DOCUMENT CONTROL

REVISION LOG

Current Issue

UWA Design and Construction Standards: Mechanical Services - B, Version 1.0 (September 2016)

Previous issues

<table>
<thead>
<tr>
<th>Version</th>
<th>Author(s)</th>
<th>Description</th>
<th>Date completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Campus Management</td>
<td>UWA Design and Construction Standards: Mechanical</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Services - B</td>
<td></td>
</tr>
</tbody>
</table>

REVISION MANAGEMENT

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

ENDORSEMENT BODY

To be determined.

OWNER

Director, Campus Management

AUTHOR(S)

The Standards have been developed by Campus Management with the assistance of UWA staff, external consultants, contractors and colleagues from other education institutions.

CONTACT PERSON

Associate Director Capital Works, Campus Management

COPYRIGHT

This document is the property of The University of Western Australia and may not be copied as a whole or in part without the approval in writing of the Associate Director Capital Works, Campus Management.
# Table of Contents

1 Introduction ..................................................................................................................................... 6
   1.1 Purpose ........................................................................................................................................ 6
   1.2 Services ........................................................................................................................................ 6
   1.3 Related Documents ...................................................................................................................... 7
       1.3.1 University Documents ............................................................................................................ 7
       1.3.2 Relevant Legislation .............................................................................................................. 7
       1.3.3 Manufacturer Specifications and Data Sheets .......................................................................... 7
       1.3.4 Project Specific Documentation ............................................................................................ 7
   1.4 Discrepancies ................................................................................................................................ 8
   1.5 Departures .................................................................................................................................... 8
   1.6 Professional Services ................................................................................................................... 8
   1.7 Structure of Document ................................................................................................................ 8
   1.8 Definitions .................................................................................................................................... 9

2 General Requirements ................................................................................................................... 10
   2.1 Design Considerations ................................................................................................................ 10
   2.2 Coordination of Services ............................................................................................................. 10
   2.3 Access ......................................................................................................................................... 10
   2.4 Heating, Ventilation and Air-Conditioning (HVAC) Systems ..................................................... 10
   2.5 General Design Criteria ............................................................................................................. 11
   2.6 Specific Design Criteria ............................................................................................................. 11
   2.7 Air Filtration .................................................................................................................................. 12
   2.8 Acoustic Requirements ............................................................................................................... 12
   2.9 Vibration Isolation ....................................................................................................................... 12
   2.10 Pipework and Ductwork ............................................................................................................ 12
       2.10.1 Design ................................................................................................................................ 13
       2.10.2 Access ................................................................................................................................. 13
   2.11 Duct Dampers ............................................................................................................................ 13
   2.12 Variable Air Volume System Control ....................................................................................... 13
   2.13 Variable Air Volume Boxes ..................................................................................................... 13
   2.14 Fans and Drive Motors ............................................................................................................. 14
   2.15 Power Quality ............................................................................................................................ 14
   2.16 High Efficiency Motors ............................................................................................................. 14
   2.17 Dedicated Room Air Conditioning Units .................................................................................. 14
   2.18 Building Management and Control Systems (BMCS) .............................................................. 15
   2.19 Services Metering ...................................................................................................................... 15
   2.20 Mechanical Services Switchboards (MSSB) ............................................................................. 15
   2.21 Low Voltage Wiring Systems .................................................................................................. 15
   2.22 Chilled Water Systems .............................................................................................................. 15
   2.23 Balancing Valves ....................................................................................................................... 16
   2.24 Condensate .................................................................................................................................. 17
   2.25 Corrosion Protection ................................................................................................................ 17
   2.26 Air Handling Units .................................................................................................................. 17
   2.27 Valve Selection ........................................................................................................................... 17
   2.28 Make Up Water Tanks ............................................................................................................. 17
   2.29 Heating Water Systems ............................................................................................................ 17
   2.30 Labelling ..................................................................................................................................... 17
   2.31 Mechanical Plant Rooms (Refurbished and New) ................................................................... 18
       2.31.1 Drains ................................................................................................................................. 18
       2.31.2 Lights ................................................................................................................................. 18
       2.31.3 Bunding ............................................................................................................................. 18
       2.31.4 Plinth ................................................................................................................................. 19
### 1. Ductwork

#### 1.1 Material

#### 1.2 Branch Connections

#### 1.3 Spigots for Flexible Ducts

#### 1.4 Pressure Classification

#### 1.5 Exhaust Ductwork

#### 1.6 Duct Supports

#### 1.7 Access Opening

#### 1.8 Flexible Ductwork

#### 1.9 Flexible Ductwork

#### 1.10 PVC Ductwork

#### 1.11 Cleaning

#### 1.12 Flashings

#### 1.13 Test Points

#### 1.14 Dampers

#### 1.15 Non-Return Dampers

#### 1.16 Fire Dampers

#### 1.17 Ceiling Diffusers

#### 1.18 Registers

#### 1.19 Grilles

#### 1.20 Bird Screens

#### 1.21 Anodising

#### 1.22 Insulation

### 2. Air Filtration Systems

#### 2.1 Dry Media Filters

#### 2.2 Specialised Filters

### 3. Mechanical Pipework

#### 3.1 Pipe Sizes

#### 3.2 Design Pressure

#### 3.3 Design Temperatures

#### 3.4 Clearances

#### 3.5 Accessibility

#### 3.6 Flexibility

#### 3.7 Expansion and Contraction

#### 3.8 Vibration Isolation

#### 3.9 Supervision

#### 3.10 Installation

#### 3.11 Pipeline Types

#### 3.12 Joints

#### 3.13 Fittings

#### 3.14 Supports

#### 3.15 Building Works

#### 3.16 Gauges

#### 3.17 Testing
4.3.18 Pipework Insulation ................................................................. 47
4.4 Fume Cupboards ........................................................................ 49
  4.4.1 Design Procedures ............................................................... 49
  4.4.2 Materials .............................................................................. 50
  4.4.3 Containment of Contaminants ............................................ 51
  4.4.4 Performance ................................................................. 51
  4.4.5 Fans ...................................................................................... 52
  4.4.6 Fume Discharge Duct Velocities ........................................ 53
  4.4.7 Construction ................................................................. 53
  4.4.8 Fume Cupboard Floor ................................................................. 54
  4.4.9 Baffles ........................................................................... 55
  4.4.10 Siting ............................................................................... 55
  4.4.11 Commissioning ................................................................. 55
  4.4.12 Electrical Services .............................................................. 56
  4.4.13 Instruments ..................................................................... 57
  4.4.14 Piped Services ................................................................. 57
  4.4.15 Controls and Outlets ............................................................ 57
  4.4.16 Luminaires ...................................................................... 57
  4.4.17 Gas ................................................................................ 58
  4.4.18 Water ........................................................................ 58
  4.4.19 Colour Coding ................................................................. 58
  4.4.20 Access Panels ................................................................ 58
4.5 Evaporative Coolers .................................................................. 58
  4.5.1 Location ........................................................................... 59
  4.5.2 Dump and Cold Water Solenoid Valves ......................... 59
  4.5.3 Backflow Requirements .................................................... 59
  4.5.4 Waste Outlet .................................................................. 59
  4.5.5 Overflows ....................................................................... 60
  4.5.6 Roof Penetrations .............................................................. 60
  4.5.7 Roof Protection ............................................................... 60
  4.5.8 Water Connection ............................................................ 60
4.6 Cooling Towers ........................................................................... 60
  4.6.1 Structure ........................................................................ 61
  4.6.2 Basin ............................................................................. 61
  4.6.3 Air Inlet Louvres ............................................................... 61
  4.6.4 Access ............................................................................. 61
  4.6.5 Ladder and Service Platform ........................................ 61
  4.6.6 Wet Deck Surface (Fill Media) .................................................. 62
  4.6.7 Water Distribution System ..................................................... 62
  4.6.8 Water Level Control ........................................................ 62
  4.6.9 Drift Eliminators .............................................................. 62
  4.6.10 Strainer ........................................................................ 62
  4.6.11 Hardware .................................................................... 63
  4.6.12 Accessories ................................................................ 63
  4.6.13 Mechanical Equipment .................................................... 63
  4.6.14 Warranty ..................................................................... 64
  4.6.15 Tests ............................................................................. 64
  4.6.16 Plumbing Approvals ......................................................... 64
4.7 Cool Rooms, Freezers and Constant Temperature Rooms ........ 64
  4.7.1 Room Construction ............................................................ 64
  4.7.2 Refrigeration Plant ............................................................. 66
  4.7.3 Controls .......................................................................... 68
  4.7.4 Refrigeration Electrical Work ................................................. 68
4.8 Refrigeration Pipework ................................................................. 69
  4.8.1 Pipework ....................................................................... 69
  4.8.2 Supports ......................................................................... 69
  4.8.3 Building Works ................................................................. 69
4.8.4 Pipework Insulation ........................................................................................................ 69
4.8.5 Refrigeration Systems Testing ....................................................................................... 70
4.9 Building Management and Control Systems ......................................................................... 72
  4.9.1 Local Push Buttons ........................................................................................................ 72
  4.9.2 Pressure Switches ......................................................................................................... 73
  4.9.3 Building Energy Monitoring ........................................................................................ 73
  4.9.4 Mechanical Services Switchboards (MSSB) ................................................................... 73
  4.9.5 Electric Motors and Motor Control Equipment .............................................................. 73
  4.9.6 Variable Speed Drives (VSDs) ..................................................................................... 74
  4.9.7 Size of Control Panel .................................................................................................... 74
  4.9.8 Toilet Ventilation Systems ............................................................................................ 75
4.10 Identification Colours ....................................................................................................... 76
Abbreviations....................................................................................................................................... 81
References............................................................................................................................................. 82
1 Introduction

1.1 PURPOSE

The UWA Design and Construction Standards (the Standards) outline UWA’s expectations for its built forms in order to achieve consistency in the quality of the design and construction of those built forms. They are aligned with the UWA’s Campus Plan 2010 planning principles and UWA’s requisites for aesthetic appeal, maintainability and environmental sustainability, while ensuring that there is sufficient scope for innovation and technological advancements to be explored within each project.

The Standards are intended for use by any parties who may be involved in the planning, design and construction of UWA facilities. This includes external consultants and contractors, UWA planners, designers and project managers as well as faculty and office staff who may be involved in the planning, design, maintenance or refurbishment of facilities. These Standards also provide facility managers, maintenance contractors and other service providers with an understanding of UWA services in order to assist in the maintenance and operation of facilities.

1.2 SERVICES

The UWA Design and Construction Standards for Mechanical Services (this document) are a part of UWA Design and Construction Standards set of documents (the Standards). The Standards are divided into the following service documents for ease of use, but must be considered in its entirety, regardless of specific discipline or responsibilities:

A Building and Architecture
B Mechanical Services (this document)
C Electrical Services
D Communication Services
E Hydraulic Services
F Security Services
G Fire Services and Fire Safety Engineering
H Structural Works
I Civil Works
J Irrigation Services
K Sustainability
L Vertical Transport
1.3 RELATED DOCUMENTS

1.3.1 University Documents

The Standards are to be read in conjunction with the following relevant University documents:

- UWA General Preliminaries Document
- UWA Specification for As-Constructed Documentation
- Relevant UWA planning and policy documents such as the UWA Campus Plan, Commercial Masterplan, Landscape Vision and Integrated Infrastructure Strategy, University Policy on Alterations to University Buildings, etc.
- Relevant UWA operational and maintenance documents such as preferred vendors lists, room data sheets, operational and maintenance manuals, etc.
- Other documents as referenced within the UWA Design and Construction Standards.

1.3.2 Relevant Legislation

The planning, design and construction of each UWA facility must fully comply with current relevant legislation, including but not limited to:

- Relevant Australian or Australian / New Zealand Standards (AS/NZS),
- National Construction Code (NCC),
- Occupational Safety and Health (OSH) legislation,
- Disability Discrimination Act (DDA),
- Accessibility Aspiration Design Factors, and
- Local council and authority requirements.

1.3.3 Manufacturer Specifications and Data Sheets

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

1.3.4 Project Specific Documentation

Requirements specific to a particular project, campus or other variable, will be covered by project specific documentation, such as client briefs, specifications and drawings. These Standards will supplement any such project specific documentation.

The Standards do not take precedence over any contract document, although they will typically be cross-referenced in such documentation.
Extracts from the Standards may be incorporated in specifications, however it must remain the consultant’s and contractor’s responsibility to fully investigate the needs of the University and produce designs and documents that are entirely ‘fit for purpose’ and which meet the ‘intent’ of the project brief.

1.4 DISCREPANCIES

The Standards outline the University’s generic requirements above and beyond the above mentioned legislation. Where the Standards outline a higher standard than within the relevant legislation, the Standards will take precedence.

If any discrepancies are found between any relevant legislation, the Standards and project specific documentation, these discrepancies should be highlighted in writing to the Associate Director Capital Works, Campus Management.

1.5 DEPARTURES

The intent of the Standards is to achieve consistency in the quality of the design and construction of the University’s built forms. However, consultants and contractors are expected to propose ‘best practice / state of the art’ construction techniques, and introduce technological changes that support pragmatic, innovative design.

In recognition of this, any departures from relevant legislation, or the Standards, if allowed, must be confirmed in writing by the Associate Director Capital Works, Campus Management.

Any departures made without such written confirmation shall be rectified at no cost to UWA.

1.6 PROFESSIONAL SERVICES

For all works, it is expected that suitably qualified and experienced professionals are engaged to interpret and apply these Standards to UWA projects. Works cannot be carried out by unqualified and unlicensed consultants or contractors.

1.7 STRUCTURE OF DOCUMENT

This document is structured into 4 parts:

Part 1 Introduction (this Section)

Part 2 General Requirements – outlines the general requirements or design philosophies adopted at UWA

Part 3 Checklist for project team (if applicable) – checklist of items for consideration at various stages of a project

Part 4 Specifications (if applicable) – materials specifications and/or preferred lists for materials, processes or equipment used by UWA.
1.8 DEFINITIONS

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

**Can:** Implies a capability of possibility and refers to the ability of the user of the document, or to a possibility that is available or might occur.

**May:** Indicates the existence of an option.

**Shall:** Indicates that a statement is mandatory.

**Should:** Indicates a recommendation.
2 General Requirements

2.1 DESIGN CONSIDERATIONS

The following functional requirements shall be given special design consideration.

- Energy efficiency
- Simplicity of design, particularly in relation to controls
- Accessibility, ease of operation, simple maintenance with minimal maintenance frequency
- Adequate space for installation and maintenance of machinery in designated plant rooms, ceiling spaces or other areas
- Access to plant rooms and equipment.

2.2 COORDINATION OF SERVICES

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

2.3 ACCESS

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

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

2.4 HEATING, VENTILATION AND AIR-CONDITIONING (HVAC) SYSTEMS

HVAC is to be provided to all new buildings or parts of buildings subject to major refurbishment. Where air-conditioning is provided, windows are to be inoperable, or lockable if access is required for window cleaning.

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

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

Preliminary system selection shall be discussed with UWA prior to final design. System selection should be based on life cycle costing analyses of one or more options.

Innovative solutions for HVAC systems should be presented to UWA for consideration.
2.5 GENERAL DESIGN CRITERIA

When connecting to the campus chilled water network, consult with UWA to determine the differential pressure available in the chilled water ring main at the site of the new installation. This information is required to select air handling units and to size chilled water lines and control valves.

The chilled water supply temperature is controlled by a floating set-point referenced to the ambient temperature. The parameters are:

Winter: ambient temperature < 15°C; CHW temperature 10°C
Summer: ambient temperature > 35°C; CHW temperature 5.5°C.

A suggested design chilled water supply temperature of 9°C with a 7K temperature split should be considered for all new air conditioning installations.

Particularly in buildings with intermittent usage, main heating coils shall be incorporated in air handling units to facilitate short warm up time on winter start up. Heating water boilers shall be selected accordingly.

A suggested design heating water temperature of 70°C with a 20K temperature split across the boiler should be considered for all new air conditioning installations.

Careful consideration should be given to the design conditions for various areas. The following design assumptions may be made:

External Design Conditions
- Summer All Areas - 37°CDB 24°CWB
- Winter All Areas - 3°C day time operation

Internal Design Conditions
- Summer (Unless specifically nominated otherwise) 23°CDB ± 1K, 50% RH ± 10%
- Winter 21°C ± 1K

2.6 SPECIFIC DESIGN CRITERIA

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

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

Required outside air quantities should be in accordance with AS/NZS 1668.

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

Animal research facilities and laboratories where the production of dangerous gases is considered likely, and other special facilities where recirculation of air is not acceptable, will require full fresh air systems. Pre-cooling of
the outside air, using heat exchange equipment, shall be considered and evaluated on the basis of life cycle cost analysis.

Toilet Ventilation should provide a minimum of 20 air changes per hour.

### 2.7 AIR FILTRATION

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

- efficient removal of dust particles from the airstream
- low resistance to air flow
- maximum dust holding capacity, to minimise frequency of replacement
- optimum accessibility for inspection and replacement
- efficient perimeter sealing to eliminate bypass, and facilitate cell replacement without deterioration of the seal effectiveness.

Refer **Section 4.2** of this document.

### 2.8 ACOUSTIC REQUIREMENTS

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

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

### 2.9 VIBRATION ISOLATION

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

Plant located on Waffle Pad and secured to the floor will not be accepted. Ductwork, piping, electrical conduit, etc. shall be suspended with vibration isolating hangers and couplings, if required.

### 2.10 PIPEWORK AND DUCTWORK

Sheet metal ductwork and associated fittings shall comply with **AS 4254**.

Refer **Section 4.1** of this document for ductwork specification.

Refer **Section 4.3** of this document for pipework specification.
2.10.1 Design

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

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

2.10.2 Access

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

Ductwork access openings shall be provided as detailed in Section 4.1 of this document.

2.11 DUCT DAMPERS

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

2.12 VARIABLE AIR VOLUME SYSTEM CONTROL

Variable air volume system control shall be achieved through the use of variable frequency drive fan motor control, unless otherwise specified. Fans, motor drive units and controls shall be selected to yield a minimum airflow turndown ratio of 3:1. Variable speed drives shall be Danfoss.

2.13 VARIABLE AIR VOLUME BOXES

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

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

Fans and drive motors shall be selected in such a way that 100% design air quantities for a given system are delivered when air handling equipment is operating at not more than 80% of the maximum available design static pressure or design flow (L/s), whichever is less. In general, larger fan sizes that allow lower operating speeds and noise levels are preferred.

2.15  POWER QUALITY

Power Factor on final mechanical installation must be a minimum of 0.90 or better.

Harmonics imposed on the electrical supply to mechanical plant and equipment must be kept to a minimum. As a general requirement, THD at the Point of Common Coupling (PCC) must be less than 5%.

Coordinate with Electrical Services design requirements and consult UWA Campus Management regarding power factor optimisation.

2.16  HIGH EFFICIENCY MOTORS

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

All motors shall comply with the Australian Government’s Equipment Energy Efficiency Program (www.energysaving.gov.au/).

The highest efficiency motor should be selected for all applications.

2.17  DEDICATED ROOM AIR CONDITIONING UNITS

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

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

Standalone, fit for purpose, air conditioning units are to be provided for communications rooms and other equipment rooms which are intended to operate 24 hours a day. Domestic air conditioning units are not to be utilised for 24 hour operation.
2.18 BUILDING MANAGEMENT AND CONTROL SYSTEMS (BMCS)

BMCS are utilised to:

- reduce energy costs
- enable instantaneous remote indication, monitoring and control of selected functions
- Provide selected malfunction reports to Central Plant
- Provide data to enable forecasting of energy requirements
- Provide load-shedding facility.

Refer Section 4.9 of this document. UWA shall be consulted regarding any connections to the BMCS.

2.19 SERVICES METERING

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

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

2.20 MECHANICAL SERVICES SWITCHBOARDS (MSSB)

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

2.21 LOW VOLTAGE WIRING SYSTEMS

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

2.22 CHILLED WATER SYSTEMS

The UWA Crawley campus has one main chilled water system comprising a ring main around the campus, served by centrifugal chillers located in a central plant room. Chilled water systems shall be designed so that they may be interlinked with the existing ring main. This means that temperatures, pressures etc. should be compatible. All control valves shall be two-way. UWA has modified certain systems from three-way to two-way valves. Any type of bypass is not acceptable.
2.23 BALANCING VALVES

Commissioning or balancing valves shall not be installed on chilled or heating water systems.

Chilled and heating water coil flows through UWA’s air handling units are controlled by the BMCS to maintain leaving air temperatures to meet the cooling or heating demand. This is achieved by the provision of leaving air temperature sensors on all air handling and fan coil units.

Balancing valves are not installed on air handling and fan coil units resulting in the central chilled water plant operating at lower differential pressure and resulting operating cost.
2.24 CONDENSATE

Condensate lines shall be run to sewer or stormwater. Condensate or waste water shall not run on to roofs, into gutters or directly into downpipes unless gutters and downpipes are copper or stainless steel.

2.25 CORROSION PROTECTION

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

2.26 AIR HANDLING UNITS

All air handling units that can be walked or crawled into must have internal lights. Where there is a dual inlet fan in the air handling unit a second light fitting shall be located over the non-drive end bearing. The light switch shall be located outside the air handling unit and must meet IP 56 specifications and must have a red neon indicator light.

2.27 VALVE SELECTION

Valves in service ducts etc. to be approved butterfly valves 100mm and larger. Smaller valves to be full flow ball valves.

Valves 100m and above installed below ground level to be Norcast Rislan "Nylon II" powder coating as standard.

2.28 MAKE UP WATER TANKS

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

2.29 HEATING WATER SYSTEMS

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

Gas supply pressure shall be confirmed by the hydraulic services consultant. OPSO valve and filters will be specified by the hydraulic services consultant.

2.30 LABELLING

After painting, all equipment, ducts and pipework shall be identified with Safetyman labels in accordance with AS1345 - "Rules for the Identification of Piping, Conduits and Ducts". Labels shall be located at approximately 3m intervals in plantrooms and labels shall be provided at each service access opening into pipe shafts. Where pipes run together the labels shall be grouped together.
All apparatus shall be labelled as to its designation and status. Each label shall be conspicuous and manufactured from three layer rigid material engraved to approval, particularly in respect of size and lettering.

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

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

2.31 MECHANICAL PLANT ROOMS (REFURBISHED AND NEW)

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

2.31.1 Drains

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

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

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

2.31.2 Lights

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

2.31.3 Bunding

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

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

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

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

2.31.5 Outside Air

All outside air intakes shall be fitted with a volume control damper and filters in accordance with Section 4.2 of this document.

2.31.6 Electrical Power Point

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

2.31.7 Plant Room Penetrations

Where services, ducting, pipe work and electrical conduits penetrate the plant room wall they must be sealed.

2.31.8 Ducting

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

2.31.9 Pipes

Pipes and electrical conduits passing through the plant room walls shall be sleeved with light gauge PGI, which will protrude 100 millimetres either side of the plant room wall penetration. The sleeve must be sealed around the outer edge between the brick or concrete.

2.31.10 Painting

The floor, walls, ceilings and all other services shall be painted as per Section 4.10 of this document.
2.32 REDUNDANT SERVICES

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

Cut and seal off services at the source of supply.

Existing branch valves shall be removed and made good.

Existing redundant services exposed during excavation shall be highlighted to UWA and removed where appropriate.

2.33 TESTING AND CERTIFICATION

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

2.33.1 System Balancing

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

2.33.2 Cleaning

All equipment, piping, ductwork etc. are to be protected and kept in a clean condition prior to commissioning.
## 3 Checklist for Project Team

The following activities should be considered by the project team during the planning of the project.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Responsibility</th>
<th>Stakeholder(s)</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled water supply and connections</td>
<td>Mechanical consultant</td>
<td>CM (Building Operations)</td>
<td>Gate 2 Feasibility</td>
</tr>
<tr>
<td>Design for PC3 and PC4 labs fume cupboards exhaust system</td>
<td>Mechanical Consultant / contractor</td>
<td>Institutional Biosafety Committee / OGTR</td>
<td>Gate 2 Feasibility</td>
</tr>
<tr>
<td>Mechanical services electrical supply</td>
<td>Mechanical Consultants / Electrical consultant</td>
<td>CM (Building Operations)</td>
<td>Gate 2 Feasibility</td>
</tr>
<tr>
<td>Natural gas requirements site connection and supply location</td>
<td>Hydraulic Consultant</td>
<td>CM (Building Operations)</td>
<td>Gate 2 Feasibility</td>
</tr>
<tr>
<td>Structural checks for mechanical loading</td>
<td>Structural Consultant</td>
<td>CM (Engineering Services)</td>
<td>Gate 3 Planning Detail Design</td>
</tr>
<tr>
<td>Acoustic treatment</td>
<td>Acoustic Consultant / Contractor</td>
<td>Acoustics Consultant / CM (Building Operations)</td>
<td>Gate 3 Planning Detail Design</td>
</tr>
<tr>
<td>Provision of BMCS to all water &amp; gas meters including expansion tank supplies</td>
<td>Mechanical Consultant / Communications Consultant</td>
<td>CM (Building Operations)</td>
<td>Gate 3 Planning Detail Design</td>
</tr>
<tr>
<td>Provision of BMCS to all kWhr meters</td>
<td>Mechanical Consultant / Communications Consultant</td>
<td>CM (Building Operations)</td>
<td>Gate 3 Planning Detail Design</td>
</tr>
<tr>
<td>Electrical and hydraulic provisions for evaporative coolers, fume cupboards, plant rooms, etc.</td>
<td>Electrical Consultant / Hydraulic Consultant / contractor</td>
<td>CM (Building Operations)</td>
<td>Gate 3 Planning Detail Design</td>
</tr>
<tr>
<td>Power quality checks for mechanical installation</td>
<td>Contractor</td>
<td>CM (Engineering Services)</td>
<td>Gate 5 Implementation / Construction</td>
</tr>
<tr>
<td>Chilled water pipework pressure testing and witnessing</td>
<td>Mechanical Consultant / Contractor</td>
<td>Campus Management</td>
<td>Gate 5 Implementation / Construction</td>
</tr>
<tr>
<td>Natural gas heating water system compliance with the Gas Code</td>
<td>Hydraulic Consultant / Contractor</td>
<td>ATCO Gas</td>
<td>Gate 5 Implementation / Construction</td>
</tr>
<tr>
<td>Medical gas pipework commissioning</td>
<td>Mechanical Consultant / Contractor</td>
<td>ATCO Gas</td>
<td>Gate 5 Implementation / Construction</td>
</tr>
<tr>
<td>Water treatment</td>
<td>Hydraulic Consultant / Contractor</td>
<td>CM (Engineering Services)</td>
<td>Gate 5 Implementation / Construction</td>
</tr>
</tbody>
</table>
4 Specifications

4.1 DUCTWORK

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

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

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

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

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

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

4.1.1 Material

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

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

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

Rivets for stainless steel ductwork shall be of monel metal.

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

4.1.2 Branch Connections

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

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

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

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

4.1.4 Pressure Classification

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

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

4.1.5 Exhaust Ductwork

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

4.1.6 Duct Supports

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

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

4.1.7 Access Opening

Access shall be provided to all motorised dampers and fire dampers and where shown on drawings. Panels installed in insulated ducts shall be insulated.

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

Ductwork Access Openings shall be to the following minimum dimensions:

**Access Doors 1350 x 500** - walk in access.
Stiffened to prevent distortion under normal use, hinged to open against air pressure, with clamp type latches and handles which can be opened from both inside and outside, sealed with mechanically fixed rubber or soft Neoprene Gaskets to make the door airtight.

**Manholes 450 x 600** - crawl/climb in access.

Double panel, deep formed, GSS. Insulated as ductwork or filled with minimum 25mm mineral wool with rigid matching G.S.S. frame securely attached to the duct and 4 off wedge type sash latches sealed as for access doors.

**Handholes 200 x 300** - hand and sight access.

Double panel, deep formed GSS as for manholes but with 2 only latches.

### 4.1.8 Flexible Connections

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

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

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

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

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

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

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

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

Provide material types and usage to the requirements of *AS 1668 Part 1* and *AS 4254*. 
Use the following types:

- Heavy duty vinyl
- Neoprene fire retardant, waterproof (1.005kg/m²).
- Heavy duty PVC coated vinyl.
- Fibreglass reinforced PVC fabric.
- Neoprene coated glass fabric (1kg/m²).
- PVC coated fabric with cotton sateen backing (0.5kg/m²).
- Woven plastic material.

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

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

For smoke, spill, stairwell pressurisation systems and spraybooths provide fabric to be able to withstand the test required by AS 1530, based on the Standard Time Temperature Curve for 2 hours. Use non-combustible yarn and conceal and sew down raw edges.

### 4.1.9 Flexible Ductwork

**Material**

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

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

**Joints**

Seal the joints with 50mm wide minimum PVC tape.

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

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

**Fastening**

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

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

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

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

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

4.1.10 PVC Ductwork

Material

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

Fittings

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

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

Flexible Connections

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

Dampers

Construct all the parts within the duct from UPVC.

Supports

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

Spacing (maximum centres):

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

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

Welding

Continuously weld all joints, including seams, stiffeners, flanges, corners of fabricated bends and tees, and the like. Weld stiffeners on both sides. Back weld slip socket joints.
Butt welding: Vee type, using hot air equipment, as follows:

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

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

**Bending**

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

**Seams**

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

**Flanged Joints**

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

**4.1.11 Cleaning**

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

**4.1.12 Flashings**

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

**4.1.13 Test Points**

Provide 12mm diameter holes, closed off with rubber grommets or other approved means suitable for the pressure classification of the ductwork, to allow testing with a velometer or pitot tube in accordance with *PD ISO/TR 15377*.

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

Locate the holes in circular ducts at 0° and 90° relative to an axis of the duct. Locate holes in rectangular ducts, evenly spaced across the duct with a half space at each end, according to the list below.
Up to 300mm 2 holes
301mm to 450mm 3 holes
451mm to 630mm 4 holes
631mm to 1220mm 5 holes
Above 1220mm 6 holes

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

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

### 4.1.14 Dampers

#### General

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

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

#### Construction

Dampers are to:

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

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

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

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

Bearings shall be self-aligning type, either

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

Provide an adequate means of external lubrication where required.
Spindle materials shall be cadmium plated steel.

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

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

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

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

Application

Single blade dampers:
- manually adjustable at branch take-offs
- manually adjustable at air outlets and grilles

Splitter dampers:
- manually adjustable at branch connection to main duct and/or supply air registers
- manually adjustable at air outlets and grilles

Multi-blade dampers:
  Use opposed blade type for
  - throttling applications where flow is varied
  - size damper for wide open resistance between 3 to 6% of the total system resistance.
  
  Use parallel blade type for
  - mixing applications such as outdoor air and return air dampers with constant pressure drop across the damper. Size damper for wide open resistance between 10 to 30% of total system resistance.

Dimensions

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

Operation

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

Extend the operating shafts through the duct where manually adjustable dampers are installed in ductwork or other inaccessible locations and fit a lockable quadrant.
For remote operation; have damper operator mounted externally/externally to suit application, with flexible operating cable run to the location (such as ceiling or outlet) shown on drawings.

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

**Location**

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

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

Paint visible ductwork and dampers behind grilles matt black.

**4.1.15 Non-Return Dampers**

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

**4.1.16 Fire Dampers**

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

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

Fire dampers shall not be used for air volume control.

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

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

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

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

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

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

Louvred Face Type

Louvred cores shall be removable with neatly mitred corners.

Perforated plate type

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

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

Linear Louvre Type

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

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

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

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

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

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

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

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

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

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

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

4.1.18 Registers

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

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

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

4.1.19 Grilles

Egg Crate Grilles

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

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

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

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

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

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

4.1.20 Bird Screens

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

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

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

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

4.1.21 Anodising

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

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

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

4.1.22 Insulation

Insulate ductwork in accordance with AS 4426.

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

Internally insulate the following:

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

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

Internal insulation materials shall have not less than the following sound absorption coefficients:

<table>
<thead>
<tr>
<th>Insulation with spec. facing. Thickness mm</th>
<th>Absorption Co-efficient at Octave Band Centre Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>125Hz</td>
</tr>
<tr>
<td>25</td>
<td>0.13</td>
</tr>
<tr>
<td>50</td>
<td>0.28</td>
</tr>
</tbody>
</table>

External Insulation

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

**Items not to be insulated**

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

4.2 AIR FILTRATION SYSTEMS

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

4.2.1 Dry Media Filters

**Deep Bed Filters**

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

300 deep pocket filters will only be accepted where 660 deep pockets cannot be accommodated due to space restrictions.
V-Form Filters

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

Flat Panel Filters

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

Filter Selection

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

Filter Frames

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

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

4.2.2 Specialised Filters

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

4.3 MECHANICAL PIPEWORK

4.3.1 Pipe Sizes

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

4.3.2 Design Pressure

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

4.3.3 Design Temperatures

The design temperature is the maximum / minimum temperature of the contents permitted in the pipework.
4.3.4 Clearances
Provide adequate spacing, measured clear of pipe insulation, of at least 25mm between pipes and 50mm between pipes and electrical cables. Take off branches are to be at right angles.

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

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

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

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

Springing
Cold springing shall be installed where piping systems operate through a temperature range exceeding 35K. Cold springing shall provide 50% of the calculated total expansion for the length under consideration.

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

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

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

Manufacturer’s Recommendations

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

Approval

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

4.3.9 Supervision

Fabrication and installation of pipework shall be carried out by or under the direct supervision of appropriately licensed personnel.

Inspection

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

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

Completion

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

4.3.10 Installation

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

Make junctions between dissimilar metals with special compatible material fittings.

Joints

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

Expansion

Make suitable provisions for expansion.

Valves

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

4.3.11 Pipeline Types

Copper Pipelines - Hydraulic Services and Compressed Air

Pipework - to AS 1432.

Capillary Fittings - to AS 3688

Compression Fittings - to AS 3688

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

Brazed Joints - use either a capillary fitting or expand one tube over the other leaving a minimum clearance and an effective overlap of not less than the following:

<table>
<thead>
<tr>
<th>PIPE SIZE (mm)</th>
<th>OVERLAP (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 - 20</td>
<td>12</td>
</tr>
<tr>
<td>25 - 32</td>
<td>15</td>
</tr>
<tr>
<td>40 - 50</td>
<td>25</td>
</tr>
<tr>
<td>65 - 80</td>
<td>30</td>
</tr>
<tr>
<td>100-125</td>
<td>35</td>
</tr>
<tr>
<td>150-200</td>
<td>40</td>
</tr>
</tbody>
</table>

Brazing - use a minimum of heat and avoid damage to pipe and fittings. Brazing alloy to AS/NZS 1167.1.
- Brazing copper to copper
- Brazing copper to brass: A suitable copper to brass alloy.
UPVC Pipelines

Pipes & fittings - to AS/NZS 1477
Moulded Fittings class - to AS/NZS 1477
Fabricated fittings class - to AS/NZS 1477
Installation - to AS/NZS 2032.

Rubber ring joints - to AS/NZS 2032. After making joint, ensure that the ring is in the correct position.

Natural Gas Pipelines

Pipework installation - to AS/NZS 5601.
Materials, Fittings & Jointing - to AS/NZS 5601.
Pipe joints - to AS/NZS 5601.
Fittings - to AS/NZS 5601.

4.3.12 Joints

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

Permanent Joints

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

Demountable Joints

Provide demountable joints:

- where required for maintenance of piping or fittings
- at connections to components of equipment such as coils, valves, instruments, gauges and the like
- where permanent joints are impracticable
- flanged for 65mm and greater
- union type or screwed for 50mm and below

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

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

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

- flange is no lighter than AS 2129
- flange is not less than 12mm thick.
Bolts for flanges - to AS 2129. Bolt thread shall protrude through nut but not more than 6mm. Bolt material to be cadmium plated carbon steel in non-corrosive environments, otherwise a material with equivalent corrosion resistance to, and compatible with, the flanges.

**Flange gaskets**

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

**Screwed Joints**

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

- screwed joints unless welding or brazing is impracticable.
- long screws or barrel nipples.

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

**4.3.13 Fittings**

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

**Compressed Air**

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

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

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

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

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

**Heating and Chilled Water**

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

- at high points in pipework systems
- at the end of horizontal runs before drops

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

- above all ceilings
- under coil headers to terminal coil valve assemblies.

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

Install strainers in a position permitting ease of maintenance.
4.3.14 Supports

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

Support Material

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

Fixing to Masonry

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

Support Spacing

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

<table>
<thead>
<tr>
<th>Pipe Size (mm)</th>
<th>Copper Pipes to AS 1432 Type B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Horizontal (m)</td>
</tr>
<tr>
<td>10</td>
<td>1.5</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>2</td>
</tr>
<tr>
<td>32</td>
<td>2.5</td>
</tr>
<tr>
<td>40</td>
<td>2.5</td>
</tr>
<tr>
<td>50</td>
<td>3</td>
</tr>
<tr>
<td>65-100</td>
<td>3</td>
</tr>
<tr>
<td>125-225</td>
<td>4</td>
</tr>
<tr>
<td>Over 225</td>
<td>4</td>
</tr>
</tbody>
</table>
Hanger Rods

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

<table>
<thead>
<tr>
<th>Pipe Size (mm)</th>
<th>Hanger Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>32</td>
<td>10</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>65</td>
<td>12.5</td>
</tr>
<tr>
<td>80</td>
<td>12.5</td>
</tr>
<tr>
<td>90</td>
<td>12.5</td>
</tr>
<tr>
<td>100-150</td>
<td>16</td>
</tr>
<tr>
<td>200-300</td>
<td>19</td>
</tr>
<tr>
<td>350 and over</td>
<td>To Structural Engineer's specification</td>
</tr>
</tbody>
</table>

Pipe Support Attachments

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

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

Straps - PVC Piping

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

<table>
<thead>
<tr>
<th>Outside Diameter Pipe or Sheathing (mm)</th>
<th>Strap or Clip Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 30</td>
<td>25 wide x 1 thick</td>
</tr>
<tr>
<td>31 to 75</td>
<td>25 wide x 3 thick</td>
</tr>
<tr>
<td>26 to 250</td>
<td>40 wide x 6 thick</td>
</tr>
<tr>
<td>Over 250</td>
<td>To Structural Engineer’s specification</td>
</tr>
</tbody>
</table>
Straps - Copper Piping

Provide straps or clips as above with nylon or other suitable inserts or as follows:
- Copper material 25mm x 1.6mm thick for piping up to 50mm.
- Nylon coated steel sections 20mm wide x 5mm thick for piping up to 1 50mm.

Saddle Type Supports

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

Copper Packing

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

4.3.15 Building Works

Building Penetrations

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

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

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

Chases and Encasing

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

**Pipes Encased in Concrete**

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

**Roof Penetrations**

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

**Underground Installations**

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

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

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

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

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

**Bedding**

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

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

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

Bed UPVC pipes of 80mm pipe size or greater and metal pipes if the excavation is excessive or is unstable ground or rock on a continuous cushion of underlay material of 75mm minimum thickness.
Underlay material shall be to AS 2032.

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

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

**Minimum cover over pipe**

Apply the following unless overridden by regulatory authority requirements.

Pipes not subject to vehicular loading - 450mm

Pipes subject to vehicular loading:
- not in roadways - 600mm
- under sealed roadways - 600mm
- under unsealed roadways - 750mm

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

**Pipework under slabs**

Protect copper pipework laid in the ground beneath a concrete floor slab by:
- encasing in continuous UPVC pipework sleeves or
- encasing in PVC coated tube sealed to prevent ingress of moisture or
- support on compacted underlay material 150mm thick, and provide compacted overlay and side support of fine crushed rock, grading up to a maximum size of 14mm, to not less than 150mm above the top of the pipe.

**Corrosion protection**

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

### 4.3.16 Gauges

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

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

Thermometers
Where required dial thermometers to be of the following types:
• capillary type with mercury in steel and capillary to suit convenient mounting
• rigid stem type. Provide screwed shoulders in the stem suitable for installing in a separate well.

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

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

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

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

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

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

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

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

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

- Test mains to meter to AS/NZS 4645.
- Test reticulation pipework to AS/NZS 5601.

Cleaning Out

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

Capping Off

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

4.3.18 Pipework Insulation

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

Buried Chilled Water Pipework

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

Above Ground Pipework

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

Insulation Material

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

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

Buried Chilled Water and Heating Water Pipework

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

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

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

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

Above Ground Pipework

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

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

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

Minimum Insulation Thickness

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

Rigid Preformed Cold and Heating Pipework Insulation

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

Metal sheathing

Metal sheathing of insulation is required in:

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

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

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

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

**Painting Insulation**

Painting of insulation is required:

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

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

**4.4 FUME CUPBOARDS**

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

The fume cupboard make and models shall be approved by UWA before purchase and installation.

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

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

**4.4.1 Design Procedures**

**Risk Assessment**

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

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

Some criteria for consideration include:

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

**Safety Requirements**

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

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

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

4.4.2 Materials

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

- Determine the type of effluent that shall be generated in the fume cupboard and handled by the exhaust system.
- Classify types as organic or inorganic, and state whether they occur in gaseous, particulate or vapour form. Also classify decontamination materials if used.
- Determine the concentrations of reagents used and the temperature of the effluent at the fume cupboard exhaust throat. Although it may prove difficult, some attempt should be made in determining the likely range of reagents and concentrations used.
- Determine whether a fume scrubbing system will be required.
- Estimate the highest probable dewpoint of the effluents.
- Determine the likely ambient temperatures of the spaces in which the exhaust ductwork and exhaust...
fans will be located.

- Consider the length and arrangement of duct runs and how they may affect the periods of exposure to fumes and the degree of condensation that may occur.
- Determine whether water sprays will be required within ducts and at what intervals.
- Determine the slope and drainage requirements and the means to achieve leak proof joins.
- Determine whether exhaust ducts will require external insulation.
- Determine the means of achieving the required fire rating for penetrations through different fire compartments.
- Determine whether the fume cupboard exhaust fan should operate at 10% of full flow when turned off at the fume cupboard.
- Select materials most suitable for the application, considering resistance to attack, weight, flame and smoke spread rating, and cost.
- Determine the method to be used for testing exhaust duct leak tightness.

4.4.3 Containment of Contaminants

Containment of contaminants is based on the principle that an airstream entering the face of the fume cupboard will “entrain” the contaminants and carry them to the exhaust, thus effectively preventing the escape of the contaminants from the fume cupboard to the room.

Critical design parameters are as follows:

- Face velocity
- Size of the face opening
- Shape/geometry of the opening surfaces
- Back baffle and plenum arrangement
- Location of exhaust ports from the fume cupboard
- Inside dimensions and location of work area relative to face edge
- Proportional bypass if fitted
- Supply/make up air quantities to room and temperatures and interaction with exhaust air being exhausted through the fume cupboard
- Size and number of exhaust stacks or outlets.

4.4.4 Performance

Flow Control

Flow control is afforded by the back baffle and horizontal slots. One horizontal slot shall be located at the bottom of the back baffle to draw air across the top of the working surface and under the working surface when it is suspended. Another slot shall be located at the top to exhaust the canopy and at least a third shall be located midway on the back baffle. The openings provide regulation of exhaust distribution to maintain face velocity within the requirements of AS/NZS 2243.8. The openings shall be set and the settings made...
Face Velocity
Face velocities at the sash shall be in accordance with the requirements of AS/NZS 2243.8.

Containment
Corner and intermediate posts, deep deck lip depressions and projecting service fittings near the face produce air turbulence and potential loss of containment. Plain entry edges produce a vena contracta at the surface and fumes generated in this area are likely to escape from the fume cupboard enclosure. Aerofoil shapes at the entry edges correct this condition. Sinks and service fittings should be located at least 170mm inside the hood face and deck lips should have minimal projections.

Radioactive Work
The radiotoxicity and quantity of radioactive material determine the quantity that can be safely handled in a fume cupboard. Large quantities of radioactive material of high activity are generally handled in heavily shielded cells or glove boxes, maintained at negative pressure to the cell or boxes environment via a continuously filtered exhaust.

AS/NZS 2243.4 and UWA’s registration conditions under the Radiation Safety Act for radioactive work apply. For high level radioactive glove box exhaust systems, flanged and gasketed joints with quick disconnect fasteners will provide minimum exposure time to decontamination personnel.

Perchloric Acid
Perchloric acid fume hoods (most with scrubbers) are required for research involving work with perchloric acid. Nearly all metal and organic perchlorates are explosive, and many of them are extremely shock sensitive. Perchloric acid may also cause spontaneous ignition of some organic materials. Perchloric acid deposits in ductwork can become a major explosion hazard, thus internal water spray systems for periodic washing of the duct surfaces are mandatory. In general, designers should consult AS/NZS 2243.8 for more detailed information.

Hydrofluoric Acid
Hydrofluoric acid can be fatal if split on skin and great care is required in its use. Fume cupboards may require scrubbers. Refer to AS 2243.8 for more information.

Microbiological Work
Microbiological safety cabinets are covered in AS 2252.1 and AS 2252.2. In some cases, fume cupboards may be adequate for some microbiological work, providing that the discharge does not carry pathogens.

4.4.5 Fans
Fans shall be of the centrifugal type with a pressure-flow characteristic that allows “constant” flow with
pressure variations, or a flat flow-pressure loss profile.

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

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

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

### 4.4.6 Fume Discharge Duct Velocities

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

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

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

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

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

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

### 4.4.7 Construction

Lining materials in all fume cupboards shall be impervious with a smooth finish. All welds shall be dressed to a smooth finish.

Fume cupboards for use in biological, pathological and radioactive laboratories shall have an internal base (which may be under the working surface) which is coved up to the walls. All interior surfaces shall have
smooth finishes. The work surface shall be flat. The fume cupboard shall be capable of containing any spillages.

The fume cupboard sash shall comply with the appropriate Clauses in AS/NZS2243.8. Sash materials shall be selected to suit the primary intended purpose of the fume cupboard.

- Ordinary window or plate glass and wire glass shall not be used as a fume cupboard sash.
- Laminated glass has a poorer thermal shock resistance than toughened glass and the plastic interlayer may weaken through organic chemical attack. Laminated glass may have sharp edged blisters being projected under explosion conditions, however, it is designed to remain in place if fracture occurs.
- Transparent plastic materials may be used as they may have a higher impact resistance than glass and are not etched by hydrogen fluoride. However, their temperature resistance and surface hardness are inferior to glass and some may shatter dangerously in an explosion.
- Toughened glass is usually the material of choice for fume cupboard glazing. Under conditions of explosion blunt grains of shattered glass would be ejected, but these should only cause superficial injuries to persons.
- Toughened laminate anti-explosion glass may be used.

All joints in PVC or polypropylene shall be welded by forming a vee and filling with a minimum of three runs of weld.

All joints exposed to view or the air stream shall be shaved flat and buffed to produce a neat finish.

The structure shall be reinforced where necessary, however, any reinforcement shall not interfere with the airflow through the fume cupboard.

Where bolted joints are required in a PVC or polypropylene fume cupboard, UPVC bolts shall be used. No penetrations for fixing shall be made through the wall of the work zone.

The sash shall be counterbalanced and all materials used in the counter balance gear shall be acid and alkali resistant and as far as practicable be located outside the contaminated air zone.

An extruded air deflection strip shall be fitted to the bottom of the sash. The wire supporting the sash and lead counter-balanced weights shall be 3mm diameter stainless steel. The pulleys shall be machined and sized to take 3mm stainless steel wire and shall include press fit roller bearings. The pulley housing shall be easily removed if required.

4.4.8 Fume Cupboard Floor

The entire bottom of the fume cupboard shall be a one piece, fully moulded section incorporating a full width runnel to rear.

The flow shall have a grade of 1:50 fall towards the rear runnel.

A removable 25mm thick epoxy resin cast sheet shall be fitted in the base to provide a horizontal work surface and ventilated bottom catchment or sump area.
Also include a hump at the front and an upper level service shelf to the left and right hand sides.

Care shall be taken to seal all joints around the floor to ensure against leakage of fluids which may be spilt. For PVC or polypropylene fume cupboards this seal shall be welded.

### 4.4.9 Baffles

The fume cupboard shall contain a minimum of three baffles positioned to provide maximum air control to the face of the fume cupboard.

The function of the baffles shall form a rear plenum with low level, intermediate level and high level extract slots. The baffles shall be readily removable for cleaning. The top and bottom slots shall be adjustable from 2mm to 20mm for final balancing of the fume cupboard air flow except where the final balance has been preset at the factory.

The velocity of air passing through the extract slots in the rear baffles shall be greater than 7.5m/s. The edges of the baffle shall be rounded to prevent wind whistles.

### 4.4.10 Siting

As the most hazardous laboratory work is generally carried out in a fume cupboard, this item should generally be the first item to be located when planning a laboratory layout.

In general, the fume cupboard shall be located away from the main circulation areas, doorways, opening windows and emergency and egress paths. Note that care shall be taken to locate fume cupboards away from doors as:

- movement of personnel is concentrated near the doors
- major air turbulence is generated by the opening and closing of doors
- the fume cupboard is a major hazard area and shall be located as far as possible from egress points.

Care shall be taken in siting room supply air registers and the like. Reference shall be made to the appropriate clauses in AS/NZS2243.8; however, UWA reserves the right to specify a more stringent requirement based on the risk assessment described in Section 4.4.1 of this Standard.

The proposed siting of the fume cupboard shall comply with AS/NZS 2243.8.

### 4.4.11 Commissioning

Each fume cupboard shall undergo commissioning tests in accordance with the appropriate sections of AS/NZS2243.8. However, the following modifications shall be made to the method of determining face velocity for by-pass fume cupboards having a constant exhaust rate irrespective of sash position.

The fume cupboard shall exhibit the following performance characteristics when tested as specified:

Total exhaust air from the fume cupboard shall be as nominated for the associated exhaust fan.
With the sash fully open, the average face velocity shall be 0.5m/s.

With the sash door closed to a position 50mm above the front sill, the average face velocity shall be 0.6m/s.

The noise level of the fume cupboard shall not exceed 62dBA when measured on the centre line and one metre away from the sash.

**Working Aperture Test**

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

**Testing Label**

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

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

### 4.4.12 Electrical Services

All electrical services shall be in accordance with *AS/NZS2243.7, AS/NZS3000 and UWA Design and Construction Standards – Electrical Services*. Services shall only be installed by a contractor on UWA’s Preferred Contractors list.

**Thermal Detector**

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

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

Activation of the detector shall initiate the following functions:

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

**Fire Alarm**

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

When electrical SSOs are specified for a fume cupboard the requirement shall normally be for one double SSO to be mounted at each side. One of these double SSOs shall be an RCD type with a light indicator for power availability feeding the second double SSO which is also to have light indicators for power availability. For laboratories having electrical Power Emergency Insulator buttons near the entrance door, the circuit supplying the fume cupboard SSOs shall also be isolated when the laboratory Emergency Isolator is activated.

The fume cupboard SSOs shall not receive power until the exhaust fan has been operating for one minute and power shall be immediately disconnected if the fume cupboard OFF, EMERGENCY STOP or FIRE DETECTOR is activated as required in AS2243.8.

4.4.13 Instruments

For by-pass type fume cupboards with a constant exhaust rate through the fume cupboard, a differential pressure measuring gauge of the ‘magnahelic’ type, with a range of 0 to 250Pa, shall be mounted on the front panel of the fume cupboard immediately above the sliding sash.

This gauge shall read the differential pressure between the exhaust duct at the rear of the fume cupboard and the room external to the fume cupboard. The normal differential pressure between these points shall be marked on the face of the gauge.

4.4.14 Piped Services

Piped services shall be provided as part of hydraulics works. Deionised water pipework within the fume cupboard shall be high density polyethylene. All other pipework to gas and water outlets shall be in Type B copper tube to AS 1432 unless stainless steel is required for biological fume cupboards.

4.4.15 Controls and Outlets

Controls and outlets for all services other than deionised water shall be located on the outer surface of the fume cupboard or the supporting structure. Permission to locate electrical controls in the hazardous areas (refer to AS/NZS2243.1) of the fume cupboard shall only be given by UWA in exceptional cases.

Control knobs and handles shall not protrude beyond the line of the face of the fume cupboard. Controls and their outlets within the fume cupboard shall be colour coded and labelled.

4.4.16 Luminaires

Luminaires shall be coordinated with electrical services.

The luminaire in the fume cupboard shall be mounted into the top of the work zone. The luminaire shall be
accessible and easily removed for servicing.

The luminaire shall be located in an enclosure which does not connect to the working volume of the fume cupboard.

The luminaire shall be suitably distant from the panel on which it is mounted to substantially avoid heat transferred to the panel from the luminaire.

The luminaire shall be controlled by a switch mounted on the fume cupboard in a location most convenient to the operator.

All wiring and fittings shall comply with relevant sections of AS/NZS 3000 and AS/NZS 2243.7.

4.4.17 Gas

All gas service outlets shall be located on the inner surface of the fume cupboard with controls on the front fascia as in accordance with AS/NZS 2243.8. In general, all gas piping and fittings shall be in accordance with UWA Design and Construction Standards - Hydraulic Services and any other requirements of the relevant statutory authorities. Solenoid valve and wiring to terminals connected to the fume cupboard controller for emergency shut-off shall be included.

4.4.18 Water

All water outlets shall be located on the inner surface of the fume cupboard with controls on the front fascia as in accordance with AS/NZS 2243.8. Include solenoid for perchloric acid wash-down.

Scrubber fume cupboards shall have additional water and drainage services.

4.4.19 Colour Coding

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

4.4.20 Access Panels

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

4.5 EVAPORATIVE COOLERS

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

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

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

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

4.5.1 Location

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

4.5.2 Dump and Cold Water Solenoid Valves

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

All valves used on evaporative cooler installations shall be Water Corporation approved. No other type will be accepted.

4.5.3 Backflow Requirements

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

4.5.4 Waste Outlet

Where evaporative coolers are installed at ground level, the waste lines from the basin shall be run to a storm water drain. A gap between the drain and the end of the waste pipe of at least 100mm shall be provided.

Where storm water drains are not available, the waste line shall be run along the side of the building with a 90 degree elbow on the end. A concrete channel at the bottom of the waste line shall be provided to take the water away from the base of the wall.

Where evaporative coolers are installed on a tile roof, the waste line shall be run down the wall of the building, terminating in a 45 degree bend. A concrete channel at the bottom of the waste line shall be provided to take the water from the base of the wall.

Where evaporative coolers are located on a metal deck roof, waste water shall not run onto the roof. The 40mm dump valve line shall terminate with a 90 degree bend directly above the downpipe, leaving a minimum of 100mm clearance above the entry to the downpipe. However, where buildings have copper or
stainless steel gutters and downpipes, dump water can be run directly into the gutter.

4.5.5 Overflows

The 50mm overflow from evaporative coolers shall terminate in a visible place, ie., over the edge of a parapet. If the contractor is unsure where to run the overflow, consult with UWA.

4.5.6 Roof Penetrations

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

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

All copper water pipes and SWV PVC drains shall be secured to the ribs on the decking roof. Clip spacing shall be as per AS/NZS 3500.

4.5.7 Roof Protection

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

4.5.8 Water Connection

Water connections and waste outlets for evaporative air conditioning equipment shall be supervised by a licensed plumber and shall meet the following requirements.

For domestic installations, the isolating valve shall be located in an accessible position not greater than 1.8m above ground level. Provision for metering is not required.

For industrial installations, the isolating valve shall be located in an accessible position not greater than 1.8m above ground level and shall be positioned to accommodate a metering device connected to BMCS.

4.6 COOLING TOWERS

Cooling towers shall be CTI certified of the counter flow draw through type of Evapco or approved equivalent.

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

Make up water connections shall be installed to AS/NZS 3500.
4.6.1 Structure

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

4.6.2 Basin

The basin shall be constructed of 304-grade stainless steel. The basin shall have a smooth internal finish and slope to a centre drain for ease of cleaning as nominated in AS 3666. A suction, drain, overflow and quick fill connections shall be furnished as standard and comply with AS 3500 where applicable. The suction connection shall be 304-grade stainless steel a standard for high strength and durability and be table “E” flanged pattern in accordance with AS 2129. Easy and complete access shall be possible from all sides.

Each basin shall contain a factory fitted electronic make up water device with a slow operating fail open butterfly valve to prevent water hammer. Manual float valve assemblies with ball float will not be acceptable.

4.6.3 Air Inlet Louvres

Air inlet louvres shall be PVC, designed to prevent splash-out and minimise the passage of sunlight to the cooling tower interior. Louvres shall be easily removable lightweight sections providing easy access for cleaning. 304-grade stainless steel deflector shall be factory fitted at the bottom of and inside the louvres to direct water away from the louvre preventing splash-out.

4.6.4 Access

One full side of the casing shall be removable to provide full and open access to all internal tower components for inspection, maintenance and cleaning. The access panel shall be retained by easily removable knobs not requiring dismantling of the tower structure.

4.6.5 Ladder and Service Platform

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

A low level fibreglass platform for basin access shall be provided and installed by the cooling tower manufacturer.
Supplied equipment shall conform to current UWA Safety Health and Wellbeing and Worksafe safety requirements.

4.6.6 Wet Deck Surface (Fill Media)

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

4.6.7 Water Distribution System

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

4.6.8 Water Level Control

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

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

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

4.6.9 Drift Eliminators

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

4.6.10 Strainer

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

All wetted hardware, fill, eliminator, water distribution supports and miscellaneous metal components shall be 304-grade stainless steel.

4.6.12 Accessories

The following items shall be provided:
- Louvre access door
- Motor davit with base
- Stainless steel fan shafts
- Two equalizer connections 300ø
- External service platform with ladder
- Flange inlet and outlet connections

4.6.13 Mechanical Equipment

Fan

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

Motors

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

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

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

Mechanical Support

The mechanical support shall be of 304 stainless steel construction.

The fan shaft shall be of 304 stainless steel supported by heavy duty, self-aligning, grease packed ball bearings specifically suited to vertical shaft application with moisture proof seals and integral slingers.

Extended lubrication lines shall be provided as standard to the bearings with grease nipples located outside for ease of scheduled maintenance.

Belt Drive

Units shall be fitted with a belt drive. Motors, if located in the discharge air stream, shall have a suitable IP rating for the duty.
Motor and fan pulleys shall be of aluminium type. Mild steel pulleys are not acceptable.

4.6.14 Warranty

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

4.6.15 Tests

A simple thermal test shall be carried out on the cooling tower to assess its performance at time of commissioning on a design day. The test shall consist of water in and out temperatures, water flow rates and air in and out wet bulb and dry bulb temperatures. If the results of this test fail to prove the cooling tower capacity then at the discretion of the Superintendent the cooling tower shall be tested to the *ASME Power Test Code PTC23-1958* and amendments, to guarantee the cooling tower meets the specified duty. Should the cooling tower fail to meet the specified duty then the cooling tower shall be rectified to provide cooling tower performance to the specified duty.

4.6.16 Plumbing Approvals

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

4.7 COOL ROOMS, FREEZERS AND CONSTANT TEMPERATURE ROOMS

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

COOL ROOMS served by refrigerated forced draft coolers are generally controlled down to 0°C.

FREEZER ROOMS served by refrigerated forced draft coolers are generally controlled to -20°C.

C.T. ROOMS (Constant Temperature Rooms) served by chilled water air handling units are generally controlled down to +18°C.

C.T ROOMS served by glycol air handling units are generally controlled down to +5°C.

4.7.1 Room Construction

Walls

The rooms shall be constructed on insulated panels fixed to the structural floor slab of the building. An insulated floor shall be provided to the rooms. The rooms shall meet or exceed the current food hygiene regulations.

Specified sizes shall be internal room dimensions.
Stainless steel components shall be type 302 grade having a smooth No. 4 satin finish. A PVC coating protection shall be retained until commissioning and blemished or scratched surfaces will not be accepted.

Aluminium components shall be clear anodised after extrusion.

All steel work shall be hot dipped galvanised after fabrication. Where cutting is required sections shall be removed from site and re-galvanised before final installation.

The Cool Room walls shall be composite sandwich panels comprising self-extinguishing expanded polystyrene foam having the following specification as determined by AS 1366, Part 3 Class "S".

<table>
<thead>
<tr>
<th></th>
<th>Walls and Ceiling</th>
<th>Floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>16kg/m³</td>
<td>24kg/m³</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>0.036 W/mK</td>
<td>0.034 W/mK</td>
</tr>
<tr>
<td>Permeability</td>
<td>580 UG/m²</td>
<td>460 UG/m²</td>
</tr>
<tr>
<td>Compressive Strength</td>
<td>85 kPa</td>
<td>135 kPa</td>
</tr>
</tbody>
</table>

Walls and ceilings insulation shall have all exterior and interior surfaces clad in 0.6mm thick off white colorbond. The cladding shall be glued under pressure by means of a solvent free thermostable adhesive.

The finished internal surface to 1800mm above the floor shall meet Department of Health requirements. All joints on the exterior shall be sealed vapour tight with butyl mastic.

A minimum practical number of joints shall be used. Joints between panels shall be made using aluminium "H" section on both sides of the panel and 75mm wide x 5mm thick hardboard spline down the middle and full length of the panel.

The gaps between the building walls and the rooms insulated walls shall be filled with insect and vermin proofed impregnated fibreglass wool and sealed with trimming angle fabricated from the panel skin material.

The ceiling panels shall be reinforced where necessary to support the forced draft evaporator.

Panel thickness shall be 75mm for Constant Temperature Rooms and Cool Rooms. Panel thickness shall be 150mm for Freezer Rooms.

**Floors**

The room floor shall be insulated and a concrete wearing slab shall be provided.

The structural concrete floor shall be properly primed and vapour sealed with "Flintkote" vapour barrier.

A further 0.25 thick polythene sheet vapour barrier shall be installed. Joints shall be lapped and taped. An approved adhesive shall be used to fix the sheeting and seal the joints.

Following the installation of the vapour barrier, the expanded polystyrene insulation boards shall be laid.

A further 0.25mm thick polythene sheet vapour barrier shall be installed on top of the insulation, lapped but unsealed at the joints.
Floor surface shall be either metal deck sheeting or reinforced concrete acid etched or mechanically abraded to eliminate surface irregularities with 1:100 fall to floor waste or doorway.

Aluminium cover strips shall be secured to the base of the walls with a bead of silicone rubber. Door threshold fitting shall be installed as detailed.

**Coving**

All wall and ceiling and wall to wall corners shall be fitted with aluminium coving mitred at the corners and fully sealed with butyl mastic.

**Doors**

All doors shall be constructed as per standard detail. Doors shall be insulated with polystyrene with fibreglass or stainless steel trims and fitted with Jarrah timber inserts for fixing of hinges and door handles, etc. as required.

Where timber components are used they shall be fully termite proof.

The door gasket shall be of Hi-Lo hollow core type bonded to the door with an approved adhesive. A neoprene scraper gasket with a stainless steel strip shall be provided at the bottom of the door.

Hinges and latches shall be chrome plated, lockable "EFCO or Kason" type. All doors shall be provided with an internal safety release mechanism. Hinges shall be rising butt self-closing type. Viewing windows shall be double glazed with sealed cavity.

**Wall and Ceiling Penetrations**

All necessary wall and ceiling penetrations, including room vapour sealing, shall be provided.

Where piping or conduits penetrate any part of the Cool Room, PVC sleeves shall be installed. The sleeves shall be bonded to the insulation panel and the annulus between the sleeve and pipe packed with mastic.

Electrical penetrations shall be made in a similar manner to the pipe penetrations.

4.7.2  **Refrigeration Plant**

Condensing units and forced draft evaporators shall be provided.

The Cool Room system shall be fully tubed up, charged and commissioned. Condensing unit support stands and evaporator support steel work shall be provided.

The proposed refrigeration capacity and saturated suction temperature to meet specified room temperature shall be submitted for approval prior to commencing work.

**Condensing Units**

Fully hermetic compressors are preferred using condensing units comprising unit base, condenser, receiver, compressor and electric motor.
Equipment selection shall be made within the manufacturers recommended speed range for the compressor.

Only equipment with a fully supported spare parts facility in Western Australia shall be used.

Refrigerant receivers, where specified, shall be of sufficient capacity to hold the system charge at 80% full and be fitted with relief valves to AS/NZS 1677.

Safety guards shall be fitted to all items of equipment which may cause damage or injury to personnel, the building or other equipment.

Ensure that all the equipment offered can be satisfactorily accommodated and serviced in the positions allocated.

Condensing units shall be of the air cooled type complete with compressor, motor, condensing coil, condenser fan and motor, liquid receiver and all ancillary fittings, controls, etc.

Compressors shall be fitted with suction and discharge shut-off valves. Condenser coils shall have copper tubes and aluminium fins.

Condenser fans shall be of the propeller type and shall be arranged to draw air through the coil.

A solid filter drier together with site glass moisture indicator shall be installed in the liquid line adjacent to each liquid receiver.

Oil traps shall be fitted.

Cool Room condensing unit condensing temperatures shall not exceed 40°C with 42°C air on condenser.

**Forced Draft Evaporators**

The unit cabinet shall be constructed of heavy gauge hammered aluminium with the fan and motor assembly rigidly fixed to the cabinet with stainless or monel fasteners.

Forced draft evaporators shall be supported on cadmium plated rods and galvanised angles as required.

The vapour barrier of the Cool Room shall be maintained by sealing to the bolts at the point of penetration.

Each forced draft evaporator shall incorporate housing, drip tray, cooling coil, fan, motor, TX valve, solenoid valve and liquid and suction line shut off valves.

Drip tray drains shall be trapped and the run to the nearest drain in 25mm diameter copper or PVC piping.

Coils shall be staggered type ripple aluminium plate fin with seamless copper tubing.

The unit TX valve shall be accessible.

**Refrigerant and Oil**

The Contractor shall provide the initial charges of appropriate recommended refrigerant oil and shall also supply and charge it to the system including additional refrigerant during the maintenance period should leakage of refrigerant occur due to defective parts, materials or workmanship.
4.7.3 Controls

The room temperature shall be controlled from a digital type thermostat mounted adjacent to the Cool Room door. The thermostat shall have an adjustable set point from and an adjustable differential as specified and continuously displaying the room temperature.

Each room shall be fitted with an additional alarm sensor set 3°C (adjustable) above set point. The signal from the sensor shall be relayed to the BMCS system.

Room temperatures shall be controlled by operation of a liquid line solenoid valve to isolate flow to the TX valve. The unit shall cycle off/on from the low pressure switch.

Unit safety controls shall include refrigerant high pressure and low pressure cut-out switches and oil safety switches where pressurised lubrication systems are fitted to compressors.

Each Cool Room controller shall be programmable and shall provide:

- Digital temperature display.
- Defrost control via time and manual control for Freezer Rooms.
- Anti-short cycle control.
- Temperature alarm logging, and defrost logging where appropriate.

Door switches shall be provided to interlock with the controller to de-energise evaporation fans and close solenoid valves when Cool Room doors are opened.

4.7.4 Refrigeration Electrical Work

Electrical work shall be in accordance with AS/NZS 3000 and UWA Design and Construction Standards – Electrical Services.

The electrical work associated with the refrigeration plant essentially comprises:

- All power and control wiring between the condensing units, switchboards, thermostats, solenoid valve, safety controls etc.
- Electrical testing and commissioning of all electrical equipment.
- Supply of "as wired" electrical drawings.
- Provision of a remote alarm fault signal to the BMCS system.
- Cool Room shall have Pierlite type NPSK fluorescent fitting (rated at -7°C) or equivalent standard fitting to UWA’s approval. The light fitting shall have electronic control gear with 0.95 PF, and a 4000K, Ra>84 Triphosphor tube with a minimum life of 13,000 hrs. Light switches and socket outlets shall be Clipsal IP56 rated.
- Freezer Room shall have Pierlite type NLT fluorescent fitting (rated at -30°C) or equivalent Standard fitting to UWA’s approval. The light fitting shall have electronic control gear with 0.95 PF and a 4000K, Ra>84 Triphosphor tube with a minimum life of 13,000hrs. Light switches shall be Clipsal IP66 rated. Socket outlets not required.
• Light switches shall be mounted adjacent to the door inside the room - not switched from outside the room, with a neon indicating light outside the room adjacent to the door that is illuminated when the lights are turned on.

4.8 REFRIGERATION PIPEWORK

4.8.1 Pipework

Refrigeration pipework shall comply with AS/NZS 1571.

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

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

Flare nuts shall be of:
• frost proof design when used in refrigerant suction piping.
• of the long pattern type wherever prone to vibration. Copper flare gaskets and flare seal bonnets shall be to ANSI B70.1.

4.8.2 Supports

Refer Section 4.3.14 of this document.

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

Ensure continuity of vapour barrier over the ferrule and insulation.

4.8.3 Building Works

Refer Section 4.3.15 of this document.

4.8.4 Pipework Insulation

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

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

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

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

Application of Flexible Insulation

- Apply to straight lengths, formed sets and bends prior to erection without longitudinal joints
- Neatly cut and form around fittings
- Seal at all joints with adhesive and finish as recommended by the insulation material manufacturer to provide effective vapour seal and UV protection.
- Insulate with preformed tubular sections, selected to accurately match the pipe O.D. for a tight fit without longitudinal joints.
- Circumferential butt joints to be sealed with approved adhesive to ensure a complete vapour seal without air gaps and the butt joint wrapped with a complete layer of self-adhesive 3mm x 50mm wide tape, of the same elastomeric material as the insulation. Aerotape or approved equivalent.

Aluminium or Sheet Metal Cladding

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

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

Painting Insulation

Painting of insulation is required:

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

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

4.8.5 Refrigeration Systems Testing

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

Equipment shall pass appropriate tests at the manufacturer’s works and certification of the tests shall be submitted, on request, to UWA.
Pressure Tests

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

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

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

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

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

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

Pressure change for ambient change will be recognised.

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

Pressure test shall be repeated after leaks are corrected.

Evacuation tests

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.9 BUILDING MANAGEMENT AND CONTROL SYSTEMS

All air conditioning and mechanical services controls are to be electronically compatible with the Schneider system currently installed.

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

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

4.9.1 Local Push Buttons

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

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

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

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

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

4.9.2 Pressure Switches
Pressure switches for FAN STATUS shall be direct mounted on a vibration free section of ductwork, avoiding the use of pressure connecting tubing, utilising PENN SERIES P32AC2 switch with direct mounting probe, "U" bracket and airtight gasket to facilitate service without the need to unscrew self-tappers, or access inside the duct.

4.9.3 Building Energy Monitoring
Each Building shall be provided with chilled water energy monitoring comprising electromagnetic flow metering and temperature differential measurement to process and record building chilled water energy usage.

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

4.9.4 Mechanical Services Switchboards (MSSB)
All switchboards including the MSSB and any other plant specific switchboards should be designed and specified in accordance with the Design and Construction Standards – Electrical Services.

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

4.9.5 Electric Motors and Motor Control Equipment
All electrical motors shall be suitable for operation on 415/240 volts.

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

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

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

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

During commissioning, contractors will be expected to carry out spot checks on fan capacities and motor kW loadings as requested.
Motors should be selected for their duty. Ball or roller bearings shall be specified except in areas where noise from these motors may be a nuisance when sleeve bearings may be permitted. When situated close to teaching areas, super-silent type shall be specified.

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

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

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

- motors up to and including 4kW may be started DOL
- motors from 5.5 - 8kW Star-Delta started or a soft starter
- motors above 8kW to be auto-transformer started and the number of steps (or a soft starter) approved by UWA.

**Motor Control Cubicles**

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

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

- Green light - Switch open. Motor not running. (Ready IEC)
- Red light - Switch closed. Power on.
- Yellow or Amber light - Switch tripped on Fault (Caution IEC)
- White - Normal Operation IEC

**4.9.6 Variable Speed Drives (VSDs)**

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

All VSDs shall be Danfoss.

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

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

**4.9.7 Size of Control Panel**

Each control panel shall be generously sized. The number of power circuits continually grow as additional
equipment are added. New control panels therefore should have at least 100% additional spare capacity when installed.

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

4.9.8 Toilet Ventilation Systems

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

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>BACKGROUND COLOUR</th>
<th>BANDING COLOUR</th>
<th>LABEL</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acids &amp; Alkalis</td>
<td>Violet</td>
<td>Lilac P.23</td>
<td>Yellow Black 45° Stripes Y.14 As applicable</td>
<td>BLACK</td>
</tr>
<tr>
<td>Air Pipework</td>
<td>Light Blue</td>
<td>Aqua B.25</td>
<td>C.A. &quot;_&quot; kPa WHITE</td>
<td>Exposed Ductwork outside Plant rooms. Colours specified by Architect</td>
</tr>
<tr>
<td>Air Ductwork (Air-conditioning &amp; General Ventilation)</td>
<td>Light Blue</td>
<td>Aqua B.25</td>
<td>SUPPLY AIR RETURN EXHAUST OUTSIDE AIR RELIEF</td>
<td>WHITE with Direction of flow Chevron (arrows)</td>
</tr>
<tr>
<td>Air Ductwork (Hazardous Exhaust)</td>
<td>Light Blue</td>
<td>Aqua B.25</td>
<td>Yellow Black 45° stripes Y.14 As applicable</td>
<td>BLACK</td>
</tr>
<tr>
<td>Belt Guards</td>
<td>Golden Yellow</td>
<td>Y.14</td>
<td>Black 45° stripes</td>
<td></td>
</tr>
<tr>
<td>Boiler Blowdown (Steam)</td>
<td>Silver Grey</td>
<td>N.24</td>
<td>Yellow Black 45° Stripes Y.14 BLOWDOWN BLACK</td>
<td></td>
</tr>
<tr>
<td>Chilled Water</td>
<td>Green</td>
<td>Jade G.21</td>
<td>CHW WHITE</td>
<td>Direction of flow Chevron (arrow)</td>
</tr>
<tr>
<td>Cold Water (NON POTABLE)</td>
<td>Green</td>
<td>Jade G.21</td>
<td>CW WHITE</td>
<td>Direction of flow Chevron (arrow)</td>
</tr>
<tr>
<td>Cold Water (POTABLE)</td>
<td>Mid Blue</td>
<td>B.15</td>
<td>Mid Blue B.15 POTABLE WATER WHITE AS.1345 cl.8.1</td>
<td></td>
</tr>
<tr>
<td>Communications Conduits</td>
<td>White</td>
<td></td>
<td>As applicable BLACK</td>
<td></td>
</tr>
<tr>
<td>Condensate (Steam)</td>
<td>Silver Grey</td>
<td>N.24</td>
<td>CONDENSATE BLACK</td>
<td>Direction of flow Chevron (arrow)</td>
</tr>
<tr>
<td>SERVICE</td>
<td>BACKGROUND COLOUR</td>
<td>BANDING COLOUR</td>
<td>LABEL</td>
<td>COLOUR</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------</td>
<td>-----------------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>Condenser Cooling Water</td>
<td>Green</td>
<td>Jade G.21</td>
<td>CCW</td>
<td>WHITE</td>
</tr>
<tr>
<td>Distilled Water</td>
<td>Green</td>
<td>Jade G.21</td>
<td>DISTILLED</td>
<td>WHITE</td>
</tr>
<tr>
<td>Domestic Hot Water</td>
<td>Green</td>
<td>Jade G.21</td>
<td>DHW</td>
<td>WHITE</td>
</tr>
<tr>
<td>Drains</td>
<td>Black</td>
<td></td>
<td>DRAIN</td>
<td>WHITE</td>
</tr>
<tr>
<td>Electrical Conduits</td>
<td>Orange</td>
<td>X.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric Motors</td>
<td>Orange</td>
<td>X.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Services</td>
<td>Red</td>
<td>Signal Red R.13</td>
<td>As applicable</td>
<td>WHITE</td>
</tr>
<tr>
<td>Heating Water</td>
<td>Green</td>
<td>Jade G.21</td>
<td>HTGW</td>
<td>WHITE</td>
</tr>
<tr>
<td>High Temperature Water</td>
<td>Silver Grey</td>
<td>N.24</td>
<td>HTW 150oC</td>
<td>BLACK</td>
</tr>
<tr>
<td>Medical Gases</td>
<td>Yellow Ochre</td>
<td>Sand Y.44</td>
<td>Dark Blue</td>
<td>B.24</td>
</tr>
<tr>
<td>Motor Plinths and Inertia Bases</td>
<td>Charcoal</td>
<td>Dark Grey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Yellow Ochre</td>
<td>Sand Y.44</td>
<td>NATURAL GAS</td>
<td>BLACK</td>
</tr>
<tr>
<td>Oil, Flammable and Combustible Liquids</td>
<td>Brown</td>
<td>Golden Tan X.53</td>
<td>As applicable</td>
<td>WHITE</td>
</tr>
<tr>
<td>Overflow (water)</td>
<td>Black</td>
<td></td>
<td>OVERFLOW</td>
<td>WHITE</td>
</tr>
<tr>
<td>Pipe Supports and Hangers</td>
<td>Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant Room Floors</td>
<td>Bauxite</td>
<td>by Dulux Product</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES
- Direction of flow Chevron (arrow)
- Hazard Identification ref. AS.1345 cl.8.2 where appropriate
- Ref. AS.2896 Table 3.1
- Hazard Identification ref. AS.1345 Appendix ‘C’
<table>
<thead>
<tr>
<th>SERVICE</th>
<th>BACKGROUND COLOUR</th>
<th>BANDING COLOUR</th>
<th>LABEL</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NAME</td>
<td>AS.2700 No</td>
<td>NAME</td>
<td>AS.2700 No</td>
</tr>
<tr>
<td>Plant Room Walls &amp; Ceilings</td>
<td>Low Sheen White</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerant Lines</td>
<td>Yellow Ochre</td>
<td>Sand Y.44</td>
<td>R &quot; ____ &quot;</td>
<td>BLACK</td>
</tr>
<tr>
<td>Steam</td>
<td>Silver Grey</td>
<td>N.24</td>
<td>Steam &quot; ____ &quot; kPa</td>
<td>BLACK</td>
</tr>
<tr>
<td>Stop or Emergency Stop Control Buttons</td>
<td>Red</td>
<td>Signal Red R.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Switchboards</td>
<td>Sand</td>
<td>Y.44</td>
<td>As appropriate</td>
<td>BLACK</td>
</tr>
<tr>
<td>Tube Conveyors</td>
<td>Light Blue</td>
<td>Aqua B.25</td>
<td>MESSAGE CARRIER</td>
<td>WHITE</td>
</tr>
<tr>
<td>Vacuum</td>
<td>Light Blue</td>
<td>Aqua B.25</td>
<td>VACUUM</td>
<td>WHITE</td>
</tr>
<tr>
<td>Vents (Steam Equipment)</td>
<td>Silver Grey</td>
<td>N.24</td>
<td>Yellow Black 45° Stripes</td>
<td>Y.14</td>
</tr>
<tr>
<td>Vents (Other than for Steam Equipment or Hazardous gases)</td>
<td>Black</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vents (Hazardous gases)</td>
<td>As for gas relieved</td>
<td>Yellow Black 45° Stripes</td>
<td>Y.14</td>
<td>As applicable</td>
</tr>
<tr>
<td>SERVICE</td>
<td>JOTUN COLOUR</td>
<td>JOTUN NUMBER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------</td>
<td>------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td>Horizon Blue</td>
<td>PE 754134</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum</td>
<td>Autumn Red</td>
<td>PE 734120 SG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen Gas</td>
<td>Notre Dame</td>
<td>PE 774201</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetylene</td>
<td>Claret</td>
<td>PE 35057 SG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td>Gloss Black</td>
<td>PE 775197</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helium</td>
<td>Hammersley Brown</td>
<td>PE 784082 W</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>Transformer Grey</td>
<td>PE 775242</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deionised Water</td>
<td>Cabana Green</td>
<td>PE 765098</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Primrose</td>
<td>PE 744161</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non Potable Water</td>
<td>Cabana Green</td>
<td>PE 765098</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potable Water</td>
<td>Atlantic Blue</td>
<td>PE 750226</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbogen</td>
<td>Gloss Black - Transformer Grey</td>
<td>PE 775197, PE 775242</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Argon</td>
<td>Wizard</td>
<td>PE 754180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>French Blue</td>
<td>PE 754187</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SERVICE</td>
<td>BACKGROUND COLOUR</td>
<td>BANDING COLOUR</td>
<td>LABEL</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------</td>
<td>----------------</td>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>Compressed Air</td>
<td>Light Blue</td>
<td>Aqua B.25</td>
<td>CA* &quot;kPa</td>
<td></td>
</tr>
<tr>
<td>Laboratory Vacuum</td>
<td>Light Blue</td>
<td>Aqua B.25</td>
<td>VACUUM</td>
<td></td>
</tr>
<tr>
<td>Pathological Suction</td>
<td>Red Gum</td>
<td>Red Gum R.53</td>
<td>PATHOLOGICAL SUCTION</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Gas</td>
<td>Pewter</td>
<td>N.63</td>
<td>NITROGEN</td>
<td></td>
</tr>
<tr>
<td>Acetylene</td>
<td>Claret</td>
<td>R.55</td>
<td>ACETYLENE</td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td>Black</td>
<td>-</td>
<td>OXYGEN</td>
<td></td>
</tr>
<tr>
<td>Helium</td>
<td>Brown</td>
<td>X.54</td>
<td>HELIUM</td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>Green/Grey</td>
<td>N.32</td>
<td>CARBON DIOXIDE</td>
<td></td>
</tr>
<tr>
<td>Deionised Water</td>
<td>Green</td>
<td>Jade G.21</td>
<td>DEIONISED WATER</td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Yellow Ochre</td>
<td>Sand Y.44</td>
<td>NATURAL GAS</td>
<td></td>
</tr>
<tr>
<td>Non Potable Water</td>
<td>Green</td>
<td>Jade G.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potable Water</td>
<td>Green</td>
<td>Jade G.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbogen</td>
<td>Green/Grey</td>
<td>N.32</td>
<td>CARBOGEN</td>
<td></td>
</tr>
<tr>
<td>Argon</td>
<td>Blue</td>
<td>Peacock T.53</td>
<td>ARGON</td>
<td></td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>Blue</td>
<td>Ultra Marine B.21</td>
<td>NITROUS OXIDE</td>
<td></td>
</tr>
</tbody>
</table>

Labels to be to AS.2896 Fig. 3.3 and AS.1345 Fig 1 (Pipe Markers)
Symbols for Ionizing Radiation and Biological Hazards shall be to AS.1345 Fig.2
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>BMCS</td>
<td>Building Management and Control Systems</td>
</tr>
<tr>
<td>BCA</td>
<td>Building Code of Australia</td>
</tr>
<tr>
<td>CHW</td>
<td>Chilled Water</td>
</tr>
<tr>
<td>CM</td>
<td>Campus Management</td>
</tr>
<tr>
<td>CTI</td>
<td>Cooling Technology Institute</td>
</tr>
<tr>
<td>DNA</td>
<td>Deoxyribonucleic Acid</td>
</tr>
<tr>
<td>DOL</td>
<td>Direct On Line</td>
</tr>
<tr>
<td>DX</td>
<td>Direct expansion</td>
</tr>
<tr>
<td>ELV</td>
<td>Extra Low Voltage</td>
</tr>
<tr>
<td>FCU</td>
<td>Fan Coil Unit</td>
</tr>
<tr>
<td>FRP</td>
<td>Fibreglass Reinforced Plastic</td>
</tr>
<tr>
<td>GEC</td>
<td>General Electric Company</td>
</tr>
<tr>
<td>GSS</td>
<td>Galvanised Sheet Steel</td>
</tr>
<tr>
<td>HEPA</td>
<td>High Efficiency Particulate Arrestance</td>
</tr>
<tr>
<td>HRC</td>
<td>High Rupturing Capacity</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating, Ventilation and Air-conditioning</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
</tr>
<tr>
<td>MSSB</td>
<td>Mechanical Services Switchboard</td>
</tr>
<tr>
<td>NATA</td>
<td>National Association of Testing Authorities, Australia</td>
</tr>
<tr>
<td>OGTR</td>
<td>Office of the Gene Technology Regulator</td>
</tr>
<tr>
<td>OPSO</td>
<td>Over Pressure Shut Off</td>
</tr>
<tr>
<td>PC</td>
<td>Physical Containment</td>
</tr>
<tr>
<td>PCC</td>
<td>Point of Common Coupling</td>
</tr>
<tr>
<td>PGI</td>
<td>Painted Galvanised Iron</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl chloride</td>
</tr>
<tr>
<td>RCD</td>
<td>Residual Current Device</td>
</tr>
<tr>
<td>SSO</td>
<td>Switched Socket Outlet</td>
</tr>
<tr>
<td>SWV</td>
<td>Soil Waste and Vent</td>
</tr>
<tr>
<td>TDF</td>
<td>Transverse Duct Flanges</td>
</tr>
<tr>
<td>THD</td>
<td>Total Harmonic Distortion</td>
</tr>
<tr>
<td>TX</td>
<td>Thermostatic Expansion</td>
</tr>
<tr>
<td>UPVC</td>
<td>Unplasticised Polyvinyl Chloride</td>
</tr>
<tr>
<td>UV</td>
<td>Ultraviolet</td>
</tr>
<tr>
<td>VAV</td>
<td>Variable Air Volume</td>
</tr>
<tr>
<td>VSD</td>
<td>Variable Speed Drive</td>
</tr>
</tbody>
</table>
## References

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANSI B70.1</td>
<td>REFRIGERATION FLARE TYPE FITTINGS</td>
</tr>
<tr>
<td>AS 1111</td>
<td>ISO metric hexagon bolts and screws</td>
</tr>
<tr>
<td>AS 1112</td>
<td>ISO metric hexagon nuts</td>
</tr>
<tr>
<td>AS/NZS 1167</td>
<td>Welding and brazing - Filler metals</td>
</tr>
<tr>
<td>AS 1192</td>
<td>Electroplated coatings – Nickel and chromium</td>
</tr>
<tr>
<td>AS 1210</td>
<td>Pressure vessels</td>
</tr>
<tr>
<td>AS 1231</td>
<td>Aluminium and aluminium alloys - Anodic oxidation coatings</td>
</tr>
<tr>
<td>AS 1324</td>
<td>Air filters for use in general ventilation and air conditioning - Application, performance and construction</td>
</tr>
<tr>
<td>AS 1345</td>
<td>Identification of the contents of pipes, conduits and ducts</td>
</tr>
<tr>
<td>AS 1349</td>
<td>Bourdon tube pressure and vacuum gauges</td>
</tr>
<tr>
<td>AS 1359.5</td>
<td>Rotating electrical machines - General requirements - Three-phase cage induction motors - High efficiency and minimum energy performance standards requirements</td>
</tr>
<tr>
<td>AS 1366</td>
<td>Rigid cellular plastics sheets for thermal insulation</td>
</tr>
<tr>
<td>AS 1397</td>
<td>Continuous hot-dip metallic coated steel sheet and strip coatings of zinc and zinc alloyed with aluminium and magnesium</td>
</tr>
<tr>
<td>AS 1432</td>
<td>Copper tubes for plumbing, gasfitting and drainage applications</td>
</tr>
<tr>
<td>AS/NZS 1477</td>
<td>PVC pipes and fittings for pressure applications</td>
</tr>
<tr>
<td>AS 1530</td>
<td>Methods for fire tests on building materials, components and structures</td>
</tr>
<tr>
<td>AS 1565</td>
<td>Copper and copper alloys - Ingots and castings</td>
</tr>
<tr>
<td>AS/NZS 1571</td>
<td>Copper - Seamless tubes for airconditioning and refrigeration</td>
</tr>
<tr>
<td>AS 1657</td>
<td>Fixed platforms, walkways, stairways and ladders - Design, construction and installation</td>
</tr>
<tr>
<td>AS/NZS 1668</td>
<td>The use of ventilation and airconditioning in buildings</td>
</tr>
<tr>
<td>AS/NZS 1677</td>
<td>Refrigerating Systems</td>
</tr>
<tr>
<td>AS 1682</td>
<td>Fire, smoke and air dampers</td>
</tr>
<tr>
<td>AS 1722</td>
<td>Pipe threads of Whitworth form - Fastening pipe threads</td>
</tr>
<tr>
<td>AS 1807</td>
<td>Clean Rooms and Work Stations</td>
</tr>
<tr>
<td>AS 1851</td>
<td>Routine service of fire protection systems and equipment</td>
</tr>
<tr>
<td>AS/NZS 2032</td>
<td>Installation of PVC pipe systems</td>
</tr>
<tr>
<td>AS/NZS 2107</td>
<td>Acoustics – Recommended design sound levels and reverberation times for building interiors</td>
</tr>
<tr>
<td>AS 2129</td>
<td>Flanges for pipes, valves and fittings</td>
</tr>
<tr>
<td>AS/NZS 2243</td>
<td>Safety in Laboratories</td>
</tr>
<tr>
<td>AS 2338</td>
<td>Preferred Dimensions of wrought metal products</td>
</tr>
<tr>
<td>AS 2252</td>
<td>Controlled Environments – Biological Safety Cabinets</td>
</tr>
</tbody>
</table>
AS 2700 Colour standards for general purposes
AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3500 Plumbing and Drainage
AS/NZS 3666 Air-handling and water systems of buildings
AS 3688 Water supply and gas systems - Metallic fittings and end connectors
AS 4254 Ductwork for air-handling systems in buildings
AS 4426 Thermal Insulation of pipework, ductwork and equipment - Selection, installation and finish
AS 4645 Gas distribution networks - Steel pipe systems
AS/NZS 5601 Gas installations
AS D26 Tube fittings with Dryseal American standard taper pipe and unified threads for automotive and industrial use
ASHRAE Handbooks, SMACNA Manual for Balancing Attached Appendices
Guidelines for Small Scale Genetic Manipulation Work.
Guidelines for Large Scale Genetic Manipulation Work.
Guidelines for the Planned Release of Genetically Manipulated Organisms
National Construction Code
National Code of Practice for the Safe Use of Synthetic Mineral Fibres
PD ISO/TR15377 Measurement of fluid flow by means of pressure-differential devices
PTC23-1958 ASME Power Test Code