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E.2 MECHANICAL SERVICES – SCHEDULE OF CHANGES – REVISION 4.1

As a guide only, attention is drawn to changes that have been made in the following clauses since the last revision:

Revision	Date	Details
General revision		
Rev 4.1	August 2004	General Update
Rev 4.2	February 2014	General Update
Rev 5	April 2016	General Update
Rev 6	April 2018	Formatting Update + General Updates

E.2 MECHANICAL SERVICES

E.2.1 General

This section outlines the University's minimum requirements for air conditioning and ventilation systems. It describes some of the materials, equipment, methods of construction and installation that is required by the UNSW.

This section is a Specification Document for use by the designers. It does not replace the project specification which should describe and detail all the equipment, method of installation, commissioning, testing, etc required for that particular project.

Sensible and appropriate levels of technology and design should be applied to obtain the correct level of quality and reduce energy wastage and carbon dioxide emissions arising from the building operation without reducing the functional standards necessary.

The mechanical services shall be comprised of systems and equipment that have been tried and tested. Service options with brand new or untried technologies or suppliers will not be accepted without approval by UNSW EM Engineering.

The mechanical services will need to be adaptable and flexible due to the changing needs of the University. Systems are to be designed and zoned to accommodate the building design, proposed future users and will require the approval of the University.

In as much as the design can be developed to be efficient, the future operation and management of the building and its systems will have a huge bearing on energy consumption. To this end the designers shall liaise closely with EM Engineering to assist in checking that all design features are clearly understood, and systems properly handed over for successful operation of the systems. Refer also to UNSW "Facilities & Asset Management Checklists for Completion and Handover of Projects".

The quality aspects of the services must be proposed to UNSW EM Engineering for agreement before the project is tendered. The design team will need to allow sufficient time for the review that will be required. Initial items to be provided as a minimum include:

- Manufacturers
- Specifications
- Equipment Types
- Drawings
- Maintenance Requirements
- Warranties Applicable to Equipment

The design team shall allow for signoff stages for UNSW as appropriate which as a minimum shall include:

- Return Brief
- Concept Design
- Schematic Design
- Detailed Design
- Tender Documents
- Construction Documents
- Project Completion

A peer review of documentation packages may be arranged at the discretion of UNSW.

The designer must provide Quality Assurance plan to UNSW outlining the quality assurance measures and procedures to be followed for the project.

Specifications provided by the designer must be tailored to suit the specific project requirements and must not include generic or non-applicable material.

E.2.1.1 *Air Conditioning Policy*

The existing UNSW Thermal Comfort Policy specifies the circumstances under which air conditioning systems may be installed.

The policy needs to be referred to before contemplating an air conditioning installation.

For refurbishment of existing buildings where infrastructure limitations, such as available power supply, preclude provision of air conditioning throughout, priority shall be given to provision of air conditioning to essential areas where a controlled environment is critical to the functions performed. Examples of such areas include PC-1 and PC-2 laboratories, computer areas, animal houses, clean rooms, fly rooms and insect breeders.

E.2.1.2 *Departures from UNSW Specifications*

Any departures from these minimum requirements is required to be agreed with UNSW EM Engineering. All departures are to be notified in writing detailing the following items:

- Reason for the departure
- Financial benefit
- Benefit to project
- Benefit to Contractor

Departures will be accepted only on engineering grounds.

Refer also: Section B – Development and Planning.

E.2.1.3 Design Requirements

In selecting a system due regard shall be given to the following criteria:

- a) Size or capacity of the system including peak and minimum loads
- b) Performance requirements
- c) Energy utilization through seasonal cycles
- d) Noise considerations
- e) Location and space considerations
- f) Owning and operating costs
- g) Reliability
- h) Ease of maintenance
- i) Capability of future expansion
- j) Separation of process and comfort cooling systems to ensure reliability
- k) Project specific green star rating targets

Systems selected must be suited to the purpose for which they are designed and installed, must be technically sound and must meet the current requirements of the National Construction Code (NCC), AS1668, AS3666 as well as any other applicable standards, Regulations or Acts in force at the time.

For large projects risers shall be walk in type for the services of the building.

E.2.1.4 Environmentally Sustainable Design

E.2.1.4.1 Passive Design Considerations

The project team shall consider the benefits derived from incorporation of passive design measures from the earliest stages of the design process.

The mechanical services designer will work in conjunction with the architect in analysis and implementation of passive design measures to reduce thermal plant sizing and maximise energy efficiency of the building.

Passive design measures to be considered include but are not limited to the following:

- a) Building orientation and floor plate configuration
- b) High performance glazing and facade design
- c) External shading elements
- d) Natural ventilation (where appropriate)

E.2.1.4.2 System Selection

The mechanical services designer shall undertake analysis of various system types during the concept design phase to identify appropriate energy efficient system selections and secondary energy efficiency measures to be incorporated into the mechanical services design.

System design measures to be considered include but are not limited to the following:

- a) Outdoor air economy cycle on air handling plant
- b) Chilled water temperature reset
- c) Heat recovery systems
- d) Use of VSDs on system components with variable demands
- e) A preference for water cooled chillers over air cooled chillers
- f) The use of higher efficiency chiller technologies
- g) Use of condensing type gas boilers
- h) The use of EC fans wherever possible

A value engineering analysis shall be undertaken during the concept design phase to assess appropriateness of the potential system types and energy efficient design measures to validate the final systems selections. Payback period shall be less than 10 years.

The value engineering analysis, including detailed life cycle costing, shall incorporate as a minimum the following elements:

- a) Capital expenditure
- b) Recurrent maintenance and repair costs
- c) Payback periods
- d) Replacement at end of economic life
- e) Energy usage costs

The value engineering analysis shall be based on the building's operating schedule and take into consideration areas and systems with extended hours of operation (i.e. the economic service life of equipment serving a 24-hour facility will be significantly shorter than for a typical weekday 9-5 type application).

Life cycle costing shall be determined over a 30-year period for major projects and account for cost of equipment replacement which may be required during the life of the building.

E.2.1.5 Calculations

A set of all calculations and secondary information, such as air conditioning loads, life cycle costing, noise control measures etc, arranged in logical sequence, shall be provided to the EM Engineering prior to issuing any of the documentation.

Heating and cooling capacities shall be determined by computer-based heat load calculation software utilising calculation procedures established by either CARRIER or ASHRAE.

Due consideration shall be given to diversification of loads on systems in determining the scheduled capacity requirements for major plant items. Details of diversification figures to be included in design calculations are to be discussed and agreed with UNSW EM Engineering.

Detailed calculations shall be undertaken during design documentation for the following:

- f) Building fabric U-Values

- g) Outside air quantities
- h) Ventilation systems
- i) Ductwork and pipework sizing
- j) Fan static pressures
- k) Pump heads
- l) Psychrometric analysis for critical areas

Heat generation rates associated with specialist items of equipment, along with area defined per square metre heat generation rates, shall be nominated in the design documentation and shall be submitted to the EM Engineering for review and approval. Wherever possible, heat generation rates for equipment shall be based on the various equipment manufacturer's literature.

The project specific briefing documentation shall be consulted in the first instance for details of applicable space equipment loads.

E.2.1.6 Site Inspections

Site inspections for large projects shall occur on a regular basis with reports provided to suit the inspection interval. Inspections shall be completed by competent engineers who are familiar with the project and with experience in quality control and defect reporting. A mechanical engineer from EM engineering should be accompanied on inspections during the construction phase on an agreed frequency (weekly, monthly etc). The frequency will be determined by what phase the project is entering and the duration of the project.

E.2.1.7 Existing Installations

In areas where an existing installation is in place, consideration should first be made to the possibility of extending the system to take in the proposed additional load. The proliferation of diverse self-contained systems in the same location is to be avoided.

E.2.1.8 Hours of Operation

Hours of operation of air conditioning systems are to suit the application and user requirements. For comfort air conditioning of small spaces, the preference is for operation via adjustable run-on timers set initially for two hours. A number of research laboratories, libraries and computer facilities and other areas may require twenty-four hour operation. Detailed requirements for the operation of air-conditioned spaces must be clarified with the end user and EM Engineering at an early design stage.

Consider independent systems or the ability for the plant unload or to turn down for small areas that are planned to run during out of normal hours operation.

E.2.1.9 Population Density

For the purpose of calculating the air conditioning load, the following population densities shall be used unless noted otherwise in the briefing documents:

General Office	SQM/Person
General Office	8.0
Library Reading Rooms	3.0
Laboratory-Undergraduate (other years)	4.7
Laboratory-Postgraduate	12.0
Seminar Rooms	1.8
Lecture Theatres	1.1

E.2.1.10 Kensington Campus Design Conditions

E.2.1.10.1 External Design Conditions - Summer

For comfort and non-critical installations

32.8 °C DB
22.6 °C WB

For critical installations 24 hours operation

34.5 °C DB
23.5 °C WB

E.2.1.10.2 External Design Conditions – Winter

For Comfort and non-critical installations

6.3 °C DB & 80% RH

For critical installations 24 hours operation

4.5 °C DB & 80% RH

Values are taken from AIRAH DA9. This document should be referred to for alternate locations design conditions.

E.2.1.11 Performance Standards

E.2.1.11.1 Humidity Control

Humidity control will be provided to spaces where special circumstances dictate. Where special conditions are required, these will be nominated by the user and agreed to by EM Engineering. The strict control of humidity will be undertaken utilising the most efficient

approach as possible. The use of a dedicated unit should be considered so that this space does not drive the unnecessary running of a chiller in winter. Also, the use of localised reheat should be considered to avoid the unnecessary operation of a boiler in summer for a small space.

E.2.1.11.2 Internal Design Conditions

Unless specifically otherwise requested, the air-conditioning plant must be designed to maintain the following internal design conditions:

Internal Design Criteria		
Area	Indoor Summer Conditions	Indoor Winter Conditions
Office	24±1.0°C 50% RH (No Direct Humidity Control)	21±1.0°C
Classroom	24±1.0°C 50% RH (No Direct Humidity Control)	21±1.0°C
Foyers	24±1.0°C 50% RH (No Direct Humidity Control)	21±1.0°C
Meeting Rooms	24±1.0°C 50% RH (No Direct Humidity Control)	21±1.0°C
PC-1 Laboratories	23±1.0°C 50% RH (No Direct Humidity Control)	21±1.0°C
PC-2 Laboratories	21±2.0°C 50% ±15%	21±2.0°C
Laboratory Corridors	24±1.0°C 50% RH (No Direct Humidity Control)	22±1.0°C
Clean rooms	18±0.5°C 50% ±5% RH As Required by ISO	18±0.5°C 50% ±5% RH
Comms Room	23±2.0°C 50% RH (No Direct Humidity Control)	
Toilets Corridors Workshops Store rooms	No Temperature Control	No Temperature Control

All values are subject to final agreed temperatures provided in the Room Data Sheets and agreement with EM Engineering.

E.2.1.12 Redundancy Requirements

Appropriate levels of redundancy are to be incorporated within the design of the mechanical services systems with the extent of redundancy provisions reflective of the criticality of the application.

The project specific briefing documentation must be referred to for details of critical applications and specific redundancy requirements which may be applicable.

Detailed consultation must be undertaken with project stake holders in both the assessment and design of the redundancy provisions required for the project during the early stages of the design process.

Items to be given consideration during analysis of the adequacy of redundancy measures include but are not limited to the following:

- Maintaining continuity of service during plant fault or maintenance procedures
- Single point of failure analysis
- Duty/standby plant configurations
- Cost benefit analysis and risk assessment
- Redundancy in controls provisions
- Generator backed power supplies
- On site water storage in the event of loss of water supply
- Diverse paths for services reticulation where duplicated

A detailed report is to be prepared by the designer outlining the redundancy measures to be incorporated in the design. This report is to be submitted to EM Engineering for review and approval.

E.2.1.13 Condensation

The design shall incorporate appropriate condensation protection measures within critical areas to mitigate risk of moisture damage. Insulation, impervious membranes, dehumidification cycles on air handling equipment and insulated drip safety trays shall be specified as appropriate. Both Chilled Water supply and return lines **MUST** be insulated. The condensation piping from air handling equipment shall be made of copper and insulated for the length to the open drain.

E.2.1.14 Noise and Vibration

The maximum permissible noise rating recommended design sound levels for different areas of occupancy in buildings due to continuous mechanical plant noise shall be as stated in table 1 of AS 2107.

It is the responsibility of the Consultant to specify all necessary noise and vibration control measures in relation to the mechanical installation so that the sound levels stated above are not exceeded. The Consultant shall calculate the noise levels in occupied spaces, due to mechanical equipment, in order to check that the design adopted will permit the acceptable sound noise levels to be achieved.

Maximum acceptable noise sound levels should always be stated in the Tender specification. In addition, wherever possible, the sound power levels of major items of equipment shall be specified, and these shall be the basis of the acoustical computations.

As noise and vibration control is achieved by isolation and absorption measures incorporated in the mechanical plant, the Consultant shall examine the project, determine the extent to which noise and vibration control should be designed into the building and make appropriate recommendation to the Architect. If the mechanical consultant does not have expertise in noise and vibration, an acoustic consultant shall be sub contracted to perform the required works.

Care shall be taken to ensure that noise generated by mechanical plant shall not impinge adversely on adjacent buildings and shall not exceed the acceptable limits of background noise as set out by the local council or relevant authorities. All rectification works due to noise levels being above specified values shall be carried out without the alteration of the facility architectural design and operation of the services.

E.2.1.15 *Mechanical Ventilation*

In all air-conditioned and non-air-conditioned areas, the mechanical ventilation requirements shall conform to AS1668.

For spaces which are occupied, fresh air shall be filtered at the point of entry and shall be heated.

E.2.1.16 *Electric Motors*

All motors for the Mechanical services equipment shall be enhanced high efficiency motors as specified in clause B3.1.8.

All motors shall be as specified in the Tender specification. All motors shall be selected for quiet running characteristics and efficiency in operation in the equipment's operation range.

E.2.1.17 Installation of Plant and Equipment

The following sections outline the minimum requirements for the installation and construction of plant and equipment making up the mechanical services and must be addressed in the preparation of the design and specification.

Refer to the UNSW Preferred Equipment Suppliers List for details of manufacturers considered appropriate for installation in UNSW buildings.

E.2.1.18 Plant Access and Replacement

Consideration shall be given to plant access and replacement requirements during initial spatial planning and design of plant room configurations particularly with respect to provision of maintenance and statutory egress clearance requirements. A plant maintenance and removal strategy report shall be provided detailing the following:

- Statutory maintenance requirements
- Manufacturer maintenance requirements
- Method and main routes for equipment removal requirements

The intent of the replacement strategy is to ensure maintenance and replacement costs are not excessive for the future operation of the building.

For laboratories, due consideration shall be given to ensuring that safe and ready access is provided to enable plant to be maintained and easily removed and replaced without exposing maintenance staff to undue risk. It is preferred that all plant is located outside of laboratories and other critical spaces.

E.2.2 Fans

The University prefers the use of EC fans. EC fans should be the standard fan used when selecting AHU's or FCU's. Centrifugal and axial fans will only be accepted where EC fans are not available or viable

E.2.2.1 Power Consumption

Fans shall be selected to achieve the lowest practical power absorbed at the specific operating conditions. Fans shall be selected with 20% spare capacity in airflow.

E.2.2.2 Performance Curves

Guaranteed typical characteristic performance curves shall be supplied with each fan in technical submittals and provided in Operating & Maintenance Manuals.

E.2.2.3 Noise

An octave band analysis of the fan and motor sound power levels for the octave bands 125 Hz to 8000 Hz shall be supplied for each fan.

E.2.2.4 Fan Casing

Fan casings shall be of rigid construction, air tight and shall be treated for corrosion protection.

E.2.2.5 Impeller

Static and dynamic balancing required for fan impellers.

E.2.2.6 Mountings

Mountings must be arranged for ease of maintenance and to prevent transmission of noise or vibration to ductwork or the building structure. Where fan and motor form an integral assembly, they shall be on a common base, mounted on an inertia block. In all other instances the rotating parts shall be isolated from the fan casing using appropriate resilient mountings.

E.2.2.7 Connection to Ductwork

Total isolation through a flexible connection must be provided for fan connections to ductwork.

All flexible connections shall be a minimum 50mm long and specified in accordance with the fan manufacturer's recommendations

E.2.2.8 Belt Drives

Belt drives shall consist of no less than two belts evenly matched. As a minimum requirement, belts shall be of "B" section.

"A" section belts are not acceptable.

E.2.2.9 Belt Guards

Effective belt guards shall be provided, easily removable for maintenance and adjustment purposes. An inspection window shall be provided at each guard for inspecting the belts. Where exposed to weather, the guard shall be manufactured from galvanised steel and shall be weatherproof, ventilated and drained to the outside.

E.2.2.10 Direct Drives

Motor speed shall not exceed 1450 rpm. On large fans a flexible coupling of rubber sheathed pin type shall be provided.

E.2.2.11 Motors

All motors shall be squirrel cage induction or EC type with suitable enclosure as specified in the tender specification.

E.2.2.12 Speed Control

In applications where the full capacity of the fan is required for only short periods of time, consideration shall be given to means of controlling the fan speed. The resultant benefits should be reflected in reduced noise and reduced energy consumption.

Variable speed drives shall be provided for all three-phase fans where fan capacity control is necessary and where required for compliance with NCC Section J. The University has a preference for ABB manufactured VSD's

E.2.3 Ductwork

The following requirements shall be addressed in the preparation of the design and specifications. In the design of air transmission, due regard shall be given to first cost and operating cost and where necessary effective attenuation must be provided to achieve the required noise levels.

Duct runs within the building are to be preferably run in risers or ceiling spaces for minimum aesthetic impact and must be adequately supported.

E.2.3.1 Air Velocities

Low velocity systems are preferred. Ductwork must be designed to limit air velocities to the figures stated in table below:

Item	Component	Max Velocity (m/s)	Max Friction (Pa/m)
Sheet Metal Duct	Main duct more than 1500 l/s – sheet metal on floor	6.0	1.2
	Main duct/primary branch less than 1500 l/s	6.0	1.0
	Secondary branch	2.0 - 3.5	0.8
Flexible Duct	<=200mm	3.0	
	>=250mm	4.0	

Velocities above are to be used for guidance only. The designer will select final velocities based on the project specific acoustic requirements.

E.2.3.2 Duct Risers

Main riser ducts must be sized to handle an increase of 20% in air quantity, and fans and motors must be selected with this in mind.

E.2.3.3 Office Areas

In general office areas, ductwork systems shall enable subdivision of 40% of the net useable space into single offices of not less than 10 square metres.

E.2.3.4 Ductwork Construction

Installation shall be in accordance with the latest edition of AS 4254 – Ductwork for Air Handling Systems in Buildings.

E.2.3.5 Construction Material

For general purpose installations, the material used in the construction of ductwork shall be galvanised steel. For external applications, the material used in the construction of ductwork shall be stainless steel.

Alternate ductwork materials may be specified where suited to particular applications subject to the review and approval of EM Engineering. Examples of alternate ductwork materials include:

- Aluminium
- Plastic
- PVC
- Flexible duct
- Fabric

E.2.3.6 Ductwork Exposed to Weather

Ductwork must be water-tight and all joints sealed to prevent water entering the duct. The topside of the duct shall be crowned to allow water runoff and the duct side shall be cross-broken between the corners and the crown. Stiffening angles on topside of the duct shall be bent to follow the set of the crown. Covers shall be provided to ductwork flanges. Ductwork shall be installed angled to one side to prevent pooling of rainwater or alternatively cross broken rain covers will be provided.

E.2.3.7 Ductwork Supports

Ductwork shall generally be supported as follows:

E.2.3.8 Trapeze

Ductwork installed with any cross dimension of 500mm or greater will be supported from the slab above with booker rod and under bracing (trapeze style). The use of straps on this sized ductwork is unacceptable.

E.2.3.9 Strap or Shelf

Ductwork smaller than 500mm in size may be supported by metal strapping and screws from the slab above.

Angle type hangers on horizontal or vertical ducts running adjacent to vertical structure.

E.2.3.10 Shoulder Angles

Shoulder angles are to be provided on vertical ducts passing through floors. Structural engineer approval will be required for the standard detail specified for shoulder angles.

E.2.3.11 Penetration to Walls and Floors

Ductwork penetrations to walls and floors must be flanged on both sides of the penetration. No ductwork is to be concreted into wall openings. When penetrating a Fire Wall, the penetration must be packed with fire-rated insulation and fire dampers installed with readily accessible inspection hatches. Fire dampers are to be installed in accordance with AS 1682.2. Refer also to section E.2.3.19.

Flexible ductwork shall not be used at wall or floor penetrations.

E.2.3.12 Tapers.

E.2.3.12.1 Diverging

Air flow tapers where the duct size is increased; the slope of any side shall not exceed 30°.

E.2.3.12.2 Contracting

Contracting airflow tapers where the duct size is decreased; the slope of any side shall not exceed 45°.

E.2.3.13 Offsets

Change in directions, horizontally or vertically, shall be accomplished using offset as per fig 2.3(N), Type 3(e) of AS 4254.

E.2.3.14 Obstructions

Where space limitations will not allow Type 3 offset above, it shall be dealt with using fig 2.3(O), (d) of AS 4254

E.2.3.15 Bends

As per Fig 2.3 (J), bend type A(a) or bend type B(b). Where it is not possible to use type A or B, then Fig 2.3(K), (b) square throat elbow with vanes shall be used.

E.2.3.16 Tees

Tee connections shall be long radius unvaned. Where it is not possible to use a long radius Tee, short radius vaned elbows or square throat vaned elbows shall be used. A splitter damper, of length equal to the small duct width, is to be provided at each Tee.

E.2.3.17 Turning Vanes and Splitters

Where required for air direction turning vanes with adjustable blade settings or splitter dampers, where appropriate, shall be used. These are not to be used for air balancing.

E.2.3.18 Opposed Blade Dampers

Opposed blade dampers shall be used for throttling air quantities for balancing purposes.

E.2.3.19 Duct Access Panels

Shall be provided for inspection and/or cleaning. Access panel locations above ceilings must be coordinated with the building access panels, ceiling grid, lights and equipment layout.

Access panels for kitchen exhaust systems must be no more than 3 metres apart.

Minimum size of access panel shall be 450mm x 450mm and shall be increased to suit the ductwork.

E.2.3.20 Fire Dampers

Where installed shall be in accordance with AS 1668. The installation of fire dampers must be in accordance with AS 1682.2. An inspection panel shall be provided to allow access to the fire damper for testing, inspection and maintenance.

The inspection panel shall be suitably labelled for location and identification and be the largest size to suit the ductwork.

E.2.3.21 Dampers

E.2.3.21.1 General

All dampers, actuators and components shall be designed for operation at ambient conditions in the installed location.

Dampers shall be of Air Grilles or Holyoake manufacture or to the approval of EM Engineering.

Outside air dampers shall be constructed from stainless steel and incorporate nylon bushes. Other dampers shall be constructed from aluminium.

Aluminium blades and frames shall be manufactured from aluminium extrusions of alloy and shall have a minimum thickness of 3 mm.

Shafts and linkages shall be stainless steel with shafts of 12 mm minimum diameter.

Bearings on dampers shall be manufactured from sintered bronze or polyamide moulding material (nylon) specifically designed for this application.

Damper frames shall be formed for rigidity and punched to allow for bolting to a mating flange or in fill panel. The corners shall be fully welded.

Dampers shall have rubber edge seals on each blade and metal seals at blade ends.

Damper modules shall be designed such that the linkages and bearings can be easily removed for servicing or the whole module removed for servicing.

In multi blade dampers, the blades shall be interconnected by means of a bar linkage, to approval, for ganged operation, and shall be free of slackness. The linkages shall be located at the side of the damper module, out of the air stream.

Dampers shall be installed with sufficient bracing to eliminate any flexing, distortion and binding and be capable of withstanding a static pressure differential across the damper of not less than 200% of the fan shut off pressure, when in the fully closed position.

Where manually adjustable damper sets are installed in ductwork or other inaccessible locations, the operating shafts shall be extended through the duct and fitted with a lockable metal quadrant. Engrave the shaft end with a slot parallel to the damper blade position.

E.2.3.21.2 Motorised Dampers

Motorised modulating control dampers shall be of the opposed blade type.

Install motorised dampers with blades horizontal.

Provide drive shaft extending clear beyond the extremity of the frame by not less than 150 mm and drive arms designed to withstand the greatest torque applied by the fitted actuator. Engrave the end of the drive shaft with a slot parallel to the damper blade position.

A jackshaft or shafts shall be installed between damper modules to ensure that blades operate in unison when only one motor is fitted to drive multiple modules.

E.2.3.22 Flanges, Stiffeners and Hangers

Materials used shall be galvanised steel sheets, rolled steel angles or round bars coated for protection against corrosion after fabrication and before being assembled to the duct.

E.2.3.23 Air Outlets

Shall be positioned at least 7 equivalent diameters down stream of any take-off to avoid turbulence

E.2.3.24 Flexible Connections

Shall be used to connect ductwork to fans. The connections shall be arranged to allow the removal of the connection without disturbing the ductwork or the plant. Connections are to be weatherproof in external applications.

E.2.3.25 Flexible Ductwork

Flexible ducts shall be in accordance with AS 4254 and shall be as short as possible whilst satisfying the requirements of clause Air Outlets above, and shall be installed to smooth out corrugations and kinks. Long radius bends shall be installed.

E.2.3.26 Flexible Duct Supports

Shall be spaced not more than 1500 mm apart. Supports shall be a band clamp or saddle type and shall not cause out of round shape or damage to the ductwork. Flexible ductwork shall be supported from the slab above and shall not rest on the ceiling or ceiling tiles.

E.2.3.27 Flexible Duct Length

Flexible duct lengths shall not exceed 3000 mm in accordance with NCC Section J.

E.2.3.28 Balancing Points

Balancing points shall be provided in sufficient number to facilitate proper testing and balancing of the air system. Holes shall be drilled in the duct and plugged with rubber grommets.

E.2.3.29 Ductwork Insulation

All ductwork insulation thermal performance must be compliant with the NCC Section J.

Wherever architectural and acoustic requirements do not require internal insulation, all ductwork insulation must be external with the exception of outdoor locations and locations subject to mechanical damage such as plant rooms.

All externally insulated ductwork shall utilise tight plastic packing straps every 400mm to help maintain the long-term integrity of the insulation.

Externally insulated ductwork in plantrooms that is exposed to the weather through adjacent louvres shall be sheathed in metal skin lining.

All ductwork sections are required to be delivered to site with all openings plastic sealed.

Any internally insulated ductwork sections arriving to site that have been subject to water damage from rain or other source of moisture will be rejected.

Where ductwork and equipment have internal insulation for acoustic purposes, it must be lined with perforated sisalation or perforated metal. Where the infill material is exposed to the weather, then the infill material shall be sealed in a polyester membrane, "Mylar" or similar.

E.2.4 Air Intakes

E.2.4.1 External Air Intake Louvres

Louvres shall be manufactured from marine grade aluminium, or other required materials to guarantee adequate performance and service life, and painted to match adjacent wall with approval of the colour by the project architect.

Louvres shall be sized for a maximum face velocity of no greater than 2.5m/s to mitigate the risk of rain ingress.

To limit noise generation, pressure drop across the louvre shall not exceed 40 Pa when mounted not higher than 5 m above ground.

Removable UPVC or marine grade aluminium vermin proof screens shall be provided with each louvre.

There is a preference for full chevron style weather proof louvres however if for architectural reasons other styles are preferred, then the contractor must ensure rain will not enter the building even in extreme windy raining conditions

Where exposed to rain ingress, an aluminium plenum will be provided behind the louvre. The plenum will be provided with a drain for removal of water and to prevent corrosion.

E.2.4.2 Outside Air Dampers

Refer to section E.2.3.21 Dampers.

E.2.4.3 Acoustic Louvres

Where an acoustic louvre is installed it must also perform as the external air intake or exhaust discharge louvre in accordance with the requirements outlined in this document.

E.2.4.4 Location

Air intakes shall be located to conform to the requirements of AS 1668 and AS/NZ 3666

E.2.5 Exhaust Discharges

Requirements generally as per Air Intake Louvres specified above. Care shall be taken to avoid cross contamination with nearby air intakes, cooling tower intakes or openings such as windows and doors. The minimum separation distances between air intake and discharge points shall be in accordance with the requirements of AS 1668.

E.2.6 Piping, Valves and Fittings

The piping system, valves and fittings shall include the following design, performance and installation features:

E.2.6.1 Pipe Material

All refrigerant, chilled, heating and condenser water pipework and headers are preferred to be copper subject to the calculated pipework pressure rating requirements. Condenser water piping can be stainless steel for the larger sizes.

Crimped or pressed fittings are not acceptable for any HVAC pipework.

The use of “Victaulic” grooved style fittings and connections are not acceptable for any HVAC pipework.

In the event that other materials are required to serve a particular function the material is to be approved by UNSW EM Engineering.

E.2.6.2 Pipe Sizes

Main distribution pipes must be installed of a size adequate to permit future expansion of the installation. To that end velocities shall initially be limited to the following range:

Description	Velocity (m/s)
Risers	1.5 – 2.4
Main Distribution	1.2 – 2.4
Headers	0.9 – 1.5

Pipework pressure loss shall not exceed 360Pa/m.

Pipework shall be designed taking into account acoustic requirements of the space, which may require differing velocities from those stated above.

E.2.6.3 Pipe Runs

Pipe runs within the building are to be preferably run in service ducts, risers or ceiling spaces for minimum aesthetic impact and must be adequately supported.

E.2.6.4 Flexible Connections

Flexible connections shall be provided at rotating and vibrating machinery to accommodate the axial and dynamic deflections of the isolated equipment or preferably hard fix the connections and provide adequate pipework flexibility into the system via pipework bends and spring mounts adjacent to the pump systems.

Provision for Expansion

Piping shall be arranged with sufficient bends so that where possible the system will absorb the whole of its own expansion or contraction without inducing excessive stresses in the piping itself or the connected equipment.

E.2.6.6 Anchors and Expansion Devices

Where expansion devices are used, sufficient and adequate pipe anchors and guides shall be provided to ensure that the devices take the expansion and contraction.

E.2.6.7 Pipe Headers

All headers are to be provided with at least one spare flanged and valved connection for future use.

E.2.6.8 Pipe Supports

Clips, rollers, hangers and supports shall be of propriety manufacture and treated for corrosion protection. Where the supports and piping material are dissimilar metals, the pipework shall be isolated from the supports by a ferrule of suitable material forming a positive barrier. Pipe supports shall be in accordance with AS 4041 and AS 3500 as a minimum. Powder coated or painted brackets must still incorporate rubber or foam gaskets to form a positive barrier between the pipework and bracket. Pipework support or hangers should not be greater than 3 metres apart.

E.2.6.9 Dirt and Air Separators

Deaerators and dirt separators for fluid systems shall:

- Be provided for all closed circuit chilled water, heating water and condenser water systems
- Be of full pipe diameter or larger
- Be suitable for use with the piped fluid at the design temperatures and pressures
- Have large capacity gas and dirt collection chambers
- Have effective micro bubble and microscopic particulate separator element/s
- Have demountable connections

E.2.6.10 Fasteners

Wooden plugs and explosive powered fasteners are not acceptable for fastening of supports to the building or structure.

E.2.6.11 Pipes Through Walls

Where pipes pass through walls, floors and ceilings of all areas, sleeves of the same material as the pipe must be provided and filled with appropriate insulation or fire-rated material to suit the application. Escutcheon plates shall be provided over the sleeves and fitted neatly.

E.2.6.12 Pipe Risers

All pipe risers must be provided with dirt legs and drains at the bottom of the riser in accordance with AS/NZ 3666.

E.2.6.13 Drains

All drain points are to be fitted with a valve suitable for hose connection. Sufficient drains shall be provided to allow the whole or any part of a pipe system to be drained.

E.2.6.14 Condensate Drains

All condensate drain pipework shall be UPVC or Type C copper. Where subject to mechanical damage such as in plantrooms, all drains shall be in Type C copper and insulated the full length.

All condensate drain pipework inside buildings must be insulated to prevent condensation.

E.2.6.15 Air Vents

Automatic air bleeds must be provided at all localised high points of the system and all other points where air may collect.

E.2.6.16 Connections to Plant

Isolating valves shall be used at connections to all items of plant and equipment.

Connections shall allow the removal of the plant without removing a large section of pipework or draining the system.

Isolating valves shall be:

- ball valves in sizes 15 to 50 mm
- wafer type butterfly valves in sizes 65 mm to 300 mm; or
- wedge type gate valves 65 mm and above.

Isolating valves shall be of materials suitable for the applicable design pressures, temperatures and service conditions particularly with respect to corrosion prevention of components.

Isolation valves shall be of high quality construction, supplied by a reputable manufacturer and be capable of maintaining a leak free seal over the duration of the valve's service life.

E.2.6.17 Valve Sizes

Valves shall be sized to at least the nominal pipe size, unless a smaller size is necessary for throttling or similar purpose. Connections in all instances shall be as follows:

Valves less than 50 mm diameter shall be screwed to AS 1722
Valves 65mm and larger diameters shall be flanged to AS 2129

E.2.6.18 Valve Removal

All screwed valves and fittings must have unions to allow removal of the valve or the equipment it serves without dismantling an extensive amount of pipework.

Where flanged valves are used to isolate equipment which may be disconnected for servicing, a spool piece shall be installed next to the valve so that disconnection can be made at the spool piece, leaving the flange connection at the valve undisturbed.

E.2.6.19 'Binder' Cocks

Must be fitted to the following:

- all chilled, heating and condenser water headers
- to flow and return lines at all air-handling units, fan coil units and pumps
- to any equipment requiring temperature and flow to be measured

Binder cocks must extend a minimum of 15mm beyond the outside surface of the insulation. All fittings to be fitted with removable caps to avoid leaking even with valves closed.

'Binder' cocks must be located next to a pressure/temperature DDC point.

E.2.6.20 Balancing Valves

STAD or Griswold valves must be specified. At least one balancing valve shall be provided at each item of equipment. If necessary, additional valves shall be provided to facilitate balancing between groups of items clustered together as modules. Main branches shall include balancing valves. All fittings to be fitted with removable caps to avoid leaking even with valves closed.

E.2.6.21 Pressure Independent Control Valves

Pressure independent control valves may be applicable for certain projects where the design consultant shall analyse the overall benefit compared to traditional systems. The analysis shall include not only the purchase cost of the valves, but also the commissioning and operational benefits that can be achieved.

E.2.6.21.1 Screwed Type DN10-DN50

- The valve housing shall be PN25 rated and suitable for 120°C.
- The valve shall have a maximum operating differential pressure of 400 kPa (4 Bar)
- The valve housing shall be hot stamped DZR brass CW602N.
- The valve characterization shall not be changed at different flow settings.
- The valve shall have a leakage rate at maximum 0,01% of max rated volumetric flow and comply to EN1349 Class IV.
- The length of the modulating stroke shall be independent of flow setting.
- The modulation and flow setting shall be one combined unit with a linear modulating motion and a rotational flow setting motion.
- The combined flow setting and modulating control unit shall be pressure independent.
- The Pressure Independent Control Valve shall contain a combined flow setting, differential pressure control and modulating bonnet assembly.
- The valve shall have an external adjustable analogue step-less pre-setting scale from minimum to maximum flow.
- The valve shall have an external thread ISO 228 or internal ISO 7/1.
- The valve shall have a spring made of stainless steel, a Diaphragm made of HNBR and O-rings made of EPDM.
- P/T plugs shall be provided.

E.2.6.21.2 Flanged Type DN50-DN150

- The valve housing shall be GJL-250 (PN16) or GJS-400 (PN25)
- The valve housing shall be suitable for 120°C.
- The valve shall have a maximum operating differential pressure of 600 kPa (6 Bar)
- The valve characterization shall not be changed at different flow settings.
- The valve shall have a leakage rate at maximum 0,01% of max rated volumetric flow and comply to EN1349 Class IV.
- The length of the modulating stroke shall be independent of flow setting.
- The modulation and flow setting shall be one combined unit with a linear modulating motion and a rotational flow setting motion.
- The valve shall have an external adjustable analogue stepless presetting scale from minimum to maximum flow.
- The combined flow setting and modulating control unit shall be pressure independent.
- The Pressure Independent Control Valve shall contain a combined flow setting, differential pressure control and modulating bonnet assembly.
- The valve shall have a spring made of stainless steel, a Diaphragm made of HNBR and O-rings made of EPDM.
- The valve shall have flange connections according to EN 1092.

- P/T plugs shall be provided.

E.2.6.22 Balancing Valve Location

Balancing valves shall be located on the return lines from each item of equipment, and a straight distance of at least 5 pipe diameters upstream, and 2 pipe diameters downstream of the valve.

E.2.6.23 Valves in Ceiling Spaces

All chilled water and compressed air valves located in ceiling spaces and which are subject to sweating must be insulated and fitted with a safety drip tray.

E.2.6.24 Gauges

Pressure gauges shall be installed on the suction and discharge points of all pump systems.

All gauges shall be of high quality construction supplied by a reputable manufacturer, compliant with AS1349 requirements and shall be of a suitable range for the static and operating pressures of the system in which they are installed. Gauge assembly shall be treated for corrosion prevention.

Temperature gauges shall be installed on the return and flow sides of chillers, heat exchangers and heating water generators, process coolers and common flow and return pipes.

Gauges proposed for use in the facility are to be submitted to EM Engineering for review and approval.

E.2.6.25 Cleaning

On completion prior to filling with water, all pipework must be chemically cleaned.

E.2.6.26 Pipe Insulation

As a minimum, insulation shall be provided to:

- Any pipework where contact with pipe poses and OH&S risk
- Chilled water and heating water piping
- Steam, condensate and cold refrigerant piping
- Valves and all associated fittings.

Insulation shall be non-mineral fibre shedding.

Metal colourbond, sheet aluminium or galvanised sheathing shall be provided where piping is exposed to view, in plant rooms, corridors and where exposed to weather.

Moulded polystyrene section shall be used for “cold piping” with an appropriate vapour barrier.

Mineral wool or glass fibre shall be used for “hot piping”.

“Bradflex, Aeroflex, Armaflex” elastomeric foams or similar type are to be used for refrigerant piping and some condensate applications.

All pipework insulation thermal performance must be compliant with the NCC Section J.

E.2.7 Pumps – Centrifugal

Pumps shall be selected to achieve the lowest practical power absorbed at the specified condition. Pumps shall have constant falling characteristics curves to ensure stable performance over the curve.

The proposed pump curve operating point or range will be provided to EM Engineering for review prior to the selection and ordering stages of a project.

E.2.7.1 Pumps In Parallel

Pumps to be used in parallel shall be selected to ensure no instability when operating either singly or in parallel at the same nominal speed.

E.2.7.2 Flexible Connections

Provide approved flexible connections to each pump suction and discharge equipment or preferably hard fix the connections and provide adequate pipework flexibility into the system via pipework bends and spring mounts adjacent to the pump systems.

50 mm pipe dia. and below may be screwed. Provide flanged connections for pipe dia. above 50 mm.

E.2.7.3 Isolating Valves

Provide isolation valves at the suction and discharge side of each pump.

All isolating valves shall be of high quality construction supplied by a reputable manufacturer and shall be of materials suitable for the applicable design pressures, temperatures and service conditions for the system in which they are installed. Valve assembly shall be treated for corrosion prevention.

Valves are to be submitted to EM Engineering for review and approval.

Provide a STAD valve on the discharge of each pump where balancing is required at the pump. The installation of VSDs is also acceptable.

E.2.7.4 Non-Return Valves

A non-return valve shall be provided at each pump discharge.

Non-return valves will be oriented to suit the pump discharge with the spindle direction in line with the convolute of the pump.

E.2.7.5 Gauges

Provide gauges with a gauge cock at each pump suction and discharge. Refer also to Section E.2.6.24 Gauges.

E.2.7.6 Strainers

Strainers shall be provided on the suction side of each pump connection.

Strainers shall be fitted with stainless steel screens and all 65mm diameter and larger strainers shall also be fitted with 25mm ball valve blow.

E.2.7.7 Pump Seals

Pump seals shall be mechanical type seals of proven manufacture and design.

E.2.7.8 Flexible Coupling

Where specified, flexible couplings shall be rubber sheathed pin type.

E.2.7.9 Alignment Tolerances

After installation and with piping connected, the alignment of pump and motor shafts shall be checked and adjusted to achieve alignment to tolerances recommended by the pump manufacturer.

E.2.7.10 Mounting

Pumps and motors shall be assembled on a common bedplate on an inertia block, the whole mounted on a concrete plinth and arranged for ease of maintenance.

E.2.7.11 Vibration Isolation

Rubber or neoprene in shear mountings or the combined use of spring mountings and ribbed neoprene pads shall be used for vibration isolation.

E.2.7.12 Installation

Install pump so that it can be removed for maintenance without dismantling or removal of pipework.

E.2.8 Air Conditioning Water Chillers

Chilled water systems supplying individual air handling units are preferred, particularly where such a system already exists and the proposed installation would be an extension.

Chillers and chiller systems shall be analysed during the design phase to determine the most suitable type of chiller for the facility with due consideration given to both air-cooled and water-cooled systems. The Uni does have a preference for water cooled chillers but if not viable, will consider air cooled chillers. The analysis shall consider not only peak load but also low load and seasonal changes. The analysis and recommendations shall be provided to EM Engineering for approval. Any design for water cooled chiller systems shall be based on York YMC2 or York YZ series of magnetic bearing chillers or the Carrier 23XR series of variable speed screw chillers.

Air cooled chiller design shall be based on Carrier or York scroll or screw chillers. In all cases the air-cooled chillers shall incorporate anti corrosion treatment to the coils and the option for enhanced acoustic treatment.

Chilled water systems shall be designed to provide effectively a 10% to 100% capacity range. The design consultants shall consider the staging of the chillers and the chilled water flow temperature stability requirement to be maintained for the intended application.

Chilled water pipework systems must incorporate a bypass line where necessary to ensure that the required minimum water flow through the chillers is maintained during low load conditions and to cater for the minimum flow rates associated with the chilled water pumps.

E.2.8.1 General

Chillers shall be of proven design, factory assembled complete with all components, accessories, internal power circuits, controls, motor starters and safety controls and mounted on a steel base or frame of suitable inertia and strength to support the equipment under all operating conditions.

The whole unit shall be placed on a concrete plinth using spring anti-vibration mountings.

It is preferable that chillers be provided with at least two independent refrigeration circuits, however the number of refrigeration circuits must also take into consideration the redundancy requirements of the application.

Chillers compressors shall be provided with a suitable means of providing continuous, infinitely variable capacity control (e.g. VSD, slide valve etc). Part load performance characteristics shall be submitted to EM Engineering for review and approval.

Chillers shall be provided with touch screen controls where these are available and shall have a HLI in accordance with [Appendix 1 – Automation and Control Systems](#).

For installations with multiple chillers, due consideration must be given to the staging strategy for the chillers. Staging strategies must be tailored to suit the project specific load profiles, chilled water distribution systems, chiller configurations and must ensure the stability of the leaving chilled water temperature at all times.

E.2.8.2 Chiller Operation

Each chiller shall operate under the control of their own integral control systems to maintain the specified leaving chilled water temperature.

The UNSW CBACS shall monitor the chiller operating parameters directly via the HLI, in accordance with [UNSW Design Guideline Appendix 1 – Automation and Control Systems](#).

For multiple chiller installations, each chiller shall have a dedicated BMS control panel and a dedicated MSSB. These dedicated panels/boards shall also serve all ancillary equipment associated with a particular chiller to ensure that upon loss of a single BMS control panel or switchboard, the operation of the alternate chillers in the system remains unaffected.

E.2.8.3 Noise and Vibration

Appropriate steps shall be taken to minimize transmission of noise and vibration to the surrounding structures. All chillers shall be fitted with optional acoustic treatment to ensure quiet operations

An octave band analysis of the chiller sound power levels for the octave bands 63 Hz to 8000 Hz shall be supplied for each machine.

E.2.8.4 Corrosion Protection

All chiller components shall be treated specifically for corrosion protection.

Air-cooled chillers located externally on roofs shall incorporate treated coils to prevent corrosion and galvanised or stainless steel fixings.

E.2.9 Air Handling / Fan Coil Unit

E.2.9.1 General

Large built up central air handling units (AHUs) are to be avoided. Packaged type AHUs are preferred. Air handling units shall incorporate heating coils and the use of terminal re-heat shall be avoided for the purpose of energy conservation unless dictated by the application.

The University prefers the use of EC fans. EC fans should be the standard fan used when selecting AHU's or FCU's. Centrifugal and axial fans will only be accepted where EC fans are not available or viable

Packaged AHUs should be readily disassembled to enable ready removal of fans, coils, trays and filter frames.

Units shall be manufactured from colourbond sandwich panel with insulation to meet the requirements of the NCC. Units shall be manufactured to have no cold bridging.

AHU fans must be provided with belt guards which shall be fitted to each belt driven fan complying with all statutory codes and shall be readily removable. Provide fan Inlet screen, complying with Statutory Authorities requirements, over all fan inlets exposed by access doors or panels.

E.2.9.2 Sprayed Coil

Spray coil assemblies are not acceptable.

E.2.9.3 Outside Air

Outside air shall be provided to each air-handling unit where required to conform to the requirements of AS 1668. In addition, an outside air economy cycle shall be provided in all instances in central systems in accordance with the requirements of the NCC Section J, unless dictated otherwise by the type of application the equipment is to serve.

The outside air / return plenum shall be provided as part of the main air handling unit.

E.2.9.4 Outside Air Heat Exchanger

Pre-cooling of the outside air using an air-to-air or air-to-water heat exchanger system shall be considered and evaluated for each system.

E.2.9.5 Cooling Coils

All coils exposed to outdoor conditions shall be treated to protect against salt and other contaminants found in the local area. Blygold or Dulux coil guard coating shall be provided as a minimum.

E.2.9.6 Chilled Water

Coils shall be arranged in sections to maintain adequate heat transfer characteristics and facilitate installation and removal. Maximum height of section 1060 mmm

E.2.9.7 Face velocity

Cooling coils shall generally be designed for a nominal face velocity of 2.5 m/s across the coil. At no time should the face velocity exceed 3 m/s.

E.2.9.8 Drip Trays

Individual drip trays shall be provided at each coil section, all connected to a main drain. Drip trays shall be manufactured from stainless steel.

E.2.9.9 Heating Coils

Where heating coils are exposed to corrosive or damaging air stream applications such as outside air ventilation systems, all coils shall be treated to protect against salt and other contaminants found in the local area. Blygold or Dulux coil guard coating shall be provided as a minimum.

E.2.9.10 Heating Hot Water

The maximum allowable face velocity across a heating hot water heating coil is 4 m/s. Due allowance shall be made for the air side pressure drop in determining the face area of the coil.

E.2.9.11 Electric Resistance Heaters

Electric heaters are not preferred and must only be considered if proven to be the only practical means of providing heating. The heater element shall be low surface temperature type suitable for operation at black heat. The heater elements shall be arranged to ensure an even distribution across the air stream. Controls using SCR shall be used for all electric heaters installations.

Heaters together with their thermal protection components must be fully accessible for testing and maintenance. All overload protection controls must be provided at the heater control panel located in an unconcealed area for ease of access.

Step switching for electric heaters is not acceptable.

E.2.9.12 Coils in Ceilings

An access panel, for inspection and maintenance, shall be provided in all instances where coils are installed above set ceilings or in other concealed spaces. The inspection panel shall be suitably labelled for location and identification and be generously sized to allow safe and easy maintenance.

E.2.10 Cooling Towers

The use of water-cooling towers shall be dictated by the design conditions and parameters. Air-cooled equipment where possible is preferred. Where cooling towers are used, strict adherence to AS/NZ 3666 shall be followed.

Careful consideration must be given to the sighting of cooling towers with respect to adjacent exhaust system discharge points and adjacent ventilation openings and acoustic constraints.

A minimum 100-mm dia. drainpipe connection shall be installed for quick draining.

Ladders, handrails and maintenance access platforms for cleaning and servicing of components on the top of the tower must be provided. Ladder, handrails, platforms and kick plates shall comply with the requirements of Statutory Authorities.

Platforms shall be provided around the entire top of each tower. The access arrangement shall be documented by the designer and not designed by the supplier of the cooling tower. Submit details of stair and platform arrangement to EM Engineering for review and approval. Access ladders and restricted platforms will be rejected.

Side stream filtration shall be incorporated into the condenser water systems sized to suit the application. Provide basin sweeping piping with inductor nozzles to effectively prevent sediment from collecting in the cold water basin, with pipe for connection to the side-stream filtration system.

Variable speed drives shall be fitted to fans for capacity control with VSDs connected to the UNSW CBACS. Refer to [UNSW Design Guideline Appendix 1 – Automation and Control Systems](#) for details.

Induced type cooling towers are preferred to be of BAC or Evapco manufacturer.

Where cooling towers are appropriate for heat rejection of specialist laboratory cooling water systems, closed circuit cooling towers are to be considered.

All condenser water systems shall be reviewed by Clive Broadbent & Associates for a legionella review of the proposed system at detailed design stage.

Water treatment shall be provided by the incumbent water treatment specialist of UNSW.

Where cooling towers are installed, a quick fill system shall be provided incorporating a minimum 50 mm dia. fill pipe connection point. The water supply installed to this quick fill connection point must be matched to this connection point size and be designed for quick fill supply.

E.2.11 Evaporative Coolers

Evaporative coolers shall not be used.

E.2.12 Air Cooled Condensers

Air-cooled condensers shall be selected to deliver the heat rejection capacity required by the design at an ambient temperature of 40°C DB. Air-cooled condensers shall remain operational at an ambient air temperature of 50°C DB for critical applications. Submit details of the capacity de-rating of the equipment at an ambient air temperature of 50°C DB to EM Engineering for review.

All condenser coils shall be treated to protect against salt and other contaminants found in the local area. Blygold or Dulux coil guard coating shall be provided as a minimum. Details of the proposed anti-corrosion treatments are to be submitted to EM Engineering for review and approval.

Each condenser shall include details of the required refrigerant charge volume on the equipment name plate.

E.2.13 Gas Fired Heating Water Generators

Heating water generators shall be factory assembled units, complete with burner, combustion chamber, refractories, heat exchanger/s, flue connection, piping and valves, instrumentation, control system and control panel, safety and heating water generator protection devices and auxiliary equipment as necessary for the satisfactory operation of the heating water generators.

Heating water generators can be of the sectional cast iron type with modulating burners and stainless steel flues suitable for 80 / 60 °C water temperatures subject to EM approval. Condensing heating water generators are preferred by EM Engineering.

Heating hot water pipework systems must incorporate a bypass line where necessary to ensure that the required minimum water flow through the heating hot water generators is maintained during low load conditions and to cater for the minimum flow rates associated with the heating hot water pumps.

Part load performance characteristics shall be submitted to EM Engineering for review and approval.

E.2.14 Feed and Expansion Tanks

Provide copper or stainless steel feed and expansion tanks with sufficient capacity without overflowing to accommodate the expansion of water contained within chillers and heating water generators and associated chilled and heating water piping systems.

Provide low and high level water alarms for each tank and connect to the UNSW CBACS system.

Ensure that the tanks are located at least one metre above the highest point of the respective system.

The use of pressurisation type expansion units may be considered subject to the approval of EM Engineering. The unit shall be connected to the UNSW CBACS system via a high level interface. Refer to [UNSW Design Guideline Appendix 1 – Automation and Control Systems](#) for details.

E.2.15 Filters

E.2.15.1 Filter Material

The filter material shall be vermin proof and shall have early fire hazard properties in accordance with AS 1530 as follows:

Spread of flame - 0

Smoke developed - not greater than "4"

E.2.15.2 Media

Filter media shall be disposable. Washable type media is not acceptable.

E.2.15.3 Tests

For all projects, the tender documents shall include testing to cover resistance, arrestance efficiency and dust holding capacity.

E.2.15.4 Arrestance Efficiency

E.2.15.4.1 Deep Bed Type

The requirements below are the minimum to be achieved. Filters shall be selected to achieve the air quality required for the specific function of the space. Refer to room data sheets for final requirements.

Not less than 95% to AS1132 No. 2 test dust and not less than 85% against No 3 test dust. Final resistance 125 Pa when handling specified air quantity.

At the final resistance of 125 Pa the dust holding capacity shall be not less than 4300g per 1000 l/s for No. 2 dust and not less than 6400g per 1000 l/s for No 3 dust.

E.2.15.4.2 Panel Type

Not less than 60 % to AS1132 No. 4 test dust. Final resistance will be 125 Pa when handling the specified air quantity.

E.2.15.5 Face Velocities

The maximum face velocity corresponding to the final resistance shall be as follows:

- Deep Bed Filters - 2.0 m/s
- Panel Filters - 1.8 m/s

E.2.15.6 Mounting

All gaps shall be sealed between the filter frame and the air handling plant casing such that no air bypasses the filter unit.

E.2.15.7 Filter Banks

All filters in any filter bank shall be identical. Adequate access clearances must be allowed for maintenance and for changing the filter media.

E.2.15.8 Filter Gauges

Each filter bank shall be provided with a Magnehelic gauge with a full-scale deflection no more than twice the dirty filter condition. The gauge is to be located in an unconcealed position, exposed to view and which facilitates the reading of the pressure drop across the filter.

Where digital type gauges are proposed, a technical submission is to be provided to EM Engineering for review and approval.

E.2.15.9 Inclined Manometers

Inclined Manometers are not acceptable.

E.2.15.10 Other Filters

High performance extended surface anti-microbial filters shall be specified where filtering bio organisms. The preferred approach is for activities involving bio organisms to be undertaken within an approved containment equipment

HEPA filters shall be specified where very high efficiency filtration is required.

For the control of odours, activated carbon filters shall be considered. Where activated carbon filter systems are specified, these systems shall be soundly engineered with due consideration given to the nature of the application and liaison undertaken with suppliers to ensure the filter specified is fit for purpose.

E.2.16 Packaged DX Air Conditioning Systems and VRV / VRF Systems

The determining factor in the use of DX air conditioning equipment shall be the use and size of the application, the energy consumption costs, the building aesthetics, the available space for equipment installation, and the type of equipment for the particular application. The design shall be based on Mitsubishi Electric manufactured systems.

The design consultants design is to include the required refrigeration vapour alarm systems where required although the design intent will be for systems that will not require the need for these alarms.

The Consultant will determine the refrigerant concentrations for every space served by a DX system, and will ensure that concentrations meet the requirements of all Australian Standards and that the building design includes all provisions for safe occupation.

The Consultant will include the VRV/VRF suppliers piping and electrical schematics to UNSW EM Engineering for review, including the design consultant inputs.

E.2.16.1 Outdoor Equipment

Outdoor equipment shall be installed on 100mm high solid concrete plinths using suitable anti vibration mounts.

Allow sufficient space around the equipment for maintenance and airflow purposes as recommended by the manufacturer.

All condenser coils shall be treated with approved corrosion treatment of the fins and casings for both critical and long-life applications.

All split unit systems shall be of the inverter type.

E.2.16.2 Indoor Equipment

Wall or ceiling mounted equipment shall be isolated from the building structure using anti-vibration mounts.

E.2.16.3 Outside Air

Where possible outside air shall be built into the system to conform to the requirements of AS 1668.

E.2.16.4 Controls

Where practical, and particularly for larger installations, DX air conditioning units shall be connected to the UNSW CBACS system (refer to [UNSW Design Guideline Appendix 1 – Automation and Control Systems](#) for details). Where permitted by EM Engineering, packaged units may be controlled by an independent 365-day programmable timer to enable operation during normal occupation hours, and an additional “one-shot” timer to enable operation out of hours for a maximum run-on time of two hours.

E.2.17 Air Compressor Plant

Compressed air plant shall be designed in accordance with AS2986. Depending on the required system capacity, the intent is for the compressor plant to be an oil free air or water cooled rotary screw with after cooler and dryer all to be acoustically housed. Each compressor shall be installed on a plinth and shall be drained to a floor waste.

The system shall include a receiver with drain, low pressure pressure-switch, safety valve, gauge and access hatch. The receiver shall have isolation valves on the inlet and outlet.

Two stage air filtration shall be provided with an auto drain and bypass protection. The units shall automatically change over.

Air pressure regulators designed on full flow shall be provided to AS 2896 and be in duplicate. Units shall be provided with isolation valves for ease of maintenance.

The plant and equipment shall be provided on a separate electrical control panel.

All control and indication points shall be available via a HLI in accordance with [Appendix 1 – Automation and Control Systems](#).

E.2.18 Refrigerated Freezers and Cool Rooms

E.2.18.1 General

Refrigeration equipment, systems and ancillaries for freezers and cool rooms will comply with AS 1677.2.

Refrigeration equipment shall comply with the energy efficiency requirements of NCC Section J.

Refrigeration equipment shall be inclusive of compressors, condensers, forced draft evaporators, refrigeration piping and all components and accessories necessary for reliable operation with minimum maintenance and outage of the system.

The capacity of the refrigeration system, shall, as a minimum, be that required to maintain the thermal performance of the room taking into account loads associated with items to be stored.

The maximum run period of the refrigeration equipment shall not exceed 16 hours in a 24-hour period during normal operation

E.2.18.2 Construction

The preference is for factory assembled freezer and cold rooms wherever possible.

Where freezer and cool rooms must be constructed, construction must be carried out by a reputable contractor with proven experience in the installation of equipment for comparable projects.

The wall, floor and ceiling panels must be constructed from expanded polystyrene insulation material having the following specifications:

Item	Requirement
Floor insulation density	24 kg per cubic metre
Walls and ceilings insulation density	16 kg per cubic metre
Thickness:	Walls and floor: 75 mm
Ambient to minus 5°C	Door/s: 100 mm
	Ceiling: 75 mm minimum or as required for the room span.
Thickness:	Walls and floor: 100 mm
< minus 5°C to minus 15°C	Door/s: 100 mm
	Ceiling: 100 mm minimum or as required for the room span.

Thickness:	Walls and floor: 150 mm
< minus 15°C to minus 25°C	Door/s: 150 mm
	Ceiling: 150 mm minimum or as required for the room span.
Thermal conductance	0.038 W/mm ² K at a mean temperature of 10°C.
Water vapour transmission	0.002 to 0.007 kW/m ² per 24 hours at 37.8°C and 90% RH.
Coefficient of linear expansion	0.0000396/°C.
Compressive strength (ultimate breakdown load)	120 kPa

All interior and exterior surfaces of the walls and ceilings are to be clad in 0.6 mm white steel sheeting and glue the cladding to the insulating material under pressure to ensure a good permanent bond over the entire glued surfaces.

Proprietary type extruded aluminium sections at all wall, floor and ceiling joints to form the required structural strength without creating cold bridging, and seal with mastic to produce the necessary vapour seal and internal surfaces.

The floor sealant shall be bitumen based and suitable for waterproofing and adhesion to the surfaces of the cool room and shall be stable for the complete range of temperatures to which the cool room is subjected.

All pipe and electrical penetrations of the insulated walls or roof shall be provided in a neat and workman like manner which will maintain the thermal and vapour barrier performance of the panel and ensure the continuance of the vapour barrier.

E.2.18.3 Forced Draught Evaporators

The complete assembly is to be housed in a heavy gauge aluminium cabinet with removable sections as required for access to the refrigerant valves and electrical connections. Provide the drip tray as an integral part of the casing with coil condensate discharging via a piped condensate drain line to a floor drain point.

Fan motors shall be fitted with inbuilt thermal overload protection, ball bearings and dust seals.

The thermal expansion valve/s are to be externally equalised type.

Coil face velocities must not exceed 4 m/s.

Ensure that integrity of the room's vapour seal is maintained when mounting the evaporator assembly and installing the refrigeration lines and condensate drain line.

E.2.18.4 Refrigeration Condensing Equipment

Each forced draught evaporator must be provided with a standard size matched hermetic compressor and air-cooled condenser.

The compressor/condenser unit must be sized to handle the evaporator load when operating a maximum of sixteen hours per day at the suction temperature of:

- cool rooms -3.5°C
- freezer rooms -30°C

Aluminium finned condenser coil and condenser fan combinations sized to operate at an ambient temperature 5oC above the maximum design temperature for the installed location are to be provided. Provide for a condensing temperature difference of 11oK maximum and from a rise in suction temperature.

Coils shall be prepared and corrosion protected in accordance with the manufacturer's recommendations. The coating shall be applied to completely cover the fins, tubes, headers and frames of the coil.

The compressor motor shall not overload or overheat when operating under normal or pull-down conditions coincident with the extremes of the ambient conditions for the location of the installation.

Provide the condensing unit with a refrigerant liquid receiver sized to be not more than 80% full when containing the whole refrigerant charge of the system. Provide fan guards complying with Statutory requirements and rigid galvanised steel casing and screen to protect the condensing coil fins from damage.

Condensing units are to be on spring and rubber isolators to provide 95% vibration isolation at the operating speeds of the compressor motor and condenser fans.

Install all connections of refrigerant piping, condensate piping, electrical and control conduits with sufficient flexibility to prevent vibration being transmitted to the building structure.

Provide refrigerant externally equalised expansion valves for each of the forced draught evaporator coil feed connections. Match the refrigeration capacity and power head charge to that of the evaporator duty.

Install full liquid line sized solenoid valves ahead of each thermostatic valve and fit with hermetically sealed magnetic coils.

Provide an approved equal full flow filter drier and combination sight glass in the liquid line leaving the liquid receiver.

E.2.18.5 Controls

The freezer and cool rooms shall be complete with all electric controls necessary for the successful operation of the rooms generally as indicated on the drawings.

Power will be provided as described in the Electrical section of the specification.

Include a panel adjacent to the cool rooms or condensing units with the necessary control gear. For cool rooms also include a high temperature alarm and pilot light for each room.

Provide each room with an occupancy distress alarm device located outside, but controllable only from within the room, to the requirements of Statutory Authorities.

E.2.19 Water Treatment

Water treatment is to be provided during construction, commissioning, and practical completion, and ensure that materials in contact with water are protected from corrosion and fouling.

The UNSW incumbent water treatment specialist is to be engaged to visit the site each month and undertake inspections, tests and services as specified below where applicable to the project:

- upon filling of the cooling tower or evaporative condenser and condenser water system
- during the commissioning period
- at practical completion
- for the duration of the defects liability period.

Water treatment is to be provided as necessary to achieve the following objectives:

- prevent system deterioration during construction
- clean systems prior to putting into service
- maintain systems in such a condition as to allow design operating parameters to be achieved at all times.

Details of the proposed water treatment system, process and program are to be submitted to EM Engineering for review. Details provided shall include cleaning chemicals, inhibitor types with initial passivation and maintenance levels required, biocide types and maintenance levels required, frequency of dosing of biocide, treatment levels required, and proposed water chemistry control limits.

The water treatment system, process and program, chemicals, equipment, components and accessories shall comply with the requirements of AS 3666 as applicable to the project.

Detailed operation and maintenance instructions for the water treatment system are to be provided.

Before putting systems into service, closed systems and condenser water systems, with cooling towers bypassed, shall be cleaned and disinfected, inclusive of cooling towers and evaporative condensers where applicable to the project.

E.2.20 Air Conditioning Electrical Requirements

The following requirements should be addressed in the preparation of the design and specifications:

Refer also Section E.3.1

E.2.20.1 Switchboards and Motor Control Centres

Switchboard and motor control centres must normally be of type tested construction with IP rating approved by EM Engineering prior to manufacture.

Boards shall be Form 2b minimum.

Form 3a separation shall be provided when in excess of 150kW motor load occurs. Separate ducting must be provided within the switchboard to separate Direct Digital Control (DDC) and power cables.

Refer also Section E.3.1 (Clause E. 3.1.2)

E.2.20.2 Labels in Switchboards

Permanent clearly legible traffolyte labels must be screw fixed to all internal and external controls. All labels in switchboards must be mounted on stand-off brackets and must not be surface-fixed to the back plate of the board.

E.2.20.3 Fire Alarm Trip Relays

Fire alarm trip relays must be provided in accordance with the requirements of AS1668 and AS1670 as applicable. All fire trips shall have automatic reset and associated indicator lights mounted at the switchboard / MCC.

E.2.20.4 Spare Capacity

Buildings designed as not being fully air-conditioned must be provided with a minimum of 25% spare space and capacity in all switchboards, sub-boards and control panels to allow for future expansion of the air-conditioning system.

This spare capacity also applies to the switchboard feeder cables. Fully air-conditioned buildings must have 10% spare capacity.

E.2.20.5 Cable Separation

Medium and low voltage cable and controls must not be installed in the same duct.

E.2.20.6 Spare Consumables

Provide the following spare switchboard consumables, mounted in trays or secured by holding clips fixed to the back of the switchboard cubicle doors:

- Three (3) fuses of each type and size
- One (1) relay of each type/coil voltage
- Ten (10) indicator lamps.

E.2.20.7 Cable and Duct Trays

Cable and duct trays must be clearly labelled as to their contents.

E.2.20.8 Circuit Breakers

Circuit breakers are to be of either Terisaki or Schneider manufacture.

E.2.20.9 Polyphase kilowatt-hour meters

Meters must be provided to the air conditioning switchboards to meter the power consumption in accordance with UNSW metering requirements. These meters may be located on the main electrical switchboard and grouped with all other meters, suitably labelled.

E.2.20.10 Cables

Cables must all be run on cable ladders and terminated in terminal strips. Numbered ferrules at each termination including field terminations must identify cables. All cables entering switchboards, control panel etc. which are part of a multi-core cable, and any other cable which is unused, must enter the switchboard through a gland nut and be terminated on a terminal block, labelled as to its origin and numbered. All neutral and control wiring must also be number ferruled both in the switchboard and at field terminations. Wrap around tape numbering systems are not acceptable.

E.2.20.11 Heater Protection Thermostats

Heater protection thermostats complete with fault lights must be provided to all heaters and located within switchboards. Airflow switches must be incorporated in all heated air systems using electric element heating.

E.2.20.12 Fan Coil Units

Fan coil units must have an auxiliary relay on the fan in lieu of airflow switch.

E.2.20.13 Electrical Drawings

Electrical drawings must be prepared with Circuit Reference Numbers to indicate the number of contacts and their location, all to ISO Standard on an approved drawing.

E.2.20.14 Switchboard Illumination

Provide a GPO and single 20W fluorescent lamp in each switchboard cupboard greater than 2m² in face area

E.2.20.15 *The Auto/OFF/Manual*

Control to all AHUs and fan coil units must isolate all components including all controls to electric heaters when in the "off" position, and must enable all controls when in the 'Auto' or 'Manual' positions.

E.2.20.16 *Control of Individual Plant*

Individual plant must be controlled from the switchboard via an Auto/Off/Manual switch which, when in the 'Auto' position, enables the operation of the unit by a local BMS or similar control system.

E.2.20.17 *The Earth and Neutral Bar*

The earth and neutral bar must be sized to accommodate separately all earth and neutral cables. Multi-joining of cables prior to termination on bars is not acceptable.

E.2.20.18 *Connected Load in Excess of 50kW*

On all projects with a connected air-conditioning electrical load in excess of 50kW, all air-conditioning switchboards must be checked by the contractor prior to the expiration of the defects liability period using a Thermoscan unit or similar. Any defects found must be rectified and a complete report including thermal photographs must be supplied prior to the Certificate of Practical Completion being granted.

E.2.20.19 *Lamp Test Facility*

All mechanical switchboards must have a lamp test facility incorporated into the control system via relays and not diodes.

E.2.20.20 *Local Isolators*

Provide suitable isolators at each item of plant.

Isolators shall be of the weatherproof type when located outside and when considered necessary.

Isolators are not to be mounted directly to the associated plant but must be located in a nearby position within clear line of sight to the plant served.

E.2.20.21 *DDC cables*

DDC cables must all be screened and not run adjacent to any 240V electrical cables. Separate ducting must be provided within the switchboard to separate Direct Digital Control (DDC) and power cables.

E.2.21 Air Conditioning Controls

E.2.21.1 Standard Controls Configurations

UNSW has developed some generic control diagrams and drawings showing minimum standard of functionality that is to be provided in a control system. These drawings are a guide only and are not to be used for tendering purposes or as a design specification.

These standards are not intended to provide details concerning sequences of operation, sensors, actuators, etc. It is the Consultant / Designers responsibility to specify the control system functionality to suit the installation at hand.

Refer Appendix 3 – “UNSW Control System Standards HVAC”

E.2.21.2 Standard Controls Configurations

Refer to [UNSW Design Guideline Appendix 1 – Automation and Control Systems](#) for details.

E.2.21.3 Safety and Alarms

The system shall be capable of providing audible and/or visual alarms and be capable of responding to specific operating conditions such as shutting down of equipment, initiating smoke control modes and other appropriate measures.

E.2.21.4 Air Handling Units

AHUs must be fully automatic in operation and must be time switch controlled from the UNSW CBACS where applicable. The proposed after hours zoning and control configuration shall be submitted to UNSW EM Engineering for review and approval. Refer to [UNSW Design Guideline Appendix 1 – Automation and Control Systems](#) for details.

E.2.21.5 Refrigeration Plant

Refrigeration plant must be fully automatic and must normally respond to a call for cooling from any fan coil units or draught cooler.

E.2.21.6 Control Cables

Must be screened and not run adjacent to any 240V electrical cables.

E.2.21.7 Service Interruption

Provide automatic restoration of the control system after any service interruption.

E.2.22 Operation and Maintenance Manuals

Operation and maintenance manual format and contents shall be specified within the Tender documentation and will adhere to the following format as required:

E.2.22.1 Folder requirements

- 1) Plastic hard-backed three or four ring binder
- 2) All pages in plastic sleeves
- 3) Section separation by coloured dividers with numbered tabs
- 4) Sub-section separation by coloured dividers with no tabs

Folder Front Cover

Contractors name and logo and project name in full – i.e. UNSW, Kensington, Building, Level, Room, Project Title.

Folder Spine

Project Title

E.2.22.2 Contents

First Page

- 1) Contractors name and logo and project name in full – i.e. UNSW, Kensington, Building, Level, Room, Project Title.
- 2) Full contact details of all parties to the project – Contractor, Consultant, Architect, Client, Sub-Contractors - addresses, phone and fax numbers, email addresses.

Second Page

- 1) Date of awarding of Practical Completion.
- 2) Date and time of commencement of defects liability period.
- 3) Date and time of completion of defects liability period.

Third Page

- 1) Contents page.

Section 1 – Plant and Systems Descriptions

- 1) Detailed description of complete installation, including all separate systems, all plant locations, ID names, etc.
- 2) For D&C projects, all design criteria for each system – design heat loads rates, internal and external design temperatures and %RH, design air change rates, velocities, etc.

Section 2 – Description of Plant Operation

- 1) Detailed description of all plant and systems operation and control methods – how everything works – including all controls topography drawings, controls settings and controls logic diagrams.

Section 3 – Plant Schedules

- 1) Complete schedules of all plant – ID numbers, make and model, capacities.

Section 4 – Plant Catalogues

- 1) Comprehensive plant manufacturers' literature for every item of plant and/or equipment – each plant literature separated by coloured divider.

Section 5 – Maintenance Schedules

- 1) Manufacturers' maintenance requirements for each and every item of plant.
- 2) Contractors' maintenance requirements for each system.

Section 6 – Plant Test Certificates

- 1) All certification documents – each plant or system certification separated by coloured divider.

Section 7 – Commissioning Data

- 1) Comprehensive plant commissioning data for every item of plant and/or system – each plant data separated by coloured divider.

Section 8 – As-Installed Drawings

- 1) Every approved as-installed drawing for the contract – each drawing within a plastic sleeve with fold-over top.

E.2.23 Commissioning & Testing

The following requirements for Testing and Commissioning should be addressed in the preparation of the design and documentation.

Commissioning of buildings and building services is vitally important to the safe and energy efficient operation of buildings, but it is not always carried out or carried out systematically. Commissioning involves functional testing to determine how well mechanical and electrical systems work together, and seeks to determine whether equipment meets a facility's operational goals or whether it needs to be adjusted to improve efficiency and overall performance.

The operation of buildings and their services are a key target for action to improve energy efficiency and reduce carbon emissions. For this reason, proper and thorough commissioning can make a significant contribution to achieving an efficiently running building.

Many studies have been carried out to demonstrate the benefits of properly conducted commissioning. These benefits are not solely related to energy savings, but provide improvements in a number of areas including:

- Thermal Comfort
- Improved Indoor Air Quality
- Improved System Function
- Improved Building Operation & Maintenance
- Improved Building Occupant Productivity
- Lower Utility Bills through Energy Savings
- Increased Occupant & Owner Satisfaction
- Significant extension of Equipment / Systems Lifecycle

Laboratory buildings present individual challenges to be addressed during the commissioning process, especially in consideration of the integration of systems. Additionally, there are many specialised services – pneumatic tube systems, medical gases, steam sterilisation etc, which require specific commissioning methodologies and rely heavily on the integration of other services.

The services of a Commissioning Management Organisation (CMO) should be engaged on all projects to provide the necessary framework and holistic overview of the commissioning process. The Commissioning Management Organisation is required to have engineering experience on all relevant disciplines and be able to engage the various stakeholders in the process to provide a focus on the successful delivery of a project.

The CMO should be engaged during the design development process to provide input into system commissionability, review system functionality and maintainability and to introduce relevant clauses & specifications into the contract documentation.

The CMO shall develop a Commissioning Plan for the project. This document will provide a framework for the commissioning of the services and include, as a minimum:

- List of systems to be commissioned
- Details of agreed methods & procedures used for testing & commissioning
- Results of all testing & commissioning
- Final Commissioning Report detailing any issues requiring resolution, and recommendations for further testing including deferred testing & seasonal testing

Additionally, thorough commissioning to published recognised Standards and post-construction fine-tuning of the mechanical services shall be implemented to reduce energy consumption with a “Soft Landing” approach is suggested. At the end of defects liability period the building shall be recommissioned to take into account the building operation and any fine tuning that is required.

The mechanical services shall be commissioned in accordance with CIBSE Commissioning Codes:

- CIBSE Commissioning Code A: Air distribution systems
- CIBSE Commissioning Code B: Boilers
- CIBSE Commissioning Code C: Automatic controls
- CIBSE Commissioning Code M: Commissioning management
- CIBSE Commissioning Code R: Refrigerating systems
- CIBSE Commissioning Code W: Water distribution systems

The design team shall provide a commissioning management plan taking into account all load testing to prove the services are working adequately.

The designers shall include a specific requirement for comprehensive “re-commissioning” including full testing and witnessing at the end of the contract Defects Liability Period.

E.2.23.1 *Procedures*

The Consultants and/or designer shall establish the procedures to follow for testing and commissioning the installation in order to establish that the plant is operating and performing correctly before it is handed over to the UNSW.

Air and water distribution systems shall be commissioned and tested in accordance with procedures and recommendations of CIBSE commissioning codes A and W respectively.

Each piece of mechanical equipment shall have its own comprehensive commissioning sheets recording the commissioned data. As a minimum equipment shall include:

- Chillers
- Heating Water Generators
- Pumps
- Heat Exchangers
- Fume Cupboards
- VAVs
- FCU's
- AHU's
- VRF/VRV
- DX Units
- CRACs
- Cooling Towers
- Pressure Sets
- Humidifiers
- Desiccant Dehumidifiers
- Vacuum Systems
- Compressed Air
- Grilles
- Fans
- MCC
- Freezers

E.2.23.2 *Pressure Testing*

Pipework and ductwork pressure testing shall occur on all systems in accordance with Australian Standards.

Pipework shall be pressure tested at 1.5 times the design pressure for water and compressed air systems for a period of 24 hours.

R410a systems shall be pressure tested for a 24-hour period at pressure recommended by the manufacturer.

EM Engineering must be provided with details of pressure testing schedules well in advance of proposed test dates in order to attend for witness testing purposes.

E.2.23.3 *Type Test*

Certified Factory Type Tests of an identical item of equipment to the one installed shall be provided for all items of plant, stating that the item meets the specified requirements.

E.2.23.4 *Balancing*

All water and air systems shall be balanced to give the designed flow rates within + 10%, - 0%.

E.2.23.5 Acceptance Tests

Acceptance tests shall be witnessed by EM Engineering and shall commence only when the Contractor has finalised his preliminary tests and can demonstrate that the plant is operating as intended via submission of completed commissioning sheets for systems to be witnessed.

Sufficient notice shall be provided to EM engineering to enable the completed commissioning sheets to be reviewed and mutually agreeable times for witness testing to be scheduled.

It is to be outlined within the tender documentation that failure of the Contractor to satisfactorily demonstrate the correct operation of the mechanical services system during witness testing may result in delays to the construction program subject to the ongoing availability of EM Engineering staff to attend the additional witness testing sessions which result.

E.2.23.6 Functional Performance

Tests shall be carried out for each item of equipment to verify and demonstrate that the equipment meets the specified requirements.

E.2.23.7 Controls

Shall be checked with the operation of the plant to ensure that the specified modes of operation and conditions are achieved.

E.2.23.8 BACnet Controls

All devices, BACnet objects, points, systems and sub-systems shall be labelled and tested, including graphics and operational matters such as trending and alarms. Refer Appendix 1 – “Building Automation and Control Systems Specification”.

E.2.23.9 Measurements

Shall be recorded for each item of equipment and a report for inclusion in the “As-installed manuals” shall be provided to include at least the following:

- Date and time of test.
- The item tested.
- The test procedures instruments used and calibration certificates for each instrument.
- The ambient and other relevant conditions.

- All readings of airflow, water flow, pressures, temperatures, noise levels, volts, kW etc as applicable.
- Instrument readings, control settings, valve position and the like.
- The nameplate ratings and the like.

E.2.23.10 Adjustments

Where necessary, adjustments shall be made to ensure that the equipment is performing as specified both during the commissioning process and throughout the duration of the defects liability period.

E.2.24 Plant Room Schematics

As-Installed air and water system schematics shall be provided within each major plant room for ease of reference. Each schematic drawing will be reproduced at A0 size and be laminated in rigid clear plastic having a total thickness of approximately 1mm and securely fastened to the plant room wall in a readily visible location.

Where appropriate, As-Installed drawings for main plant rooms shall incorporate equipment schedules for plant items located within this plant room for ease of reference.

E.2.25 Equipment Identification

All items of equipment must be suitably identified with traffolyte labels of an approved size and type. All thermometers, pressure gauge tapplings, remote sensing points and the like, must be similarly labelled to indicate their function.

E.2.25.1 Pipework

All pipes must be identified in accordance with AS1345 – Identification of Contents of Piping, Conduits and Ducts, and AS1318 – SAA Industrial Accident Prevention Signage Pipework whether exposed in plant rooms or concealed in risers and ceiling spaces must be identified in accordance with the UNSW colour schedule.

E.2.25.2 Method of Identification

Service	Lettering	Colour
Water	Chilled water	Jade – G21
	Potable cold water	
	Condensate	Blue b.24
	Condenser water	
	Cooling water	
	Demineralised water	
	Distilled water	
	Domestic hot water	
	Hot water heating	

	Make up water	
Air	Compressed air Instrument air Vacuum Vents	Aqua B25
Gases	Medical gases Natural gas Vents (hazardous)	DIN 12920
Steam	Steam Vents	Silver Grey N24
Acids & Alkalis		Lilac P23
Fuel oil	Flammable and combustible liquids	Golden Tan X53
Miscellaneous	Drains Vents (other than steam) Pipe supports Overflow (water)	Black N61
Plinths & inertia bases		
Electrical Conduit		Orange X 15
Switchboard		Orange X15
Fire services		Signal Red R13

“Safetyman” adhesive labels will be used for identification of pipework and shall be applied at not more than 8 m intervals on straight runs, both sides of any wall, floor or other partition through which the pipe passes, adjacent to valves, branch line, control point and any outlet. Labels are to make use of a high strength adhesive suitable for fixing to the pipework surface material including low surface energy materials.

Flow direction arrows must be provided to all pipework and the Flow and Return pipes must be identified with labels reading “Chilled Water Flow” and “Chilled Water Return” or “High Temp Hot Water” as applicable. Further examples of pipe work systems requiring labelling are:

- Cooling water
- Compressed air
- Steam
- Gases

Provide labelling of pipework systems as appropriate for all pipework system within the project.

Colour standards shall be in accordance with AS2700 where not referenced elsewhere in these specifications.

Refer also Section E.1 – Hydraulic Services

E.2.26 Colour Schedule for Plant and Equipment

All plant and equipment in plantrooms, services risers and whenever exposed to view must be painted.

Where colours are not specified for particular items of plant, EM Engineering shall be consulted before colours are nominated.

All pipework, valves and fittings must be colour banded. Pipework identification must be achieved throughout using Safetyman pipe markers and labels to indicate content and flow.

E.2.27 Mechanical Services for Laboratories and Critical Applications

E.2.27.1 Laboratory Design

The design of mechanical services for laboratories shall be in accordance with the requirements set out in AS 2243.

Design of air conditioning and ventilation systems to laboratory areas is to take into consideration the impact of localised effluent removal systems at the source of contaminant generation and the resulting reduction of outside air flow rates required, rather than be based on generic air change rates. Refer to Labs21 best practice guideline “Optimizing Laboratory Ventilation Rates”, for further information.

Refer to project specific room data sheets for the project for room requirements where available.

E.2.27.2 Critical Areas

Critical areas including laboratories where applicable shall be supplied with essential services including power, chilled water, condenser water, humidification, heating, ventilation, controls, etc. The systems shall be designed so the appropriate load shedding occurs.

Single point of failure analysis is to be completed for critical areas with agreement of solutions with the UNSW EM Engineering.

E.2.27.3 Cleanrooms

The design of cleanrooms shall be in accordance with AS2243, ISO 14644, and approving body requirements. The consultant shall liaise with users in determining the production requirements of the cleanroom to ensure the design process is followed to be able to achieve sign off and shall include design, installation and commissioning qualification processes.

Refer to Room Data Sheets for temperature, humidity, pressure and filtration requirements.

Cleanroom redundancy shall be reviewed by the consultant with proposal referred to EM Engineering for review and sign off.