### E.2 MECHANICAL SERVICES – TABLE OF CONTENTS

**UNSW DESIGN & CONSTRUCTION REQUIREMENTS – WEB ENTRY PAGE**

**SECTION A – INTRODUCTION**

**SECTION B – DEVELOPMENT & PLANNING**

**SECTION C – ARCHITECTURAL REQUIREMENTS**

**SECTION D – EXTERNAL WORKS**

**SECTION E.1 – HYDRAULIC SERVICES**

**SECTION E.2 – MECHANICAL SERVICES – SCHEDULE OF CHANGES – REVISION 4.1 ...........3**

**E.2 MECHANICAL SERVICES.................................................................................4**

**E.2.1 General........................................................................................................4**

**E.2.2 Fans.............................................................................................................7**

**E.2.3 Ductwork....................................................................................................9**

**E.2.4 Air Intakes................................................................................................13**

**E.2.5 Exhaust Discharges...................................................................................13**

**E.2.6 Piping, Valves and Fittings........................................................................13**

**E.2.7 Pumps – Centrifugal..................................................................................17**

**E.2.8 Water Chillers............................................................................................18**

**E.2.9 Air Handling / Fan Coil Unit.....................................................................19**

**E.2.10 Cooling Towers........................................................................................21**

**E.2.11 Evaporative Coolers................................................................................21**

**E.2.12 Air Cooled Condensers ..........................................................................21**

**E.2.13 Gas Fired Boilers.....................................................................................21**

**E.2.14 Feed and Expansion Tanks....................................................................21**

**E.2.15 Filters.......................................................................................................22**

**E.2.16 Unitary Plant.............................................................................................23**

**E.2.17 Air Conditioning Electrical Requirements............................................24**

**E.2.18 Air Conditioning Controls.................................................................27**

**E.2.19 Commissioning & Testing......................................................................28**

**E.2.20 Equipment Identification.......................................................................29**

**E.2.21 Colour Schedule For Plant And Equipment..........................................31**

**SECTION E.3.1 – ELECTRICAL SERVICES**

**SECTION E.3.2 – LIGHTING**

**SECTION E.3.3 – SPECIAL SYSTEMS**

**SECTION E.3.4 – HIGH VOLTAGE**

*UNSW Design & Construction Requirements (Rev 4.1)*

1/31
SECTION E.4 – COMMUNICATIONS

SECTION E.5 – LIFTS

SECTION E.6 – FUME CUPBOARDS

SECTION F – SPECIFIC AREA REQUIREMENTS

APPENDIX 1 – BUILDING AUTOMATION AND CONTROL SYSTEMS SPECIFICATION

APPENDIX 2 – CONCRETE FOR STRUCTURES

APPENDIX 3 – UNSW CONTROL SYSTEM STANDARDS HVAC

APPENDIX 4 – DOCUMENT REQUIREMENTS

APPENDIX 5 – UNSW STANDARD PRELIMINARIES

APPENDIX 6 – SECURITY SYSTEMS
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

<table>
<thead>
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<th>Clause</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>General revision</td>
<td></td>
</tr>
<tr>
<td>E.2.1.10</td>
<td>August 2004</td>
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UNSW Design & Construction Requirements (Rev 4.1)
E.2 MECHANICAL SERVICES

E.2.1 General

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

This section is a Guideline 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.

Air Conditioning Policy

The existing air conditioning policy specifies the circumstances under which air conditioning systems may be installed.

In brief, air conditioning will only be allowed in essential areas where a controlled environment is critical to the functions performed, such as selected laboratories, computer areas and some animal houses.

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

Where air conditioning is required in a building, chilled and heating water systems shall be provided in the building which can connect to a future campus wide central energy plant via underground service tunnels and ducts.

All new air conditioning systems proposed for the existing and new buildings on the campus which have a cooling capacity greater than 30 kilowatts, shall be based on a chilled water cooling system to allow the future connection to the campus wide central energy plant when available.

Refer also: Section B

E.2.1.1 Design Requirements

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

a) Size or capacity of the system
b) Performance requirements
c) Energy utilisation
d) Noise consideration  
e) Location and space consideration  
f) Owning and operating costs  
g) Reliability  
h) Ease of maintenance  
i) Capability of future expansion

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 BCA, AS1668, AS3666 as well as any other applicable standards, Regulations or Acts in force at the time.

E.2.1.2 Calculations

A copy of a set of all calculations, such as air conditioning loads, life cycle costing, noise control measures etc, arranged in logical sequence, shall be provided to the Engineering Services prior to issuing any of the documentation for whatever purpose.

E.2.1.3 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.2.1.4 Hours of Operation

Normal hours of operation are between 8.00 am and 10.00 pm Monday to Friday. Research laboratories, libraries and computer facilities may require twenty-four hour operation. Detailed requirements for each air-conditioned space must be clarified with Engineering Services at an early design stage.

E.2.1.5 Population Density

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

<table>
<thead>
<tr>
<th>General Office</th>
<th>SQM/Person</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Office</td>
<td>8.0</td>
</tr>
<tr>
<td>Library Reading Rooms</td>
<td>3.0</td>
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<tr>
<td>Laboratory-Undergraduate (other years)</td>
<td>4.7</td>
</tr>
<tr>
<td>Laboratory-Postgraduate</td>
<td>12.0</td>
</tr>
<tr>
<td>Seminar Rooms</td>
<td>1.8</td>
</tr>
<tr>
<td>Lecture Theatres</td>
<td>1.1</td>
</tr>
</tbody>
</table>

UNSW Design & Construction Requirements (Rev 4.1)

5/31
E.2.1.6 Design Conditions

a) External Design Conditions - Summer
   For comfort and non-critical installations
   32.8 °C DB
   22.6 °C WB

b) For critical installations 24 hours operation
   34.5 °C DB
   23.5 °C WB

c) External Design Conditions – Winter
   7 °C DB & 80% RH

E.2.1.7 Performance Standards

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

a) Internal Design Conditions - Summer
   23 °C DB ± 1 °C
   55% RH nominal

b) Internal Design Conditions - Winter
   21 °C DB ± 1 °C

E.2.1.8 Humidity Control

Humidity control will not be provided unless specifically called for or where special circumstances dictate. Where special conditions are required these will be nominated by the user and agreed to by Engineering Services.

E.2.1.9 Air Filtration

Air filtration shall be provided at all air handling and mechanical ventilation plants.

In general air filtration systems shall use dry, replaceable type media.

E.2.1.10 Noise and Vibration

The maximum permissible noise rating recommended design sound levels for different areas of occupancy in buildings levels due to continuous mechanical plant noise shall be as stated in table 1 of AS 2107:2000 follows:
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 noisel 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 both the building and 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.

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.

E.2.1.11 Mechanical Ventilation

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

All fresh air shall be filtered at the point of entry and where appropriate, shall be heated / tempered for winter conditions.

E.2.1.12 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.

E.2.1.13 Installation Plant and Equipment

The following clauses 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.

E.2.2 Fans.

E.2.2.1 Power Consumption.
Fan shall be selected to achieve the lowest practical power absorbed at the specific operating conditions.

**E.2.2.2 Performance Curves.**

Guaranteed typical characteristic performance curves shall be supplied with each fan.

**E.2.2.3 Noise.**

An octave band analysis of the fan and motor sound power levels for the octave bands 125 Hz to 4000 Hz shall be supplied for each fan.

**E.2.2.4 Fan Casing.**

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

**E.2.2.5 Impeller**

Static and dynamic balancing required

**E.2.2.6 Mountings**

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.

All flexible connections shall be a minimum 50mm long.

**E.2.2.8 Belt Drives**

Belt drive 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 adjustments 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 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.

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.

E.2.3.1 Air Velocities

Low velocity systems are preferred. Ductwork must be designed to limit air velocities between 6 m/s and 8 m/s in main ducts and 5 m/s in branch ducts.

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 usable 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

Unless otherwise specified all material used in the construction of ductwork shall be galvanised steel.

E.2.3.6 Ductwork Exposed to Weather

Ductwork must be watertight and all joints sealed to prevent water entering the duct. The topside of the duct shall be crowned to allow water run off 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.

E.2.3.7 Ductwork Supports

Ductwork shall generally be supported as follows:

E.2.3.8 Trapeze

Type hangers for ducts running underneath a horizontal structure.

E.2.3.9 Strap or Shelf

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

E.2.3.10 Shoulder angles

On vertical ducts passing through floors.

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.

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 1 in 7.

E.2.3.12.2 Contracting
Contracting airflow tapers where the duct size is decreased; the slope of any side shall not exceed 1 in 4.

**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.

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.2.3.15 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.2.3.16 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.2.3.17 Opposed Blade Dampers**

Shall be used for throttling air quantities for balancing purposes.

**E.2.3.18 Access Panels**

Shall be provided for inspection and/or cleaning. Access panels must be not more than 3 metres apart and their location above ceilings must be coordinated with the building access panels, ceiling grid, lights and equipment layout.

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

**E.2.3.19 Fire Dampers**

Where installed shall be in accordance with AS 1668. An inspection panel shall be provided to allow access to the FD 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.2.3.20 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.2.3.21 Air outlets

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

E.2.3.22 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.2.3.23 Flexible Ductwork

Flexible ducts shall be in accordance with AS 1668.1 and shall be as short as possible and shall be stretched to smooth out corrugations. Long radius bends shall be used.

E.2.3.24 Flexible Duct Supports

Shall be spaced not more than 3000 mm apart. Supports shall be a band clamp or saddle type and shall not cause out of round shape or damage to the ductwork.

E.2.3.25 Flexible Duct Length

Shall not exceed 4500 mm.

E.2.3.26 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.2.3.27 Ductwork Insulation

Wherever possible ductwork insulation must be external.

Where ductwork and equipment have internal insulation for acoustic, 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.

Ensure all internal insulation is not exposed directly to the air stream.
E.2.4 Air Intakes

E.2.4.1 External Air Intake Louvres

Louvres shall be manufactured from marine grade aluminium and painted to colour to match adjacent wall.

To limit noise generation, pressure drop across the louvre shall not exceed 40 pa when mounted not higher than 5 m above ground and 100 pa when mounted higher.

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

E.2.4.2 Outside Air Dampers

Shall be manufactured from stainless steel and incorporate nylon bushes.

E.2.4.3 Louvre Drainage

Drainage shall be provided to each louvre to nearest drain.

E.2.4.4 Acoustic Louvres

Where an acoustic louvre is installed it shall form an integral part of the external air inlet and or outlet discharge louvre.

E.2.4.5 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 discharge or openings such as windows and doors.

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 chilled, heating and condenser water lines within buildings must be of Type B Copper.

UNSW Design & Construction Requirements (Rev 4.1)

13/31
**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:

<table>
<thead>
<tr>
<th>Description</th>
<th>Velocity (m/s)</th>
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<tbody>
<tr>
<td>Risers</td>
<td>1.0 – 1.8</td>
</tr>
<tr>
<td>Main Distribution</td>
<td>1.0 – 1.8</td>
</tr>
<tr>
<td><strong>Headers</strong></td>
<td>0.9 – 1.5</td>
</tr>
</tbody>
</table>

**E.2.6.3 Pipe Runs**

Pipe runs within the building must be run in service ducts, risers or ceiling spaces 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.

**E.2.6.5 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.

**E.2.6.9 Fasteners**
Wooden plugs and explosive powered fasteners are not acceptable for fastening of supports to the building or structure.

**E.2.6.10 Pipes Through Walls**

Where pipes pass through walls, floors, 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.2.6.11 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.2.6.12 Drains**

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

**E.2.6.13 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.

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

**E.2.6.14 Vents**

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

**E.2.6.15 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.

**E.2.6.16 Valves 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.2.6.17 Screwed Valves

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.

E.2.6.18 'Binder' cocks

Must be fitted to all chilled, heating and condenser water headers, to flow and return lines at all air-handling units, fan coil units, pumps and any equipment requiring flow to be measured and must extend a minimum of 15mm beyond the outside surface of the insulation.

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

E.2.6.19 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.

E.2.6.20 Balancing Valve Location

Balancing valves shall be located on the return lines from each item of equipment and a straight distance of at least 10 pipe diameters is to be provided each side of the valve.

E.2.6.21 Valves in Ceiling Spaces

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

E.2.6.22 Cleaning

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

E.2.6.23 Pipe Insulation

Insulation shall be provided to chilled water and heating water piping, steam, condensate and cold refrigerant piping, valves and all associated fittings.

Metal sheathing shall be provided where piping is exposed to view, in plant rooms 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”.

UNSW Design & Construction Requirements (Rev 4.1)
“Bradflex, Aeroflex, Armaflex” elastomeric foams or similar type are to be used for refrigerant piping and some condensate applications.

**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.

**E.2.7.1 Pumps In Parallel**

Shall be so 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.

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.

Provide a STAD valve on the discharge of each pump in lieu of the isolation valve where balancing is required at the pump.

**E.2.7.4 Non-Return Valves**

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

**E.2.7.5 Gauges**

Provide a gauge cock complete with suitable pressure gauge at each pump suction and discharge.

**E.2.7.6 Provide a strainer at each pump suction**

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**

Shall be mechanical type seals of proven manufacture and design.
E.2.7.8  Flexible Coupling

Where specified 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 manufacturer.

E.2.7.10  Mounting

Pump and motor 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  Water Chillers

A chilled water system feeding individual air handling units, or where appropriate condenser water loops, are the preferred systems, particularly so where such a system already exists and the proposed installation would be an extension of it.

E.2.8.1  General

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

Each chiller shall be provided with at least two independent refrigeration circuits.

E.2.8.2  Compressor Safety Controls

Provide a Low Pressure Manual Reset switch as part of the compressor safety controls.
Each refrigerant circuit shall be provided with its own common alarm signal and interface suitable for connection to the Bacnet system.

E.2.8.3 Chiller Operation

Provide Bacnet native controls including electronic thermal expansion valves to allow fully automatic operation of the chiller/s.

E.2.8.4 Noise and Vibration

Appropriate steps shall be taken to minimize transmission of noise and vibration to the surrounding structures.

An octave band analysis of the chiller sound power levels for the octave bands 63 Hz to 4000 Hz shall be supplied for each machine.

Noise measurements taken at 3 metres from the chiller shall not exceed 65 dBA.

E.2.8.5 Heat Rejection Equipment

Preferably air cooled equipment shall be used.

All condenser coils shall be treated with approved corrosion treatment of the fins.

E.2.8.6 Corrosion Protection

All fabricated steel components shall be treated specifically for corrosion protection.

E.2.9 Air Handling / Fan Coil Unit

E.2.9.1 General

Large central air handling units are to be avoided. Units serving small numbers of similar areas are preferred. Terminal re-heat should also be avoided for the purpose of energy conservation unless dictated by the application.

E.2.9.2 Sprayed Coil

Assemblies are not acceptable.

E.2.9.3 Outside Air

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

**E.2.9.4 Outside Air Heat Exchanger**

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

**E.2.9.5 Cooling Coils**

**DX Type**

Coils shall be arranged in banks such that the capacity of each is matched to its associated compressor. To maintain system control each bank shall be appropriately sub-divided into sections and each section fitted with an electronic thermal expansion (TX) valve. Maximum height of section 1060 mm.

**Chilled Water**

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

**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.

**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.2.9.6 Heating Coils**

**Hot Water**

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

**Electric Resistance Heaters**

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 O/L 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.2.9.7 Coils in Ceilings**
An access panel, for inspection and maintenance, shall be provided in all instances where coils are installed in ceilings or concealed spaces. The inspection panel shall be suitably labelled for location and identification.

**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.

Where cooling towers are installed a quick fill system shall be provided incorporating a minimum 50 mm dia. fill pipe.

Similarly a minimum 100-mm dia. drainpipe shall be installed for quick draining.

Variable speed drives shall be fitted to fans for capacity control.

**E.2.11 Evaporative Coolers**

Evaporative cooler shall not be used.

**E.2.12 Air Cooled Condensers**

Air-cooled condensers shall be selected to operate at an ambient temperature of 40 °C db.

Condenser coils shall be constructed from solid drawn seamless copper tubes with copper fins evenly spaced and attached to the tubes in an appropriate manner.

All condenser coils shall be treated with approved corrosion treatment of the fins.

**E.2.13 Gas Fired Boilers**

Boilers shall be of the sectional cast iron type with modulating burners and stainless steel flues suitable for 80 / 60 °C water temperatures.

**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 boilers and associated chilled and heating water piping systems.

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

Ensure that the tanks are located at least one metre above the highest point of the respective system.
E.2.15 Filters

E.2.15.1 Filter Material

The filter material shall be vermin proof and shall have an 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

Shall be disposable.
Washable type media is not acceptable.

E.2.15.3 Tests

In all filter installations, the tender documents shall include testing to cover resistance, arrestance efficiency and dust holding capacity.

E.2.15.4 Arrestance Efficiency:

Deep Bed Type
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.

Panel Type
Not less than 60 % to AS1132 No 4 test dust. Final resistance 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 - 2.5 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 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 location.

UNSW Design & Construction Requirements (Rev 4.1)
position, exposed to view and which facilitates the reading of the pressure drop across the filter.

E.2.15.9 Inclined Manometers

Not acceptable.

E.2.15.10 Other Filters

High performance extended surface anti-microbial filters shall be specified where filtering bio organisms.

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

For the control of odours, activated carbon filters shall be considered.

E.2.16 Unitary Plant

The determining factor in the use of Unitary 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.

Unitary plant shall be only used for systems having cooling capacities not exceeding 30 kW.

E.2.16.1 Outdoor Equipment:

Shall be installed on 100mm high solid concrete plinths using suitable anti vibration mounts.

Condenser shall not be boxed-in or positioned such that a reduction in airflow could occur.

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

All condenser coils shall be treated with approved corrosion treatment of the fins.

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 Outdoor Air:

Where possible outdoor air shall be built into the system to conform to the requirements of AS 1668
E.2.16.4 Controls:

All packaged units shall be connected and controlled by Bacnet. Where permitted by Engineering Services, 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.

All split unit systems shall be of the inverter type and controlled by an adjustable timer with a maximum run-on time of four hours.

E.2.17 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.2.17.1 Switchboards and Motor Control Centres

Must normally be of type tested construction with IP rating approved by Engineering Services prior to manufacture.

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

E.2.17.2 Labels in Switchboards

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

E.2.17.3 Fire Alarm Trip Relays

Must be provided in accordance with the requirements of AS1668 and AS1670 as applicable.

E.2.17.4 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.2.17.5 Cable Separation
Medium and low voltage cable and controls must not be installed in the same duct.

**E.2.17.6 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.2.17.7 Trays**

Must be clearly labelled as to their contents.

**E.2.17.8 Hour-run meters**

Must be provided on all items of equipment that are duplicated or run in parallel, and where else considered necessary.

**E.2.17.9 Circuit Breakers**

Terisaki or Schneider

**E.2.17.10 Polyphase kilowatt-hour meters**

Must be provided to the air conditioning switchboard to meter the power consumption. This meter may be located on the main electrical switchboard and grouped with all other meters, suitably labelled.

**E.2.17.11 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.2.17.12 Heater protection thermostats**

Complete with fault lights must be provided to all heaters. Airflow switches must be incorporated in all heated air systems using electric element heating with fault lights on switchboards.
E.2.17.13 Fan coil units

Must have an auxiliary relay on the fan in lieu of airflow switch.

E.2.17.14 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.2.17.15 Switchboard Illumination

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

E.2.17.16 The Auto/OFF/Manual

Control to fan coil units must isolate all components including all controls to heaters and chilled water when in the “off” position, and must enable all controls when in the ‘Auto’ or ‘Manual’ positions.

E.2.17.17 Air handling units

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 BMS or similar control system. Pumps must be similarly controlled.

E.2.17.18 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.2.17.19 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.2.17.20 Lamp Test Facility

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

E.2.17.21 Local Isolators
Provide suitable isolators at each item of plant.

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

**E.2.17.22 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.2.18 Air Conditioning Controls**

It is the policy at UNSW that all new installations shall use BACnet native control systems using the ASHRAE building automation and control networking protocol in compliance with the latest edition of ANSI/ASHRAE Standard 135.

Where the installation exists, it shall be assessed for conversion to BACnet protocol or for straight out replacement if economically viable.

Interfacing Gateways are to be used only in instances where practical or economical reasons justify the retention of existing non-BACnet equipment.

Refer Appendix 1

As a guideline, 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.

It must be stressed that 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 - Mechanical Drawings - UNSW Control System Standard.

**E.2.18.1 Trend Logging**

The system shall be capable to store input and output values for a number of points in the installation.

**E.2.18.2 Safety and Alarms**

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

**E.2.18.3 Air Handling Units**

**UNSW Design & Construction Requirements (Rev 4.1)**

27/31
Serving general offices must be fully automatic in operation and must be time switch controlled from the Bacnet system. Local push button station with adjustable run timer must be provided to allow operation after hours.

E.2.18.4 Refrigeration plant

Must be fully automatic and must normally respond to a call for cooling from any air handling Unit

E.2.18.5 Control Cables

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

E.2.18.6 Service Interruption

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

E.2.19 Commissioning & Testing

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

E.2.19.1 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.

E.2.19.2 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.2.19.3 Balancing

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

E.2.19.4 Acceptance Tests

Acceptance Tests shall be witnessed by the Engineering Services and shall commence only when the Contractor has finalised his preliminary tests and can demonstrate that the plant is operating as intended.

E.2.19.5 Functional performance
Tests shall be carried out for each item of equipment to verify and demonstrate that the equipment meets the specified requirements.

E.2.19.6  Controls

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

E.2.19.7  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.

E.2.19.8  Measurements

Shall be recorded 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.
- 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.2.19.9  Adjustments

Where necessary shall be made to ensure that the equipment is performing as specified.

E.2.20  Equipment Identification

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

E.2.20.1  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.2.20.2  Method of Identification

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<tr>
<th>Service</th>
<th>Lettering</th>
<th>Banding colour</th>
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UNSW Design & Construction Requirements (Rev 4.1)

29/31
| Water                           | Chilled water | Potable cold water | Condensate | Condenser water | Cooling water | Demineralised water | Distilled water | Domestic hot water | Hot water heating | High temp hot water | Brine | Make up water | Blue b.24 |
|                               |              |                   |            |                  |               |                   |                 |                   |                 |                       |       |              |          |
|                               |              |                   |            |                  |               |                   |                 |                   |                 |                       |       |              |          |
|                               |              |                   |            |                  |               |                   |                 |                   |                 |                       |       |              |          |
|                               | Air          | Compressed air    | Instrument air | Vacuum | Vents | Yellow y.14 |
|                               |              |                   |            |                  |               |                   |                 |                   |                 |                       |       |              |          |
|                               | Gases        | Medical gases     | Natural gas | Refrigerant lines | Vents (hazardous) | Blue b.24 | Yellow y.14 |
|                               |              |                   |            |                  |               |                   |                 |                   |                 |                       |       |              |          |
|                               | Steam        | Steam             | Vents steam equipment. | Yellow y.14 | “ “ |
|                               | Acids & Alkalies | Flammable and combustible liquids | Yellow y.14 |
|                               | Fuel oil     |                   |               |                   |                   |                   |                 |                   |                 |                       |       |              |          |
|                               | Miscellaneous | Drains            | Vents (other than steam) | Pipe supports | Overflow (water)  |               |                   |                 |                 |                       |       |              |          |
|                               | Plinths & inertia bases | | | | | |
|                               | Electrical | Conduit | Switchboard | Fire services | | |

“Safetyman” adhesive labels are acceptable 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.
Flow direction arrows must be provided to all pipework and the Flow and Return pipes must be identified with labels that say “Chilled Water Flow” and “Chilled Water Return” or “High Temp Hot Water” as applicable.

Colour standards shall be in accordance with AS2700.

Refer also Section E.1

E.2.21 Colour Schedule For Plant And Equipment

All plant and equipment in plantrooms, services risers and whenever exposed to view must be painted to the colour scheme detailed below.

Where colours are not specified for particular items of plant, Engineering Services Department 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.