**Document contact officer:**  Gary Higgins  
GM assets and Maintenance

**Approval:**

**Approval Authority:**  Director PDCSO

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<th>REV</th>
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### 1 Introduction

The purpose of this document is to outline the minimum acceptable standards for air conditioning and ventilation systems that apply for all new building works and all refurbishment works to existing buildings on any Murdoch University campus.

All design works for new and refurbished buildings shall consider and address the following key points to the satisfaction of the University Project and Technical staff:

- Alignment with the Green Star requirements based upon the Universities aspiration to achieve volume certification for Design & As built and Interiors rating tools.
- Provision of additional Green Star credits to meet the minimum 4 star rating
- Energy efficiency. This may have to be proved by comparison of various design options available using life cycle costing analysis as well as Energy modelling consistent with Green Star requirements.
- Adequate access for ongoing maintenance of all mechanical services plant and equipment.
- Compliance with the University’s convention for equipment numbering and labelling.
- Consideration should be given to interchangability and continuity on site when selecting brands of all equipment. Consult with Murdoch University for approval.
- It is Murdoch University’s preference to not have fan coil units located in concealed ceiling spaces. This should be considered in the design.
- Whenever possible, life cycle cost analysis shall govern the selection of systems and equipment and the University may call for calculations on competing systems.
- Chilled water systems are preferred in areas that are in close proximity to existing or planned chilled water reticulation systems. It is accepted that chilled water systems may initially require a higher capital cost that DX systems, but, on a life cycle cost analysis, may be preferable.
- Compliance with all statutory building requirements specifically the Building Code of Australia and reference standards within.
- All buildings are to be designed to have sufficient capacity to allow for extension or expansion; this includes making provision for piping systems within the building. The designer should reference the master plan and discuss the options with Murdoch to consolidate the design intent. All chilled water and heating pipe systems to each building shall, as a minimum, be designed to have a 20% spare capacity throughout.

### 2 Scope

This document is supported by or supports the following documents:

<table>
<thead>
<tr>
<th>Masterplan</th>
<th>Murdoch Strategic Asset Management Plan 2011-2021</th>
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<tr>
<td>Murdoch Policies:</td>
<td>Acts and their corresponding Regulations are:</td>
</tr>
<tr>
<td>Act, Regulations, Codes, Authorities, Regulatory bodies and standards to be referenced:</td>
<td>- Building Act 2011 – Building Regulations 2012</td>
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<tr>
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<td>- Occupational Safety and Health Act 1984 - Occupational Safety and Health Regulations 1996</td>
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<tr>
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<td>- WA Electrical Regulations</td>
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<td></td>
<td>- WA Health Act</td>
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</table>
The following Authorities and Regulatory bodies

- Gas - ATCO
- Electrical – Western power
- DFES
- City of Melville
- WAPC
- Water Corporation
- Worksafe WA
- Australian Communications Authority (ACA)

In all instances, use the latest issue of relevant Australian Standards referenced by the Building National Construction Code (NCC) current at the time. In this document NCC refers to NCC 2016 Volumes 1 to 3 and amendments.

In particular, but not limited to:

<table>
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<tr>
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<td>The use of Ventilation and Air-conditioning in buildings</td>
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<td>AS 3666</td>
<td>Air-handling and water systems of buildings</td>
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<td>AS 4254</td>
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<td>AS 3000</td>
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<td>AS 3500</td>
<td>Plumbing and drainage</td>
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<td>AS 2053</td>
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<td>AS 2430</td>
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<td>Low-voltage switchgear and control gear assemblies - Type-tested and partially type-tested assemblies</td>
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<td>AS 1345</td>
<td>Identification of the contents of piping, conduits and ducts</td>
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<td>AS 2252</td>
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<td>AS 2444</td>
<td>Portable fire extinguishers and fire blankets - Selection and location</td>
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<td>AS 2982</td>
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<td>AS 2665</td>
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<td>AS1571</td>
<td>Copper Seamless Tubes for Air Conditioning and Refrigeration</td>
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<td>Refrigerating systems and heat pumps - Safety and environmental requirements Definitions, classification and selection criteria (ISO 5149-1:2014, MOD)</td>
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These design guidelines are intended to set out Murdoch University’s preferences and/or minimum standards for some aspects of construction works on campus. In the event that consultants and/or contractors are not able to comply with aspects of these guidelines then they should consult with the University Liaison. These guidelines are not intended to constitute a complete design manual and it is assumed that professional knowledge and good practice will be applied by contractors at all times.

### 3 Environmental considerations
See Environmental/Ecological Guidelines – Design Guidelines for details on Murdoch University’s commitment to the environment and its potential impact on this project.

Consultants must show that their designs have viable energy efficient capabilities. Where this results in a higher capital cost a payback calculation shall be provided to estimate the savings over a period of time.

### 4 General Definitions and clarifications
Where the words “or approved equivalent” appear in this document, the entity approving whether an alternative brand to that nominated is equivalent shall be Murdoch University.

Air Handling Unit (AHU) – refers to a large floor mounted unit generally located within a dedicated mechanical services plant room.
Fan Coil Unit (FCU) – refers to a smaller air handling unit generally located at a high level, supported by structure over.

5 General Safety and access considerations
Designers are required to provide Murdoch with a Safety in Design report as required by the Construction Act. Safety in design reports must meet, as a minimum, information on the requirements below. Designers are responsible for ensuring the adequacy of their reports. All low level ductwork and pipework installed on plant rooms floors shall be covered with a grated mesh safety step complete with safety tape.

All low level (below 2000mm AFL) sheetmetal ductwork, piping and conduits within plant room areas shall be adequately marked with safety tape.

All plant shall have the facility of being locally isolated for required servicing and maintenance.

Allowance for adequate space for the installation and maintenance of machinery whether it be in a designated plantroom, ceiling spaces or otherwise. Lack of space is not considered an acceptable constraint on mechanical design. Reference is to be made to BCA A2.1 Suitability of materials and Table D1.13 AREA PER PERSON ACCORDING TO USE

Consultants shall ensure that their design provides for and indicates:

- How each item of plant is to be installed initially;
- How the University’s routine service personnel will access each plant item;
- The method to be used in changing the largest item of plant in any plantroom or plant area.

Any equipment installed in a trafficable ceiling space or on the roof, shall have a permanently fixed ladder and easily opened trap door. The design and location shall be approved by Murdoch.

6 Plantrooms
Generally plantrooms are required to house all mechanical services equipment, equipment located within ceiling spaces or exposed on the roof is not preferred and approval is required.

The Consultant shall ensure that the plant room layout at the design stage provides for adequate services access and future expansion.

Direct access from corridors to roof areas, plant rooms, tunnels, etc. shall be provided where possible to enable access by maintenance personnel. Emergency escape egress must be considered as part of the design and building egress code compliance.

Plantrooms shall be located convenient to the most direct point of vehicular access which can be achieved without the introduction of extensive service road connections.

It is preferred that plant rooms be located at roof top or basement level rather than in the body of the building. Provision shall be made in elevated plant rooms for hatches and lifting equipment to facilitate conveyance of equipment to ground.
Drainage of plantrooms should consider the risk of chilled/heating water pipework leak. Risk assessment should consider alternative ways of mitigating flood risk into the occupied space of a building.

Plant room floors shall be graded to floor outlets in order to permit hosing down of floor. Floor surfaces are to be sealed against spillages and flooding by bunding or other approved methods and painted with paving paint. Drainage of plantrooms shall consider the risk of chilled/heating water pipework leak. A risk assessment shall consider alternative ways of mitigating flood risk into the occupied space of a building.

Plant rooms shall be provided, where required, with mechanical exhaust ventilation.

Plant rooms shall be designed so that the noise level measured with all the equipment operating under full load will not exceed the current exposure standard less 3dbA. Where this cannot be achieved approval shall be sought.

7 Existing mechanical services infrastructure

7.1 South Street Campus

7.1.1 Central Chilled Water Generation Plant
The central chilled water generation plant has the following characteristics:

- B356 Library South plantroom chiller (Trane CVHF1300) nominal capacity 4400 kW
- B352 Library North plantroom chiller (Trane CVHG780) nominal capacity 2579 kW
- B365 Vet Plant room chiller (Trane) nominal capacity 2227 kW
- B383 Maintenance Plant 1 off Trane RTAA434A Air Cooled Chiller nominal capacity 1084 kW
- B383 Maintenance Plant 1 off Trane “Stealth” RTAE300 Air Cooled Chiller nominal capacity 1055 kW
- Chiller water design supply temp and return temperatures 7°C/14°C
- The Chilled water system primary process chillers are arranged in one of three configurations:
  - B352 and B356 are decoupled primary water systems with secondary variable speed pumps utilised for chilled water distribution to the Campus. With B352 the primary pump is D.O.L. whereas the primary for B356 is variable flow via a VSD.
  - B265 used to serve an ice storage plant and its primary circuit is totally decoupled from the main reticulation by a heat exchanger.
  - B383 – Aircooled chillers are directly coupled to the flow and return lines for the system reticulation.
- The chillers and associated plant are controlled via the Smartstruxure Building Operations Building Management Control System (SBO). Some interface at High Level Interfacing with the Trane Tracer and chiller controllers where cooling towers and pumps are controlled by Trane hardware and firmware. Others are hybrid with the BMS taking control of towers, pumps and valves leaving the chiller controller to manage the chiller.
- Chiller staging is controlled according to chiller system COSP whereby observed system parameters are used to trigger staging dependent on the most efficient chiller or combination of chillers to satisfy the load.
- A reticulated chilled water distribution system is provided across the campus serving most buildings.
- There are secondary chilled water pumps serving individual buildings, these are speed controlled via VSD’s to maintain the required DP set point when there is a building cooling call and the main chiller secondaries are not delivering sufficient flow to maintain the required building DP set point. The building secondary DP is reset dependent upon ambient temperature and return water temperature. Additionally each pump has a further control which disables the pump should the return system pressure fall below 160kPa. This automatically specifies independent pressure transducers on the flow and return lines. Differential pressure transducers are not permitted to control building secondaries.
- A cooling call is generated from each building which enables the secondary pumping plant for that building. The cooling call is typically generated via any chilled water valve that opens more than 70% and the cooling call is disabled when all chilled water valves for that building are closed less than 20%. Generally on low demand days (in winter) the chiller pumps are more than sufficient to supply the required flow rate to all buildings – for the majority of winter the total pump power used is around 9kW.
- The chilled water system utilises a Duraflex Variomat pressurisation and expansion tank system located in B356. The system is set to monitor system pressure and deliver a static pressure of 220kPa at the B356 plant room FFL- AHD 33m. There is 6 m³ of expansion capability in the tanks which are kept at a 26% nominal fill level. This system is monitored on the SBO BMS via a HLI. This system is the primary chilled water fill system.
- There is a Duraflex Servitec Vacuum De-aeration plant adjacent to the pressurisation system which currently is not connected to the BMS and operates on an internal time clock.
- There is a secondary chilled water makeup system in B352 which operates via a pressure reduction valve set to 210 kPa.
- The old expansion tank system is kept in place in the B350 Level 5 but isolated from the system as a final contingency.
- If a new building is being planned to run off any existing chilled water systems the designer shall review that system in its entirety to ensure that the existing pipe sizes are capable of delivering the design flow rates, existing pump heads and capacities are not affected. They must also ensure that existing chillers have the capacity, existing expansion tanks are suitable in volume and that the new control system interfaces with the existing control system for the plant, currently the University specifies SBO for all building control systems. Consideration for an additional differential pressure sensor (comprised of two independent sensors) to form part of the chiller plant control logic shall be assessed for each new building.

### 7.1.2 Site Reticulated Pipework
The existing underground Campus Chilled Water System operates generally in accordance with the following parameters;

The Lowest point on the CHW system is AHD 19m (SE corner of the system) and the highest point AHD 48m (B350 Library North L5). The system is pressurized at between 200kPa and 230kPa at AHD 33m (B356) this gives limits of static pressure as follows:

- High point B350 L5 50kPa to 80kPa
- Reference point B356 L1 200kPa to 230kPa
- Low point SE corner of system 340kPa to 370kPa
- Design supply water temperature 7°C.
- Design return water temperature 14°C

New secondary CHW piping circuits to new air conditioning systems within new or existing buildings shall generally comply with the following:

- Underground piping - welded polyethylene preferred, insulated.
- Above ground piping - copper with insulation, fitted with pipe covers where exposed to mechanical damage, uncovered elsewhere and painted where visible.
- Pipe sizing - maximum pressure drop 0.5kPa/m, maximum velocity 2.5m/s.
- Size new mains to a building with sufficient capacity to eventually serve all usable areas of the building, even if not required for the current project.
- Design the chilled water circuit for a maximum dynamic head of 200 kPa through the index leg at maximum flow conditions.
- Prefabricated pipe/insulation systems are also available and should be considered as part of the design analysis.
- Pipe circuit isolation capability should be considered and included for ease of maintenance and drain downs.

7.1.3 Typical Building Mechanical Services
Connected to the Central Plant Chilled water systems complete with localised gas fired heating water systems are preferred in areas which are in close proximity to existing or planned chilled water reticulation systems. It is accepted that chilled water systems may initially require a higher capital cost than the DX systems, however, on a life cycle cost analysis such systems are preferable. A DX system is generally only used if it is not possible to provide chilled water to the site and on approval from Murdoch. This is due to extensive use of DX driving up Murdoch peak demand and associated electrical charges and electrical infrastructure requirements. Additionally as a general principle Electric Duct Heaters are not to be specified.

7.2 Mandurah campus
The two buildings at Mandurah campus, B100 and B107, have differing mechanical services systems installed. B100 is fed from the TAFE Chilled Water network and B107 is DX throughout.

7.2.1 Existing Plant
B100 has 16 fan coil units supplied by TAFE reticulated Chilled Water. This building is dependent on the TAFE chillers, pumps and reticulation supplying chilled water. Other equipment includes supply air and exhaust air fans for the FCU’s, extractor fans in toilets, split units for the server room and lift motor room.
B107 has 18 DX type ducted fan coil units

7.2.2 Typical Building Mechanical Services
Central Plant Chilled water is provided by the TAFE, historically their record of maintaining CHW to B100 is patchy. There may be opportunity to provide CHW from Murdoch owned plant in the future.
7.3 Rockingham campus

7.3.1 Existing Plant
CHW is reticulated to all buildings from the plant room B106, where a currently oversized Trane D.O.L. start chiller is installed. There is a mix of AHU and FCU in the 5 buildings on this campus, buildings have HHW but most FCU’s have a single CHW coil.

7.3.2 Typical Building Mechanical Services
Connected to the Central Plant Chilled water systems complete with localised gas fired heating water systems are preferred in areas which are in close proximity to existing or planned chilled water reticulation systems. It is accepted that chilled water systems may initially require a higher capital cost than the DX systems; however, on a life cycle cost analysis such systems are preferable. A DX system is generally only used if it is not possible to provide chilled water to the site and on approval from Murdoch. Additionally, as a general principle Electric Duct Heaters are not to be specified.

8 Design criteria
The University’s standard design criteria for the Mechanical services are as follows:
Refer to Design conditions for PERTH INTL/BELMONT, Australia AIRAH

8.1 Ambient conditions

8.1.1 External Conditions – Summer
8.1.1.1 Teaching Areas 37.0°C DB / 24.0°C WB
8.1.1.2 Office & Research Areas 37.0°C DB / 24.0°C WB

8.1.2 External Conditions – Winter
8.1.2.1 Non Critical Applications 7.0°C DB
8.1.2.2 Critical Applications 4.0°C DB

8.1.3 Internal conditions- Cooling
8.1.3.1 Teaching Areas 22.5°C DB
8.1.3.2 Office & Research Areas 22.5°C DB

40 - 60% relative humidity anticipated by virtue of cooling coil performance

8.1.4 Internal conditions- Heating
8.1.4.1 Teaching Areas 22.5°C DB
8.1.4.2 Office & Research Areas 22.5°C DB
Control Tolerance
Plus or minus 1°C at the point of control for heating and cooling

Internal conditions for critical rooms e.g. Computer Suites, Server Rooms, Medical Procedure Rooms, Laboratory Test Rooms may require humidity control. Additionally, specialised research facilities will require consultation with University specialist stakeholders. Consultants are to advise Murdoch of proposed internal conditions suitable for the critical areas nominated in the project brief.

8.1.5 Internal conditions- Carbon Dioxide Levels
8.1.5.1 Teaching Areas 500-800 ppm
8.1.5.2 Office & Research Areas 500-800 ppm

8.1.6 Internal conditions- VOC Levels
8.1.6.1 Teaching Areas Currently under investigation
8.1.6.2 Office & Research Areas Currently under investigation

8.2 Lighting & equipment loads
Lighting loads shall be obtained from the Electrical Consultants based on their lighting layout. LED lighting in being rolled out throughout the University and a general rule lighting load can be calculated as follows:

<table>
<thead>
<tr>
<th>Area</th>
<th>Lighting Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching, Research and Computer Labs</td>
<td>8.5W/m²</td>
</tr>
<tr>
<td>Offices</td>
<td>8.5W/m²</td>
</tr>
<tr>
<td>Lecture Theatres</td>
<td>11W/m²</td>
</tr>
<tr>
<td>Corridors</td>
<td>8W/m²</td>
</tr>
</tbody>
</table>

Equipment loads can be approximately equal to those shown below subject to confirmation by the University Engineering team via the Project Manager.

<table>
<thead>
<tr>
<th>Area</th>
<th>Equipment Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Labs</td>
<td>100W/m²</td>
</tr>
<tr>
<td>General Office</td>
<td>15W/m²</td>
</tr>
<tr>
<td>Library Reading Rooms</td>
<td>10W/m²</td>
</tr>
<tr>
<td>Laboratory - Undergraduate (1st Year)</td>
<td>30W/m²</td>
</tr>
<tr>
<td>Laboratory - Postgraduate</td>
<td>30W/m²</td>
</tr>
<tr>
<td>Laboratory – with specialist equipment</td>
<td>TBC</td>
</tr>
<tr>
<td>Seminar Rooms</td>
<td>10W/m²</td>
</tr>
<tr>
<td>Lecture Theatres</td>
<td>10W/m²</td>
</tr>
<tr>
<td>Lecture Class Rooms</td>
<td>10W/m²</td>
</tr>
</tbody>
</table>

Where equipment loads have not been identified for a particular area, forward a request to the Universities Project Manager for the relevant information.

8.3 Occupant loading
The design consultant shall coordinate with Murdoch University and the project architect to resolve the acceptable design population loads for each space in the project subject to the minimum requirements below.
### General Office

<table>
<thead>
<tr>
<th>Room Type</th>
<th>Area (m²/person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Office</td>
<td>10.0</td>
</tr>
<tr>
<td>Library Reading Rooms</td>
<td>2.5</td>
</tr>
<tr>
<td>Laboratory - Undergraduate (1st Year)</td>
<td>3.7</td>
</tr>
<tr>
<td>Laboratory - Undergraduate (other years)</td>
<td>4.7</td>
</tr>
<tr>
<td>Laboratory - Postgraduate</td>
<td>12.0</td>
</tr>
<tr>
<td>Seminar Rooms</td>
<td>2.0</td>
</tr>
<tr>
<td>Lecture Theatres</td>
<td>1.0</td>
</tr>
<tr>
<td>Lecture Class Rooms</td>
<td>1.75</td>
</tr>
<tr>
<td>Computer labs</td>
<td>3.5</td>
</tr>
</tbody>
</table>

### Note:
Space Planning aspirations are that, overall, within 10-15 years UFA per EFTSL will be between 5.0 and 6.7 m² and that the proportion of open plan office space will increase.

How these translate into modifications to the above table with be determined and the table revised in future versions.

Where seating information is provided seat numbers can be used as a guide to population density subject to Murdoch Approval.

### 8.4 Minimum outside air requirements

The minimum outside air requirements for all rooms and enclosures shall be in accordance with the requirements of the current version of Australian Standard AS 1668.2 adopted by the Building Code of Australia. Note that although a design may satisfy Code requirements with respect OA per occupant the University is more concerned about maintaining high standards of indoor air quality this is usually achieved by dilution of CO₂ and VOC concentrations by supplying excess air.

### 8.5 Exhaust ventilation

The minimum exhaust air requirements for all rooms and enclosures shall be in accordance with the requirements of the current and adopted version of Australian Standard AS 1668.2.

Note that where a toilet exhaust system serves more than one compartment (WC), then duty/standby exhaust fans, complete with run/fault lights and automatic change over on fault, are required as stipulated by the Health Act.

### 8.6 Evaporative cooling

If there is a requirement for evaporative cooling (for rooms such as commercial kitchens and the like), then the minimum acceptable air change rate is for 25 to 30 air changes per hour. Adequate consideration shall be given for sufficient relief air paths for all evaporatively cooled areas.

### 8.7 Ventilation in Photographic Darkroom and or photocopy printroom areas

All fumes are to be extracted at source and systems are not to exhaust fumes by extracting past operator’s breathing zone.
Manufacturers (of photographic development or photocopy equipment) recommendations with respect to extraction of exhaust fumes are to be complied with.

8.8 Fire & Smoke Control
Shall be in accordance with AS 1668 Part 1 and as nominated by the Building Code of Australia. Certification and commissioning documentation, maintenance and testing procedures are all to be included in the operating and maintenance manuals.

8.9 Humidity Control
Humidity control will not be provided unless specifically called for or where special circumstances dictate. Where special conditions are required these will be nominated by the user and agreed by the Project Manager.

Areas where Humidity control may be required include:
- Computer/Server rooms
- Operating Theatres
- Special Purpose Laboratories
- Test rooms environmental
- Archival storage

8.10 Chilled Water Temperatures
For design purposes the following chilled water temperatures are to be used:

Supply Water Temperature 7.0°C
Return Water Temperature 14.0°C

Leaving chilled water temperature may vary around the design temperature dependant on staging and demand but the flow and return temperatures stated above are to be used in design.

Special attention must be paid when modifying or extending an existing chilled water system with respect to the impact on the existing plant capacity, distribution system and controls. The Consultant shall review the design parameters of all equipment on that system to ensure design chilled water temperatures and flow rates are normalized to meet the current design standard for the site and that the piping and valve configurations for the system are in accordance with the design intent of the system. Information on currently installed loads within buildings is variable on a building by building basis. Works are underway to upgrade logging of gross cooling and heating loads at the secondary building CHW pumps and on HHW systems. This empirical information should be used as either a reality check against theoretical calculations or the data used as the basis for determining existing system capacity for growth.

8.11 Heating Water Temperatures
For design purposes the following heating water temperatures are to be used:

Supply Water Temperature 70.0°C
Return Water Temperature 50.0°C
Leaving heating water temperature set point shall be re-scheduled from 70.0°C to 50.0°C based on outside air temperature. Special attention must be paid when modifying or extending an existing heating water system with respect to the impact on the existing plant capacity, distribution system and controls. The consultant shall review the design parameters of all equipment on that system to ensure design heating water temperatures and flow rates are normalized to meet the current design standard for the site and that the piping and valve configurations for the system are in accordance with the design intent of the system. The lower temperatures are to encourage the use of condensing boilers.

For retrofitting boiler upgrades in existing facilities consideration is to be given to whether coil capacity and performance would be sufficient with a flow reduced temperature. Again this to encourage the use of condensing boilers.

8.12 Condenser Water Temperatures
For design purposes the following condenser cooling water temperatures are to be used:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Water Temperature</td>
<td>26.0°C</td>
</tr>
<tr>
<td>Max Return Water Temperature</td>
<td>35.0°C</td>
</tr>
</tbody>
</table>

Leaving condenser water temperature set point from the cooling tower shall be re-scheduled from 26.0°C to 22.0°C based on a combination of ambient wet bulb air temperature and time of day. Studies on the MU Centrifugal Trane chiller systems over a number of years have demonstrated higher plant COSP when condenser water temperatures are maintained below a maximum of 14°C Delta T between evaporator entering temperature and condenser entering temperature. Experience of chiller plant operations has it that COSP begins to drop once condenser-entering temperature rises above 26°C. Consideration should be made to oversizing cooling towers.

8.13 Noise and Vibration Control
The system shall be designed to minimise the transmission of noise and vibration from air-conditioning and mechanical equipment (all in accordance with the relevant Australian Standard and noise levels listed below). Sound attenuators and/or internally lined duct work shall be installed where necessary to minimise the transmission of fan noise.

Care should be taken to minimise transmission of vibration to the structure from mechanical equipment. Where reciprocating or rotating equipment is installed these shall be isolated from the structure by vibration isolators. Reciprocating or rotating equipment shall be mounted on inertia bases weighing not less than 1.5 times the weight of the equipment. The allowable noise levels are scheduled below:

<table>
<thead>
<tr>
<th>Area</th>
<th>Satisfactory</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Offices</td>
<td>40 dB(a)</td>
<td>45 dB(a)</td>
</tr>
<tr>
<td>Laboratories</td>
<td>35 dB(a)</td>
<td>40 dB(a)</td>
</tr>
<tr>
<td>Teaching Working</td>
<td>40 dB(a)</td>
<td>45 dB(a)</td>
</tr>
<tr>
<td>Lecture Theatres</td>
<td>30 dB(a)</td>
<td>35 dB(a)</td>
</tr>
<tr>
<td>Seminar Rooms/Class Rooms</td>
<td>30 dB(a)</td>
<td>35 dB(a)</td>
</tr>
<tr>
<td>Individual Offices</td>
<td>35 dB(a)</td>
<td>40 dB(a)</td>
</tr>
<tr>
<td>Library</td>
<td>40 dB(a)</td>
<td>45 dB(a)</td>
</tr>
</tbody>
</table>

Where information on room noise levels is not provided above conform to AS 2107.
9 Mechanical services equipment

9.1 Chillers

9.1.1 General
Acceptable plant types for generating process chilled water include centrifugal, scroll or screw. The consultant shall perform comparison analysis on different machine types and present a case to the University detailing the recommended chiller type together with all supporting reasons and documentation. As indicated in the section describing existing plant, management of the current seasonal, semester and day/night loading on the chilled water system is via a staging algorithm based upon chiller and associated plant COSP. The range of chilled process water production currently ranges from 270kW to 5.9MW, night time out of semester winter to daytime in summer semester.

Chilled water machines shall be Trane.

Chillers shall be selected to deliver the required cooling capacity at an ambient dry bulb temperature of 40°C.

Where necessary water boxes shall be internally treated with an approved bituminous epoxy resin to protect against corrosion with sacrificial anodes also provided.

Where chillers are installed into plant rooms, all lifting beams required for servicing, maintenance and replacement of parts shall be certified.

All chiller/pressure vessels shall be Worksafe certified and provided with pressure relief rupture discs, or equivalent, vented to the outside.

9.1.2 Performance Tests
The University will expect that a full performance test be carried out on site to prove the capacity of the plant. Chiller performance tests shall occur on a day where there is sufficient load on the system.

All chillers shall be factory tested and test certifications shall be included in project Operation and Maintenance Manuals.

9.1.3 Chiller Plant Controls
Centrifugal chiller plant control shall be provided by the manufacturer’s standalone microprocessor based chiller control panel which shall monitor and control the chiller(s) and associated plant.

Air Cooled Chiller plant control shall be provided by the manufacturer’s integrated microprocessor based chiller control panel which shall monitor and control the chiller. Chilled water field pump/s associated with the chiller shall be controlled by SBO. Field circulation pump/s for duty air cooled chillers shall continue to run even if the internal chiller controls have commanded the chiller to stop producing chilled water. This is to avoid the chiller faulting on low refrigerant pressure.

The chiller plant control system shall perform the following control functions/strategies as a minimum:
- Chiller plant system scheduling.
- Internal Chiller sequencing – where multiple compressors are part of the same machine.
- Cooling tower fan speed & temperature optimisation.
- Colour graphic based chiller plant status screens.
- Colour graphic based chiller status screens.
- System and chiller diagnostic messages.
- System and chiller reports.
- Critical valve or pressure reset strategy.
- High level interface to SBO
- Hard wired enable to SBO

9.2 Cooling towers

Cooling towers shall be of the rectangular or circular, induced draft, counter flow, wetted surface type of “BAC” or approved equivalent manufacture. Cooling towers shall comply with the requirements of AS/NZS 3666 and relevant local Statutory Authority requirements.

All cooling towers shall be constructed of UV stabilised fibreglass or PVC and shall be complete with fan, water distribution system, remoVAVle corrugated honeycomb fill, tower basin, sump, drift eliminators, valves and fittings. All metal fixings and components are to be minimum 316 grade stainless steel.

The floor of the water basin shall be sloped to an integral sump, fitted with a remoVAVle screened suction outlet connection.

The basin shall also incorporate an overflow, valved drain and float controlled make-up connection. For each cooling tower, provide a hot dip galvanised access structure for each cooling tower to provide access for maintenance and cleaning – the structure is to be designed such that there is access to safely remove and maintain or replace all components on the tower.

9.2.1 Performance Tests

The University will expect that a full performance test be carried out on site to prove the capacity of the cooling towers. Cooling tower performance tests shall occur on a day where there is maximum load on the system to ensure that the filling system is sufficient for maximum duty.

9.2.2 Balance Lines

Where multiple cooling towers are being installed or a new cooling tower is interfacing with existing through a common supply and return condenser water piping network, adequate consideration should be given to balance lines between cooling tower basins to maintain even basin water levels throughout operation.

9.2.3 Tower Water Levels

Where multiple cooling towers are being installed or a new cooling tower is interfacing with existing through a common supply and return condenser water piping network, the siting of the tower feet or basin water levels shall ensure that all towers have less than 10mm height deviation. Tower
support footing heights shall be verified by survey prior to installation of the tower. Any remedial works to footings shall be undertaken prior to the installation of the tower.

When commissioning towers, the makeup water float levels shall be set to prevent overflow to waste occurring.

9.3 Water Treatment

The filtration and treatment system shall be an integrated water management system using the current MU contracted engineering water treatment company, incorporating a multi media filter designed specifically for the type of solids that accumulate in cooling towers.

The package will be a combined tower basin cleaning system and complete water chemistry control system which is capable of remote monitoring and control. The back wash water used for the filter is to be reclaimed water.

- The supplier of the water treatment equipment is also to provide the chemical treatment and services for the 12 months defects/liability period.
- The system is to be capable of maintaining the tower basin free of sediment, using flush fitting dispersion nozzles that rotate incrementally and are capable of maintaining a sediment free tower basin. Staging and zoning are to be controlled by a sequencing valve. Initial solids separation is to be via a MultiCyclone centrifugal separator manufactured by Water Co Europe Ltd. The filtering stage is to be a deep bed multimedia system, sole use of a Centrifugal Separator is not acceptable. All plumbing is to be external to the basin with a maximum pump size of 3kw. Circulation pump to be either stainless steel or cast iron housing with stainless steel shaft. The package construction is to consist of a hot dip galvanised steel frame and base suitable for crane lifting and be suitably weather proofed for outside installation.
- The water chemistry control equipment is to be integrated with the automatic cooling tower cleaning system package and is to consist of an integrated tower controller for TDS control, inhibitor & biocide dosing. All pipe work is to be run in ridged PVC. The system must connect to the SBO BMS via a HLI, example alarms would be common fault, filter pressure and pump fault.
- The system is to come with its own switchboard and control system complete with motor starter/overload and breakers housed in and IP55 rated enclosure.

Provide commissioning and training of operational staff.

Provide monthly water analysis and adjustment of dosing and filtration equipment. The monitoring of the treatment program is to consist of the following

- Monthly service visits.
- Monthly tests for legionella.
- Monthly dipslide tests for total bacterial counts
- Monthly cooling tower inspections to verify cleanliness.
- Provide chemicals for 12 months operation including chemicals pre-commission cleaning.
- Provide a site maintenance manual for the above systems integrated into the Building Maintenance Manual.
- Provide a risk based management plan.
9.4 Heating water boilers

Boilers for installation in existing building shall be capable of delivering HHW at existing coil temperatures unless analysis indicates that there will be no detrimental performance of existing HHW coils. Current standard equipment for these type of boiler upgrades are from the Rinnai 200 series. Balanced flue/room sealed Rinnai 200i units are standard for installation internally providing acceptable flue lengths.

Boilers for installation in new buildings shall be condensing modular types. Modular units manufactured by Meridian shall be specified.

Consideration shall also be made with respect to a condensate drain neutraliser arrangement.

Rather than use of storage tanks the use of a hydraulic separator is standardised. Hydraulic separators shall have sufficient flanges connections to allow at least 3 separate circuits to be connected. This is to allow future provision for an additional boiler loop or expansion with a second field loop.

It is acknowledged that, in time, the University will move away from natural gas as a heating source, as a result emerging technologies such as electric powered heat pumps will be considered as an alternative to gas powered boilers. Electric powered heat pumps will be the preferred alternative in buildings that are powered directly by renewable energy from within the Universities embedded network.

Due to construction of a boiler involving Aluminium Silicate needing exceptional water treatment the boiler must be decoupled from the secondary circuit of the system via a heat exchanger. This precludes the use of these type of boilers at the University.

The boiler shall be suitable for use with natural gas. Gas supply pressure at the main shall be determined for the campus and suitable gas pressure regulating devices used if necessary to deliver the required gas pressure to suit the boiler.

Any boiler vessels shall be Worksafe certified.

9.5 Chilled, heating and condenser water circulation pumps

Pumps shall be of the centrifugal, end-suction type. Pumps shall be of Grundfos or KSB / Ajax manufacture.

All pumps shall be complete with drip trays which shall be drained to an adjacent floor waste.

All pumps shall be VSD driven. Grundfos composite pumps from the Magna 3 series, TPE series with Modbus HLI card are to be specified where the system requirements can be matched to a pump. Larger head and flow pumps are to be selected from the Grunfoss N series in preference to KSB. Where revenue recovery from HHW is not required the energy metering function of composite pumps is to be used.

Where VSD’s are used they are to be original Danfoss brand only, other brands, including those that may from time to time be acquired by Danfoss are unacceptable. All VSD’s must be connected via their internal HLI interface to SBO.
All pumps shall be complete with pressure gauges and binder points on both the suction and discharge sides. Pump control for secondary field pumps is to be via an appropriately sized pressure transducer/transmitter/s at index points on the flow side of secondary pipework.

9.6 Chilled/Heating water air handling units
Air handling units shall be Fan Coil Sales (Industries), Temperzone, Trane, or approved equivalent manufacture.

System design is to include Economy Air Cycle provision. Where possible natural ventilation principles are to be used in the holistic building design.

Air handling units shall be complete with hinged doors with inspection windows.

Provide artificial lighting – LED preferred - to each accessible chamber of Air Handling units and ensure that they are individually switched and provide sufficient illumination to undertake necessary service work.

Housings shall be of cold-bridge free, double skin construction incorporating 50mm thick insulation sandwiched between powder coated sheet metal outer skins. Alternative high performance construction materials will be reviewed and approved on merit.

All units shall be complete with coil drip trays and drain lines run to floor wastes within plant rooms. The condensate trap must be easily disconnected for cleaning.

The face velocity of air passing over the air handling unit coils shall not exceed 2.5 m/s.

When units incorporate both cooling and heating coils, each coil shall be mounted independently to allow individual removal.

All air handling units shall be of the variable air volume type unless otherwise advised. All variable air volume air handling units shall be either EC or VSD driven.

Filters must be readily accessible for maintenance. Pressure feedback to the control system to indicate filter condition and subsequent “dirty filter” SBO alarm notification shall be incorporated.

Supply air building terminations are to be fully covered with 2mm Blue Mountain Mesh to protect against ember attack and vermin entry. Overriding this requirement will be specific requirements for Physical Containment and Biological Containment facilities where 250 micron or other size mesh will be required. Notwithstanding this the protection shall be inherently fire proof. Consideration to free area and resistance shall be taken into account when sizing such terminations.

9.7 Chilled/heating water fan coil units
Fan Coil Units shall be Fan Coil Sales (Industries), Temperzone, Trane, or approved equivalent manufacture of an EC motor type. Permanent Split capacitor (PSC) motors are unacceptable.

System design is to include Economy Air Cycle provision. Where possible natural ventilation principles are to be used in the holistic building design.
In accordance with the BCA equipment must be designed with an Economy Air Cycle (EAC) if the system capacity is greater than 35kW for our climate zone 5. The BCA guide J5.2(a)(i)(C) includes the following:
In this clause, the air-conditioning system capacity means the capacity of each air-conditioner serving a space, not the combination of all the units serving a space because an outdoor air economy cycle is cost effective only in a larger unit.

The University has identified that designers have taken the opportunity to design multiple fan coil or cassette units to serve spaces where the total capacity is greater than 35kW although opportunity existed to design a system incorporating EAC. This interpretation is unacceptable to the University in its position as owner/occupier as the operational cost throughout the lifecycle of such units far outweighs the initial investment cost. Should a system be specified without an EAC such proposals must be accompanied by a Life Cycle Costing Analysis indicating the relative lifetime costs of systems with and systems without EAC.

Sufficient fresh air delivery has been problematic using FCU’s with a small outside air duct – additionally this generally precludes the use of an Economy Air cycle. If designing with FCU’s provision of sufficient fresh air within the design for maximum likely occupancy is to be demonstrated. The installation of heat recovery units in addition to FCU’s shall be considered. Heat recovery units shall be Mitsubishi Lossnay unless otherwise approved by MU Engineering.

Fan Coil Motor control is to be via 0-10Vdc to an EC motor from SBO.

All units shall be complete with coil drip trays and drain lines run to tun dishes and thereon to waste. Ensuring adequate fall of the condensate line to waste shall be part of the Mechanical Consultants brief. The condensate trap at the unit must be easily disconnected for cleaning. Alternatively if a natural fall cannot be achieved a condensate pump may be used.

Filters must be readily accessible for maintenance. Pressure feedback to the control system to indicate filter condition and subsequent “dirty filter” SBO alarm notification shall be incorporated.

Supply air building terminations are to be fully covered with 2mm Blue Mountain Mesh to protect against ember attack and vermin entry. Overriding this requirement will be specific requirements for Physical Containment and Biological Containment facilities where 250 micron or other size mesh will be required. Notwithstanding this the protection shall be inherently fire proof. Consideration to free area and resistance shall be taken into account when sizing such terminations.

9.8 Chilled water/heating water control valves
Valves shall be of the type to suit the application, but generally be as scheduled below:

<table>
<thead>
<tr>
<th>Isolation</th>
<th>Ball valves to 40 mm diameter Resilient Seat Gate valves from 50 mm diameter - Karon (Challenger Valves &amp; Actuators). Chilled Water Ring isolation RSG valves to be fitted with Limitork (Acrodyne) Actuators and controlled by the BMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Throttling Plus Isolation</td>
<td>Double regulating valves from 15 mm to 65 mm diameter (for bypass legs across coils at index runs only) Wafer type butterfly valves from 50 mm to 300 mm diameter</td>
</tr>
<tr>
<td>Modulating Control Valves</td>
<td>Belimo Energy Valves or PICCV (on approval)</td>
</tr>
<tr>
<td>Non Return Valves</td>
<td>Swing Check Valves (note spring loaded butterfly valves are not to be used)</td>
</tr>
<tr>
<td>Gauge Cocks</td>
<td>Ball Valves</td>
</tr>
</tbody>
</table>

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Belimo Energy Valves shall be used for all water balancing and control of cooling and heating coils and the like, in lieu of the traditional double regulating valves. An alternative to be approved by MU Engineering are PICCV. All valves shall be labelled and clearly identify their flow control setting.

Ensure valves and fittings are adequately spaced and distanced from bends and the like, in accordance with manufacturer’s recommendations. This is particularly relevant for the installation of Belimo Energy Valves, throttling valves and pressure / temperature test points. Ensure that pressure / temperature test points are located across individual coils and individual control valves without bends or other fittings in between equipment.

9.9 Variable air volume (VAV) boxes
VAV boxes shall be Johnson, Trane or approved equivalent. Depending on the design, variable volume boxes utilising a single primary air system is preferred. Subject to justification to and approval by Murdoch, the use of series or parallel type fan assisted VAV boxes may be considered. Where fan assisted VAV boxes are utilised, they shall incorporate a fan air flow or pressure switch which shall be suitable for low air pressure at minimum airflow. Fan motors shall be of an EC type, Permanent Split capacitor (PSC) motors are unacceptable. Reheat shall be by heating hot water coils wherever practicable. The airflow / pressure switch shall be interlocked with any electric duct heaters in accordance with AS1668.1.

The size of each VAV box shall be selected to suit the design minimum / maximum airflows and control ranges of the box, in accordance with manufacturers recommendations.

9.10 Direct expansion packaged plant
Large packaged direct expansion plant shall be of Mitsubishi Electric/Heavy Industries, Temperzone or approved equivalent manufacture. This includes packaged or split ducted plant generally over 15kW(R).

Smaller split direct expansion plant shall be of Mitsubishi, Daikin or approved equivalent manufacture. This includes systems having fan coil units of wall mounted, cassette, ducted, bulkhead or floor mounted console type, generally up to 15kW(R).

Direct Expansion Package Plant shall utilize chlorine free, zero ODP refrigerants such as R410A or approval equivalent.

Direct Expansion Package Plant shall be controlled via the Building Management System.

9.11 Variable speed drives
Variable Speed Drives (VSD) shall be of original Danfoss manufacture from the VLT range. No alternative equipment such as other brand VSD’s that may now be owned by Danfoss are acceptable.

Installation of VSD’s shall be in accordance with current standards as provided by Standards Australia and relevant legislation.
VSD shall have a mains supply isolation contactor installed before the VSD. The contactor shall, be sized sufficiently to allow the controlled motor to operate Direct On-line (DOL) should the VSD be removed for service. The intent is to allow conversion to DOL operation as a contingency in instances where failure of a VSD occurs and it is necessary to keep the facility in service.

Control wiring shall be such that the VSD can be enabled/disabled via a “Manual/Off/Auto” switch located on the Mechanical Services switchboard.

All VSD’s are to have a in built HLI picked up by SBO.

9.12 Ventilation fans
All fans for toilet areas, kitchens, labs, etc shall be of Fantech or approved equivalent manufacture. Adequate access shall be provided for all required servicing and maintenance. Fan locations shall be adequately coordinated with all other building services to ensure that access is not compromised.

Fans shall be direct driven wherever possible.

All duty/standby fan arrangements shall be of the dual fan type in preference to dual motor.

Where a single phase fan is available to meet the required duty point, this is preferred over a three phase equivalent. All single phase fans should be complete with speed controllers.

All fan assemblies shall be equipped with adequate sound attenuation to achieve both breakout and in-duct noise levels to comply with Acoustic requirements.

Supply air building terminations are to be fully covered with 2mm Blue Mountain Mesh to protect against ember attack and vermin entry. Overriding this requirement will be specific requirements for Physical Containment and Biological Containment facilities where 250 micron or other size mesh will be required. Notwithstanding this the protection shall be inherently fire proof. Consideration to free area and resistance shall be taken into account when sizing such terminations.

9.13 Computer Room Air Conditioning Units
Where required, environmental control units shall be of Liebert manufacture.

All units shall generally be of the downflow discharge, chilled water type, suitable for mounting on a raised floor.

9.14 Filtration
Shall conform to the minimum filter efficiencies as outlined in AS 1668 Part 2 and as a minimum, achieve 20% efficiency using Dust Test No 1 as per AS1132.5. The following is a guide to the type of filters to be specified:

<table>
<thead>
<tr>
<th>Air handling plant above 3,000 L/s</th>
<th>Four Peak or deep bed type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air handling plant under 3,000 L/s</td>
<td>V-Form extended media type</td>
</tr>
<tr>
<td>Grease filters</td>
<td>Email type GW - Aluminium</td>
</tr>
</tbody>
</table>

Dry media filters shall be of the disposable type.
Outside air intakes for large air handling systems shall be provided with both ember/vermin protection in the form of 2mm Blue Mountain Mesh located behind the grille and pre-filters located behind the mesh. Pre-filters shall be of panel type filter with G2 type media.

Magnahelic gauges shall be provided to sense filter bank pressure drop. Engraved labels secured adjacent to magnahelic gauges shall state the pressure at which filters shall be cleaned/replaced. Magnahelic pressure transmitters with an electronic output 4-20mA shall be connected to the BMS to provide filter monitoring and filter dirty alarms.

9.15 Variable refrigerant flow systems
Variable refrigerant flow systems shall be of Mitsubishi, Daikin or approved equivalent manufacture.

The design of such systems should adequately address the requirements of Australian Standard AS 1677.1.

All variable refrigerant flow systems shall be designed such that they can adequately interface with the site Building Management System to give advice on system status, enable/disable and fault indication as a minimum.

All fan coil units connected to variable refrigerant flow systems shall be complete with refrigerant isolation valves for ease of maintenance or replacement.

All variable refrigerant flow systems should be designed to cater for 20% additional future capacity should manufacturer allow capped isolation valves for future expansion. This should be discussed with Murdoch University on a project by project basis.

9.16 Electric duct heating elements
Heater banks may be only be electric where other alternatives are cost prohibitive. Utilise pulse width modulation for the staging of the heater banks

Where required for Variable Air Volume (VAV) systems, electric heating elements shall be integral with individual VAV boxes.

The electric heating elements shall be mounted in a removable section for insertion or removal through the side or bottom of the casing.

The location of all electric heating elements shall ensure that access for servicing or removal of the heating elements is not compromised.

9.17 Fume Cupboards
Fume cupboard specifications, manufacturer and model are to be agreed upon with key stakeholders at the concept stage. In all cases variable flow systems are to be specified which necessitate an interlocked variable volume air conditioning system. For laboratory designs calling for multiple fume cupboards consideration is to be given to a system whereby exhaust is drawn into an extract plenum that is maintained at a constant suction pressure by a constant speed extract fan and bypass damper, individual fume cupboards ensure compliant face velocities via variable positon
Sashes and variable flow exhaust fans, overall slightly negative pressure is maintained in the lab by supply air delivered from a VAV system.

Exhaust air building terminations for Physical Containment and Biological Containment facilities shall be protected by 250 micron or other size mesh as specified. Notwithstanding this, the protection shall be inherently fire proof and readily accessible for maintenance. Consideration to free area and resistance shall be taken into account when sizing such terminations and fan power.

9.18 Chilled and heating water pipework
Chilled water and heating water lines within buildings shall be of Type B Copper. Consideration should be made with regards stainless steel for condenser water pipes for major central plant. Underground Chilled water pipework shall be suitably protected and insulated copper type B and/or insulated Welded Polyethylene laid direct in the ground. Galvanised pipe or other material shall not be used unless approved by Murdoch.

Chilled water and heating water underground mains are to be located under paving unless funds allow their location in culvert ducts or covered way ceilings.

All headers are to be provided with at least one spare flanged and valved connection for future use. Typically, headers should be sized for the future capacity of the plant or at least one size larger than the main distribution pipe leaving the plantroom.

Ensure layout of pipework in plantrooms does not interfere with direct route of removal of equipment within plantrooms.

Where pipes pass through floors or walls, sleeves shall be specified and filled with appropriate sealant to suit application. Provide suction plates where exposed to view.

All risers shall be provided with dirt legs and drains at the bottom. Each level of pipework shall be isolated and provided with drains at the low point of each branch and at the riser.

All bolts, studs to valves, water boxes and equipment especially exposed to wet conditions are to have threads coated in nickel anti seize.

Where existing chilled / heating water system is to be extended, the consultant shall check and verify the capacity of the existing piping mains and plant to ensure that they are capable of meeting current and future demands.

9.19 Insulation to Pipework
Insulation for valves, flanges and fittings shall be arranged for easy removal for maintenance purposes and shall be provided with hinged and clipped casings. All exposed pipework which is insulated shall be metal sheathed in plant rooms, ducts and where exposed and sisalation wrapped where concealed. Metal straps shall be provided to both metal sheathing and sisalation. Sisalation shall be continuous over all wooden insulation blocks at hangers.

Alternatively, flexible foam insulation may be utilised.

Insulation shall:
- Be sized in accordance with NCC Specification J5.2(c) Table 2a Water Piping Minimum R-Value.
- Have closed cell construction inherently vapour sealed type “Armaflex” (HHW), “Bradflex”, “Aeroflex”, “Insulex” manufacture and be slip-on style (not slit).
- Have butt joints fully glued to each face and the pipe. Adhesive shall be as recommended by insulation manufacturer. Taped joints not allowed.
- Be applied in lengths 10% greater than pipe length to allow for shrinkage.
- Have cork ferrules at supports, glued as for insulation.
- Metal sheath to exposed pipework.

### 9.20 Underground Services

All underground services including pipe work, conduits etc. shall be laid in sand and shall be identified by laying continuous PVC marker tape not less than 300mm above the pipe. The marker tape shall be colour coded, magnetic and be printed with the identification of the contents of the pipe and/or conduits. At ends of straight lengths of pipes, provide permanent concrete or cast iron markers located at ground level.

All pits laid in paving are to be trafficable to Class B minimum. All pits laid in roads or areas susceptible to high axle weights to be Class D.

All bolts, studs to valves, water boxes and equipment especially exposed to wet conditions are to have threads coated in nickel anti seize.

### 9.21 Chilled/heating water pits

All chilled water pits shall be of masonry or concrete construction. Pits shall be of adequate cross sectional area and depth to enable uninterrupted access to all required chilled water valves. Adequate access into the pits by way of gatic lids and vertical ladders shall be provided.

Gatic lids shall be rated for the appropriate loading (minimum Class B). Class D in trafficable areas.

Pits shall be provided for:

- Entry to Building (change of piping material).
- Inground valves or branches.

All pit lids shall be adequately labelled in accordance with the University’s labelling convention for ease of identification on site.

All pits and underground chilled water pipes shall be accurately surveyed and located on site during the progress of the works and prior to backfilling to enable accurate “As Constructed” documentation to be produced for future reference by the University.

### 9.22 Ductwork insulation requirements

Insulation systems are required for:

- Acoustic Control
- Thermal Control
- Condensation Control

Insulation thicknesses are to comply to BCA requirements.
Insulation where exposed to supply or return air systems serving occupied spaces shall be encapsulated fibre glass from the Bradford HVAC range or approved equivalent.

BCA requirements do not consider acoustic or condensation control. Designers must consider these requirements independent of BCA thermal insulation requirements.

9.23 Distribution ductwork
In general, low velocity systems are preferred. Ductwork shall be designed to limit duct air velocities to a maximum of 6.5 m/s for constant volume air conditioning systems and exhaust ventilation systems. However main riser ducts shall be capable of handling an increase of 15% in air quantity. Fans and motors should be selected with this in mind.

Where variable Air Volume systems are deemed appropriate to provide zoning flexibility, then ductwork shall be designed to limit air velocities to 10.5 m/s in riser ducts and a maximum of 8.5 m/s at VAV box inlets. Static regain should be utilised wherever possible in sizing the ductwork.

Main distribution ductwork shall be galvanised sheet metal ductwork, thermally and acoustically insulated in accordance with AS1451.2 and Specification J5.2 of the NCCS 2012 - BCA Class 2 - Class 9 Buildings

Rigid fibre glass ductwork shall not be used.

Where fibre glass insulation is used, it shall be encapsulated fibre glass type insulation.

Flexible ductwork is to be kept to a minimum and in accordance with BCA specification J5.2b

The minimum ductwork insulation value should be calculated from Specification J5.2 of the current BCA for Class 2 - Class 9 Buildings

Heater bank linings shall be in accordance with AS 1668

9.24 Air diffusion
Ceiling diffusers shall be of the swirl diffuser type for typical applications and shall be of Trox, SW Harts, Dragon or other approved manufacture. Additionally, where motorized diffusers are installed, access to the diffuser motor for servicing is to be provided to the acceptance of Murdoch. Ceiling diffusers shall be retained in position by a threaded screw/bolt arrangement. Where it is proposed to use an alternative arrangement, approval from Murdoch is required. All diffusers shall incorporate insulated cushion head with short lengths of flexible ductwork to spigot takeoff from the main distribution duct, to allow easy relocation of diffusers as required. All raw edges of the insulation shall be sealed.

Wall registers shall be of the adjustable blade type. Front set of blades are to be horizontal. Maximum blade spacing shall be 20mm.

Toilet exhaust grilles shall be eggcrate type.

Return air/relief air grilles to be half chevron or full chevron type.

Or as specified by the architect and agreed by the University.
Door grilles as specified by the architect
Weatherproof louvres as specified by the architect

9.25 Electrical
Switchboards and Motor Control Centres shall normally be of type tested construction.

Permanent, clearly legible traffolyte labels shall be fixed to all internal and external controls. All Electrical equipment is to be labelled in accordance with MU Electrical Labelling nomenclature included in the Electrical Design Guidelines.

Fire Alarm relays shall be provided in accordance with the requirements of AS 1668 and AS 1670 as applicable.

A minimum of 25% spare capacity shall be provided in all Switchboards, Sub-boards and Control Panels to allow for future extension. High and low voltage cable and controls (DDC) shall be separated within cubicles in accordance with AS 3000.

A minimum of three (3) fuses of each size and type shall be specified as spares and shall be secured in holding clips on the inside of Switchboard Cubicle Doors.

Hours run meters shall be provided on all items of equipment which are duplicated or run in parallel, and where else considered necessary, unless controlled by a direct digital control system, in which case the control system shall record operating hours.

Provision shall be made to override local start-up controls by means of BMS control where specified.

kWhr meters shall be Smart Type Energy Meters complete with digital display and high level interface.

All cables shall be run on a cable tray and terminated strips. Cables shall be identified by numbered ferrules at each termination.

Heater banks shall be controlled by BMS, irrespective of air conditioning controls, for energy load shedding.

Electrical drawings shall be prepared with Circuit Reference Numbers to indicate the number of contact and their location.

9.26 Energy Management
At preliminary design stage, and as part of the life cycle costing of the selected plant, the consultant shall advise Murdoch of the estimated energy consumption profiles over a 12 month period and the energy modelling scenarios. The consultant is to identify, nominate and / or investigate all scenarios for limiting energy consumption and greenhouse gas emissions.

The consultant shall be responsible for monitoring the operation and control of the air conditioning plant for a period of 12 months after practical completion. This work shall form part of the consultants brief for the design and documentation of the project. This shall include regular site visits or remote dial in to the site to observe operation and performance of plant, make modifications to the control logic of the plant and equipment to improve efficiency and reduce operating costs. The consultant shall instruct the contractor to make all necessary changes at no cost.
to Murdoch, as required to achieve efficient operation of the plant. The consultant shall submit
energy consumption profiles and sign off on the operation and control of the plant and equipment
every 3 months, to the approval of Murdoch.

The consultant shall also specify energy monitoring equipment to be provided for all forms of energy
consumed for the building. This shall include, but not be limited to:

- Ambient temperature
- Chilled water consumption (entering water temperature, leaving water temperature,
  chilled water flow rate)
- Heating water consumption (entering water temperature, leaving water temperature
  heating water flow rate)
- Gas consumption
- Electricity consumption
- Domestic hot water consumption
- Energy consumption/production from miscellaneous sources such as bore water,
  geothermal, solar hot water, wind, photovoltaic, etc.
- Water meters
- Trade Waste metering

The consultant shall specify all necessary metering equipment necessary to develop an energy and
water consumption profile for each building. Where the control logic or equipment parameters have
been altered, the consultant shall ensure that the Operating and Maintenance Manuals are
upgraded accordingly.

9.27 Equipment labelling nomenclature
All items of equipment shall be identified with engraved trafficyte labels, in accordance with the
University’s Equipment labelling System. Thermometer bulbs, pressure gauge tapings and remote
sensing points shall be labelled to indicate their function.

All pipes shall be identified in accordance with AS 1345-1972 for the Identification of Piping,
Conduits and Ducts and AS 1318, Industrial Accident prevention Signs. “Safetyman” adhesive labels
are an acceptable method for identification of pipework ductwork, conduits and equipment in plant
rooms and risers and wherever else exposed to view shall be fully painted in accordance with the
University’s “Colour Schedule for Plant and Equipment”. Colours standards shall be in accordance
with AS 2700.

9.28 Operating and maintenance manuals
The Consultant shall ensure that one complete set of operating and maintenance Manuals are
checked, complete and approved by the consultant before being forwarded on to Murdoch for
acceptance. Upon approval and subject to changes identified by the consultant and Murdoch. The
consultant shall ensure that complete sets of operating and maintenance manuals are forwarded to
Murdoch in electronic format, cloud or similar link and a copy via a USB.

The Operating & Maintenance manuals for mechanical services shall:

- Identify the Campus, building name and number. The layout of the titles and headings
  for the manuals shall be obtained from Murdoch.
- Identify the Builder, Architect, Consultant & mechanical contractor.
- Identify the date of Practical Completion.
- Incorporate a description of the works undertaken, description of operation, equipment schedules, functional description of the control system including flow diagrams and point schedules, manufacturers data, commissioning data, maintenance procedures, fire testing procedures and as constructed drawings.
- The control system documents may be provided in a separate volume to match the project manuals.
- Include an Asset Management List in a Murdoch University compliant format
- Incorporate one electronic copy of “as constructed drawings per set of Operating & Maintenance Manuals. The As-Cons are to be delivered in the format described in the MU CAD Standards.

9.29 Asset Management
The University maintains Campus Assets listings for all campuses. Any works involved in upgrading assets will inevitable mean removal of current assets and replacement with new. The contractor will be responsible for maintaining a demolition list and identifying the assets that are being removed by their asset number/s (this can be either a six digit barcode beginning with 2 or 6 or both). This list is to be provided to the University on completion of the demolition phase. On practical completion the contractor is to supply the University with a list of installed maintainable equipment inclusive of equipment description, location, quantity and serial number.

9.30 University Location Information
The University maintains a rigorous location code for each built space on all Campuses:

Campuses are identified by a Site Number 1 through to 5,

1 Murdoch
2 Rockingham
3 Mandurah
4 Fremantle
5 Whitby Falls Farm

A room barcode is on the door frame and is always of the form:

v.xxx.y.zzz(a)

where:

v = Site Number
xxx = Building Number
y = Floor – there are no ground floors at the University the lowest floor is always 1
zzz = Room (Which can be pure numbers e.g. 001 or alphanumeric e.g. E01)
(a) = occasionally a letter of the alphabet is used for rooms which have been subdivided i.e. a room originally numbered 001 becomes 001A and 001B

9.31 Energy efficiency requirements
Energy Efficiency requirements of the Building Code of Australia specifically section J3, 4 and 5 as applicable shall be complied with.
9.32 Design process and certification

During the course of the design the following reports shall be provided by the Consultant for review by Murdoch (allow minimum of 21 working days).

Schematic Design Report

Comprising:
- Proposed HVAC, System Type/s
- Proposed Plantroom locations
- Proposed connection points for underground mains and design flow rates required.
- Implications of load on central plant
- Identification of possible central plant or distribution pipe upgrades

Design Development Report

Comprising:
- Indicative Plant Layout
- Access and Maintenance provisions
- Indicative Equipment Types/Selections
- System Life Cycle Costings

Tender Report

Comprising:
- Tender Drawings
- Tender Specification
- Final design flow rates for central plant
- Design Certification to comply with Murdoch standards and BCA requirements.

Practical Completion Report

Comprising:
- Commission data witnessing
- Report formats for:
  - Energy
  - Trend Logging
- Maintenance Manual reviewed and approved

End of Defects Warranty Report

Comprising:
- Maintenance sheets witnessed
- Defects programme report
- Energy Reports included
- Defects completed witnessed
- Control Strategy amendments noted

9.33 Water treatment

Murdoch University’s has a preferred supplier of water treatment of chilled, heating and condenser water systems is determined by the Universities procurement policy and processes and may change from time to time. For details of the current incumbent, contact the FM Helpdesk.
10  Building management system, controls and electrical
This section is included for completeness for the Mechanical Services Consultant. Reference should be made to the current Schneider Electric/MU Building Management System Design suite of documents. Where current strategies in the two design guidelines conflict SE/MU BMS Design document suite takes precedence over that included here. This is due to the fact that adoption of control techniques and emerging technologies will be first updated in the BMS docs and then reflected at a later date in this guide.

10.1  Building Management system
The University’s buildings are controlled and monitored through Schneider Electric SBO, all remote Automation Servers and associated I/O modules communicate via the University wide LAN back to a central server. The Contract shall allow for the supply and installation of an SBO system in the building and connected back to the SBO Enterprise Server by the University’s ethernet communications network and to any relevant points in the building to be determined in conjunction with the University.

Programming of system shall be part of the contract and group point numbering shall be determined in conjunction with Murdoch. Provision for system graphics to also be included in accordance with current methodology. See Murdoch/Schneider Electric current BMS design standards.

The contract shall provide for not less than eight hours instruction on the system operation and programming (depending on size of project) to staff of University. Allow for maintenance period to cover cost of call outs and maintenance for 12 months.

10.2  Control systems
Engage SE to undertake all controls systems as an extension to the existing SBO

All new control equipment shall be open protocol “Bacnet” or “Lon” or “ModBUS” compatible and shall run in conjunction with the existing network.

Air Conditioning Control Functionality Sequences required are as follows:

Global Set Point
Global Setpoint is an internal numeric point which floats over a temperature range of 22.5°C to 24.5°C and is established once on each air handling/fan coil unit. The Global Setpoint represents the room or space temperature setpoint before local offset. The floating Occupied Setpoint is reset according to ambient temperature in accordance with the following parameters:

- If the ambient temperature is below 18°C then GSP = 22.5°C
- If the ambient temperature is above 32°C then GSP = 24.5°C
- If the ambient temperature is between 19°C and 25°C then GSP will be proportional between 22.5°C and 24.5°C

A.C. Run Times
Air conditioning systems shall be time scheduled to operate in core hours. Core hours for the purpose of air conditioning run times is from 8:00am to 5:30pm Monday to Friday.
Once air conditioning units start in core hours, systems shall operate in a “setback mode”. Setback shall be in accordance with the following parameters:

\[
\text{Setback cool mode} = \text{GSP} + 2.5^\circ C \\
\text{Setback heat mode} = \text{GSP} - 2.5^\circ C
\]

Upon the occupant activating an A/C push button, the active zone shall revert to “occupied mode”. “Occupied mode” shall provide system control to Occupied Setpoint. In core hours an initial activation of the A/C push button shall start the air conditioning system with the active zone operating in “occupied mode” while inactive zones operate in “setback mode”. Out of hours run time is for a duration of two (2) hours. When in “occupied mode” in either out of hours or during a time scheduled run time the push button shall turn the A/C off for that zone and into “setback”. Another press on the button whilst in this condition will re-enable an afterhour’s call or return to the time schedule.

A/C push button control stations shall incorporate a green neon indicator light that provides the occupant with an indication of air conditioning status and that the zone is active.

Some areas, such as Auditoriums, Theatres and the like, do not operate on core hours. The air conditioning plant is initiated when the push button is activated and then controls as required to achieve GSP. However, if the area is not occupied and the room temperature exceeds 28.0°C or is lower than 19.0°C then the air-conditioning plant shall start automatically and run until the room temperature falls below 26.0°C or rises above 20.0°C.

Where there is existing air handling plant that does not follow the above control logic and modifications to the existing air handling or distribution system are required, the designer shall identify the control logic employed and modify as required, subject to Murdoch’s approval, in order to provide a plant that operates effectively and is energy efficient. The control logic finally employed should be similar in intent to the design intent of the control logic described herein.

Where live occupancy data is available for a scheduled space from a BMS BACNet integrated DALI occupancy sensor for a zone this can be used to override timeshdules when a space is not occupied. Alternative means of occupancy data may come from occupancy counting software or devices which are integrated into the BMS via BACNet. Occupancy data should be used as an input into the control run times as a feedback loop.

Bookable space should be linked to the Syllabus Plus room booking via an API to provide a direct enable signal 15 minutes prior to the booking time to enable conditioning to occur. Should the room not be occupied within 15 minutes the HVAC should turn off. A signal should also be sent to Gallager to unlock and lock the room accordingly at these points. Should staff or students wish to access to the space after a booking was closed due to no operation, a swipe card would have to be used to gain access to occupy the room. This enable signal should feedback to the BMS system and Syllabus Plus to enable the HVAC and lighting to turn on. The idea is to provide a safe light and comfortable space when occupied.

### 10.3 Secondary Pump Controls

Secondary CHW pumps to be controlled the same as all existing secondary pumps, as follows:

- Provide a DP sensor connected across the CHW F&R lines before the isolation valves to the cooling coil at the end of the pipe system index leg.
- Manual input of secondary circuit DP setpoint, initially set at the DP required at the DP sensor to achieve design flow rate through the index leg cooling.
- Manual input of minimum and maximum ambient temperatures for the purpose of rescheduling the secondary circuit DP based on ambient temperature. Initial settings 20°C minimum & 35°C maximum.
- Automatic rescheduling of the secondary circuit DP between 0% of setpoint at minimum ambient temperature and 100% of setpoint at maximum ambient temperature
- Automatic control of pump speed between 0-100% to achieve the scheduled secondary circuit DP.
- Manual input of a minimum permissible chilled water return temperature. Initial setting 12°C.
- Automatic override of the pump speed control limit speed if return water temperature drops below the minimum return water temperature set point.
- Automatic DISABLE of all secondary circuit pumps on the campus as described in 7.1.1
- BMS front end graphics modified to include the new pump in the display of a table of all pumps, listing all setpoint and operating data for each pump.
- Set up Trend-log and extended trend logs of Rescheduled DP against Actual DP for future reference by plant operators.

10.4 Electrical Meter Sequence
Monitor kWh usage at each mechanical and electrical services switchboard via a Smart Type Energy Meter complete with digital display. Monitor meters via a high level interface to the BMS, Current Electricity meter specifications are SATEC 133 or SATEC BFM. All tenant mechanical services energy consumption shall be separately metered.

10.5 Water Meter Sequence
Monitor flow to provide usage at each meter – Metering usage information is to be transmitted to the BMS.

10.6 Gas Meter Sequence
Monitor flow to provide usage at the meter Metering usage information is to be transmitted to the BMS.

10.7 Chilled/Heating Water Energy Meter Sequence
Monitor flow and temperature to provide energy usage at each meter, for high accuracy metering Flexim Fluxus ultrasonic meters shall be installed, these come with matched pair temperature sensors

Immersion type Mag flow meters shall be
- EuroMAG International model MUT 2200 EL / MUT 2500 EL
- Kamstrup

Ultrasonic types
- Schneider Ultrasonic Multical

Pump Energy meters (Grundfos)
- Where there is capability to monitor energy flow for non-revenue purposes within the pump this shall be used.
Belimo Energy Valves

- The selection of Belimo energy valves at heating and cooling coils to enable load monitoring.

Any meter shall be of a suitable size for expected flow conditions
Note minimum of 1 meter required per building connection.

Data is to be transmitted to the BMS from the meters and logged according to the MU/Schneider trend logging standards. Where inbuilt registers already exist in meters and there are meters of that type on the network then consultants are to specify the current SBO template. Where there are no SBO templates available for a particular meter then the consultant is to refer to the MU Energy Manager for determination of the registers to be imported to SBO.

10.8 Chilled Water Flow Sequence
Monitor site chilled water main differential pressure and strainer differential pressure at each incoming CHW main lines.

10.9 Heating Water Plant Sequence
The heating water plant shall be energised via a heating call.

The heating water plant consists of a minimum of two modular boilers, in this case each performing 50% of the total duty required. In the case of more than two modules provide one extra module as a redundancy. One primary pump supplying the boilers and one secondary pump supplying the field via a hydraulically separated vessel are to be specified, in a primary/secondary arrangement.

Boilers shall be sequenced as follows:

- **Step 1**
  BMS control will command primary and secondary pumps on.
- **Step 2**
  BMS control will command lead boiler valve open.
- **Step 3**
  Lead Boiler will automatically turn on following flow detection
- **Step 4**
  Subsequent boilers will start up on return temperature falling below a set value
- **Step 5**
  Staging down of boilers is dependent on return temperature rising above a set value
- **Step 6**
  Secondary pump will be disabled when heating call is false
- **Step 7**
  Primary pump will not be disabled until return temperature rises above a set value

10.10 Heating Water Flow Control Sequence
The heating water flow control sequence shall be energised via operation of both heating water pumps.

Flow and temperature control of the heating water shall:

- Allow for heating water temperature setpoint reset based on ambient temperature.
- Maintain a nominal 150kPa ±10kPa differential pressure via the bypass valve. Actual DP to be defined during commissioning.

10.11 Packaged Air conditioning Unit Sequence
Communications Rooms, Server Rooms and the like provided with packaged air conditioning systems shall operate continuously to maintain pre-set room temperature and humidity. The Units may be Chilled water or DX and use of EC fan motors is encouraged. The setpoints shall be adjustable via the
BMS, system control, equipment running parameters, alarms etc. shall be transmitted to/from the SBO BMS via a protocol such as MODBUS or BACNET.

No local pushbuttons or controls are required, other than the proprietary control unit supplied as part of the air conditioning systems.

The design of the CRAC system shall be such that N+1 Redundancy is achieved, i.e. the total number of units required for load conditions is supplemented by a “spare unit”.

The design of the CRAC system should be resilient as well as energy efficient designs. Designers are encouraged to use site generated and reticulated chilled water for some CRAC’s and DX type units for others in any one server room. Determine the precise mix by LCCA. In this regard, information regarding the current electricity source, tariff structure and gross COSP of CHW or use in CRAC’s shall be obtained from the University. It is an aspiration of the University to generate and store electricity and although this is currently not an implementation consideration shall be made, and the likely impact, calculated for the various options.

The CRAC units shall be controlled on a lead/lag schedule, currently this is a weekly schedule with change over of CRAC’s within different server rooms occurring on different days around the centre of a working week and always in the morning. The designers should consider whether there is any advantage, from an efficiency perspective, with scheduling changeovers between CHW and DX units more frequently. In concert with this analysis must be a risk assessment of changing air paths and their effect on cool aisle air delivery with the onus on maintaining a constant through rack flow rate and temperature to minimise thermal stresses within server equipment. Other considerations are the impact of higher cycling of equipment on failure risk, use of active fan tiles, in rack cooling for very high power density racks etc.

### 10.12 Constant Volume Fan Coil Unit Sequence

The constant volume air handling unit sequences shall be enabled via local control and/or under time schedule control.

The supply air fan motor shall operate at a constant speed, determined at commissioning.

The demand for cooling from the space shall reset the supply air temperature and modulate the cooling coil valve based on space temperature set point deviation.

The heating water control valve shall also control as necessary to maintain temperature set point.

The warm up cycle sequence shall be energised under time schedule control.

Morning Warm up is enabled individually for each A/C unit when:
- Room temperature is 2°C below the setpoint
- Outside air temperature is below 18°C
- One hour before the time schedule starts
- Warm-up has not been enabled on this day before.

The sequence shall operate as follows:
- The outside air and relief air dampers close and return air damper opens.
- The chilled water valve closes.
- Fan coil heating valve modulates to provide fixed leaving temperature.
The warm up mode shall be de-energised when space and return air temperature is at set point.

Note maximum supply air temperature in warm-up heating mode to be limited to 8K above space temperature set point.

10.13 Variable Volume Fan Coil Unit Sequence
The variable volume air handling unit sequences shall be enabled via local control and/or under time schedule control.

The supply air variable speed fan motor shall be controlled by a static pressure sensor set to maintain a minimum duct static pressure set point as determined at commissioning. Locate the static pressure sensor 2/3 of the total distance of the index leg. The location of the sensor shall be shown on "As Constructed" drawings and be accessible.

The highest demand for cooling from any space shall reset the supply air temperature and modulate in sequence, the economy cycle dampers and the cooling coil valve based on space temperature set point deviation. Trim reheat at individual boxes shall control as necessary to maintain temperature set point.

The warm up cycle sequence shall be energised under time schedule control. The sequence shall operate as follows:

- The economy cycle outside air and relief air dampers closed and return air damper open.
- The chilled water valve closed.
- The highest average, demand for heating from any space shall reset the supply air temperature (limited to maximum of 8K above space temperature set point) and modulate the heating coil valve based on space temperature set point deviation. VAV boxes shall modulate supply air flow as necessary to maintain temperature set point.
- VAV boxes shall operate in a reverse acting mode during warm up and shall modulate the VAV box air quantity based on set point deviation.
- VAV boxes electric heating element to be de-energised.
- Fan coil heating valve modulates to provide fixed leaving temperature.

The warm up mode shall be de-energised when space and return air temperature is at set point.

Economy cycles shall be achieved by modulation of the outside air damper.

10.14 Economy Cycles
Provide economy cycles to all Fan Coil Units, greater than 20kWR.

The economy cycle control loop shall be energised when the outside air temperature is below the return air temperature. The outside air temperature shall be taken from the site global outside air sensor. Consideration should be made to control of Economy Air Cycles via enthalpy control or preferably advanced control methods using CO2-based demand-controlled ventilation control based upon real time look ahead prediction modelling using NARX.

Economy cycle dampers shall be driven separately to the minimum outside air dampers. Each minimum outside air damper shall be complete with its own actuator.
10.15 Variable Air Volume Box Sequence
The variable air volume (VAV) box sequence shall be initiated by local control and/or under time schedule control.

The VAV box shall modulate its air quantity in response to the space temperature set point deviation.

The VAV box heating shall operate in response to set point deviation when the box supply air quantity is at minimum set point.

The VAV boxes shall be provided with set back temperature control (nominal set point ± 2.0°C).

10.16 Typical Toilet Exhaust Fan Sequence
The control sequence shall be energised by time schedules and/or associated plant operation.

Fan status shall be via pressure switches or current switches. Provide status input to the BMS.

On failure of the lead fan the stand-by fan shall be energised, duty fan de-energised and a fault signal generated in accordance with the Alarm setting instructions in the BMS specifications.

10.17 Typical Exhaust Fan Sequence
The control sequence shall be energised by time schedules or local control or associated air handling system. Where toilets are fitted with DALI occupancy sensors that provide a feedback loop to the BMS via BACNet, toilet exhaust fans should be operated in an occupancy only mode with a 15 minute delay post occupancy to evacuate standing odours.

Fan status shall be via pressure switches.

10.18 Plant Call Sequence
The control sequence shall be initiated when any associated item is energised. Cooling/Heating calls shall be generated as follows:
- On Valve position at 70%
- Off Valve position at 20%

10.19 Fire Services Sequences
Status monitoring of:
- General fire alarm (at fire indicator panel).

10.20 Switch Plates Control Sequences
Provide a standard switch plate for local pushbutton control switches and after hours switches. Switch plate to be appropriately labelled with engraved lettering and be complete with green neon indicator to indicate unit running with the indicator to reflect status within 3 seconds of activation.

Air Conditioning Switches:
- All switches to be of the push button type.
- All switches to be wall mounted at 900mm AFFL.
- Air conditioning systems run in set-back mode.
- Activation of the switches during normal hours de-energises set-back mode and operates the associated VAV Box or Fan Coil Unit for 4 hours or until the termination of normal hours.
- Activation of the switches outside of normal operating hours operates the associated VAV Box (or VAV Boxes) in normal mode, with the remaining VAV Boxes associated with that air handling unit and all other air handling units located in that plant room operating in set-back mode. All VAV boxes associated with other air handling units to remain shut.
- Ventilation Switches:
  - All switches shall be installed at 900mm AFFL, in locations approved by the Client.
  - Activation of the switch runs the ventilation system for 2 hours (adjustable via BMS front end).

10.21 General Requirements

- Auto re-boot of BMS software following power failure.
- Power failure restart time delays for all plant ensuring correct sequence starting and adequate time delays between large motor starts. The time delays shall also operate when plant is restarted after a fire alarm or a loss of power to the building.
- Phase failure under voltage protection relays for each switchboard.
- Manual-Off-Auto (MOA) switches for each item of plant.
- Air flow proving switches connected across the suction and discharge of all the supply air fans and fan coil units to provide fan "run" and "fault" status and control interlocks.

10.22 Room Sensing Requirements

Normal location of sensors for room temperature sensing shall be:

- For perimeter zones, 1500 - 2000 mm from the outside wall, 1500mm to 1700mm above the floor, out of direct sunlight and adjacent return air path if possible.
- For internal zones, 1500mm to 1700mm above the floor and adjacent return air path.
- Sensors are not to be positioned where they can be affected by supply airflow nor adjacent to windows and doors.
- All penetrations not required for the sensors’ function are to be sealed, particularly where associated mounting boxes are fixed to cavity construction all cable and other penetrations from the box to the cavity are to be durably sealed.
- Sensors are not to be positioned where they may be unduly influenced by other equipment inclusive of, but not limited to, photocopiers, exhaust from computer equipment, touchscreen room control pads, fume cupboards.

10.23 Alarm- Reporting Requirements

Alarms shall have individually adjustable time delays. The alarm must be present for the delay period before being registered.

- Air handling units or fan coil units supply fan started and status not confirmed.
- Fan(s) started and status not confirmed.
- Pump(s) started and status not confirmed.
- Boiler fault.
- Package plant alarms.
- Any fire alarm.
- All other alarms specified in the MU/Schneider Electric BMS specifications.
10.24 Display & Reports Requirements

- Graphic plant layouts to display all the control point information. The control points shall include but are not limited to the following.
  - Air and water temperatures
  - Ambient enthalpy/temperature
  - Air and water pressures
  - Trend logs
  - Plant status and hours run
  - Meter readings - electrical, gas, steam and thermal
  - Fire alarm status
  - Heating calls
  - Cooling calls and integrated to site cooling call back to central plant.
- Reports shall be generated on a monthly basis or as required and shall include but will not be limited to the following.
  - Energy reports, including, but not limited to, the following subheadings:
    - Building name and number.
    - Mechanical thermal consumption;
    - Mechanical on peak consumption;
    - Electrical on peak consumption
    - Mechanical off peak consumption;
    - Electrical off peak consumption
    - Gas consumption mechanical;
    - Gas consumption general;
    - Total gas energy;
    - Total water consumption;
    - Total energy consumption for building (MJ/m2).
    - Total tenant consumption by utility service type (i.e. electricity (light, power mechanical), water, gas, thermal cooling, thermal heating);
  - Trend logs for all control and monitoring points shall be stored on the BMS locally, on the SBO Enterprise Server, the SBO Reports Server and/or EMS in accordance with the MU/Schneider Electric BMS trend logging specifications.

For 12 months after Practical Completion, prepare an energy report every three months.

11 Commissioning

Commissioning is considered to be vitally important for the long term operation and management of building systems. The University operates as owner/occupier for the majority of the real estate and as a result designers are encouraged to design for permanency as opposed to designing with transitory tenant occupancy in mind. As a result of this the University is embracing a Soft Landings and Green Star methodology of which a major component is the requirement to engage an Independent Commissioning Agent at latest at the Developed Design stage. The universities experience, particularly with services intensive design and construction contracts where the detailed design team are engaged by the main contractors, has in some instances resulted in significant reworks to the delivered product, accessibility issues, product substitution etc. The ICA inclusion from early design stages will go some way to ensuring that the University’s requirements as laid out in this and other guidelines are considered in full through detailed design and into construction. It is envisaged that, where the University considers it necessary, there will be a contractual requirement, placed on the Head Contractor, for the formation of a Commissioning Management Organisation at the early stages of the contract. The CMO shall have a direct communication path to the Project Management team and included as client representatives shall be the ICA, Primary Soft Landings Champion and Clerk of Works. In some situations, the same person, engaged by the University, will
occupy these positions. This does not preclude the requirement for the preparation of a Commissioning Management Plan by the CMO. CIBSE Commissioning Code M.

11.1 Independent Commissioning Agent
The Consultants are to work with the ICA at every point in the design and delivery to ensure that the project is delivered in accordance with the design brief and the expectations as laid out in the suite of Design Guidelines.

11.2 Commissioning Management Plan
All consultants are required to contribute to the CMP. The CMP is to be based upon CIBSE document Commissioning Code M: Commissioning Management. The plan will include for Commissioning of all Plant and Services in accordance with appropriate and available Commissioning Codes including but not limited to:

- CIBSE Commissioning Code C: Automatic Controls (2001)
APPENDIX A  NAMING CONVENTION

A.1  GENERAL
The University has adopted a naming convention in which its primary electrical assets are given a unique number with the following format:

\[ \begin{array}{c}
1 \\
E \\
2 \\
SS Z2 \\
3 \\
310 \\
4 \\
01 \\
5 \\
023 \\
6 \\
DB \\
7 \\
02
\end{array} \]

- **Discipline Indicator**
- **Site Indicator**
- **Building Number**
- **Level Number**
- **Room Number**
- **Asset Description Abbreviation**
- **Asset Number**

A.2  INDICATOR DESCRIPTIONS

A.2.1  Electrical Assets adopt the full Naming convention and must include Indicators 1 to 7
A.2.2  Mechanical Assets adopt only Indicators 3 – 7 (inclusive)

A.2.3  Discipline Indicator
The Discipline Indicator describes the discipline that the asset falls within.

- **E**  Electrical
- **M**  Mechanical

Should the asset being named fall within another discipline the Consultant shall apply to the University to define a suitable letter to describe the new discipline.

A.2.4  Site Indicator
Murdoch University occupies three sites in the greater Perth area.

The Site Indicator describes the site, and if applicable the Electrical Zone within the site, that the asset is located on.

- **SS Z1**  South Street Campus Zone 1 (St Ives)
- **SS Z2**  South Street Campus Zone 2 (Murdoch University Main Campus)
- **PC**  Peel Campus
- **RC**  Rockingham Campus

A.2.5  Building Number
Every building on the University Campuses is assigned a Building Number.

The Building Number(s) for the project shall be obtained from the University.
A.2.6 **Level Number**
The University does not describe the floors in buildings as Basement, Ground First, etc. It assigns levels to floors in the buildings according to campus wide hierarchies.

The level numbers for the project shall be obtained from the University, or the project Architect.

A.2.7 **Room Number**
Every room on the University Campuses is assigned a Room Number.

The Room Number(s) for the project shall be obtained from the Architect.

**NOTE:** Room numbers often change during the course of a project. The final Room Numbers shall be confirmed with the Architect prior to the labels being manufactured and installed.

A.2.8 **Asset Description Abbreviation**
The Asset Description Abbreviation is intended to give a quick concept of the nature of the asset.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVI</td>
<td>High Voltage Isolator</td>
</tr>
<tr>
<td>HVC</td>
<td>High Voltage Circuit Breaker</td>
</tr>
<tr>
<td>HVF</td>
<td>High Voltage Fuse Switch</td>
</tr>
<tr>
<td>TRF</td>
<td>Transformer (22kV/415V)</td>
</tr>
<tr>
<td>MSB</td>
<td>Main Switchboard</td>
</tr>
<tr>
<td>BMSB</td>
<td>Building Main Switchboard</td>
</tr>
<tr>
<td>DB</td>
<td>Distribution Board</td>
</tr>
<tr>
<td>FIP</td>
<td>Fire Indicator Panel</td>
</tr>
<tr>
<td>FP</td>
<td>Fire Pump</td>
</tr>
<tr>
<td>LIFT</td>
<td>Lift</td>
</tr>
<tr>
<td>UPS</td>
<td>Uninterruptible Power Supply</td>
</tr>
<tr>
<td>MSSB</td>
<td>Mechanical Switchboard</td>
</tr>
<tr>
<td>SWPP</td>
<td>Stormwater Pump Panel</td>
</tr>
<tr>
<td>SPP</td>
<td>Sewer Pump Panel</td>
</tr>
<tr>
<td>AHU</td>
<td>Air Handling Unit</td>
</tr>
<tr>
<td>FCU</td>
<td>Fan Coil Unit</td>
</tr>
<tr>
<td>CAS</td>
<td>Cassette Unit</td>
</tr>
<tr>
<td>VAV</td>
<td>Variable Air Volume Unit</td>
</tr>
<tr>
<td>EDH</td>
<td>Electric Duct Heater</td>
</tr>
<tr>
<td>HHW</td>
<td>Heating Hot Water</td>
</tr>
<tr>
<td>CHW</td>
<td>Chilled Water</td>
</tr>
<tr>
<td>BLR</td>
<td>Boiler</td>
</tr>
<tr>
<td>PMP</td>
<td>Pump e.g. Chilled Water Pump = CHW PMP</td>
</tr>
<tr>
<td>VSD</td>
<td>Variable Speed Drive</td>
</tr>
<tr>
<td>OAF</td>
<td>Outside Air Fan</td>
</tr>
<tr>
<td>EXF</td>
<td>Exhaust Fan</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>TEF</td>
<td>Toilet Extractor Fan</td>
</tr>
<tr>
<td>KEF</td>
<td>Kitchen Extractor Fan</td>
</tr>
<tr>
<td>DMP</td>
<td>Damper</td>
</tr>
<tr>
<td>MDP</td>
<td>Motorised Damper</td>
</tr>
<tr>
<td>VLV</td>
<td>Valve</td>
</tr>
<tr>
<td>FMC</td>
<td>Fume Cupboard</td>
</tr>
<tr>
<td>FMP</td>
<td>Fire Damper</td>
</tr>
<tr>
<td>CHR</td>
<td>Chiller</td>
</tr>
<tr>
<td>DPG</td>
<td>Differential Pressure Gauge</td>
</tr>
<tr>
<td>APG</td>
<td>Absolute Pressure Gauge</td>
</tr>
<tr>
<td>GPG</td>
<td>Gauge Pressure Gauge</td>
</tr>
<tr>
<td>CMP</td>
<td>Compressor</td>
</tr>
<tr>
<td>VAC</td>
<td>Vacuum Compressor</td>
</tr>
<tr>
<td>BYP</td>
<td>Bypass Valve</td>
</tr>
<tr>
<td>CRAC</td>
<td>Computer Room Air Conditioner</td>
</tr>
<tr>
<td>HUM</td>
<td>Humidifier</td>
</tr>
<tr>
<td>FTR</td>
<td>Filter</td>
</tr>
<tr>
<td>SPS</td>
<td>Split System – Single</td>
</tr>
<tr>
<td>MHSS</td>
<td>Multi Head Split System</td>
</tr>
<tr>
<td>VRF</td>
<td>Variable Refrigerant Flow (Volume)</td>
</tr>
<tr>
<td>HTP</td>
<td>Heat Pump</td>
</tr>
<tr>
<td>PRS</td>
<td>Pressurisation System</td>
</tr>
<tr>
<td>VDS</td>
<td>Vacuum Dearation System</td>
</tr>
<tr>
<td>PRI</td>
<td>Primary</td>
</tr>
<tr>
<td>SEC</td>
<td>Secondary</td>
</tr>
<tr>
<td>BEV</td>
<td>Belimo Energy Valve</td>
</tr>
<tr>
<td>PICCV</td>
<td>Pressure Independent Characterized Control Valve</td>
</tr>
<tr>
<td>UEMT</td>
<td>Ultrasonic Energy Meter</td>
</tr>
<tr>
<td>MAG</td>
<td>Magflow</td>
</tr>
<tr>
<td>RSGV</td>
<td>Resilient Seat Gate Valve</td>
</tr>
<tr>
<td>BUV</td>
<td>Butterfly Valve</td>
</tr>
<tr>
<td>BVL</td>
<td>Ball Valve</td>
</tr>
<tr>
<td>GTV</td>
<td>Gate Valve</td>
</tr>
<tr>
<td>SCV</td>
<td>Swing Check Valve</td>
</tr>
<tr>
<td>AEL</td>
<td>Air Eliminator</td>
</tr>
</tbody>
</table>

Should the asset being identified not fall within the categories given above the Consultant must approach the University to assign a new Asset Description Abbreviation to the new type of asset.

**A.2.9 Asset Number**

For Electrical assets this number shall describe the number of assets of its type in the building, on the level. i.e. the first asset of its type on a level in the building shall be 01, the second, 02 and so on. Asset numbers only totalise the number of an asset type for a level and not a building.

For Mechanical Assets where the asset serves multiple spaces the label shall describe where the asset is located along with its sequence number of like assets on that level.
Where an asset only serves one room the label shall describe where the asset is located along with the location served in the form of Level – Room.

Examples:
One of three Air Handling Units is located in the roof space (Level 4) Room 002 of B340 and serves VAV boxes in a number of rooms on Level 3:

340-4-002-AHU-03

One of 6 Fan Coil Units located in the roof space (Level 4) Room 002 of B340 serves a single Lab on level 3, Room 3.040:

340-4-002-FCU-3-040

A.3 LABELS ON ASSETS

Assets shall be identified with an Asset Label giving its unique number in 10mm high lettering.

In addition, Electrical assets shall be fitted with a separate “Fed From” Label giving the unique number of the asset from which it is fed in 5mm high lettering.

Labels shall consist of appropriate lettering engraved on white-black-white, plastic laminate and shall be fixed to the asset using machine screws or alternatively high strength adhesive.
### APPENDIX B  SCHEDULE OF APPROVED EQUIPMENT

<table>
<thead>
<tr>
<th>Clause</th>
<th>Clause Title</th>
<th>Approved Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error! Reference source not found. EDG</td>
<td>Switchboard Equipment</td>
<td>Chassis replacements and new Schneider Acti 9 IsobarChassis TNA and NOT encapsulated type</td>
</tr>
<tr>
<td>Error! Reference source not found. EDG</td>
<td>Air Circuit Breakers (ACB)</td>
<td>Merlin Gerin</td>
</tr>
<tr>
<td>Error! Reference source not found. EDG</td>
<td>Moulded Case Circuit Breakers (MCCB)</td>
<td>Schneider Electric Acti 9</td>
</tr>
<tr>
<td>Error! Reference source not found. EDG</td>
<td>Miniature Circuit Breakers (MCB), RCBO’s and RCD’s</td>
<td>Schneider Electric Acti 9</td>
</tr>
<tr>
<td>Error! Reference source not found. EDG</td>
<td>Load Break Switches and Isolators</td>
<td>Merlin Gerin</td>
</tr>
<tr>
<td>Error! Reference source not found. EDG</td>
<td>Contactors and Relays</td>
<td>Telemecanique</td>
</tr>
<tr>
<td>Error! Reference source not found. EDG</td>
<td>kWh Meters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Master meters</td>
<td>SATEC EM133 or SATEC BFM136</td>
</tr>
<tr>
<td></td>
<td>Sub meters</td>
<td>SATEC EM133 or SATEC BFM136</td>
</tr>
<tr>
<td></td>
<td>Tenant Rate Meters</td>
<td>SATEC EM133 or SATEC BFM136 with 05.5 CT’s or SATEC HACS CT’s</td>
</tr>
<tr>
<td></td>
<td>EMS – meter Interface</td>
<td>Schneider Electric COM’X 510</td>
</tr>
<tr>
<td>Error! Reference source not found. EDG</td>
<td>Ducting</td>
<td>Clipsal:- Series 900 cable duct</td>
</tr>
<tr>
<td>7.1.1 9.1.1</td>
<td>Central Chilled Water Generation Plant</td>
<td>Trane</td>
</tr>
<tr>
<td>7.1.1</td>
<td>System Pressurisation and deaeration equipment</td>
<td>Duraflex</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>7.1.2</td>
<td>Underground CHW piping</td>
<td>welded polyethylene, protected type B Copper</td>
</tr>
<tr>
<td>9.18</td>
<td>Above ground/Building piping</td>
<td>Insulated type B Copper</td>
</tr>
<tr>
<td>9.2</td>
<td>Cooling Towers</td>
<td>BAC</td>
</tr>
<tr>
<td>9.3</td>
<td>Condenser water solids pre-separation</td>
<td>MultiCyclone</td>
</tr>
<tr>
<td>9.4</td>
<td>Retrofit modular HHW Boilers</td>
<td>Rinnai 200i</td>
</tr>
<tr>
<td>9.4</td>
<td>Retrofit (where applicable) &amp; new modular HHW Boilers</td>
<td>Meridian</td>
</tr>
<tr>
<td>9.4</td>
<td>Retrofit (where applicable) &amp; new modular HHW Boilers (where renewable source of electricity is available)</td>
<td>Eco-Cute CO2 Heat Pump</td>
</tr>
<tr>
<td>9.4</td>
<td>Hydraulic Separators</td>
<td>Duraflex HydraTwin</td>
</tr>
<tr>
<td>9.5</td>
<td>Circulation pumps</td>
<td>Grundfos Magna 3 series, TPE series with Modbus HLI card, Grunfoss N series in preference to KSB</td>
</tr>
<tr>
<td>9.5</td>
<td>VSD</td>
<td>Danfoss VLT</td>
</tr>
<tr>
<td>9.6</td>
<td>Air Handling Units</td>
<td>Fan Coil Sales (Industries), Temperzone, Trane</td>
</tr>
<tr>
<td>9.7</td>
<td>Supply Terminal protection, Exhaust Terminal protection</td>
<td>2mm Blue Mountain Mesh, 250 micron SS mesh (PC &amp; BC facilities)</td>
</tr>
<tr>
<td>9.7</td>
<td>Fan Coil Units</td>
<td>Fan Coil Sales (Industries), Temperzone, Trane</td>
</tr>
<tr>
<td>9.7</td>
<td>Heat recovery units</td>
<td>Mitsubishi Lossnay</td>
</tr>
<tr>
<td>9.8</td>
<td>CHW Isolation Valves</td>
<td>Resilient Seat Gate valves from 50 mm diameter - Karon (Challenger Valves &amp; Actuators).</td>
</tr>
<tr>
<td>9.8</td>
<td>CHW Actuators</td>
<td>Chilled Water Ring isolation RSG valves to be fitted with Limitork (Acrodyne) Actuators and controlled by the BMS</td>
</tr>
<tr>
<td>9.8</td>
<td>Modulating Control Valves</td>
<td>Belimo Energy Valves or PICCV (on approval)</td>
</tr>
<tr>
<td>9.9</td>
<td>VAV Terminal Units</td>
<td>Johnson, Trane</td>
</tr>
<tr>
<td>9.10</td>
<td>Air-Conditioning Packaged Units</td>
<td>Mitsubishi Electric/Heavy Industries, Temperzone</td>
</tr>
<tr>
<td>9.12</td>
<td>Ventilation Fans</td>
<td>Fantech</td>
</tr>
<tr>
<td>9.13</td>
<td>Computer Room Air Conditioning Units</td>
<td>Liebert</td>
</tr>
<tr>
<td>9.14</td>
<td>Filter pressure drop</td>
<td>Magnahelic pressure transmitters with an electronic output 4-20mA</td>
</tr>
<tr>
<td>9.15</td>
<td>VRF systems</td>
<td>Mitsubishi, Daikin</td>
</tr>
<tr>
<td>9.19</td>
<td>Pipe Insulation</td>
<td>Armaflex, Bradflex, Aeroflex, Insulex</td>
</tr>
<tr>
<td>9.24</td>
<td>Air Diffusion</td>
<td>Trox, SW Harts, Dragon</td>
</tr>
<tr>
<td>10</td>
<td>Building Management System</td>
<td>Schneider Electric Smartstruxure Building Operations</td>
</tr>
<tr>
<td>10.4</td>
<td>Electricity Meters</td>
<td>SATEC 133 or SATEC BFM</td>
</tr>
<tr>
<td>10.5</td>
<td>Water Meters</td>
<td>Sensus or Kamstrup Multical</td>
</tr>
<tr>
<td></td>
<td>Gas Meters</td>
<td>Itron with Cybal Sensor</td>
</tr>
<tr>
<td>---</td>
<td>-------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>10.6</td>
<td>Thermal/Energy Meters</td>
<td>EuroMAG International model MUT 2200 EL / MUT 2500 EL, Kamstrup Multical</td>
</tr>
</tbody>
</table>