any desired position, such as lever and quadrant, or adjusting rods. Label the OPEN and CLOSED positions clearly and permanently, with blade position clearly engraved in the end of each spindle.

Extend the operating shafts through the duct where manually adjustable dampers are installed in ductwork or other inaccessible locations and fit a lockable quadrant.

For remote operation; have damper operator mounted externally/internally to suit application, with flexible operating cable run to the location (such as ceiling or outlet) shown on drawings.

For automatic operation, mount motors in an accessible position. The mounting must be rigid enough to prevent flexing or distortion of the ductwork during operation. Where two sets of dampers are connected to one motor, use linkages which allow either damper must be adjusted for position and movement without affecting the other.

Location

Provide diffuser, register and grille dampers connected to a branch duct with volume controls as follows:

- Install stream splitters of the parallel linkage type at the intermediate outlet neck connections, adjustable from the face of outlet or volume extractors utilising curved blades.
- Install single blade stream splitter dampers at branch duct connections to the main for directional flow control or incorporate at each individual flexible ductwork connection a butterfly damper at the spigot connection to the supply ductwork with a bell mouth or oval entry and lockable quadrant.
- Provide opposed blade dampers when necessary and as required for balancing and volume control. Fit grilles for return and exhaust air with opposed blade damper volume controls with individual blade adjustment to distribute air evenly over the face of the grille.

Paint visible ductwork and dampers behind grilles matt black.

3.30.17 -Return dampers

Provide dampers which open fully when the upstream pressure is greater than the downstream pressure. Arrange dampers to close against any reverse flow with leakage not exceeding 10% of system rated air flow. Damper blades must be rigid and stable, partially ganged in groups, counterweighted and arranged to minimise flutter. Ensure dampers are silent in operation and are capable of withstanding frequent cycling.

3.30.18 Fire dampers

Fire dampers must be constructed and installed to meet all requirements of AS 1682 and AS/NZS 1668. Manufacturer certification of compliance is required.

The free area of any fire damper must not be less than 85% of the adjoining duct area. Where necessary the duct size must be increased above the nominal airway size of the adjoining ductwork to accommodate the fire damper and access openings in the duct to enable the fusible link to be replaced and the damper operation checked.

Fire dampers must not be used for air volume control.

Fire dampers in stud walls, which have not been tested when assembled in that type of wall, must be independently supported from the soffit of the floor above. Fire damper supports must be contained within the thickness of the stud wall. Welding these supports to the fire damper is not acceptable.

3.30.19 Ceiling diffusers

Diffusers must be finished in baked enamel or powder coated to nominated colours.

Dimensional similarity must be maintained between the relative neck and face sized of the fittings specified and the nearest size standard fittings listed in the manufacturer's catalogue to ensure satisfactory air diffusion.

Where flexible ductwork connections are provided to diffusers, each diffuser must be provided with a plenum box incorporating turning vanes to provide even distribution of air through the neck of the diffuser.

Where diffusers are installed at the end of a duct run, the duct beyond the neck connection must be extended to form a "cushion head".

Ceiling diffusers must be selected so that the border frame fits the ceiling tile/suspension system.

Louvered face type

Louvered cores must be removable with neatly mitred corners.

Perforated plate type

Perforated plate type ceiling supply diffusers must incorporate 4-way louvred deflecting devices fastened to the back of the perforated plate for easy site adjustment of blow direction.

The diffuser frame must be manufactured from extruded aluminium or steel. The face plate must be removable for access and must be of perforated aluminium or steel construction.

Linear louvre type

Linear louvre type ceiling diffusers must be constructed of extruded aluminium and must consist of parallel louvre blades arranged to provide fixed horizontal air diffusion through nominal 20mm wide slots.

The number of slots, directions of discharge and lengths of diffusers must be as shown on the drawings. Each length of diffuser must incorporate an aligning device of permit long lengths to be aligned and abutted neatly. The outer flange of the diffuser must overlap the ceiling opening by nominally 25mm and must be neatly mitred at the ends of each length.

Each length of diffuser must be installed without any visible means of fastening and must be adjusted for a close fit against the finished ceiling.

Air must be supplied to the active lengths of each diffuser via plenum ducts on the back of the diffuser with circular or oval spigots for round flexible duct connections or rectangular spigots for rigid duct connections as indicated on the drawings. The design of the plenum ducts must ensure even distribution of air flow along the active length of the diffuser. The end closures on plenum ducts shall project between the louvres to prevent short circuiting of supply air into the ceiling space.

The exposed face of the diffuser shall be finished in baked enamel or powder coating to a nominated colour. Internal surfaces visible from the occupied space shall be painted matt black.

Air/Light troffer type

Troffer type diffusers shall be of the air/light boot type suitable for mounting on light fittings.

Air / light troffers must be approved by UOA prior to purchase and installation. A prototype installation with the specified light fitting may be required in order to check the air pattern under variable volume conditions.

Troffers must be fabricated in 0.8mm thick zincanneal steel sheet; be rigid, square and plumb, be cross braced by at least two spacers providing rigid support for the discharge neck and have flanged or otherwise stiffened edges to the discharge opening.

An elliptical (or round when space permits) flexible duct connection spigot with a length of at least 50mm and a perimeter dimension to provide a push fit for the flexible ducting must be fitted to each diffuser.

Troffers must be airtight air discharge normal to longitudinal axis of the troffer, formed to dimensional tolerances permitting interchangeability of boots with ceiling light fittings. Dimensions of the diffuser must suit the profile of the ceiling light troffers on which they must be mounted.

Troffers must have sufficient clearance so as to not obstruct ventilation opening for the light fitting. Double troffers must have a single flexible duct connection with a permanently attached integral duct connecting the two halves of the troffer.

3.30.20 Registers

Registers must be of aluminium construction and must be finished in a baked enamel or powder coat finish in a nominated colour. The face of the register must incorporate a neatly mitred flanged border which overlaps the register opening by nominally 25mm.

Registers must have two sets of adjustable aerofoil shaped vanes for directional control of air distribution. The front set of vanes must be horizontal and the rear set of vanes must be vertical. The spacing of the horizontal and vertical vanes must not exceed 20mm and the vane depth/vane spacing ratio must not be less than 1.0. Registers must be installed without any visible means of fastening and close fitted against the finished surface. A suitable gasket around the border of the register where the border acts as the seal against air leakage must be provided.

Adjust volume controls and register control vanes to give a satisfactory distribution of air without the introduction of noise.

3.30.21 Grilles

Egg crate grilles

Egg crate grilles are not to be used for exhaust or return air applications. Grilles of this type collect dust and are difficult to clean.

Chevron Grilles

Chevron grilles must have extruded aluminium, inverted vee, sight proof, horizontal blades fixed in an extruded aluminium frame. Half chevron grilles must have extruded aluminium, half chevron, horizontal blades fixed in an extruded aluminium frame. Blade spacing must not exceed 30mm. Blades must not vibrate or rattle when air flows through the grille at any face velocity up to 5m/s. The frame must form a nominal 25mm border with neatly mitred corners and must incorporate concealed fixings.

The static pressure loss must not exceed 25Pa when operating at a face velocity of 1.25m/s.

Grilles visible from the occupied space on both sides must have a border on both sides and a telescopic frame, adjustable to the width of the partition in which they are mounted.

For walls too thick to suit the above grille, half chevron grilles must be provided on each side of the wall.

Grilles must be either powder coated or natural anodised in accordance with the architect's requirements.

3.30.22 Bird Screens

Bird screens are to be provided over air openings to outside of the building.

Screens must be manufactured from 12mm x 12mm heavy duty industrial plastic mesh.

Bird screens behind external louvres must be constructed from 12mm x 12mm aluminium frames.

Bird screens over other openings must be constructed from 12mm x 12mm in galvanised steel frames.

3.30.23 Anodising

Colour anodising must be by the integral metal oxide process with inorganic metal oxide pigment particles deposited at the base of the anodised coating in accordance with AS 1231. Consult with UOA prior to selection of anodising material.

External louvres must have an etched anodic coating thickness not less than 0.025mm.

Internal grilles specified to have anodised finish, must have an etched anodised coating thickness not less than 0.01mm.

3.30.24 Insulation

Insulate ductwork in accordance with AS 4426.

Insulation work must be carried out by experienced personnel in accordance with the WorkSafe Standard "National Code of Practice for the Safe Use of Synthetic Mineral Fibres".

Internal insulation

Internally insulate the following:

- Conditioner housings
- Hot and cold plenums downstream of heating and cooling coils, including the dividing panel between the hot and cold ducts
- Supply and return air ductwork where indicated on the drawings.

Internal insulation materials must have a thermal conductivity not greater than 0.036W/m.K at a mean temperature of 20°C.

Internal insulation materials must have not less than the following sound absorption coefficients outlined in

Table 1 Insulation with specification facing

Insulation with spec. facing. Thickness mm	Absorption Co-efficient at Octave Band Centre Frequency			
	125Hz	250Hz	500Hz	1000Hz
25	0.13	0.30	0.62	0.86
50	0.28	0.61	0.99	1.00

External insulation

Externally insulate air conditioning supply and exhaust air ductwork where indicated on the drawings and flexible duct runouts.

Items not to be insulated:

- Outside air, ventilation supply air and exhaust air ductwork except where specified otherwise.

3.31 Air filtration systems

For general air conditioning applications, extended surface pocket type air filters are required to be incorporated wherever possible with 660mm deep pockets for maximum dust retention and minimal service frequency.

3.31.1 Media filters

Deep bed filters

Filter media must be Type 1, Class A NATA certified to meet the requirements of AS 1324.1 performance rating F6. With a minimum initial efficiency of 61% on No 1 dust and 96% on No 4 dust. With a maximum dust holding capacity of 704g No 4 dust, per 610 x 610 x 660 deep module and an initial clean resistance of 45Pa and a final resistance of 250Pa.

300mm deep pocket filters will only be accepted where 660 deep pockets cannot be accommodated due to space restrictions.

V-form filters

Extended surface pleated box filters will only be accepted where pocket filters cannot be accommodated due to space restrictions.

Flat panel filters

Flat panel filters will only be accepted on console type room air handling units and room air conditioning units where extended surface filters cannot be accommodated due to space restrictions.

Filter selection

Filters must be selected for initial clean resistance less than 50Pa and a final, renew, resistance of 250Pa. Clean filter banks with a pressure drop greater than 50Pa will not be accepted. The exception being HEPA filters.

Filter frames

Filter bank holding frames must be sized to accommodate standard 610 x 610 module media supporting frames, be self-supporting with all filter modules removed, and be designed to deflect less than 0.2% of the total width/depth in operation at 250Pa, differential pressure.

Adhesive tapes or sealants must not be used to seal removable modules to support frames.

All filters to be disposable type.

3.31.2 Specialised filters

Filters for special applications – Kitchen Hood Grease Filters; High Efficiency Filters for Clean Rooms; HEPA Filters; Electrostatic Filters; Activated Carbon Filters etc. – must comply with AS 1324 and be certified by NATA independent test data.

3.32 Mechanical pipework

3.32.1 Pipe sizes

Pipes sizes shown or drawings or specified are minimum nominal sizes indicated as nominal diameters.

3.32.2 Design pressure

The design pressure must be the maximum pressure at a designated temperature which is allowed in the pipework during operation. Assembly and test pressures may be up to 1.5 times the design pressure. Pipe and fittings are expected to withstand this test pressure.

3.32.3 Design temperatures

The design temperature is the maximum / minimum temperature of the contents permitted in the pipework.

3.32.4 Clearances

Provide adequate spacing, measured clear of pipe insulation, of at least 25mm between pipes and 50mm between pipes and electrical cables. Take off branches are to be at right angles.

3.32.5 Accessibility

Locate fittings in accessible positions, with adequate clearances. Obtain prior approval for locating enclosed inaccessible pipe runs and fittings.

3.32.6 Flexibility

Arrange piping connected to rotating and/or reciprocating machinery to have sufficient inbuilt flexibility together with a spring support system to absorb the vibration.

3.32.7 Expansion and contraction

Arrange piping with sufficient bends so that the system is flexible enough to absorb the whole of its own expansion or contraction without developing excessive stresses in the piping itself, in the connected equipment or in the supporting structure.

Expansion devices

Provide sufficient and adequate pipe anchors and pipe guides to ensure that the expansion and contraction is taken by the expansion devices. Where patent devices such as articulated or axial bellows or ball joints are used, design anchors and guides in accordance with the manufacturer's requirements.

Springing

Cold springing must be installed where piping systems operate through a temperature range exceeding 35K.

Cold springing must provide 50% of the calculated total expansion for the length under consideration.

Culverts

The use of culverts must be utilised for the installation of in ground pipework. Any deviations to be submitted to UoA for approval.

3.32.8 Vibration isolation

Flexible connection fittings

Provide flexible connections to rotating and vibrating machinery where the piping has insufficient flexibility to prevent transmission of vibration through it to the building structure. Flexible connections must be selected to accommodate axial and lateral dynamic deflections of the isolated equipment.

Flexible connector pipes

Provide a minimum length of flexible connector equal to six times the nominal pipe diameter and a maximum length of 900mm suitable for minimum axial compression and extension of 1% and a lateral deflection of not less than 2mm. Provide supports where necessary so that flexible connectors are not subject to external static loading.

Longitudinal forces

Install flexible connections so that their axes are parallel to the axis of rotation of the equipment to which they are connected, and provide adequate pipe anchorage to prevent stressing of the pipework or connected equipment by the longitudinal forces resulting from the flexible connections.

Manufacturer's recommendations

Flexible connections must be installed in accordance with the manufacturer’s recommendations.

Approval

The use of flexible connections will need to be approved by UoA prior to installation.

3.32.9 Supervision

Inspection

Give notice (not less than 2 working days) to UoA so that inspections may be made at the following stages:

- Work ready for specified testing.
- Enclosed work ready to be covered up or concealed.
- Sections to be isolated
- Sections ready to go on line.

Completion

Do not turn on control and isolating valves to leave the service in operation without the knowledge of UoA.

3.32.10 Installation

Pipework must:

- Be neatly installed
- Have risers arranged vertical and horizontal runs either parallel or normal to enclosure walls
- Have parallel runs neatly grouped
- Be graded up towards air release valves and down towards drain valves
- Not include any sections which will not drain or can trap air
- Not transmit vibration or noise
- Be installed with provision for expansion and contraction
- Not interfere with the removal of equipment, coils or other piping, nor restrict access to doors, hatches or windows.

Dissimilar metals

Make junctions between dissimilar metals with special compatible material fittings.

Joints

Fit joints tightly, seal and make leak proof, with no internal projections, burrs or obstructions.

Expansion

Make suitable provisions for expansion.

Valves

Arrange together where practicable in operational grouping, in convenient and readily accessible positions.

3.32.11 Pipeline Types

Copper Pipelines - Hydraulic Services and Compressed Air

- Pipework to AS 1432.
- Capillary Fittings to AS 3688
- Compression Fittings to AS 3688

Flanges – to be:

- Bronze brazing flanges (boss or plate type) and blind or blank flanges,
- Full face to AS 2129
- Flange material to be not inferior in joining properties to AS 1565, alloy C92610.

For brazed joints use either a capillary fitting or expand one tube over the other leaving a minimum clearance and an effective overlap of not less than the following, outline in Table 2.

Table 2 Pipe size and overlap

PIPE SIZE (mm)	OVERLAP (mm)
15 - 20	12
25 - 32	15
40 - 50	25
65 - 80	30
100-125	35
150-200	40

Brazing - use a minimum of heat and avoid damage to pipe and fittings. Brazing alloy to AS/NZS 1167.1.

- Brazing copper to copper
- Brazing copper to brass: A suitable copper to brass alloy.

UPVC pipelines

- Pipes & fittings - to AS/NZS 1477
- Moulded Fittings class - to AS/NZS 1477
- Fabricated fittings class - to AS/NZS 1477
- Installation - to AS/NZS 2032.
- Rubber ring joints - to AS/NZS 2032. After making joint, ensure that the ring is in the correct position.
- Natural Gas Pipelines
- Pipework installation - to AS/NZS 5601.
- Materials, Fittings & Jointing - to AS/NZS 5601.
- Pipe joints - to AS/NZS 5601.
- Fittings - to AS/NZS 5601.

3.32.12 Joints

Keep the number of joints used to a minimum. Use joints applicable to materials used.

Permanent joints

Provide welded or brazed joints where practicable, otherwise compression or screwed joints.

Demountable Joints

Provide demountable joints:

- Where required for maintenance of piping or fittings
- At connections to components of equipment such as coils, valves, instruments, gauges and the like

- Where permanent joints are impracticable
- Flanged for 65mm and greater
- Union type or screwed for 50mm and below

Do not use flared compression fittings in copper pipework subject to vibration or part of a hot or warm water system.

Install demountable joints in easily accessible locations for dismantling without disturbing plant or other piping. Provide an access panel for joints in inaccessible locations.

Flanged joints - to AS 2129 full face flanges with undistorted machined joint faces. Flange face and thickness must match the flange on the component to be joined provided:

- Flange is no lighter than AS 2129
- Flange is not less than 12mm thick.

Bolts for flanges - to AS 2129. Bolt thread must protrude through nut but not more than 6mm. Bolt material to be cadmium plated carbon steel in non-corrosive environments, otherwise a material with equivalent corrosion resistance to, and compatible with, the flanges.

Flange gaskets

Install flanges square with the run of pipe and aligned parallel to each other.

Screwed joints

To AS 1722. Seal the threads of screwed connections using Teflon tape or a thread sealing compound. Use for connections to screwed fittings such as valves. Make the joint as for screwed joints but fitted with a hexagon nipple. Do not use:

- Screwed joints unless welding or brazing is impracticable
- Long screws or barrel nipples.

Unions to be of proprietary manufacture with ground or accurately machined face joints and with not less than 3mm draw on the joint faces.

3.32.13 Fittings

Provide line fittings of an approved design and make suitable for the particular application.

Compressed air

Air Traps - fit air traps to drain pockets on all compressed air mains and equipment.

Vessel Height - install all vessels of sufficient height from their base to accommodate trap sets, and drains.

Air Pressure Balance Pipe - fit an air pressure balance pipe between the line and trap to prevent trap malfunction due to air binding where it is anticipated significant amounts of water may be collected such as at after coolers and at air receivers.

Drains - provide valved drains as necessary to drain liquids completely from piping systems.

Grade to rise in the direction of flow. Provide a drain at the lowest point.

Heating and chilled water

Air Vents - provide air vents, with hand operated ball valves in an accessible location

At high points in pipework systems

At the end of horizontal runs before drops

Drip Trays - provide copper drip trays under all valves and groups of valves, both manual and automatic, located as follows:

- Above all ceilings
- Under coil headers to terminal coil valve assemblies.

Strainers - provide bronze body strainers with stainless steel baskets as shown on drawings.

Install strainers in a position permitting ease of maintenance.

3.32.14 Supports

Provide supports including hangers, saddles, bolted clips and the like, sufficient to secure the pipework to adjacent surfaces, to restrain the internal forces of pressure piping, and to support it to joints, at changes of direction, and at intervals suitable to the size and type of pipe, and as necessary to prevent sagging of pipework. Make provision for adjustment of gradient as required.

Support material

Use galvanised or non-ferrous metals, with bonded PVC or fibreglass woven tape sleeves to separate dissimilar metals. Provide fixings of compatible material.

Fixing to masonry

Use galvanised steel or non-ferrous metal bolts or screws into expanding masonry anchors. Do not use explosive powered fixings.

Support spacing

Space pipe supports, hangers, anchors as shown on drawings, adjacent to all valves, not more than 600mm from changes in direction or at the distances shown in Table 3.

Table 3 Support spacing specifications

Pipe Size (mm)	Copper Pipes to AS 1432 Type B	
	Horizontal (m)	Vertical (m)
10	1.5	2
15	2	2.5
20	2	2.5
25	2	3
32	2.5	3
40	2.5	4
50	3	4
65-100	3	4
125-225	4	4
Over 225	as specified	as specified

Hanger rods

Provide hanger rods for pipe supports as listed in the table below:

Table 4 Hanger rods specifications

Pipe Size (mm)	Hanger Diameter (mm)
10	6
15	6
20	6
25	10
32	10
40	10
50	10
65	12.5
80	12.5
90	12.5
100-150	16
200-300	19
350 and over	To Structural Engineer’s specification

Pipe support attachments

Provide pipe support attachments for hanger type supports of the following type:

- Uninsulated pipe - clamp clips direct to uninsulated pipes.
- Metal sheathed pipe - clamp mild steel clips over the sheathing with mild steel spider type spacers installed between the pipe and sheathing. Hardwood ferrules may be used on low temperature systems. Make space and ferrule length not less than twice the clip width.
- Chilled water pipe - clamp mild steel clips over metal sheathed high density ferrules of length not less than twice the clip width and of thickness as specified for insulation. Ensure continuity of vapour barrier over the ferrule and insulation.

Straps - PVC piping

Provide mild steel straps or clips to the minimum dimensions as follows for securing piping.

Outside Diameter Pipe or Sheathing (mm)   Strap or Clip Dimensions (mm)

- Up to 30   25 wide x 1 thick
- 31 to 75   25 wide x 3 thick
- 26 to 250   40 wide x 6 thick
- Over 250   To Structural Engineer's specification

Straps - copper piping

Provide straps or clips as above with nylon or other suitable inserts or as follows:

- Copper material 25mm x 1.6mm thick for piping up to 50mm.
- Nylon coated steel sections 20mm wide x 5mm thick for piping up to1 50mm.

Saddle type supports

Use for supporting uninsulated pipes less than 50mm. Fix saddle to building member or supporting structure at each side of the pipe. Material of saddles as for straps.

Copper packing

Provide a 1.6mm thick soft copper packing where the pipe may be subject to chafing. Packing dimensions to suit the saddle. Securely fix packing between the pipe and the building member or supporting structure. Fit a 1.6mm thick soft copper liner between the pipe and saddle.

3.32.15 Building Works

Building penetrations

Set out core holes and sleeves in floors, walls, beams and columns. Obtain approval of set out from UOA prior to placing of concrete.

Sleeves must:

- Be provided at all piping penetrations of floors, walls, roof and equipment casings.
- Be metal in fire rated elements
- Have 12mm clearance all round pipe and insulation
- Have the clearance packed with self-extinguishing grade joint sealer.

Provide the following where pipelines penetrate fire barriers:

- Insulated pipes - Insulate the pipes with high temperature fibreglass or ceramic fibre insulation within the thickness of the barrier and for a minimum distance of 50mm on either side. Size sleeves to suit the specified thickness of pipe insulation and extend sleeves 50 mm on either side of the barrier. Insulate pipes with an approved high temperature sectional pipe insulation for a distance of 250mm beyond the sleeves on both sides of the barrier. Where the pipe insulation is required to be sheathed, overlap the sheathing over the sleeve by not less than 32mm and firmly strap to the sleeve.
- Uninsulated pipes - Extend the sleeve 50mm on either side of the barrier and provide a 13mm radial annular clearance around the pipe. Pack high temperature fibreglass or ceramic fibre insulation into the annular space and tamp into place.

Chases and encasing

Cut chases with a power saw unless otherwise approved. Do not chase reinforced concrete work without approval.

Insulate pipes chased into masonry or encased in concrete with 6mm thick hair felt, mineral wool or similar approved material wired on with copper wire, so that expansion and contraction can take place without damage to the pipe or to the material or surface finish of the surrounding element. Chased pipes are not to cross movement joints.

Pipes encased in concrete

Provide a minimum cover of 25mm and lay in continuous lengths without fittings unless the fittings are permanently accessible.

Roof penetrations

Flash pipes which pass through the roof with 19.5kg/m² sheet lead, or other materials (as required by zincanneal roofs) to approved or proprietary Dektite fittings installed to manufacturer's recommendations.

Underground installations

All chilled or heating water pipework installed underground must have provision for expansion and contraction to prevent stress failures with installation in culverts the preferred option.

Prior to any excavation, consult with UoA / Superintendent on excavation methods and seek permission to use any excavators or machinery. Excavations within vegetated landscape areas must be carried out by hand so as to avoid damage to existing trees and plants including root systems.

Determine the location of existing in-ground services prior to excavation. Refer to UoA in-ground services drawings where available.

Trenches must be excavated so that piping will be supported on a solid bed of undisturbed earth and/or earth compacted to eight blows per 300 on a penetrometer. Allow additional excavation under joints for proper installation.

All backfilling, except as noted, must be carried out with selected excavated sand, without large stones, to a depth of 300mm above the crown of pipes and with unselected sand for the remaining depth. Backfilling must be done in 300mm layers, thoroughly watered and compacted to eight blows per 300 on a penetrometer. The first 600 of all backfill over drains must be hand compacted. Large boulders, rubbish, etc., must not be used for backfilling and must be removed from the site. Backfilling around manholes and catch basins must be done with the same materials to the same depth as connecting piping.

All existing fencing, roads, footpaths, turf, vegetation and all other surfaces which have been disturbed by the operations shall be reinstated to a standard of at least equal to the standard they were in when the works commenced and to the satisfaction of the Superintendent and UoA.

Bedding

Lay metal pipes and pipes of less than 80mm size without underlay provided the trench:

- Is free from hard objects such as stones, sharp projecting rocks or tree roots.
- Bottom is trimmed to provide continuous, uniform and adequate support to the pipe.

Include chases where necessary to prevent sockets, flanges or the like from bearing on the trench bottom.

Bed UPVC pipes of 80mm pipe size or greater and metal pipes if the excavation is excessive or is unstable ground or rock on a continuous cushion of underlay material of 75mm minimum thickness.

Underlay material must be to AS 2032.

Form chases where necessary to prevent sockets, flanges or the like from bearing on the trench bottom or the bedding. Fill and compact the chases after the laying and testing of the pipes.

Fill to 150mm above the top of the pipes with underlay material compacted in layers of not more than 150mm.

Minimum cover over pipe

Apply the following unless overridden by regulatory authority requirements.

Pipes not subject to vehicular loading - 450mm

Pipes subject to vehicular loading:

- Not in roadways - 600mm
- Under sealed roadways - 600mm
- Under unsealed roadways - 750mm

Pipes in embankments or subject to construction equipment loading- 750mm

Pipework under slabs

Protect copper pipework laid in the ground beneath a concrete floor slab by:

- Encasing in continuous UPVC pipework sleeves or
- Encasing in PVC coated tube sealed to prevent ingress of moisture or
- Support on compacted underlay material 150mm thick, and provide compacted overlay and side support of fine crushed rock, grading up to a maximum size of 14mm, to not less than 150mm above the top of the pipe.

Corrosion protection

Apply anti-corrosion Denso tape to metal pipe where laid in the ground and unsleeved by spiral winding with an overlap of 55% of tape width to manufacturers' instructions.

3.32.16 Gauges

Gauges must be installed where equipment or systems require visual monitoring and must be in addition to sensors connected to the BMCS.

Gauges must:

- Be located where specified or shown on drawings.
- Be dial type
- Be calibrated in si units
- Have 100mm minimum diameter dials
- Have the range selected so that the indicator is normally at 0.7 full scale deflection.
- Have linear black graduations on a white background
- Be graduated in increments of not greater than 2% of full scale deflection.
- Be suitable for the duty specified
- Be protected from vibration
- Be labelled
- Have their normal working pressure or temperature delineated by a red line on the dial face.

Thermometers

Where required dial thermometers to be of the following types:

- Capillary type with mercury in steel and capillary to suit convenient mounting
- Rigid stem type. Provide screwed shoulders in the stem suitable for installing in a separate well.

Pressure gauges

Where required pressure gauges must be bourdon tube type with cock and comply with requirements of AS 1349, installed in the vertical position.

Test points

Provide Binder Twin-Lok test plugs for measuring temperature, pressure and flow.

3.32.17 Testing

Testing is to be carried out with UoA or their representative in attendance.

Do not cover or conceal enclosed work until it has been inspected and tested. Pipe joints should be left exposed during the tests.

Test completed pipework systems including equipment designed to withstand the test pressure.

Isolate items of equipment not designed to withstand the test pressure. Securely anchor pipes and fittings in position to prevent movement during the tests.

Repair faults and re-test if a section of pipework fails a test.

Hydraulic and Compressed Air

Test pipework at 1500kPa for 1 hour (unless overridden by regulatory authority requirements).

UPVC Pipework

Test to AS 2032. Ensure solvent cement joints have been cured for 24 hours before testing.

Cleaning Out

Clean piping of loose scale and dirt before and after installation and sealing of joints. Flush hydraulic piping systems with clear water to remove foreign matter.

Capping off

Seal temporarily open ends of pipes and valves during construction to prevent the entry of foreign matter into pipe systems. Use purpose made covers of pressed steel or rigid plastic. Do not use rags, paper or wood plugs.

3.32.18 Pipework Insulation

Generally any pipework where the absence of insulation would increase energy requirements during normal system operation and exposed pipework where the surface temperature is liable to be below ambient air dewpoint.

Buried Chilled Water Pipework

- Chilled Water PVC flow lines only
- Chilled Water steel or copper flow and returns
- Heating Water flow and returns
- Refrigeration suction and liquid lines

Above ground pipework

Chilled water flow and returns

- Heating water flow and returns
- Domestic hot water in plant rooms
- Domestic hot water ring mains and spurs in roof spaces, ceiling spaces and voids
- Refrigerant Suction Lines not located in coolrooms or freezers
- Refrigerant Liquid Lines strapped to suction lines for sub-cooling

Insulation material

The preferred pipework insulating material is preformed closed cell synthetic elastomer with smooth vapour barrier out surface; to AS 4426 - Nitrile rubber (closed cell) applied with adhesive and finish as recommended by the insulation material manufacturer.

Existing pipework

Where installation work involves alterations to existing pipework, the new work and reinstated works should be insulated to match the existing insulation in thickness and finish.

Buried chilled water and heating water pipework

Where available, generally up to 140mm pipe O.D. 25mm thick preformed tubular sections are preferred, selected to accurately match the pipe O.D. for a tight fit without longitudinal joints.

On larger diameter pipework, where preformed tubular sections are not available, sheet material 25mm thick should be applied to individual pipe lengths clear of the trench before installation, leaving sockets exposed and with axially staggered longitudinal joints.

All joints, longitudinal and circumferential to be sealed with approved adhesive to ensure a complete vapour seal and a tight fit to the pipe surface without air gaps.

The insulation must be wrapped with 100 wide black PVC tape with 25mm overlap for the entire length of the section. After installation and leak testing in the trench, the sockets should be insulated in a similar manner and wrapped in tape to form a continuous vapour seal without air pockets.

Above ground pipework

Insulate with preformed tubular sections, selected to accurately match the pipe O.D. for a tight fit without longitudinal joints.

Circumferential butt joints to be sealed with approved adhesive to ensure a complete vapour seal without air gaps and the butt joint wrapped with a complete layer of self-adhesive 3mm x 50mm wide tape, of the same elastomeric material as the insulation. Aerotape or approved equivalent.

Valve bodies, test pockets, air vents and drains on chilled water pipework to be wrapped with sufficient layers of polymer based, synthetic rubber and asphalt, cork impregnated pipe insulating tape - "Everseal" or approved equivalent - to eliminate condensation forming under any operating conditions.

Minimum insulation thickness

Insulated pipework must be in accordance with R values nominated in Section J of the specified version of the National Construction Code.

Rigid Preformed Cold and Heating Pipework Insulation

Must be applied in designated plant rooms in accordance with the National Construction Code.

Metal sheathing

Metal sheathing of insulation is required in:

- New plantrooms on insulated pipework and vessels

- Service locations, adjacent to walkways and to a height of 1,800mm on adjacent risers
- Locations exposed to view in occupied spaces
- Outdoor locations exposed to the weather

Aluminium cladding minimum 0.5mm is the preferred sheathing material, installed by approved insulation tradespersons.

Accurately prefabricated sections sprung over the insulation and clamped neatly in position, with longitudinal joints not exposed to view or in a downward position where exposed to weather and traverse joints lapped with a beaded edge. In exposed locations weatherproof external joints with non-setting mastic. Aluminium should only be used to match existing where additional pipework is installed alongside.

On cold piping, care is required not to penetrate vapour barriers and self- tapping screws or rivets should not be used. Clamp at minimum 450mm centres with 12mm wide x 0.15mm straps of same material as sheathing.

Painting insulation

Painting of insulation is required:

- For service identification in plantrooms, as per Section 4.10 of this document.
- For UV protection where exposed to direct sunlight.
- For architectural requirements in locations exposed to public view.

Select approved paint with sufficient flexibility and adhesion characteristics to resist cracking or peeling from the flexible surface of the insulation.

3.33 Fume cupboards

This section nominates UoA's minimum requirements with respect to the installation, design and maintenance of general purpose fume cupboards, as well as the testing methods to be used to determine their performance. Fume cupboards covered by this section are intended primarily for use in general chemical operations, but may also be used for special applications providing that the additional relevant features described are incorporated.

The fume cupboard make and models must be approved by UoA before purchase and installation.

There must be easy access to all component parts requiring service. A prototype fume cupboard must be made for inspection and acceptance by UoA. Allowances must be made for changes to the cupboard to the requirements of UoA before production of final units.

All laboratory fittings in fume cupboards must be powder coated to colours as per Section 4.10 of this document.

As a minimum the following items must be included with each fume cupboard installed on the campus:-

Fume cupboards to be selected to suit the laboratory function and be compliant with AS/NZS 2243

Manufacturer to provide to the University all access codes to the fume cupboard control and monitoring systems. All access code must to issued before the end of the product DLP.

Issue full operating and maintenance manuals for the fume cupboards

Manufacturer to supply fume cupboards which have a control system with a minimum life span of at least 5 years

3.33.1 Design procedures

Risk assessment

The project design team must consult with academic and technical staff of the relevant UoA Faculty or School and UoA Safety, Health and Wellbeing to obtain a risk assessment of the materials and procedures to be used during the life of the proposed fume cupboard. It is then the responsibility of the design team or designer to translate this risk assessment into a proper design approach.

Laboratory exposure to infectious and hazardous materials may be fatal so risk assessment and appropriate design are vital in fume cupboard design.

Some criteria for consideration include:

- The design must satisfy the requirements for safe management of the various types of hazards likely to be encountered.
- The design must facilitate research productivity.
- Safety features designed into the cupboard should closely match the assessed degree of risk of the research.
- The design must be made as flexible as possible since the use of a fume cupboard is likely to change during its lifetime.
- The design is economical to operate and construct.

Safety requirements

The design and installation of fume cupboards must comply with AS/NZS 2243.3.

In certain installations, UoA may require fume cupboards to be equipped with alarms to detect failure of exhaust air flow and/or low face velocity. Devices which monitor face velocity are recommended. An alarm, which must be visual and audible, should be extended to all cupboards served by the same exhaust fan.

Recycling of exhaust air must be avoided. Construction of a building model and wind tunnel analysis may be required. Where the proposed installation is adjacent to other facilities, exhaust stack height and exhaust exit velocities must be chosen to ensure that exhaust air is safely discharged beyond the building's atmospheric boundary layer, and in such a way that it does not affect nearby buildings.

3.33.2 Materials

Procedures and recommendations for the selection of materials and construction are as follows:

- Determine the type of effluent that must be generated in the fume cupboard and handled by the exhaust system.
- Classify types as organic or inorganic, and state whether they occur in gaseous, particulate or vapour form. Also classify decontamination materials if used.
- Determine the concentrations of reagents used and the temperature of the effluent at the fume cupboard exhaust throat. Although it may prove difficult, some attempt should be made in determining the likely range of reagents and concentrations used.
- Determine whether a fume scrubbing system will be required.
- Estimate the highest probable dewpoint of the effluents.
- Determine the likely ambient temperatures of the spaces in which the exhaust ductwork and exhaust fans will be located.
- Consider the length and arrangement of duct runs and how they may affect the periods of exposure to fumes and the degree of condensation that may occur.
- Determine whether water sprays will be required within ducts and at what intervals.
- Determine the slope and drainage requirements and the means to achieve leak proof joins.
- Determine whether exhaust ducts will require external insulation.
- Determine the means of achieving the required fire rating for penetrations through different fire compartments.
- Determine whether the fume cupboard exhaust fan should operate at 10% of full flow when turned off at the fume cupboard.
- Select materials most suitable for the application, considering resistance to attack, weight, flame and smoke spread rating, and cost.
- Determine the method to be used for testing exhaust duct leak tightness.

3.33.3 Fans

Fans must be of the centrifugal type with a pressure-flow characteristic that allows "constant" flow with pressure variations, or a flat flow-pressure loss profile.

Fans must generally be of the centrifugal type and must be direct driven. The fan motor and drive assembly must be located externally to the duct for ease of servicing. In general, fans must comply with the appropriate clauses in AS/NZS 2243.8 and must have polypropylene injection moulded forward curved multivane impellers ensuring no metal parts are in contact with the fumes and provide quiet operation at reduced power consumption.

The complete fan and motor drive assembly must be mounted on a rigid galvanised steel frame which, in turn, must have sufficient vibration isolation from any building structural components.

Vibration mounts must be of a type to ensure that no greater than 2% of vibration is transmitted to the underlying structure. Waffle pad mounting must also be installed to prevent high frequency sound transmission. The support system must be arranged to ensure the fan is restrained and that no flanking vibration paths have been established.

3.33.4 Fume discharge duct velocities

Duct velocities must comply with the appropriate clauses in AS/NZS 2243.8 for vapours, gases and smokes.

The discharge velocity must be between 10m/s and 15m/s and should be discharged through a flue of sufficient height to penetrate the building boundary layer and must be a minimum of 3m above the highest point of the roof.

All bends in fume cupboard exhaust ducts should be sweep bends.

The fume cupboard duct should proceed by the shortest path incorporating a minimum of horizontal sections to the discharge point above the building. It is desirable that horizontal sections slope back to the fume cupboard, but where this cannot be achieved, the horizontal section must be fitted with drains connected to the fume cupboard drainage system to carry away condensate and wash-down water.

Care must be taken to ensure the integrity of duct work joints on the discharge side of the fume cupboard exhaust fan.

Where a fume cupboard exhaust duct passes through fire rated compartments in a building other than the one in which the fume cupboard is located, the exhaust duct must be clad or enclosed in a fire resistant material to preserve the integrity of the fire rating of each compartment traversed by that exhaust duct.

All fume cupboard exhaust ductwork seams to be plastic welded

3.33.5 Commissioning

Each fume cupboard must undergo commissioning tests in accordance with the appropriate sections of AS/NZS2243.8.

The fume cupboard face velocity must be tested in accordance with AS/NZS 2243.8.

Testing Label

Personnel performing the test must affix an adhesive label to the lower right hand corner of the sash stating that the fume cupboard has been tested according to AS2243.8 and showing:

- Date of test
- Smoke Test result
- Average face velocity m/s
- Date for next test
- Signature

3.33.6 Electrical services

All electrical services must be in accordance with AS/NZS2243.7, AS/NZS3000 and UOA Electrical Design Standards – Electrical Services. Services must only be installed by a contractor on UOA's Preferred Contractors list.

Thermal detector

The fume cupboard exhaust air outlet must be fitted with a thermal detector. The detector must have a range of 40 to 100°C. The detector must be adjustable in increments of 2K and its probe within the air stream must be enclosed within heat-shrink PVC tubing.

For laboratories not air conditioned the detector must be set to activate at a temperature of 55°C±5K. For air conditioned laboratories the detector must be set to activate at a temperature of 45°C±5K.

Activation of the detector must initiate the following functions:

- Activate the solenoid valve controlling the water spray in the fume cupboard
- Isolate any piped flammable gas supply to the fume cupboard
- Isolate the SSOs on the fume cupboard
- Start the fume cupboard exhaust fan (if not already operating).

Fire alarm

To connect the fume cupboard to the building fire alarm system, a second thermal detector of the same type must be located in the fume cupboard exhaust throat and be set to the same operating temperature. This second detector must be linked directly into the building fire alarm system.

3.33.7 Colour coding

All service controls and outlets are to be colour coded and labelled to conform to AS 1345 and AS 2700 and Section 4.10 of this document.

3.33.8 Access panels

Removable panels must be provided where required for easy access to components within the fume cupboard.

3.34 Evaporative coolers

All plumbing to cooling towers and evaporative coolers must be installed to AS/NZS 3500. Applications and permits must be submitted to the relevant authorities prior to the commencement of work.

Plumbing work must be undertaken under the direction of a licensed plumber on UoA's Preferred Contractors list. All plumbing work must be installed to AS /NZS 3500, UOA Design and Construction Standards – Hydraulic Services and any other relevant codes.

Electrical work must be undertaken by a registered licensed electrical contractor on UoA's Preferred Contractors list. All electrical work must be to AS/NZS 3000, UOA Design and Construction Standards – Electrical Services and any other relevant codes.

All electricians and plumbers should be aware of the risks attached to non-conforming systems.

Ensure the evaporative coolers are installed with dedicated access for maintenance activities. All plant installed by the project must have local technical support for the unit during and after the DLP has expire.

3.34.1 Location

Installation and positioning of evaporative coolers must be approved by UoA prior to commencement of work. Failure to do so may result in the contractor being asked to remove or replace the non- conforming items and make good.

3.34.2 Dump and cold water solenoid valves

Dump valves and cold water solenoid valves must be fitted to all evaporative coolers in accordance with the requirements of AS/NZS 3666.

All valves used on evaporative cooler installations must be compliant with AC/NZS 3666. No other type will be accepted.

3.34.3 Backflow requirements

Evaporative coolers must meet backflow requirements as per AS/NZS 3500. All dump and overflow lines shall be SWV PVC pipe. All copper lines shall be Type B as per AS 1432.

3.34.4 Waste outlet

Where evaporative coolers are installed at ground level, the waste lines from the basin shall be run to a sewer. A type A gap between the drain and the end of the waste pipe compliant with AS/NZS 3500.

Where evaporative coolers are installed on a tile roof, the waste line shall be run down the wall of the building, terminating in a 45 degree bend over a tundish or gulley connected to the sewer system.

Where evaporative coolers are located on a metal deck roof, waste water shall not run onto the roof and be terminated over a tundish which is connected to sewer.

3.34.5 Overflows

The overflow from evaporative coolers must terminate in a visible place, ie., over the edge of a parapet. If the contractor is unsure where to run the overflow, consult with UoA.

3.34.6 Roof penetrations

Avoid roof penetrations where possible. Utilise existing risers and openings.

Electrical and plumbing penetrations through the metal deck roof must be sealed using Decktite boots (roofing collars), selected for a weathertight fit.

All copper water pipes and drainage pipework must be secured to the ribs on the decking roof. Clip spacing must be as per AS/NZS 3500.

3.34.7 Roof protection

Before commissioning evaporative coolers, an area of one meter square around the evaporative cooler and the same width down to the gutters must be painted. All pans and ribs running down to the gutter must be painted as per Architectural specifications.

3.34.8 Water connection

Water connections and waste outlets for evaporative air conditioning equipment must Comply with AS/NZS3500 and be compliant with local codes. The isolating valve must be located in an accessible position not greater than 1.8m above ground level. Confirm with the University if the project requires metering of water from the evaporative units and connection to the BMS.

3.35 Cooling towers

Cooling towers must be CTI certified, technical data to be submitted for review. The proposed cooling towers must have local support for the supply of spare parts and technical services during the operating life of the cooling tower.

Particular care must be taken when locating cooling towers, the cooling tower location and installation to comply with AS/NZS3666. Cooling towers must be well away from outside air inlets to air conditioning systems. Under no circumstances should cooling towers be located so that overspray can enter the interior of a building or drift over passers-by. Refer to AS/NZS 3666.

Make up water connections must be installed to AS /NZS 3500.

The cooling towers to be connected into the BMS for monitoring and control functions. The actual BMS requirements to be project specific, but as a minimum the following items should be included: -

- General cooling tower fault
- Water treatment system fault alarm

Filtration

The use of side stream filtration should be excluded from the cooling tower design.

3.35.1 Structure

The cooling tower structure and casing must be constructed of high strength pultruded composite materials. All pultruded composite components must be moulded to exacting standards with UV resistant polyester resins such that UV protection is afforded throughout the entire embodiment of the components as well as being an externally applied coating. All internal surfaces of the casing, basin, roof deck and fan cylinder must have an even and regular smooth faced finish resulting from either an open moulding or pultruded moulding process where the faces of these components come into direct contact with the mould to facilitate easy cleaning. Internal flow coated surfaces that have not come in contact with the mould must not be acceptable.

3.35.2 Basin

The basin must have a smooth internal finish and slope to a centre drain for ease of cleaning as nominated in AS 3666. A suction, drain, overflow and quick fill connections must be furnished as standard and comply with AS 3500 where applicable. The suction connection must be manufactured for high strength and durability and be table "E" flanged pattern in accordance with AS 2129. Easy and complete access must be possible from all sides.

3.35.3 Air inlet louvres

Air inlet louvres must be PVC, designed to prevent splash-out and minimise the passage of sunlight to the cooling tower interior. Louvres must be easily removable lightweight sections providing easy access for cleaning. A deflector must be factory fitted at the bottom of and inside the louvres to direct water away from the louvre preventing splash-out. The complete arrangement to be compliant with AS/NZS3666.

3.35.4 Access

Provide maintenance access as required by the manufacturer and AS/NZS3666.

3.35.5 Ladder and service platform

A hot dipped galvanized ladder and service platform must be provided and installed by the cooling tower manufacturer.

A low level platform for basin access must be provided and installed by the cooling tower manufacturer.

Supplied equipment must conform to current UOA Safety Health and Wellbeing, Worksafe safety requirements and AS/NZS 3666

3.35.6 Wet deck surface (fill media)

The PVC film type fill must be impervious to rot, decay and fungus or biological attacks. It must consist of high efficiency cross fluted sheets solvent welded into lightweight blocks sized for easy handling and removal for cleaning. The fill media must comply with CTI Standard STD136.

3.35.7 Water distribution system

Water must be distributed evenly over the wet deck surface by a low pressure, stationary, non-rotating type water distribution system incorporating heavy duty PVC spray branches and plastic spray nozzles. Branches and nozzles must be easily removable and the nozzles held into place with snap rubber grommets.

3.35.8 Water level control

Water level must be controlled utilising a 5 probe sensor mounted externally on each of the basins. The probe must include high and low level water alarms suitable for connection to the BMCS.

The systems must provide slow opening and closing of the make-up water supply to each tower with positive closure to prevent water hammer.

Mechanical backup in the form of an isolator and float valve must be provided on each tower so that the tower can remain operational during service of the electric control system.

3.35.9 Drift eliminators

The PVC drift eliminators must be UV resistant and impervious to rot, decay and fungus or biological attacks. They must consist of high efficiency three pass wave formed blades solvent welded into lightweight, easily removable sections. Drift loss must be less than 0.002% of the circulated water flow as required by AS/NZS 3666.

3.35.10 Strainer

The cold water basin strainer must be a 304-grade stainless steel cylindrical type having a solid top cover plate with a perforated mesh bottom of sufficient open area relative to the suction flow rate and by design, prevent vortexing at the outlet.

3.35.11 Hardware

All wetted hardware, fill, eliminator, water distribution supports and miscellaneous metal components shall be per design documents.

3.35.12 Accessories

- As required by design documents
- Provide proprietary access systems with the facility to removes motors and the like during maintenance activities.

3.35.13 Mechanical equipment

Fan

The adjustable pitch axial flow fans must be of low noise, multi-blade type heavy duty non-corrosive composite material. The fans must operate within a FRP fan cylinder having an even and regular smooth faced internal finish ensuring a streamlined air entry and minimum tip clearance for maximum fan efficiency.

Motors

The fan motors must be to IP55 standard if outside the moist discharge air stream or IP56 if mounted in the air stream with Class F insulation specifically designed for cooling tower service.

Units with fan motor located on the fan deck must be provided with safety perimeter handrails around the entire perimeter of the cooling tower casing.

Each cooling tower cell must be supplied with a motor davit and base for easy removal of each fan motor.

Mechanical support

The mechanical support must be of 304 stainless steel construction.

The fan shaft must be of 304 stainless steel supported by heavy duty, self- aligning, grease packed ball bearings specifically suited to vertical shaft application with moisture proof seals and integral slingers. Extended lubrication lines must be provided as standard to the bearings with grease nipples located outside for ease of scheduled maintenance.

Belt drive

Units must be fitted with a belt drive. Motors, if located in the discharge air stream, must have a suitable IP rating for the duty.

Motor and fan pulleys must be of aluminium type. Mild steel pulleys are not acceptable.

3.35.14 Warranty

Cooling tower warranty must be for a minimum period of five (5) years.

3.35.15 Tests

A simple thermal test must be carried out on the cooling tower to assess its performance at time of commissioning on a design day. The test must consist of water in and out temperatures, water flow rates and air in and out wet bulb and dry bulb temperatures. If the results of this test fail to prove the cooling tower capacity then at the discretion of the Superintendent the cooling tower must be tested to the CTI requirements. Should the cooling tower fail to meet the specified duty then the cooling tower must be rectified to provide cooling tower performance to the specified duty.

3.35.16 Plumbing Approvals

All plumbing to cooling towers must be installed to AS/NZS 3500. Applications and permits must be submitted to the relevant authorities prior to the commencement of work.

3.36 Cool rooms, freezers and constant temperature rooms

Rooms with typical Cool Room construction are installed in laboratory areas for experimental work and in catering areas for food storage.

- COOL ROOMS served by refrigerated forced draft coolers are generally controlled down to 0°C.
- FREEZER ROOMS served by refrigerated forced draft coolers are generally controlled to -20°C.
- C.T. ROOMS (Constant Temperature Rooms) served by chilled water air handling units are generally controlled down to +18°C.
- C.T ROOMS served by glycol air handling units are generally controlled down to +5°C.
- Install all plant and equipment for compliant maintenance access as required by the manufacturer.
- Provide a current control system which has a minimum operating life of a least 5 years
- Connect the control system for monitoring and fault alarms

3.36.1 Refrigeration electrical work

Electrical work must be in accordance with AS/NZS 3000 and UOA Electrical Design Standards.

The electrical work associated with the refrigeration plant essentially comprises:

- All power and control wiring between the condensing units, switchboards, thermostats, solenoid valve, safety controls etc.
- Electrical testing and commissioning of all electrical equipment.
- Supply of "as wired" electrical drawings.
- Provision of a remote alarm fault signal to the BMS system.

- Cool Room must have fluorescent fitting (rated at -7oC) or equivalent standard fitting to UOA's approval. The light fitting must have electronic control gear with 0.95 PF, and a 4000K, Ra>84 Triphosphor tube with a minimum life of 13,000 hrs. Light switches and socket outlets must be IP56 rated.
- Freezer Room must have fluorescent fitting (rated at -30°C) or equivalent Standard fitting to UOA's approval. The light fitting must have electronic control gear with 0.95 PF and a 4000K, Ra>84 Triphosphor tube with a minimum life of 13,000hrs. Light switches must be IP66 rated. Socket outlets not required.
- Light switches must be mounted adjacent to the door inside the room - not switched from outside the room, with a neon indicating light outside the room adjacent to the door that is illuminated when the lights are turned on.

3.37 Refrigeration pipework

3.37.1 Pipework

Refrigeration pipework must comply with AS/NZS 1571.

Pipework must be supplied in straight lengths and in the 'Hard-Drawn' temper unless annealed tubes (supplied in straight lengths or coiled) are necessary to meet a specific purpose and must be installed in accordance with AS/NZS 1677.

Fittings must be brass with flare, internal flare, capillary brazing or threaded ends, or combinations in accordance with ANSI B70.1 or equivalent. Flare type fittings to AS D26.

Flare nuts must be of:

- Frost proof design when used in refrigerant suction piping.
- Of the long pattern type wherever prone to vibration. Copper flare gaskets and flare seal bonnets must be to ansi b70.1.

3.37.2 Supports

For pipe support attachments for insulated pipe, clamp mild steel clips over metal sheathed high density ferrules of length not less than twice the clip width and of thickness as specified for insulation.

Ensure continuity of vapour barrier over the ferrule and insulation.

3.37.3 Pipework insulation

Generally, any pipework where the absence of insulation would increase energy requirements during normal system operation and exposed pipework where the surface temperature is liable to be below ambient air dewpoint, e.g.:

- Refrigerant Suction Lines not located in cool rooms or freezers
- Refrigerant Liquid Lines strapped to suction lines for sub-cooling.

Insulated pipework must be in accordance with R values nominated in Section J of the specified version of the National Construction Code.

Insulation material

The preferred pipework insulating material is preformed closed cell synthetic elastomer with smooth vapour barrier out surface to AS 4426 Nitrile rubber (closed cell) applied with adhesive and finish as recommended by the insulation material manufacturer.

Application of flexible insulation

- Apply to straight lengths, formed sets and bends prior to erection without longitudinal joints
- Neatly cut and form around fittings
- Seal at all joints with adhesive and finish as recommended by the insulation material manufacturer to provide effective vapour seal and UV protection.
- Insulate with preformed tubular sections, selected to accurately match the pipe O.D. for a tight fit without longitudinal joints.

Circumferential butt joints to be sealed with approved adhesive to ensure a complete vapour seal without air gaps and the butt joint wrapped with a complete layer of self-adhesive 3mm x 50mm wide tape, of the same elastomeric material as the insulation. Aerotape or approved equivalent.

Aluminium or sheet metal cladding

Aluminium or sheet metal cladding only required on insulated pipework must be provided:

- To prevent damage in trafficable locations, adjacent to walkways and access-ways, and to a height of 1800mm on adjacent risers.
- In existing plantrooms, where modifications are carried out to existing clad pipework, and to match existing where additional pipework is installed alongside clad pipework.
- In locations exposed to public view.

Painting insulation

Painting of insulation is required for:

- Service identification in plantrooms, as per Section 4.10 of this document.
- UV protection where exposed to direct sunlight.
- Architectural requirements in locations exposed to public view.

Select approved paint with sufficient flexibility and adhesion characteristics to resist cracking or peeling from the flexible surface of the insulation.

3.37.4 Refrigeration systems testing

Refrigeration systems must comply in all respects with AS/NZS 1677 and must be subject to the following pre-commissioning and commissioning tests.

Equipment must pass appropriate tests at the manufacturer's works and certification of the tests must be submitted, on request, to UoA.

Pressure tests

Pressure tests must be carried out using dry nitrogen gas to a pressure of 1750kPa.

Compressors must be isolated from the test circuit on pressures greater than 700kPa, if required to avoid damage to the mechanical seal of open unit compressors.

The liquid solenoid valve must be energised or mechanically opened before the tests.

Insulation of the refrigeration system must be left until the pressure tests are satisfactorily completed.

Leaks must be detected using approved electronic detectors or by using soap and water on joints.

The ambient temperature and pressure shall be recorded and the test pressure of 1750kPa shall be held for at least twelve hours (overnight) or twenty four hours if possible, without a measurable pressure drop.

Pressure change for ambient change will be recognised.

Nitrogen manifold gauges will not be accepted for checking minor pressure variations.

Pressure test shall be repeated after leaks are corrected.

Evacuation tests

The refrigeration system (including the compressor) shall be dehydrated, by means of a high vacuum pump to a pressure of 300microns Hg (40Pa).

Line connections from the pump to the system shall be as short as possible and of as large a diameter as is practicable e.g., 13mm.

The pump and compressor must be isolated and the system swept with dry nitrogen to a pressure of 350kPa.

Evacuate the system (not including the compressor) to 100microns and hold for a minimum of two hours with the pump off. Break the vacuum with dry nitrogen gas and pressurise to 70kPa.

Before further evacuation is commenced the compressor oil must be added, line filters fitted, all valves open and controls connected.

The refrigeration system must be again dehydrated to 100microns and held in this condition for one hour with the vacuum pump off. Pressure should not rise above 250microns during this period and should correspond to standard system pressure rise curves.

If the system fails to hold these conditions below 250microns, the pump shall be brought back on line and the system further dehydrated until the requirements are met.

Purging nitrogen gas from the system shall be made from a point in the system as far away from the nitrogen inlet connections as possible. This will tend to sweep moisture and particles out of the system.

Charging

Before compressors are operated, the lubrication shall be checked and oil added where necessary.

The system refrigerant gas charge should be calculated and the quantity of refrigerant required should be delivered to site in pre-weighed cylinders.

All oil must be delivered to the site in sealed containers, which must not be opened until the oil temperature is above the dew point of the ambient air.

The compressor(s) oil level(s) shall be checked and oil either added or removed to bring oil level(s) to the recommended level.

At the conclusion of the final evacuation, the pre-weighed cylinder of refrigerant shall be connected to the charging valve on the high side of the equipment. In the charging line there should be a sight glass and a line drier.

On completion of charging the system, allow the plant to operate for four hours, and then check the entire system with a halide leak detector or an electronic leak detector.

The strainer/drier elements must be replaced after 60 hours operation or earlier if inspection indicates substantial foreign material in the system.

3.38 Building management and control systems

All air conditioning and mechanical services controls must operate with Native BacNet and integrated to the Campus enterprise network. On the North Terrace Campus the system is to be Automated Logic WebCtrl.

The BMS system must integrate with the University Syllabus Plus system for A/C operation in common teaching areas as per the syllabus plus schedules.

All BacNet objects are to be Network visible to allow integration of Fault Detection Diagnostic systems.

The BMCS works should be coordinated with the Communication systems for the use of integrated ELV cabling systems where required for the project. All cabling systems, cable containment and outlet configurations/ labelling protocols should be coordinated with the requirements as described in the UOA Design and Construction Standards – Electrical and Communications Services.

A Functional Description shall be provided by the contractor within the as-constructed documentation.

3.38.1 Local push buttons

Local push buttons with neon indicator "RUN" lights, in designated locations, are required to start-stop air conditioning, with local run-on adjustable timer (normally set for one hour).

The BMCS facilitates programming of run times on a selected daily basis. Activation of the push button runs the related air conditioning system either for that (one hour) period set on the local timer, or, if activated during a BMCS programmed time until the end of that selected period.

Activation of the push button switches the air conditioning off in either case.

If the system is running on the local (one hour) timer at the start of a BMCS programmed period, the system will continue to run until the end of that programmed period unless the local button is activated.

The local start/stop functions can also be controlled from the BMCS in Central Plant.

3.38.2 Building energy monitoring

Each Building shall be provided with chilled water energy monitoring comprising electromagnetic flow metering and temperature differential measurement to process and record building chilled water energy usage. The metering system proposed must be compatible with the Schneider PME System.

Pulse type flow meters must be provided on gas supply and heating water system makeup.

3.38.3 Mechanical services switchboards

All switchboards including the mechanical services switchboards (MSSBs) and any other plant specific switchboards should be designed and specified in accordance with the Electrical Design Standards.

It is important that the Mechanical Services consultant coordinates closely with the Electrical Services consultant to ensure that the design philosophy for the whole of the electrical works is carried across into the Mechanical services design, documentation and specifications.

3.38.4 Electric motors and motor control equipment

All electrical motors must be suitable for operation on 415/240 volts.

High efficiency motors

UoA will only accept High Efficiency Electric Motors that comply with the Federal Government's energy ratings that are available on www.energyrating.gov.au.

In works where there are multiple motor drives, select the most common brand of the top three motor brands for each motor kW size required.

All High Efficiency Electric Motors must comply with AS-NZS 1359.5.

All High Efficiency Electric Motors are to be selected to operate between 80 and 100% of full load kW.

During commissioning, contractors will be expected to carry out spot checks on fan capacities and motor kW loadings as requested.

Motors should be selected for their duty. Ball or roller bearings must be specified except in areas where noise from these motors may be a nuisance when sleeve bearings may be permitted. When situated close to teaching areas, super-silent type must be specified.

Thermal overloads are to be set at the maximum current specified on the name plate of the motor.

Makes of contactors or motor starters will be specified and the selection will not be left to the discretion of the contractor.

The following motor starting guidelines should be coordinated with the Electrical Services design. Generally:

- Motors up to and including 4kW may be started DOL
- Motors from 5.5 - 8kW VSD
- Motors above 8kW to be auto-transformer started via VSD Motor Control Cubicles

All motor-control cubicles shall be supplied complete with a circuit diagram drawn in the standard used by UoA. Wiring in control cubicles must bear the same numbering as the diagram consisting of a white numbered slip on plastic ferrules close to each wire termination.

The appearance and marking of motor-control equipment must conform to AS 1431. Colours of indicating lights in particular must conform to the following standard:

- Green light - Switch open. Motor not running. (Ready IEC)
- Red light - Switch closed. Power on.

Motor can be assumed to be running (Abnormal IEC)

- Yellow or Amber light - Switch tripped on Fault (Caution IEC)
- White - Normal Operation IEC

3.38.5 Variable speed drives

Variable Speed Drives (VSDs) must be used for control of mechanical equipment such as pumps and air handling units.

All VSDs must be Danfoss.

VSDs should be appropriately sized for the application or equipment of which it is serving. Installation should be in line with manufacturers requirements.

VSDs should be supplied with harmonic and RFI filtering equipment to meet project specific requirements.

3.38.6 Size of control panel

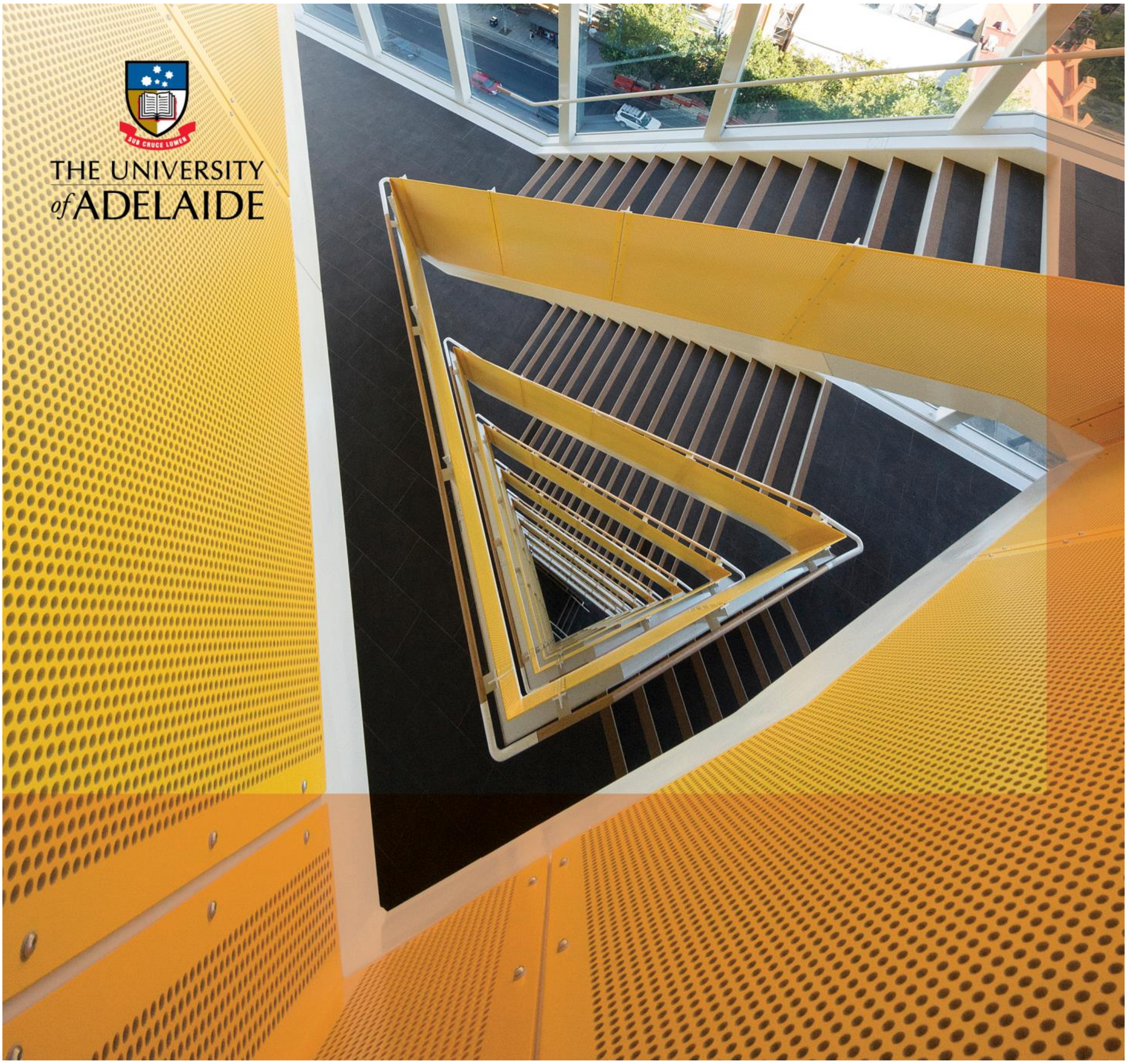
Each control panel must be sized in line with the design documentations . The number of power circuits continually grow as additional equipment are added. New control panels therefore should have at least 200% additional spare capacity when installed.

Surge suppression must be installed to protect the equipment connected to the board. Surge suppression must be installed with the indicators visible through the escutcheon or neon indicators showing suppression healthy and be connected to the BMCS.

3.38.7 Toilet ventilation systems

Lighting and ventilation must be controlled by movement sensors strategically placed to cover the trafficable zones. The sensor must be set so the lights and ventilation stay ON for a least a minimum of ten minutes after the last occupant vacated the toilets.

The fan status to be monitored by the BMS. Raise a fault alarm should the fan stop operating when a run signal has been raised by the PIR / or BMS.



SCHEDULES

C. Mechanical Services

4. Schedules

4.1 Laboratory and fume cupboard polyester powder coated tap colours

SERVICE	TAP IDENTIFICATION	
	JOTUN COLOUR	JOTUN NUMBER
Air	Horizon Blue	PE 754134
Vacuum	Autumn Red	PE 734120 SG
Nitrogen Gas	Notre Dame	PE 774201
Acetylene	Claret	PE 35057 SG
Oxygen	Gloss Black	PE 775197
Helium	Hammersley Brown	PE 784082 W
Carbon Dioxide	Transformer Grey	PE 775242
Deionised Water	Cabana Green	PE 765098
Natural Gas	Primrose	PE 744161
Non Potable Water	Cabana Green	PE 765098
Potable Water	Atlantic Blue	PE 750226
Carbogen	Gloss Black - Transformer Grey	PE 775197 PE 775242
Argon	Wizard	PE 754180
Nitrous Oxide	French Blue	PE 754187

4.2 Laboratory and fume cupboard pipeline identification colours

SERVICE	BACKGROUND COLOUR		BANDING COLOUR		LABEL	
	NAME	AS.2700 NO	NAME	AS.2700 NO	LETTERING	COLOUR
Compressed Air	Light Blue	Aqua B.25			CA" "kPa	WHITE
Laboratory Vacuum	Light Blue	Aqua B.25			VACUUM	WHITE
Pathological Suction	Red Gum	Red Gum R.53	Yellow Black 45o Stripe	Y.14	PATHOLOGICAL SUCTION	WHITE
Nitrogen Gas	Pewter	N.63	-	-	NITROGEN	WHITE
Acetylene	Claret	R.55	Yellow Black 45o Stripe	Y.14	ACETYLENE	WHITE
Oxygen	Black	-	-	-	OXYGEN	WHITE
Helium	Brown	X.54	Yellow Black 45o Stripe	Y.14	HELIUM	WHITE
Carbon Dioxide	Green/Grey	N.32			CARBON DIOXIDE	WHITE
De-ionised Water	Green	Jade G.21			DE-IONISED WATER	WHITE
Natural Gas	Yellow Ochre	Sand Y.44	Yellow Black 45o Stripe	Y.14	NATURAL GAS	BLACK
Non Potable Water	Green	Jade G.21				
Potable Water	Green	Jade G.21	Mid Blue	B.15		
Carbogen	Green/Grey	N.32	Black		CARBOGEN	BLACK
Argon	Blue	Peacock T.53	Yellow Black 45o Stripe	Y.14	ARGON	BLACK
Nitrous Oxide	Blue	Ultra Marine B.21	Yellow Black 45o Stripe	Y.14	NITROUS OXIDE	WHITE

Note:

Labels to be to AS.2896 Fig. 3.3 and AS.1345 Fig 1 (Pipe Markers)

Symbols for Ionizing Radiation and Biological Hazards to be to AS.1345 Fig.2.