

CURTIN UNIVERSITY
PROJECT DELIVERY GUIDELINES

MECHANICAL SERVICES
GUIDELINES
000311



Curtin University

Definitions of terms and abbreviations found in this guideline can be found in Appendix 4.4 – Definitions on Page 106.

Details of revisions			
Level	Details	Date	Initial
1	<i>Initial version prepared for Project Delivery Guidelines</i>	<i>Aug-16</i>	<i>RPS</i>
1	<i>Minor corrections to final version for publication</i>	<i>Oct-16</i>	<i>RPS</i>
1	<i>Minor corrections to final version for publication</i>	<i>Jul-17</i>	<i>RPS</i>
2	<i>Range of updates to section 3 and integration with 000346 Services Metering Guidelines</i>	<i>Oct-18</i>	<i>FC</i>
3	<i>Update following third-party review for currency</i>	<i>Aug-19</i>	<i>FC</i>
3	<i>Inclusion of wording to allow departures from the existing guideline</i>	<i>Nov-19</i>	<i>RPS</i>
4	<i>Update to Section 3.2.32 to include detail on COP management</i>	<i>Jan-20</i>	<i>FC</i>
4	<i>Addition of new section 2.4 – Consultant and Contractor Requirements, upgrade of Appendix 1</i>	<i>Feb-20</i>	<i>RPS</i>
4	<i>Insertion of Documentation Deliverables Guidelines as a reference</i>	<i>Aug-20</i>	<i>RPS</i>

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1 INTRODUCTION

The purpose of this Project Delivery Guidelines document is to provide an overview of planning and design principles when providing the Mechanical Services consultancy for Curtin University projects. This document is intended for use by consultants, architects, engineers and other design service providers. The Mechanical Services consultancy should consider in the design phase of any project the best design outcomes, coordination of services, coordinated installation and ensure that all selected building materials and services are fit for purpose, provide value for money, are of sound construction, offer local support, integrate with other services and design concepts, are easily maintained and can be scaled within the University environment.

Sustainability is fundamental to the ongoing success of Curtin University's business. All users of the Project Delivery Guidelines – Mechanical Services must do so in consultation with the University's Sustainable Design Guidelines.

The University has a vital interest in the quality of its built environment. A quantitative measure is life-cycle costing and these should be minimised as far as possible. The qualitative terms 'buildability' and 'maintainability' are equally relevant.

The as-installed project must conform to established University building standards and represent the best possible value for money consistent with planning and financial restraints. It must also be easy to maintain, energy efficient, easy to clean and environmentally and aesthetically acceptable, both internally and externally. It must be buildable and in the final form must be flexible enough to allow ready and inexpensive alterations.

The Project Delivery Guidelines have been prepared in consultation with Curtin University subject matter experts and stakeholders. It is recognised that the subject matter of Guidelines will not always be suitable for all project elements and departures from the Guidelines may be required or desirable. Departures from Guidelines must be agreed upon in consultation with the relevant University Guideline subject matter expert. Departures must be recorded in a project register and recorded and reviewed in the Project Control Group meeting minutes under its own meeting agenda item "Project Delivery Guideline Departures". Where the University subject matter expert identifies that a departure adds ongoing value to the University, the subject matter expert will update the relevant Guideline.

2 CURTIN REQUIREMENTS

2.1 DISABILITY ACCESS AND INCLUSION PLAN

Curtin University believes in creating equitable and inclusive access for people with a disability to its facilities, services, events and academic programs on all its Western Australian campuses.

The *Universal Design Guideline* has been developed to reflect a commitment to equity and inclusion for all by embedding Universal Design principles into project planning, design and delivery guidelines. Consultant architects, designers and engineers should make themselves familiar with the particular requirements of the *Universal Design Guideline* before responding to a project brief.

2.2 HEALTH AND SAFETY

Curtin University is committed to providing and maintaining high standards of health and safety in the workplace and will:

- ensure compliance with relevant legislation and the University's Health and Safety Management System
- promote an organisational culture that adopts health and safety as an integral component of its management philosophy
- ensure that health and safety is part of the business planning processes and that it is adequately resourced by all areas
- maintain an effective mechanism for consultation and communication of health and safety matters
- maintain an effective process for resolving health and safety issues and managing health and safety risks
- provide appropriate health and safety training
- regularly review health and safety performance to monitor the effectiveness of health and safety actions and ensure health and safety targets and objectives are met.

A copy of our Health and Safety Management Standards can be found at:

<https://healthandsafety.curtin.edu.au/local/docs/HManagementStandards.pdf>

2.3 SUSTAINABILITY AT CURTIN

It is Curtin University policy that all new or refurbishment projects on site should support its status as Australia's first university to achieve a 5-star Green Star – Communities rating from the Green Building Council of Australia (GBCA). Designers should understand and incorporate the Green Star criteria into designs and specifications in order to maintain and enhance Curtin's Green Star status. Information on the criteria can be found in the *PDG Green Star – Communities Design Guidelines*.

2.4 CONSULTANT AND CONTRACTOR REQUIREMENTS

All contractors and consultants must demonstrate the following:

- evidence of participation in training programs, including safety training, to ensure knowledge and skills are kept up to date with industry changes and related standards
- experience working on projects with complex infrastructure in campus-style environments, including client-controlled systems and services.

CONTRACTORS

Mechanical contractors must demonstrate the following:

- evidence that the company holds a Refrigerant Trading Authorisation as issued by the Australian Refrigeration Council
- evidence that air conditioning and refrigeration technicians hold relevant Refrigerant Handling Licences as issued by the Australian Refrigeration Council
- mechanical technicians, where required to work on electrical plant associated with mechanical services, hold the relevant electrical licence/qualifications
- experience installing and maintaining large-scale district heating and cooling system infrastructure
- experience with installing and maintaining laboratory mechanical infrastructure, up to prescribed containment level 3
- experience with building automation management systems and integration with associated systems/infrastructure
- very sound capability in commissioning and balancing of systems and infrastructure associated with mechanical services
- strong documentation capability using industry-recognised platforms such as AutoCAD/Revit etc.

While it is recognised that organisations may not have competencies in every facet listed above, they should have a broad understanding and capability of all areas, with specialist expertise in at least two of the areas mentioned above as a maintainer or installer, with more being desirable.

CONSULTANTS

Mechanical consultants must broadly demonstrate the following:

- experience in detailed engineering design practice as it relates to a campus-based environment, with a strong understanding and demonstrated experience with large-scale district heating and cooling systems and associated mechanical infrastructure

- experience with engineering design and compliance requirements of complex laboratory mechanical systems and infrastructure, up to prescribed containment level 3
- experience with building automation management systems, their design and integration with associated systems/infrastructure
- demonstrated capability to work with multidisciplinary engineering design teams in a collaborative way to produce desired building mechanical services outcomes
- very strong capability in understanding and overseeing the management processes in the commissioning and balancing of mechanical systems and infrastructure associated with mechanical services
- strong documentation capability using industry-recognised platforms such as AutoCAD/Revit, BIM etc.
- relevant professional engineering qualifications and affiliations
- A minimum of 5 years' experience delivering services in a similar context.

2.5 DELIVERABLES

Curtin University capital projects that utilise these Guidelines will generally involve the appointment of a Lead Consultant to manage the project on the University's behalf.

Curtin will appoint a suitably experienced Lead Consultant/Architectural Services to assist Curtin University and other key stakeholders with defining the space planning, functional and operational requirements and schedules of accommodation.

The Lead Consultant will be responsible for providing project design and management services throughout all phases of the project, including concept design, schematic design, detailed design and documentation, tender, construction contract administration, defects liability and handover phases.

The Lead Consultant will not be responsible for engagement of the cost consultant nor engineering consultants, who will be directly engaged by Curtin University. The Lead Consultant will however be responsible for coordinating the work of those other consultants and thereby ensuring that the deliverables for which they are directly responsible are delivered.

A summary of the services and deliverables to be delivered during the course of a project is as follows, and is not intended to limit or restrict the extent of the consultants' works that may be outlined herein, later in this document or in the project brief/scope of works:

- design works associated with the total delivery package
- all specifications and drawings included as a tender package
- provision of submissions and consents
- preparation of tender documentation, management of the tender process and preparation of a tender evaluation report

- management of project resources sufficient to ensure commissioning and other later-stage deliverables are not left under-resourced
- project surveillance during the course of construction from kick-off meeting to final commissioning and handover
- management of defective work and oversight of its rectification during the course of the works
- responsibility for the as-constructed component of the project, ensuring that:
 - all as-constructed drawings are provided in accordance with the Curtin University *Documentation Deliverables Guidelines*
 - Curtin University has received all operations and maintenance manuals specified
 - all in-ground infrastructure is surveyed at the time of installation, including the coordination of information into the Curtin GIS system.

The Consultant shall provide a full service unless advised by Curtin University that a nominated partial service is required.

Continuous communication with the Responsible Officer for any Mechanical Services consultancy is required throughout service delivery, in order to achieve the following deliverables:

SCHEMATIC DESIGN STAGE

SERVICES

The Consultant shall

- establish site constraints
- undertake a site survey and obtain in-ground services data from Curtin University
- prepare schematic drawings including site plan, building services, infrastructure and preliminary line diagrams as applicable
- prepare design options if required
- provide indicative equipment dimensions and loadings
- provide preliminary distribution scheme
- liaise with other consultants in the preparation of drawings, reports and cost estimates, as required
- prepare an indicative cost estimate for the project.

DELIVERABLES

The Consultant shall:

- deliver a Design Report including anticipated maximum demand and energy consumption calculations, energy management sketch drawings and an indicative cost estimate.

DESIGN DEVELOPMENT STAGE

SERVICES

The Consultant shall:

- attend design meetings with Curtin University and provide briefing and design reviews
- develop an agreed design option/options
- assist in revising cost estimates
- develop drawings and documents for University review and submission to government agencies as required
- develop a preliminary program for the works, in consultation with Curtin University.

DELIVERABLES

The Consultant shall deliver:

- drawings and documents
- submissions to government agencies
- a revised cost estimate
- a preliminary program.

DOCUMENTATION STAGE

SERVICES

The Consultant shall:

- prepare detailed tender documentation
- incorporate all consent conditions into the documentation
- provide an updated cost estimate
- review compliance of the documents with the project brief
- examine specifications prepared by other consultants (if applicable) and make comment
- be prepared to modify specific elements to comply with budgetary constraints
- participate in value engineering and management studies if nominated in the project brief
- provide an updated program of works.

DELIVERABLES

The Consultant shall deliver:

- specification and drawings

- an updated cost estimate
- an updated program of works.

TENDER STAGE

SERVICES

The Consultant shall:

- examine other consultants' documentation (if any) to avoid ambiguity or contradiction between documents
- prepare tender documentation, in association with Curtin University
- prepare a tender form and tender breakdown
- assist with the selection of tenderers
- assist with the calling of tenders if requested
- answer tender queries during the course of tendering
- issue tender addenda if required
- prepare a tender evaluation report and make a recommendation, including meeting with tenderers if necessary.

DELIVERABLES

The Consultant shall deliver:

- specification and drawings
- a tender form and tender breakdown
- addenda
- a tender evaluation report.

CONSTRUCTION STAGE

SERVICES

The Consultant shall:

- incorporate tender negotiation outcomes into documentation where necessary
- provide 'For Construction' documentation
- provide assistance in validating the contractors' claims for progress payments
- undertake regular site inspections during the course of the works and report results
- undertake factory inspections for switchboards and the like and provide a short report
- examine shop drawings and make comment
- review test results and comment

- provide an 'Outstanding Items/Defects List' at the end of the construction period and prior to Practical Completion
- ensure as-built drawings and manuals are submitted in accordance with Curtin University requirements
- provide visual observation certification that the works have been completed generally in accordance with the contract documentation.

DELIVERABLES

The Consultant shall deliver:

- 'For Construction' documentation
- site inspection reports
- factory inspection reports
- commented shop drawings
- test result comments
- 'works complete' certification.

COMMISSIONING AND HANDOVER STAGE

SERVICES

The Consultant shall:

- evaluate all commissioning results
- validate integrated functional fire testing
- review and validate BMS controls' operational functionality
- review and validate graphics, points, etc.
- review operations and maintenance manuals and As Constructed data.

DELIVERABLES

The Consultant shall deliver:

- commissioning defects lists
- BMS defects lists
- Certification of functional fire mode testing.

POST-CONSTRUCTION/DEFECTS LIABILITY PERIOD STAGE

SERVICES

The Consultant shall:

- provide a close-out of the Outstanding Items/Defects List

- undertake a site inspection within one month of the end of the Defects Liability period and report on any/all defects
- close out defects
- provide assistance to Curtin University in resolving faults during the course of the Defects Liability period.

DELIVERABLES

The Consultant shall deliver:

- a signed-off defects list
- a defects report at the end of the liability period and close out.

TUNING STAGE (IF REQUIRED)

SERVICES

The Consultant shall:

- evaluate operational performance of the system and BMS
- review and provide input into the contractors' tuning/performance report
- attend tuning/performance meetings and provide input
- close out tuning/performance defects.

DELIVERABLES

The Consultant shall deliver:

- tuning/performance reports
- tuning/performance meeting minutes.

2.6 COMPLIANCE WITH REGULATIONS

COMPLIANCE TO STANDARDS

The following standards shall be complied with as a minimum. The list of standards is not intended to limit compliance requirements where they may be relevant but not listed below. A reference to Australian Standards (AS) also includes joint Australian and New Zealand Standards; a reference to a standard includes all parts. The standard to be complied with is always the most recent and current version, unless specified otherwise.

- National Construction Code (NCC)
- AS1132 – Methods of test for air filters for use in air conditioning and general ventilation
- AS1318 – Use of colour for the marking of physical hazards and the identification of certain equipment in industry (known as the SAA Industrial Safety Colour Code)

- AS1324 – Air filters for use in general ventilation and air-conditioning.
- AS1345 – Identification of the contents of pipes, conduits and ducts
- AS1530.3 – Methods for fire tests on building materials, components and structures, simultaneous determination of ignitability, flame propagation, heat release and smoke release
- AS1668.1 – The use of ventilation and air conditioning in buildings Fire and smoke control in buildings
- AS1668.2 – The use of ventilation and air conditioning in buildings Mechanical ventilation in buildings
- AS1668.3 – The use of ventilation and air conditioning in buildings Smoke control systems for large single compartments or smoke reservoirs
- AS1668.4 – The use of ventilation and air conditioning in buildings Natural ventilation of buildings
- AS1670 – Fire detection, warning, control and intercom systems
- AS2107 – Acoustics – Recommended design sound levels and reverberation times for building interiors
- AS2430 – Classification of hazardous areas
- AS2700 – Colour standards for general purposes
- AS3000 – Electrical installations
- AS3008 – Electrical installations – Selections of cables
- AS3102 – Electric Duct Heaters
- AS3439.1 – Low voltage switchgear and control gear assemblies – Type tested and partially type-tested assemblies
- AS3666 – Air handling and water systems of buildings
- AS4041 – Pressure piping
- AS4254 – Ductwork for air handling systems in buildings
- AS4426 – Thermal Insulation of Pipework, Ductwork and Equipment – Selection, Installation and Finish
- AS4508 – Thermal resistance of insulation for ductwork used in building air-conditioning
- AS4859.1 – Materials for the thermal insulation of buildings - General criteria and technical provisions.

3 TECHNICAL REQUIREMENTS

MECHANICAL, VENTILATION AND AIR CONDITIONING (INCLUDING BMS CONTROL)

GENERAL

Sustainability is fundamental to the ongoing success of Curtin University's business. All users of the Project Delivery Guidelines – Mechanical Services must do so in consultation with the University's Sustainable Design Guidelines.

Designers interpreting these guidelines are to understand that changes to technology and policy may outpace the content of these guidelines. Prior to the calling of tenders for building services, the following must be approved by the Curtin University Project Manager and the appropriate Services Manager:

- scope document (preferably in diagrammatic format), which clearly indicates intent
- equipment schedules where appropriate
- list of suggested tenderers.

SPECIFICATIONS

The content of these guidelines must be fully integrated into consultant specifications. The practice of appending these guidelines to generic specifications will not be accepted. Generic specifications, if used, must be edited to eliminate any conflict with the content of these guidelines.

SURVEYED AS-CONSTRUCTED IN-GROUND SERVICES

All in-ground services are to be surveyed by a licensed surveyor, picking up location, inverts at critical intervals and levels of tops of pits.

Information is to be aligned to GDA94 coordinates to allow insertion into the University Master Site Services Plan.

3.1 ACCESS, MAINTENANCE, MANUALS AND DATA COLLECTION

3.1.1 GENERAL

Maintenance of the University's facilities is a significant commitment in the University's operating costs. It is therefore imperative to ensure that all facilities are constructed bearing in mind life-cycle costs and maintainability.

Planning, design documentation and construction will make adequate provision for:

- servicing and maintenance
- easy removal and replacement of plant and equipment
- access
- durability.

3.1.2 OPERATIONS AND MAINTENANCE MANUALS

Operations and Maintenance Manuals shall be provided prior to Practical Completion for every building project and they shall address all finishes and services. These manuals shall include but not be limited to:

- colour schedules
- operating instructions and technical schedules
- maintenance instructions
- supplier information
- copies of all as-installed drawings in electronic format
- control and electrical plans, complete with terminal numbers corresponding to wiring ferrules and cross-referenced as necessary
- commissioning data, set points, flow rates, timer settings etc.
- one hard copy manual and one electronic copy provided on a DVD inserted in the inside cover of the hard copy.

For specific requirements relating to Operations and Maintenance Manuals for Mechanical Services see section 3.2.34.

3.1.3 DATA COLLECTION

The mechanical services area of Curtin University maintains a comprehensive suite of data that assists the University with the master planning process that underpins the strategic development of the University. Ensuring the currency of this data is paramount and consultants and contractors are crucial to this process.

There are four key sources of data that the mechanical services field aims to maintain. These are:

1. chilled and heated water site-connected load data
2. an inventory of all metering devices, which includes electricity, gas, water and thermal chilled and heating water meters associated with building space heating
3. plant and equipment reference data
4. schematic line diagrams of air conditioning duct layout within buildings and site chilled and heating water schematic diagrams.

It is important that project specifications refer to the capture of this data and that the mechanical contractors (and other engineering disciplines) play their part in providing this data to the University so that data sets can be updated. To assist in this process, templates have been developed for the first three categories listed above that the contractor shall use to record the required data and submit to the Properties, Facilities and Development Mechanical Engineering Department at the time of project Practical Completion. Sample templates for each of the above data set areas are contained in Section 4 Appendix 1 of this document. Consultants and contractors should contact the Mechanical Engineering Department to obtain soft copies of the templates in which

the data is to be submitted to the University. Item 4 requires that the relevant as-constructed AutoCAD drawings relating to ductwork layout and site chilled and heating water drawings be compliant with the requirements described in the *Documentation Deliverables Guidelines* and are forwarded to the Mechanical Engineering Department at project Practical Completion.

3.1.4 ACCESS FOR MECHANICAL ENGINEERING SERVICES

Simple maintenance procedures throughout the buildings are vital, and shall be reviewed with the University before going to tender.

The design and construction materials shall reflect low maintenance considerations. All fabric, structural and service components shall be readily accessible and shall not be labour-intensive at the repair stage.

Consultants shall ensure that they indicate:

- 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 plant room or plant area.

'Adequate access' for routine servicing means sufficient space for a plant mechanic, irrespective of working age, to reach all items requiring routine service safely and without undue stress.

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 the University Project Manager.

Mechanical and electrical plant and equipment, particularly those requiring manual operation such as electrical control panels, or routine maintenance such as pumps and fans, shall have safe and comfortable access. A 'loose' fit is essential to enable work to be carried out around them.

The Project Architect shall ensure that there is coordination between the structural engineers and service engineers to allow incoming underground services, in the form of pipes and cables, to pass through the building footings with the ability to replace them with ease as may be required in the future.

Adequate spare conduits to allow for future growth of services shall be allowed. Such things as electrical and telephone cables may be too big and heavy to be pulled around conduit bends – straight access, without bends or obstructions, shall be provided.

3.1.5 PLANT ROOMS

The Project Architect shall request from consultants the range of sizes for all items of mechanical and electrical plant. The Architect shall ensure that the final selection of mechanical and electrical equipment will not require additional space.

The Project Architect and consultants shall ensure that the plant room layout at the design stage provides for future expansion.

Direct access from corridors to roof areas, plant rooms, tunnels, etc. shall be provided where possible to enable the independent control of these areas by Curtin Properties, Facilities and Development Department.

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

It is preferred that plant rooms be located at rooftop 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 the ground.

Plant room floors shall be graded to floor waste water outlets in order to permit hosing down of floors. Floor surfaces are to be sealed against spillages and flooding by bunding or other approved methods and painted with paving paint.

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 3 dbA. Where this cannot be achieved, the University Project Manager shall be consulted.

3.2 MECHANICAL, VENTILATION AND AIR CONDITIONING

3.2.1 GENERAL

This section of the Project Delivery Guidelines outlines the University's minimum requirements for air conditioning and ventilation systems for both new buildings and buildings being refurbished.

The following functional requirements are to be given special design consideration:

- energy efficiency
- simplicity of design
- accessibility, ease of operation, simplicity of maintenance, combined with minimal maintenance frequency
- life-cycle cost analysis to govern the selection of systems and equipment (the University may call for calculations on competing systems)
- centralised chilled and heating water systems. It is recognised that chilled water systems may initially require a higher capital cost than alternatives such as DX systems, however, on a life-cycle cost analysis, chilled water may be preferable. The decision shall be undertaken in consultation with Curtin's Infrastructure Manager Mechanical Services
- comprehensive metering of chilled water and heating water system usage, in accordance with the requirements described in *000346 PDG Services Metering Guidelines*
- allowance for adequate space for installation and maintenance of machinery whether it be in a designated plant room, ceiling space or otherwise. Lack of space is not considered an acceptable constraint on mechanical design
- compliance with all statutory requirements

- compliance with AS3000. All required test results, including earth looping impedance testing, shall be issued with the as-constructed documentation.

All staff studies are to be provided with an air conditioning system conforming to the following:

- Staff occupy their offices approximately 15 hours per week.
- The system must have an economy cycle in accordance with the NCC requirements or, where systems are greater than 36 kW(r), whichever is the stricter.
- Sensors are to be located 1,200–1,500 mm from the outside wall and on the room dividing wall where the whiteboard/pin-up board is located.

3.2.2 DESIGN CONDITIONS

Careful consideration should be given to the design conditions for various areas with the following design criteria to be the basis of all construction and associated projects.

(i) External Design Conditions – Summer

Teaching Areas 37 °C DB, 24 °C WB

Comms and AV Rooms (Critical applications) 39.7 °C DB, 23.6 °C WB.

(ii) External Design Condition – Winter

7 °C – Non-critical applications 4 °C – Critical applications.

3.2.3 PERFORMANCE STANDARDS

Air conditioning plant shall be designed to maintain the following internal design conditions:

(i) Internal Design Conditions – Summer

22.5 °C DB +/-1.5 °C

55% RH by virtue of cooling coil performance, or RH +/-5% for specific humidity control environments.

Refer to Section 3.2.10 below.

(ii) Internal Design Conditions – Winter

Internal Winter Design Conditions shall be: 22.5 +/-1.5 °C.

(iii) Internal Design Conditions – AV and Comms Rooms

Internal design conditions shall be: 22.5 ± 1.0 °C.

3.2.4 ROOM OCCUPANCY NUMBER

Occupancy levels are based on the University's space allocation rates for various building/facility utilisations. Where project briefing documentation does not stipulate space occupancy rates for specific projects that are required for determining heat-loads, consultants shall forward a request to Curtin University for further relevant

information. Where this information is not available, conform to AS1668 Part 2 as nominated by the Building Code of Australia.

3.2.5 EQUIPMENT LOADS

Equipment loads can be approximately equal to those shown below and are subject to confirmation by the University Project Manager.

- general office 10 W/m²
- laboratories 30 W/m² – to be individually determined
- computer terminal rooms 100 W/m² – to be individually determined.

A request for the comms and/or AV equipment loads shall be submitted to Curtin University to provide the relevant heat load information prior to the sizing of air conditioning equipment. Depending on the nature of the consultant's engagement, the request may need to be via the project electrical/communications/audiovisual consultants for follow-up with Curtin University.

The returned heat load information shall consider:

- equipment load
- UPS load (if provided)
- spare future expansion capacity
- fabric loads.

During construction and prior to the ordering of comms and AV air conditioning equipment, a final survey of the comms and AV equipment shall be conducted to ensure that no changes have been made to the equipment during the design phase.

Where equipment loads have not been identified for a particular area, forward a request to Curtin University for the relevant information.

3.2.6 FRESH AIR RATES

As a minimum, fresh air rates shall be in accordance with AS1668 Part 2 as nominated by the Building Code of Australia.

3.2.7 VENTILATION REQUIREMENTS

Ventilation requirements shall be in accordance with AS1668 Part 2 as nominated by the Building Code of Australia.

In reference to toilet exhaust systems, exhaust air flow rates shall be calculated to meet the minimum requirements of AS1668 Part 2 and the Health Act. 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 changeover on fault, are required as stipulated by the Health Act. Toilet exhaust fans shall be direct drive.

3.2.8 VENTILATION IN PHOTOGRAPHIC DARKROOM AREAS

All fumes are to be extracted at source and systems are not to exhaust fumes by extracting past the operator's breathing zone.

As a minimum, the following ventilation rates shall apply unless otherwise specified by the manufacturer or relevant regulations:

- for Ilfospeed fixers – not less than 15 air changes/hour for mixing and processing areas
- For Ilfospeed Multigrade Developer – not less than 15 air changes/hour for mixing and processing areas
- For Hypain Rapid Fixer – not less than 15 air changes/hour for mixing and processing areas.

For any product containing:

- hydroquinone or sodium formaldehyde bisulphite provide 10 air changes per hour
- methylaminophenol sulphate (such as Kodak Dektol Developer) provide 10 air changes per hour
- acetic acid (such as Kodak Acedic Acid 28%, Kodak Indicator stop bath) provide 10 air changes/hour. Local exhaust required
- trichloroethane (such as Kodak Film Cleaner) allow 10 air changes per hour general room ventilation.

Local exhausts are required where the following are used:

- ethoxyethanol, hydroxylamine sulphate, p-phenylene-diamene, tertiary butylamine borane, selenium oxide, platinum chloride, potassium oxalate, potassium sulphide, potassium permanganate, potassium cyanide, potassium dichromate, ammonia, mercuric chloride, acetic acid, catechin.

3.2.9 FIRE AND SMOKE CONTROL

Mechanical fire and smoke control systems shall be delivered in accordance with AS1668 Part 1, the Building Code of Australia and Curtin University's *000321 PDG Fire Safety Project Guideline*. Certification and commissioning documentation, maintenance and testing procedures, cause and effect matrices and cause and effect functional descriptions are all to be included in the operations and maintenance manuals. Fire/smoke separation is to be clearly indicated in documentation. Refer to the Fire Safety Project Guideline.

3.2.10 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 University Project Manager.

3.2.11 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.

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 designer shall review the design parameters of all equipment on that system to ensure design chilled water temperatures and flow rates are normalised 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.

Curtin University's Mechanical Services section within the Properties, Facilities and Development Department (PF & D) maintain an inventory of chilled water connected load flow rate data for chiller generation plant through to each building down to individual air handling unit coil level. To ensure accuracy of the inventory is maintained, the mechanical services engineer shall ensure that both design and as-installed flow rate data is provided to PF&D on completion of any project that results in addition or changes to chilled water flow rates. The inventory for chilled water systems is available to design engineers upon request.

3.2.12 HEATING WATER TEMPERATURES

For design purposes the following heating water temperatures are to be used:

- Boiler Temperatures – Supply Water Temperature 70.0 °C; Return Water Temperature 55.0 °C (Note that these temperatures are critical in ensuring condensation does not occur in the boiler and so shorten the life of the boiler).
- System Temperatures – Supply Water Temperature 60.0 °C; Return Water Temperature 50.0 °C (Note that these temperatures are critical in ensuring failure of rubber seals associated with Victaulic joints on in-ground heating water pipe does not occur).

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 designer shall review the design parameters of all equipment on that system to ensure design heating water temperatures and flow rates are normalised 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.

Curtin University's Mechanical Services section within PF & D maintains an inventory of heating water connected load flow rate data for boiler generation plant through to each building down to individual air handling unit coil level. To ensure accuracy of the inventory is maintained, the mechanical services engineer shall ensure that both design and as-installed flow rate data is provided to PF & D on completion of any project that results in addition or changes to heating water flow rates. The inventory for heating water systems is available to design engineers upon request.

3.2.13 CONDENSER WATER TEMPERATURES

For design purposes the following condenser cooling water temperatures are to be used:

- Supply Water Temperature 29.5 °C
- Return Water Temperature 35.0 °C.

Leaving condenser water temperature set point from the cooling tower shall be re-scheduled from 29.5 °C to 21.5 °C based on a combination of outside air temperature, time of day and charge mode of chilled water storage tank and in accordance with chiller parameters as specified by the chiller manufacturer. Refer to Air Conditioning Control Functionality in Section 3.5.

3.2.14 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 ductwork shall be installed where necessary to minimise the transmission of fan noise.

Care shall be taken to minimise transmission of vibration to the structure from mechanical equipment. Where reciprocating or rotating equipment is installed this 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 maximum allowable noise levels are scheduled below:

- general offices NR 35–40
- laboratories NR 35–40
- lecture theatres NR 25–30
- seminar rooms/class rooms NR 30–35
- individual offices NR 35–40
- library NR 35.

3.2.15 AIR HANDLING SYSTEMS

Air conditioning shall normally be provided by the use of air handling equipment using chilled and heating water supplied from the University's Central Chiller and Boiler Plant. Direct expansion (DX) refrigeration systems shall not be used unless it can be demonstrated that required conditions cannot be achieved by use of chilled and heating water. The use of direct expansion, window-mounted or through-the-wall room air conditioners (RACs) is prohibited except in transportable buildings or other locations approved by the Infrastructure Manager Mechanical Services.

To achieve better control over operation, unitary-type air handling systems serving a single room or small number of similar rooms shall be provided rather than large central station air handling systems. Air handling systems serving more than one floor

shall not be used. Additionally, multi-zone constant volume reheat systems and floor-mounted console style chilled and heating water FCUs shall not be used.

All air conditioning systems shall have adequate fresh air (in accordance with current code requirements of AS1668 Part 2) drawn from outside the building at locations well away from discharges from cooling towers, fume exhausts, traffic, cooking areas and chemical storage areas (in accordance with current code requirements of AS3666).

All air handling systems are to be of Daikin, Fan Coil Industries, G J Walker, Saiver, Skilled Air, Temperzone manufacture or approved equivalent.

Ensure access is easy and safe to all major components, including motors, fans and coils. Provide lifting points (especially to fan motors) as required to prevent damage to the equipment. Ensure there is adequate physical access in the plant rooms to manoeuvre equipment and carry out maintenance with a view to preventing manual handling injuries. Access to fire dampers shall be provided with fire damper identification labels attached adjacent to fire damper access points.

Air flow switches are to be piped across the suction and discharge sides of fans in air handling systems to indicate fan status.

Where appropriate, air handling systems shall be configured to allow for economy cycle, warm-up cycle and night purge control routines to minimise energy consumption. Base heating shall be via heating water coils located in either the air handler or zone ductwork, depending on the system design. Electric duct heating and VAV box electric reheat shall not be used. Should electric heating be required to meet a specific facility application, approval must be sought through the University's Infrastructure Manager Mechanical Services.

The use of fan-assisted constant volume VAV boxes may be used as an alternative to maintain minimum airflow rates to centre zones and to make use of secondary air as 'free' heating provided that the energy savings can be justified over the increase in cost and maintenance. Cost justification in writing will be required to be submitted to Curtin University's Infrastructure Manager Mechanical Services where fan-assisted VAV boxes are proposed.

3.2.16 COMMUNICATIONS AND AUDIOVISUAL ROOM AIR CONDITIONING REQUIREMENTS

DESIGN REQUIREMENTS

AUDIOVISUAL

It has been pre-determined by Curtin AV that any AV room is to be provided with 100 per cent duty and standby air conditioning.

COMMUNICATIONS

CITS shall be consulted during the design phase of the project with regards to its requirements for ventilation only (natural or mechanical), air conditioning duty only or air conditioning 100 per cent duty and standby, or specific humidity control. This assessment is to be conducted by CITS using a risk

matrix that considers the type of room, value of the equipment and the consequence of communications equipment failure.

100 PER CENT DUTY STANDBY DESIGN PHILOSOPHY

The term 100 per cent Duty Standby shall apply throughout the air conditioning system design such that:

- an A/C unit failure does in no way affect another
- a controls failure of a small point controller does in no way cause both units to fail
- separately fused power supplies are provided to each item of plant
- an electrical failure within the MSSB does in no way cause both units to fail, acknowledging that a single power supply to the MSSB is acceptable
- a UPS is arranged on the power supply to the network and small point controllers to allow alarming even in the event of loss of power.

AIR CONDITIONING

In the case that duty-only equipment is required, the equipment shall be in the form of a chilled water fan coil unit.

In the case that 100 per cent duty and standby units are required, the equipment shall be in the form of a chilled water fan coil unit and a DX system.

The use of CRAC units is acceptable for either the CHW or DX systems however this does not negate the need for duty and standby systems where this is a requirement by the University.

Where a DX system has been provided for duty and standby requirements, consideration for the location of the condensing unit shall be made in consultation with Curtin University and/or the Project Manager where the condensing unit is placed in a location that does not impede air flow through the unit and noise is not a nuisance to the surrounding areas.

Air conditioning units and water valves shall be provided with condensate safety trays. The air conditioning units' trays shall be in addition to the condensate tray inside the unit, and reside underneath it complete with BMS integrated moisture sensor and alarming.

APPROVED MAKES

Wall-mounted Chilled Water FCU:

- ACSON, Daikin, Polar or approved equivalent.

Ducted Chilled Water FCU:

- Dakin, Fan Coil Industries, G J Walker, Saiver, Skilled Air, Temperzone or approved equivalent.

Wall-mounted DX Split FCU:

- Daikin, Mitsubishi Heavy Industrial or approved equivalent.

Ducted DX Split FCU:

- Daikin, Temperzone or approved equivalent.

Computer Room Air Conditioner (CRAC) (CHW & DX):

- Technair or approved equivalent.

MECHANICAL – ELECTRICAL REQUIREMENTS

Run relays shall be powered from the small point controller.

For the case that there is a duty-only CHW FCU, the run relay shall default to the energised position such that a failure of the small point controller or loss of power to the run relay will result in the equipment continuing to run. The CHW valve shall maintain its position on loss of power i.e. does not spring open or closed.

For the case that there is both a duty and standby CHW FCU and DX system, the run relay to the CHW FCU shall default to the non-energised position and the DX system run relay shall default to the energised position on failure of the small point controller or loss of power to the relays. The result shall be that the CHW FCU shall stop and the DX system will start.

UPSs shall be provided for backup power to the controls on loss of mains power. A UPS shall be provided to both the small point controller(s) and to the network controller. The utilisation of UPS(s) shall allow the continuity of communications in the form of faults and alarms to Curtin University BMS front end and pager system. Where both the network controller and small point controller(s) are located within the same MSSB, a single UPS may be utilised for all controllers. If the network controller and small point controller(s) are located in separate MSSBs, multiple UPSs shall be provided as necessary to provide continuity of communications.

CITS shall be consulted during the design phase of the project for advice on the duration that the BMS UPS is required to run. The UPS shall be sized accordingly to match the requirements of CITS and the number of BMS controller devices being served by the UPS. Generally, the UPS shall be sized to match the running duration of any comms and AV UPSs.

UPSs shall be maintained by the BMS contractor for the duration of the defects liability period.

On final completion of the project, the UPS shall be maintained by the BMS contractor whose BMS controls are being supported by the UPS.

Where sufficient space is available, UPSs shall be mounted inside MSSBs. Where sufficient space is unavailable inside MSSBs, UPSs shall be mounted on the wall directly adjacent to the relevant MSSB.

DX system wall controllers shall be lockable to prevent alteration of the temperature set point. Mount DX controllers on the wall within the comms and/or AV room.

Provide run and fault indication lights on the wall adjacent to the door for each system. The DX system shall be provided as standard with an interface card for connection to the BMS and to allow remote start/stop and fault indication and BMS monitoring.

POWER FAILURE RE-ESTABLISHMENT

Provide delay start timing for all equipment which is to be re-energised in the following order following a power outage:

- comms and/or AV Room FCU or DX unit or exhaust fan serving a comms room
- air handling units and associated return air fans (if provided)
- fan coil units and associated return air fans (if provided)
- general supply and exhaust fans.

ALARMS

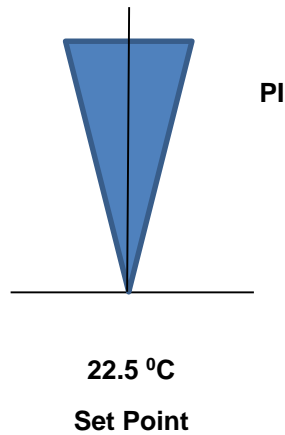
Where comms and AV rooms are put into operation before project Practical Completion, it is imperative that such rooms' environmental conditions are being monitored by the building BMS and the associated Spider systems (if installed) and are fully operational with dial-out alarming via the required alert mediums (paging, SMS, email) to the body responsible for responding to such alarms. Comms and AV rooms shall not be put into operation where this capability is not operational.

The following mismatch alarms shall disable the duty unit, enable the standby unit, raise an alarm on the BMS and on the Maintenance & Operations pager, and illuminate the fault light inside the room:

- comms and/or AV room high temperature alarm with an alarm set point of 28 °C (adjustable)
- failure of a comms and/or AV small point controller
- CHW unit fault (via DP switch across the fan)
- moisture alarm for condensate safety tray to each unit
- DX unit fault (via interface card)
- failure of network controller via another network controller or the BMS server.

SPACE TEMPERATURE CONTROL – COMMS ROOM CV SINGLE ZONE (CHILLED WATER)

Modulate the chilled water valve using Proportional Integral (PI) control to control and maintain the set point (22.5 °C adjustable). The valve opens as determined by the PI loop when space temperature is greater than set point (22.5 °C adjustable) and closes as determined by the PI loop when space temperature is less than set point (22.5 °C adjustable). When the room temperature is at set point the valve shall maintain its position.



3.2.17 CHILLED WATER SYSTEMS

BENTLEY CAMPUS

The existing chilled water system has the following characteristics:

- Central chilled water plant is located in Building 117 (Central Plant – 3-off Trane centrifugal chillers and 1-off York chiller) and Building 154 (North Plant – 2-off Trane centrifugal chillers with provision to accommodate one further 4000 kW_r chiller). One-off 4 million litre chilled water storage tank adjacent to B408 and directly charged from North Plant Chiller N^o 2 and connects into the campus chilled water ring main.
- The chilled water storage tank is discharged during the day as a 'phantom' chiller in order to reduce campus on-peak power demand. The storage tank is charged by the Building 154 chillers at night utilising Johnson Controls Metasys Building Management Systems (BMS).
- The chilled water storage tank stores chilled water at approximately 5.0 °C. Stored water is then discharged during the day at 5 °C, however the tank has the facility to allow discharge water to mix with return water to enable the resetting of tank discharge water temperature should it be required.
- The chilled water system is a decoupled primary water system at the central plant level with secondary variable speed pumps utilised for chilled water distribution to the campus. Some additional secondary pumps are also in use in various buildings where the operating head is significant.
- A reticulated chilled water distribution system across the campus serving most buildings utilises a 2-way control valve arrangement with 3-way valves on index legs.
- The secondary chilled water pumps are controlled via differential pressure sensors located in specific buildings as represented on the BMS.
- A cooling call is generated from each building, which enables the chilled water plant. The cooling call is typically generated via any chilled water valve that opens more than 70 per cent and the cooling call is disabled when all chilled water valves for that building are closed less than 20 per cent.
- A chilled water make-up tank is located at the highest point on the campus in Building 402.

- The chilled water plant utilises the Johnson Controls BMS (B117, B154 and B408) that utilises low level and high level integration to control the chilled water generation system.
- There is a smaller chilled water plant located in Building 155 that is dedicated to Building 500 (South Plant – 3-off Trane screw chillers). This system has no physical connection to the main campus chilled water ring main. This facility is controlled by a LON-based Johnson control system and is integrated into the Johnson Controls Metasys BMS.

EXTERNAL CAMPUSES

Curtin’s campuses external to the Bentley Campus have the following chilled water systems:

- 78 Murray Street – One-off air-cooled chiller with scroll compressors provides chilled water to levels 1 and 2 with the chiller controlled by a Johnson BACnet BMS that is integrated into the University’s Johnson WAN.
- Kalgoorlie – One-off water-cooled Trane reciprocating chiller that provides chilled water to Building 706. It has standalone electric control. Building 701 has one-off air-cooled Carrier chiller with scroll compressors providing chilled water to Building 701 (AHU 1 only). This chiller is controlled by a Johnson BACnet BMS that is integrated into the University’s Johnson WAN.
- Technology Park – Two-off Trane water-cooled chillers providing chilled water to Buildings 611,612 and 614. The chillers are controlled by a Johnson BACnet BMS that is integrated into the University’s Johnson WAN. The chillers are interlocked such that only one chiller can run at a time, as the power supply limitations to B612 limit the ability to run two machines together.

If a new building is being planned to run off any of the 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, the existing chillers have the capacity, existing expansion tanks are suitable in height and size and that the new control system interfaces with the existing central plant control system. Consideration for an additional differential pressure sensor to form part of the chiller plant control logic shall be assessed for each new building.

3.2.18 HEATING WATER SYSTEMS

BENTLEY CAMPUS

The existing heating water system has the following characteristics:

- Central heating water plant is located in Building 117 (Central Plant – 2-off gas-fired boilers), Building 154 (North Plant – 2-off gas-fired boilers) and B408 (1-off gas-fired boiler).

- Building 117, Building 154 and B408 boilers are controlled by Johnson Controls Metasys BMS and are fully integrated.
- The heating water system is a decoupled primary water system at the central plant level with secondary variable speed pumps utilised for heating water distribution to the campus. Some additional secondary pumps are also in use in various buildings where the operating head is significant.
- A reticulated heating water distribution system across the campus serving most buildings utilises a 2-way control valve arrangement with 3-way valves on index legs.
- The secondary heating water pumps are controlled via differential pressure sensors located in specific buildings as represented on the BMS.
- A heating call is generated from each building, which enables the heating water plant. The heating call is typically generated via any heating water valve that opens more than 70 per cent and the heating call is disabled when all heating water valves for that building are closed less than 20 per cent.
- The heating water system is a pressurised system with a large dedicated expansion tank 'farm' located at the roof top level of Building 105. Should this facility fault, expansion automatically changes over to the default atmospheric heating water make-up tank located at the highest point on the campus in Building 402. Control of the heating water expansion system in Building 105 and Building 402 is by Schneider Electric's StruxureWare BMS.
- There is a smaller heating water plant located in Building 155 that is dedicated to Building 500 (South Plant – 2-off gas-fired boilers). This system has no physical connection to the main campus heating water ring main. This facility is controlled by a LON-based Johnson control system and is integrated into the Johnson Controls Metasys BMS.

EXTERNAL CAMPUSES

Curtin's campuses external to the Bentley Campus has the following heating water systems:

- 78 Murray Street – No heating water system installed
- Kalgoorlie – One-off gas-fired boiler that provides heating water to Building 706. It has standalone electric control. Building 701 has one-off gas-fired boiler that provides heating water to Building 701 (AHU 1 only). This boiler is controlled by a Johnson BACnet BMS that is integrated into the University's Johnson WAN.
- Technology Park – No heating water system installed.

If a new building is being planned to run off any of the existing heating 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, the existing boilers have the capacity, existing expansion systems are suitable in height and size and that the new control system interfaces with the existing central plant control system. Consideration for an additional

differential pressure sensor to form part of the heating water plant control logic shall be assessed for each new building.

3.2.19 STEAM SYSTEMS

BENTLEY CAMPUS

- One Tomlinson gas-fired steam generating boiler located in B306, nominal capacity of 400 kW
- One Tomlinson gas-fired steam generating boiler in B308, nominal capacity of 400 kW.

The boilers serve multiple buildings each.

3.2.20 CONDENSER WATER SYSTEMS

Water treatment of condenser cooling water systems shall be in accordance with AS3666 and shall further provide the following as a minimum:

- monthly Legionella testing
- automatic dosing of chemicals associated with protection against corrosion
- automatic dosing of biocides associated with microbial control. Additionally, automatic dosing shall be set up to provide for rotation of biocides. Biocide chemicals shall be injected into the condenser water inlet side of chiller condensers. All condensers, pipework and cooling tower wetted surfaces shall be treated by biocides including potential 'dead-legs' such as condenser bypass pipework.

Disposal of cooling tower waste water is to be in accordance with local authority bylaws and the water supply authority.

Where a BMS is available within a condenser water system plant room, automatic time scheduling of biocide dosing shall be achieved via the BMS. A dedicated web-based remote monitoring control system of Megatronics manufacture will be provided for on all condenser water systems. Remote user access shall be by way of connection to the University's intranet. If this facility is not available or proves cost-prohibitive, then remote access shall be by a dial-in GSM capability.

3.2.21 DUCTWORK AND AIR DIFFUSION

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 per cent 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 as required to suit the application. It is the University's preference not to use rigid fibreglass ductwork but to use alternatives such as Tontine.

All flexible ductwork used for supply air or return air shall be externally insulated to reduce heat transfer. Flexible ductwork shall be in accordance with AS1668 Part 1 and shall have early fire hazard properties not exceeding the following indices when tested in accordance with AS1530 Part 3 and AS4254:

- Spread of Flame 0
- Smoke Developed 3.

Should the installation of electric heater banks be unavoidable, the heater bank linings shall be in accordance with AS1668 and be constructed from Harditherm 700 or approved equivalent.

Ceiling diffusers shall typically be of the circular Krantz diffuser type however correct engineering and selection as prescribed by Krantz Pty Ltd is to be adhered to. Alternatives to Krantz will require approval from Curtin University. Additionally, where motorised Krantz diffusers are installed, access to the diffuser motor for servicing is to be provided to the acceptance of Curtin University. Ceiling diffusers shall be retained in position by a threaded screw/bolt arrangement. Where it is proposed to use an alternative arrangement, approval from Curtin University's Infrastructure Manager Mechanical Services is required. All diffusers shall incorporate insulated cushion heads with flexible ductwork to spigot take-off from the main distribution duct, to allow easy relocation of diffusers as required. Where diffusers are located in roof spaces, the back surface of the diffuser exposed to the roof space shall also be insulated to prevent condensation on the diffuser. The insulation shall be glued with a suitable adhesive to prevent lifting of the insulation. All raw edges of the insulation shall be sealed.

Wall registers shall be of the adjustable blade type with opposable blade dampers (OBD) installed behind the register for ease of air balancing. The front set of blades is to be horizontal. The maximum blade spacing shall be 20 mm.

Toilet exhaust grilles shall be of disc or egg crate type.

Return air/relief air grilles are to be egg crate, half chevron or full chevron type.

3.2.22 PIPING, VALVES AND FITTINGS

Piping installations shall be in accordance with current best practice methodologies and be installed in strict accordance with the manufacturer's recommendations. All pipework shall be suitable for its respective service under the actual operating conditions with respect to temperature and pressure. The pipework installations shall ensure that adequate means are provided for taking up pipe expansion through its operating temperature ranges. Piping shall be arranged in a workmanlike manner, true to alignment and grade.

All condenser water pipe shall be 316 stainless steel.

In general, chilled water and heating water lines within buildings shall be of Type B copper.

For in-ground chilled water pipework situated outside of the thrust blocks, un-plasticised PVC piping (Blue Brute) shall be utilised. Stainless steel piping (minimum 316) shall be utilised for chilled water pipework situated within thrust blocks.

For in-ground heating water pipe, stainless steel piping shall be utilised. Victaulic couplings shall be utilised for pipework connections with pipes being a maximum length of six metres between each coupling to accommodate expansion of the pipe.

Specific grades and standards of pipe and associated material shall be specified by the project mechanical engineering consultant in the project specification and, as a minimum, shall reference the relevant Australian standards.

Transition from one material to another shall be made adjacent to the buildings in a pit that is always readily accessible. Valves shall be of approved manufacture and shall be in easily accessible positions.

Chilled water and heating water in ground mains pipes are to be located under paving unless funds allow their location in culvert ducts or covered walk-way ceilings. In-ground chilled water mains shall be installed to a minimum depth of 1,200 mm to the top side of the pipe while heating water pipe will be installed to a minimum depth of 800 mm to the top side of the pipe. The heating water pipe will be installed above the chilled water pipe.

Drain points (50 mm ball-type threaded valves) and air vents shall be installed in each pipe on each side of the isolation valves in the chilled water and heating water systems. The 50 mm ball-type drain valves shall be provided at the lowest point in the chilled water and heating water pipe, which allows for pipe segment drain down and as a connection point to enable the system (and pipe segment) to be flushed (see Pipework Flushing and Cleaning section). Air vents shall be of the automatic float type installed in a 'bottle' installed at the highest point within the pipework. Isolating ball valves shall be installed between each air vent and the main pipe and 13 mm drain lines shall be run from each vent to the nearest drain point. For in-ground pipework, all vents and drains shall be accessible from within the valve pit or be piped to the closest valve pit location.

Valves shall be of the type to suit the application, but generally be as scheduled below:

- Isolation Ball valves to 40 mm diameter
 - Wafer-type butterfly valves from 50 to 500 mm diameter
 - Gate valves from 300 mm diameter
- Throttling Plus Isolation
 - Double regulating valves from 15 to 65 mm diameter (for bypass legs across coils at index runs only)
 - Wafer-type butterfly valves from 50 to 300 mm diameter
- Modulating Control Valves
 - Belimo Characterised Control Valves (CCV) only (with manual over-ride capability)
- Non-return Valves

- swing check valves
- Gauge Cocks
 - ball valves
- Pressure/Temperature Test Points
 - Binder Double Seal type.

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 Characterised Control 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 apparatuses.

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 the layout of pipework in plant rooms does not interfere with the direct route of removal of equipment within plant rooms.

Where pipes pass through floors or walls, sleeves shall be specified and filled with appropriate sealant to suit the application. Provide a fascia plate 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 shall be stainless steel and, where appropriate, are to have threads coated in nickel anti-seize.

Any variation of valve types/applications from the above shall be notified in writing to Curtin University prior to the ordering of equipment.

Where an 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. The mechanical design engineer shall advise Curtin University's Infrastructure Manager Mechanical Services of the current and future system characteristics.

3.2.23 PIPEWORK INSULATION

All in-ground heating water pipe and portions of chilled water pipe as specified shall be pre-insulated incorporating rigid polyurethane foam that is machine injected into the annular void between the carrier pipe and outer casing via an acceptable factory process. The protective outer casing shall be manufactured from high density polyethylene (HDPE) extruded in one piece. Bends, tees, reducing joins and straight joins shall be site insulated using two-part rigid polyurethane foam. All fittings shall be metal sheathed and correctly vapour sealed with a heat shrink sleeve. Site insulation shall only be carried out by trained personnel. Approvals are to be sought from the

project mechanical consulting engineer and Curtin University's Infrastructure Manager Mechanical Services.

Above-ground heating water pipework insulation may utilise polyolefin foam, mineral wool or fibreglass type insulation products. Heating water insulation samples must be submitted for approval by Curtin University prior to work commencement.

For above-ground chilled water piping, polystyrene insulation complete with Sisalation vapour seal shall be specified. Insulation for valves, flanges and fittings shall be arranged for easy removal during maintenance, and shall be provided with hinged and clipping casings. Pipes must be coated with Denso bedding compound before insulation is installed to offer extra protection against moisture tracking. A complete vapour seal must be achieved via foil Sisalation sheathing over all sections of insulation with seams being fully taped and glued in all cases. Timber blocks, when used, must be properly foiled on the abutting face and have bedding compound on the mating surfaces between block, pipe and insulation preventing the migration of moisture across the block. Blocks must be 15 mm wider on each side than the strap supporting it allowing a fully vapour tight taped junction to be achieved without having to remove or loosen the strap. When possible, non-timber, thermally insulating blocks should be used to achieve a better performing joint. Block samples must be submitted for approval before work commencement.

All exposed insulated pipework in plant rooms, up to 2,000 mm above floor level or external to the building must be fully metal sheathed as an addition to the standard vapour sealing requirements. Insulated pipework in concealed areas does not require metal sheathing.

3.2.24 PIPEWORK FLUSHING, CLEANING AND DOSING

3.2.24.1 Scope

All new pipework installations, repairs and modifications are required to be pre-flushed, cleaned and dosed prior to systems being opened to the Campus ring main. The pipework flushing, cleaning and dosing shall comprise the following activities:

- pre-flushing
- chemical cleaning
- final flushing
- final filling
- dosing.

3.2.24.2 Procedures

The following flushing and cleaning procedures shall be carried out, as a minimum, in the following order:

- Fill all pipework with clean water and circulate in accordance with the minimum flushing velocities as outlined in the consultant's specifications.
- Advise the system volumes to the incumbent water treatment company.

- Inject and circulate cleaning agent and passivator (provided by the water treatment company) to the system. Make application to the Water Authority for discharge of chemicals in accordance with all statutory requirements.
- Remove water from the systems and flush with clean water to remove cleaning agents.
- Carry out a final fill with clean water and submit a sample to the water treatment company.
- On acceptance of the clean final fill test results, dosing chemicals shall be provided by the incumbent water treatment company and injected into the system.
- Circulate through the system to the satisfaction of the incumbent chemical water treatment company.
- Provide a sample to the water treatment company for acceptance testing.

3.2.24.3 Requirements

All chemicals used for cleaning and dosing shall be provided by the incumbent water treatment contractor. System volumes shall be provided to the contractor to allow correct quantities of chemicals to be determined. The contractor shall be advised of all materials used within the piping system to confirm compatibility with treatment and cleaning chemicals.

Water used for filling of pipework segments for pressure testing and final filling before opening the segment to the main campus system shall be sourced from site scheme water connection points and shall be metered. Water consumption values are to be provided in writing to the project Responsible Officer who will advise Curtin University's representative responsible for University water usage. Note – water is not to be sourced from the existing chilled and heating water systems or from the campus fire water system. Access to the fire water system will activate the campus booster pumps, resulting in the generation of an alarm to Campus Security.

3.2.24.4 Acceptance Testing

FINAL FLUSHING

The following performance criteria shall be met prior to the final dosing of the new pipeworks:

- pH: 8–10
- No visible turbidity.

FINAL DOSING

The following performance criteria shall be met prior to the new pipework being opened to the campus:

- pH: > 8.5
- TDS: < 5000 ppm

- Inhibitor: > 100 ppm.

3.2.24.5 Records

Copies of the water treatment company's final test certificates shall be included within the operation and maintenance manuals illustrating final readings in accordance with the targets set out in section 3.2.24.4.

3.2.25 IDENTIFICATION OF PIPEWORK

All pipes shall be identified in accordance with AS1345 – 1972 for the Identification of Piping, Conduits and Ducts and AS1318, Industrial Accident Prevention Signs. 'Safetyman' adhesive labels are an acceptable method for identification of pipework. Flow direction arrows shall be provided to all chilled and heating water pipework. All pipework exposed to view outside of plantrooms and riser shafts shall be fully painted, either in accordance with colour standards contained in AS2700 or to Architect's requirements where it impacts the visual amenity of facilities and the Campus.

3.2.26 UNDERGROUND SERVICES

All underground services including pipework, conduits etc. shall be laid in sand and shall be identified by laying continuous PVC marker tape not less than 300 mm 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, permanent concrete or cast iron markers located at ground level are to be provided.

All pits laid in paving are to be trafficable to medium standard as recommended by Curtin University's Properties, Facilities & Development Department.

TREES AND SHRUBS

Root systems of trees do significant damage to in-ground services and particularly to chilled and heating water pipes. Consideration needs to be given when planting trees near in-ground chilled and heating water pipes. Advice is to be sought from a Curtin University-approved horticultural consultant as the invasive nature of trees and shrubs is generally dependent on the type of tree/shrub being planted. Pipes are installed typically at a depth of 1,200 mm and 800 mm top side for CHW and HTGW respectively. Trees/shrubs that have invasive root systems shall be planted such that root systems are a minimum distance of 3,000 mm to the nearest pipe edge, recognising that excavation to repair pipes at the nominated depths would otherwise necessitate removal of trees as the angle of repose of the excavation would impact on the tree and stability of the surrounding terrain.

3.2.27 PLANT AND EQUIPMENT

AIR COOLED CONDENSERS

Where air cooled condensers are proposed, they should preferably be of the vertical air flow type with air drawing through the coil.

AIR HANDLING PLANT

Air handling plant associated with variable air volume boxes shall incorporate variable speed drives to control supply air fan speed to suit the static pressure set point.

Coil velocity shall be limited to:

- 2.2 m/s – cooling
- 3.0 m/s – heating.

The use of return/relief air fans should be avoided if possible; depending on the configuration of the air handling plant and air distribution system. The use of return/relief air fans limits the use of the economy cycle in trying to modulate to achieve the leaving air temperature set point. The use of dissimilar return/relief and supply air fans, as in centrifugal and axial type fans, is also discouraged due to the different pressure/airflow performances of the fans, particularly on variable air volume systems where both fans incorporate variable speed drives.

Economy cycle dampers that will also be utilised in the night purge control routine shall be provided where appropriate and on units greater than 36 kW_r in capacity. Air handling units shall incorporate a motorised minimum outside air damper which shall close on early morning warm-up cycle.

BELT-DRIVEN EQUIPMENT

All installations utilising exhaust fans shall be direct drive. Where installations have no option but to require belt drive means, the installation shall have a minimum of two vee belts and the pulleys shall be equivalent to Taperlock.

CHILLER SETS

Vapour compression chillers shall be of Trane, Carrier, York or Daikin manufacture while absorption chillers shall be of Broad manufacture. Generally chillers are preferred to be the low-speed multi-stage type with no gearbox. Water-cooled helical screw-type chillers are the preferred option up to 2,000 kW_r while centrifugal chillers above 2,000 kW_r shall be specified. Where water-cooled type chillers are to be provided, particularly helical screw-type chillers, regardless if they are lead or lag, they shall incorporate condenser water throttling/control for cold condenser water starts, in accordance with the manufacturer's recommendation. Air-cooled chillers up to 1,000 kW_r will generally utilise scroll compressors with a minimum of two refrigeration circuits with multiple compressors per circuit providing flexibility in staging, stable operation at low load and redundancy such that, should one circuit fault, the other continues operation.

Chiller requirements other than those specified here require approval by the University's Infrastructure Manager Mechanical Services.

Chiller condenser vessel tube-sheets shall preferably be constructed from stainless steel. Where mild steel tube-sheets are supplied with new chillers, the tube-sheet shall be treated with a protective coating such as 'Corocoate'. Where Corocoating of tube-sheets and water boxes is not provided, the application of a plastic epoxy-type coating to the tube-sheets and water boxes shall **NOT** be applied. In such cases, cathodic

protection through the application of sacrificial anodes shall be provided as a minimum along with best practice application of condenser water anti-corrosion inhibitor treatment. Treatment of tube-sheets and the cathodic protection type, along with maintenance requirements, shall be documented in plant operations and maintenance manuals.

Chiller ancillary electrical components such as contactors, contact sets, coils and relays etc., shall be freely available 'off the shelf' in Australia. In turn, power and control circuit voltage must be of a standard that allows the procurement of 'off the shelf' replacement component parts within Australia.

Chillers shall incorporate control modules, such as BacNet and LON, which allow remote chiller plant management and monitoring. Control functions shall facilitate chilled water reset, chilled water throttling valve control, chilled water bypass control and condenser water reset and/or condenser water throttling valve/bypass valve control.

Where a BacNet or LON high-level interface is provided, the control system shall be configured to:

- monitor refrigerant temperatures and pressures
- monitor percentage compressor loading
- monitor compressor Amps and run times
- allow variation of percentage load limit
- identify low-level and high-level alarms such that, on failure of one compressor, the compressor is rotated to lag position, allowing the chiller to continue operation until a major fault isolates that chiller.

The cooling capacity selected for the chiller shall take into account the staging capacity of the chiller plant to ensure a sequential and lineal grade of capacity increase and decrease. The make and model of the chiller/s to be specified shall take into account Coefficients of Performance (COPs) at part load, varying chilled water supply temperatures and varying condenser water temperatures based on an integrated part load value (IPLV) assessment. Life-cycle costing of operating and maintenance profiles over 20 years shall be forwarded to Curtin University for verification prior to the consultant issuing a tender specification.

CHILLED WATER DRINKING FOUNTAINS

Chilled water drinking fountains shall be provided on each floor and comply with needs for people with disabilities. Each fountain shall have two taps with one being a spout suitable for filling of cups and bottles.

COOLING TOWERS

Cooling towers shall be of BAC (Baltimore Aircoil) manufacture or approved equal. Cooling towers shall be constructed of fibreglass or other approved non-corrosive material and in accordance with requirements contained in AS3666. Cooling tower sumps and condenser water take-off pipe assemblies shall be of fibreglass or non-corrosive material and shall be completely free draining, that is, build-up of sediment

as a result of general maintenance and cleaning of towers, cannot occur. Cooling tower construction shall allow all wet surfaces to be exposed to chemicals associated with water treatment at all times. Cooling tower construction shall not allow the development of bio-film barriers that will affect water treatment effectiveness. Hot dipped galvanised ladder-access platforms shall be provided that enables safe working access to all serviceable components/areas of the cooling tower.

Where new cooling towers are provided they shall incorporate an automatic cooling tower cleaning filtration system complete with basin cleaning nozzles to the approval of Curtin University's Infrastructure Manager Mechanical Services. The filter type used with this type of system shall be a Filomat Auto Rinsing Screen Filter as manufactured by Filomat.

The selection of a cooling tower shall be undertaken in conjunction with the selection (or matching) of the associated chiller to ensure COPs at design and part load conditions are achieved. Cooling tower fans shall incorporate variable speed drives, suitably controlled to maintain design condenser water temperature to each cooling tower basin. Tower flow and suction header pipework shall be configured to ensure that water distribution through and from the towers is uniform across all towers. This will necessitate careful consideration by the design engineer particularly in relation to the suction header by ensuring there is sufficient head that will provide even draw from each cooling tower.

Disposal of cooling tower waste water is to be in accordance with local authority bylaws and the Water Authority's requirements. Where possible, Curtin University sustainability objectives require consideration by the design engineer for the reuse of waste water. The option of discharge to sewer as trade waste must be maintained.

EXHAUST FANS – ROOF-MOUNTED

Roof-mounted exhaust fans shall be the direct drive type and utilise speed controllers or variable speed drives as required, depending on the fan motor size to achieve required air flow rates. The use of belt-driven fans is not the preferred option and, if a belt-driven fan is proposed, then it shall be subject to approval by Curtin University's Infrastructure Manager Mechanical Services.

EVAPORATIVE COOLERS

Evaporative coolers shall be constructed of aluminium similar to 'Bonaire' or approved equivalent.

FANS

EC Plug Fans are preferred for use in air handling plant with a focus on energy efficiency and system redundancy. Where fans are centrifugal fans they are to be of approved manufacture with backward curved aerofoil-shaped blades. Fans shall be of Fantech or Ziehl manufacture or approved equivalent.

FILTERS

Filters shall be SW Hart, Email or other approved equivalent and conform to the minimum filter efficiencies as outlined in AS1668 Part 2 and, as a minimum, achieve 20 per cent efficiency using Dust Test No 1 as per AS1132.5. The following is a guide to the type of filters to be specified:

- air handling plant above 3,000 L/s shall utilise Pyracube, Four Peak or deep bed-type filters
- air handling plant under 3,000 L/s shall utilise V-Form extended media
- throwaway-type grease filters Email type GW
- dry media filters shall be of the disposable type.

Outside air intakes for large air handling systems shall be provided with pre-filters located behind the plant room air intake grille. Pre-filters shall be of Email SP panel-type filter with KO-type media or approved equivalent to achieve a minimum of 75 per cent efficiency at AS1132 Dust Test No 4.

Filter bank pressure drop shall be measured and trended via a differential pressure sensor monitored by the BMS. Non-critical alarms will be raised via the BMS alarm log requesting maintenance attendance when the filter reaches its full holding capacity. Magnahelic gauges shall be provided to sense filter bank pressure drop only where the criticality of the system necessitates local monitoring or where connection to the BMS is not possible. Magnahelic gauges shall indicate the pressure at which filters shall be cleaned/replaced.

FUME CUPBOARDS

The requirements for fume cupboards are presently under review pending the outcome of a detailed audit being undertaken by the University as part of its HAZMAT program. It is anticipated that this section will be substantially updated once the audit of fume cupboards is finalised, which is expected to be approximately 12 months from the date of this guideline. In the interim, design of all new ducted fume cupboards and recirculating cupboards must be done in consultation with Curtin's Infrastructure Manager Mechanical Services.

Design of fume cupboards shall be in accordance with the relevant standards and shall consider their intended use together with the chemicals and other hazardous substances intended to be used in them. Acceptable fume cupboards are those manufactured by Johndec, Labsystems or approved equivalent. Approved equal means as approved by the University's Infrastructure Manager Mechanical Services.

HEATER BANKS

Hot water space heating shall be provided by the Campus centralised heating water system. Electric heater banks can only be used where other alternatives are cost-prohibitive based on a full life-cycle cost analysis. Electric heater bank control shall utilise pulse width modulation for the staging of the heater banks as described in the Controls section of this document.

HEATING WATER BOILERS

Heating water boilers shall be forced-draught high-efficiency condensing boilers.

Boilers shall have waste condensate neutralisation and cooling arrangements before discharging to sewer.

Boilers shall be fitted with OPSO regulators with either a pressure relief valve piped to atmosphere or a regulator with internal relief.

MOTORS

Shall be totally enclosed fan-cooled and normally be limited to 1,450 rpm maximum. Motors for variable speed operation shall be selected for sufficient dissipation of localised motor heat when running at low speed. High-efficiency motors shall be specified. Motors over 4.0 kW are to be soft start where a VSD is not in use.

PRESSURE VESSELS

All equipment supplied to the University that contains a pressure vessel (including chillers) shall be registered in accordance with relevant Australian standards, legislation and Worksafe WA requirements. Pressure vessels will be stamped with the Worksafe WA plant registration number with pressure relief valves tagged with their next due calibration/renewal date as required under the registration.

In addition to statutory requirements, copies of registration certificates and inspection reports/datasheets shall be included in operations and maintenance manuals with a separate copy issued to Curtin University's Infrastructure Manager Mechanical Services.

Examples of equipment that contain pressure vessels that may be required to be registered include, but are not limited to, the following:

- chillers – evaporator and condenser vessels
- boilers
- air compressors
- vacuum systems
- autoclaves.

Inspection, certification and maintenance requirements of pressure vessels shall be detailed in Operations and Maintenance Manuals.

PUMPS

Close-coupled pumps may be used up to 30 kW. Beyond 30 kW, pumps shall be decoupled. Installations with a 50 mm suction and greater shall be Ajax IS 'Back End Pull Out'-type or approved equivalent. Under 50 mm suction they shall be Ajax 'Vertical Split End'-type or approved equivalent. Impellers shall be bronze; casing above 25 mm – gunmetal; below 25mm – bronze; shafts shall be 316 stainless steel minimum. All seals shall be mechanical seals.

VAV BOXES

VAV boxes shall be Johnson or approved equivalent. Depending on the design, variable volume boxes utilising a single primary air system are preferred. Subject to justification to and approval by Curtin University's Infrastructure Manager Mechanical Services, the use of series or parallel-type fan-assisted VAV boxes may be considered but is not preferred. 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. The airflow/pressure switch shall be interlocked with any electric trim duct heaters (noting that electric heating should be avoided).

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. Test certificates indicating performance testing and QA/QC checks shall be included in the operations and maintenance manuals.

VARIABLE SPEED DRIVES

Variable speed drives (VSDs) shall be of Danfoss, ABB or Zener manufacture.

Installation of VSDs shall be in accordance with current standards as provided by Standards Australia and relevant legislation.

Curtin University's Building Management Systems shall control the VSD. The BMS shall provide a minimum input/output (I/O) interface to the VSD as follows:

- one analogue output to ramp the VSD proportionally (0 – 10 vdc)
- one digital output to provide isolation contactor and VSD-enable (24 vac)
- one digital input providing the BMS with VSD fault status (dry contacts).

DDC control wiring shall be such that the VSD can be enabled/disabled via a Manual/Off/Auto switch located on the Mechanical Services switchboard. The VSD can be further controlled on the VSD by use of local control functionality.

The DDC-enable input on the VSD shall be provided with a 'bridge' (where required) to give a permanent enable on the VSD.

The DCC-enable signal shall not be removed until after the analogue output signal to the VSD is equal to or less than a value of 0 per cent and a minimum time has elapsed that is equal to or greater than the ramp-down time as set on the VSD plus 15 seconds.

Should the VSD experience a fault condition, the VSD diagnostic display shall be retained so that it can be interrogated for fault-finding purposes.

VSDs will generally not be used on EC Plug Fans. Such fans should connect directly to the University's BMS via BACnet connectivity and be controlled accordingly as stipulated by the fan manufacturer.

All VSDs shall be earthed to comply with AS3000.

3.2.28 INSTRUMENTS

All instruments shall be calibrated to read in the SI system of units. Dial gauges shall be 100 mm minimum diameter and shall be installed to allow the gauge to be zeroed when not in use. The range of the instrument shall be suitable for the application i.e. normal operating point equal to 80 per cent of full scale deflection.

All buildings shall incorporate flow meters in the chilled and heating water building return mains pipe to facilitate thermal energy consumption recording and reporting. Thermal metering shall be installed strictly in accordance with *000346 PDG Services Metering Guidelines*.

3.2.29 AIR CONDITIONING ELECTRICAL SYSTEMS

Switchboards and motor control centres shall be constructed in accordance with requirements outlined in the Electrical Services section of Curtin University's Project Delivery Guidelines.

Permanent, clearly legible Traffolyte labels shall be fixed to all internal and external controls.

Fire alarm relays shall be provided in accordance with the requirements of AS1668 and AS1670 as applicable.

A minimum of 25 per cent 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 AS3000.

Where HRC fuses are in use, a minimum of three fuses of each size and type shall be specified as spares and shall be contained in holding clips on the inside of switchboard cubicle doors.

Hours-run meters shall be provided on all items of equipment that 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.

The strategy for measuring and tracking energy use by mechanical services systems will require greater detail and consideration of requirements outlined in the Sustainability and Electrical Services sections of Curtin University's Project Delivery Guidelines.

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

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.

Heater protection thermostats, complete with fault lights (visible from within the occupied space), shall be provided to all heaters, including those associated with VAV boxes. Air flow switches shall be incorporated in all electrically heated air systems.

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

3.2.29.1 EC Motor Fans – Specific Requirements

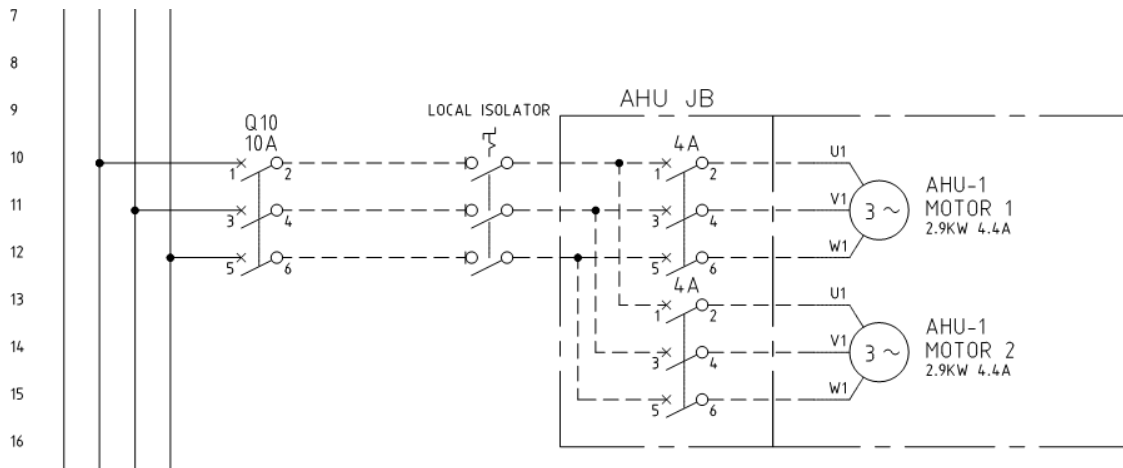
This section relates to air handling systems that contain one or more EC motor fans. The objective is to provide guidance on the standardisation of wiring requirements that meets AS wiring rules, manufacturers' requirements and Curtin operational requirements.

WIRING ARRANGEMENTS

Electrical wiring to EC fans shall comply with AS3000 and the manufacturer's requirements. For systems containing more than one EC motor in a unit:

- power from the MSSB to a single isolator switch
- power from the isolator to a sub-panel, fitted external to the unit, containing a circuit breaker for each fan.

Example diagram:



Irrespective of the number of fans per unit, consideration must be made for CTs on the power supply to each fan to aid with run and fault monitoring, interfaced to MSSB and BMS, particularly for manufacturers who do not provide HLI run/fault information and more prevalent on multi fan units.

SWITCHBOARD REQUIREMENTS

Standard requirements for fan interfaces on MSSB generally include:

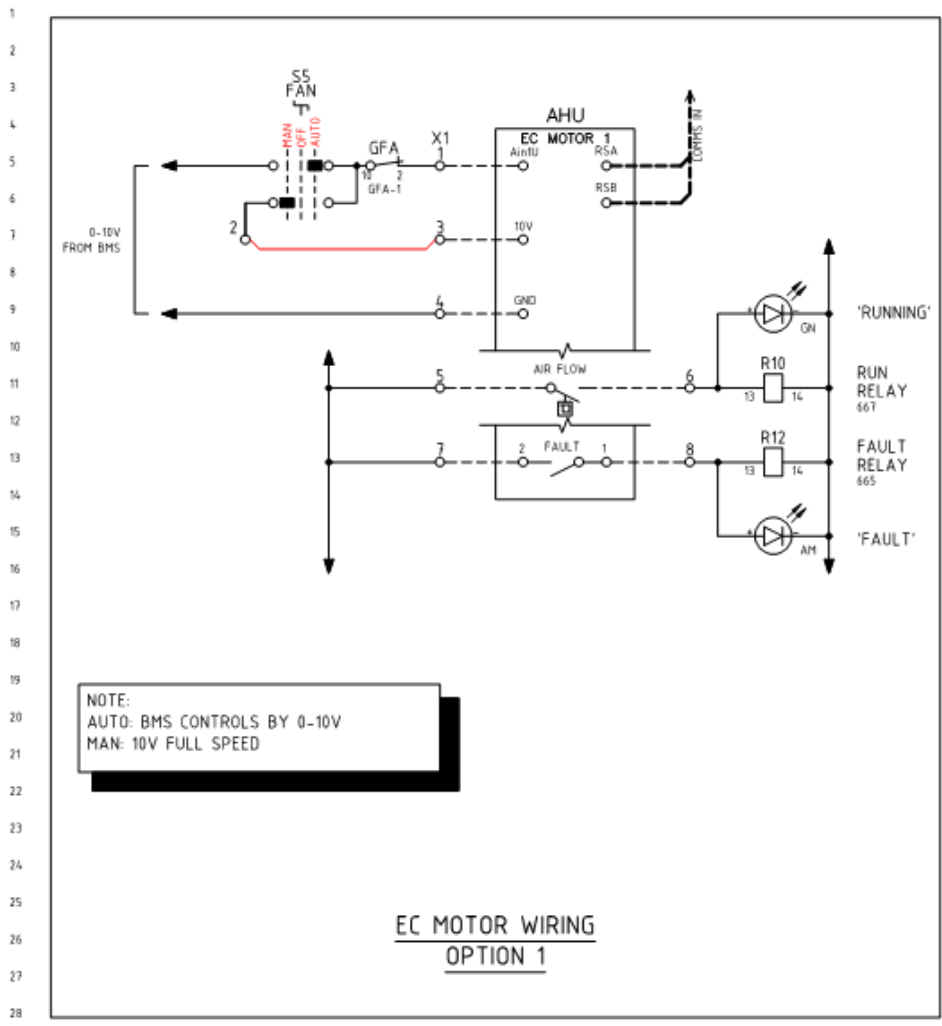
- Manual/Auto/Off or Off/Auto switches
- Run and Fault lights.

How the above is achieved will vary between manufacturers of EC motor fans. The consultant must determine the appropriate solution(s) as it may relate to specific installations, where necessary in consultation with Curtin University.

Three key options shall be considered, with examples outlined below. The examples relate to single fan units and consideration must be made to achieving the same outcomes with units containing multiple EC motor fans. This may require manufacturer-specific HLI or third-party vendor HLI be installed to provide fan fault or

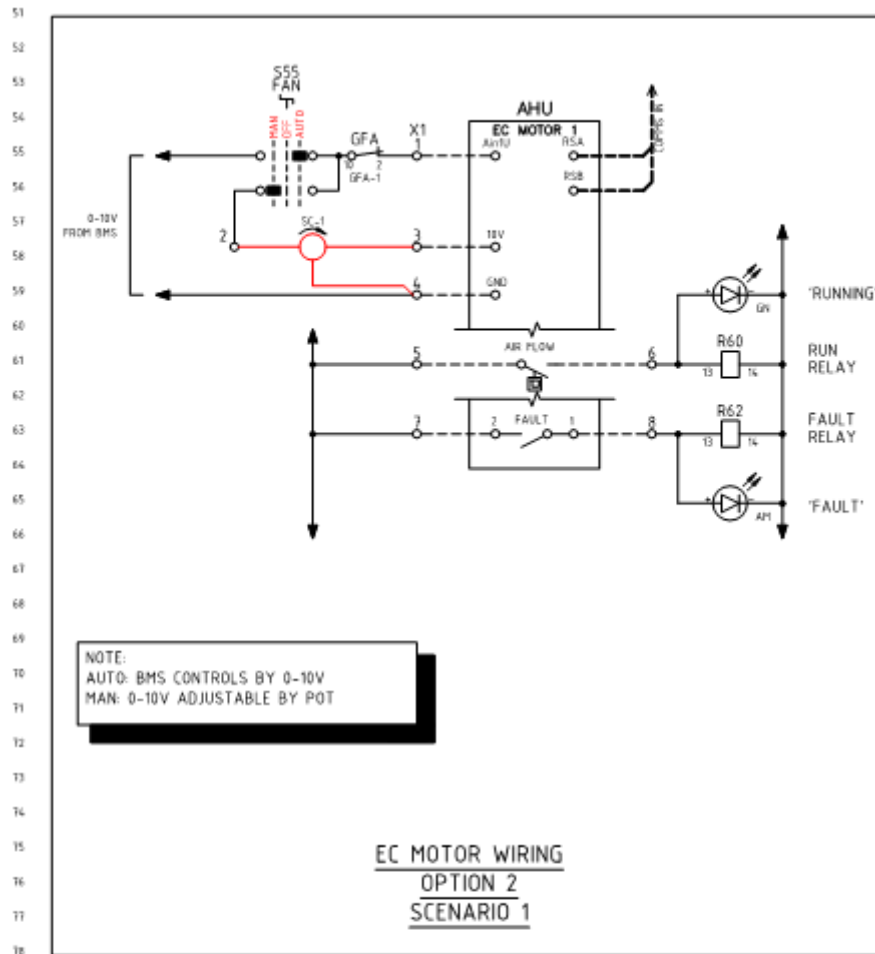
run indication/status noting that air differential pressure sensing across fans may not be adequate.

Option 1 – Fixed Speed in Manual setting where variable fan speed is not required



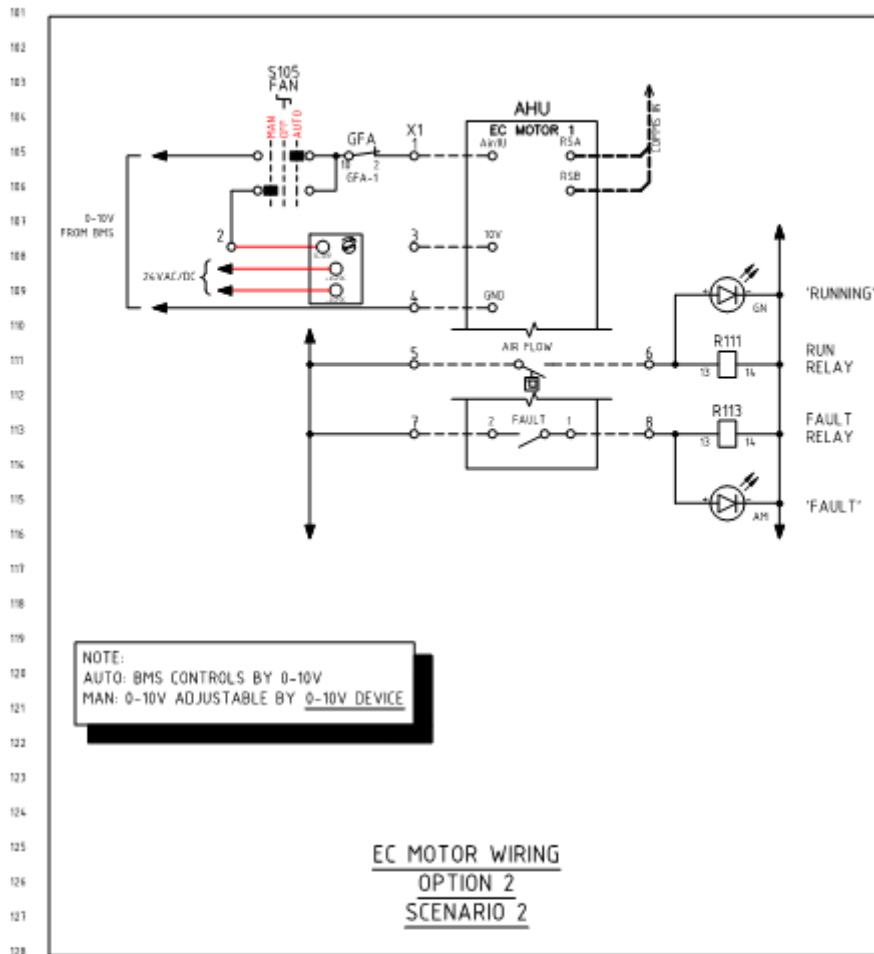
- MAN/OFF/AUTO SWITCH AT MSSB
 - **MANUAL POSITION = FULL SPEED**
 - FAULT STATUS ONLY IF AVAILABLE
- EBM-PAPST
 - FAULT STATUS AVAILABLE
 - NO RUN STATUS
 - RUN STATUS VIA AIR FLOW
- NICOTRA
 - NO FAULT STATUS
 - NO RUN STATUS
 - RUN STATUS VIA AIR FLOW
 - FAULT STATUS VIA MIS-MATCH

Option 2 – Scenario 1 – manual position via 0–10V POT – 10v from EC motor (likely for most installations)



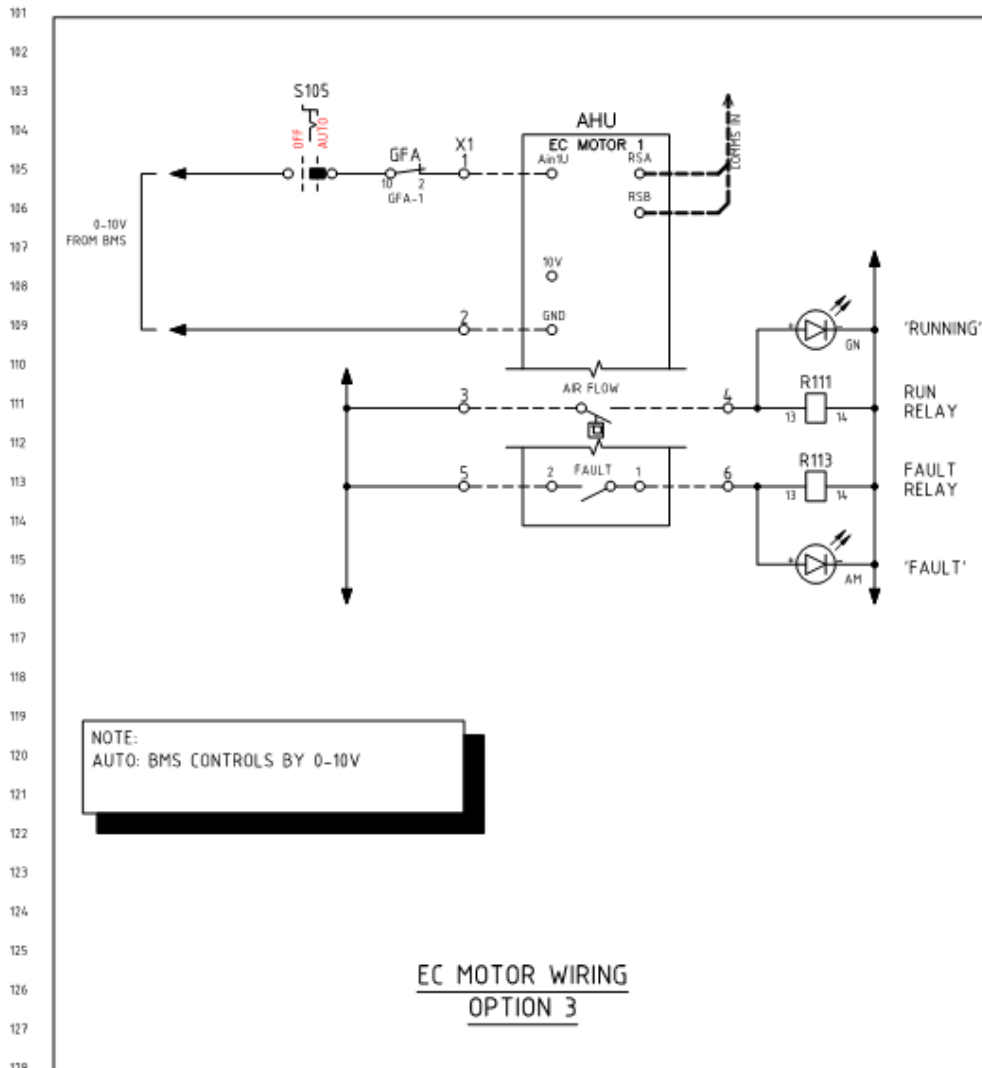
- MAN/OFF/AUTO SWITCH AT MSSB
- **MANUAL POSITION = ADJUSTABLE SPEED VIA 0-10V POT**
- FAULT STATUS ONLY IF AVAILABLE
- EBM-PAPST
 - FAULT STATUS AVAILABLE
 - NO RUN STATUS
 - RUN STATUS VIA AIR FLOW
- NICOTRA
 - NO FAULT STATUS
 - NO RUN STATUS
 - RUN STATUS VIA AIR FLOW
 - FAULT STATUS VIA MIS-MATCH
- MOST COST
- REQUIRE MORE SPACE FOR 0-10V POT IN THE MSSB

Option 2 – Scenario 2 – manual position via 0–10V using independent 0–10v device, refer to Belimo examples below



- MAN/OFF/AUTO SWITCH AT MSSB
- **MANUAL POSITION = ADJUSTABLE SPEED VIA 0-10V DEVICE**
- FAULT STATUS ONLY IF AVAILABLE
- EBM-PAPST
 - FAULT STATUS AVAILABLE
 - NO RUN STATUS
 - RUN STATUS VIA AIR FLOW
- NICOTRA
 - NO FAULT STATUS
 - NO RUN STATUS
 - RUN STATUS VIA AIR FLOW
 - FAULT STATUS VIA MIS-MATCH
- MOST COST
- REQUIRE MORE SPACE FOR 0-10V DEVICE

Option 3 – No manual function (critical applications)



- OFF/AUTO SWITCH AT MSSB
- **NO MANUAL OPERATION**
- AUTO POSITION = 0-10V VIA BMS
- FAULT STATUS ONLY IF AVAILABLE
- EBM-PAPST
 - FAULT STATUS AVAILABLE
 - NO RUN STATUS
 - RUN STATUS VIA AIR FLOW
- NICOTRA
 - NO FAULT STATUS
 - NO RUN STATUS
 - RUN STATUS VIA AIR FLOW
 - FAULT STATUS VIA MIS-MATCH

Where POTs are provided with independent devices, one of the following may apply as needed for either field mounting or MSSB panel mounting, referencing Option 2 Scenario 2 above:

- Belimo SGA24 type or equivalent for surface mounting



- Belimo SGE24 type or equivalent for control cabinet mounting (DIN Rail)



- Belimo SGF24 type or equivalent for front panel mounting



The consultant shall determine the appropriateness of which is to be used to suit the application.

BMS INTERFACES

In all cases BMS controls are required to interface to the fans for the following as a minimum:

- stop/start
- control of fan speed 0–10V
- fan run and fault to suit HLI and/or airflow DP.

FIRE MODE REQUIREMENTS

Fire mode control shall be in accordance with AS1668 and the NCC.

3.2.29.2 Dirt Separator/De-aerator Tank Control – Specific Requirements

This section relates to the control of Automatic Dirt Separator (ADS) blow-down valves where installed. Under no circumstances shall automatic control of the valves be installed. The following control arrangement shall be provided to facilitate manual operation:

- Provide a spring-return On/Off rotary switch for power supply to the transformer that serves the ADS purge valves (this would be in the off position with no power supply as a default).
- Provide a manual depress-and-hold push button to activate the purge valve of each ADS unit (again, in off position with no power supply as a default).
- Provide clear operational labelling on the panel.
- ADS units shall have spring-return purge valves.

This arrangement is aimed at requiring a two-handed operation to activate an ADS purge valve to ensure that the system could not be inadvertently left with the ADS purge valve open.

Where two purge valves are controlled from one panel i.e. an ADS for chilled water and an ADS for heating water, provide one rotary power switch and one push button per system i.e. so they are not common to each.

3.2.30 IDENTIFICATION OF EQUIPMENT

All items of equipment shall be identified with engraved Traffolyte labels in accordance with the University's Archibus asset coding structure, as contained in Curtin University's Project Delivery Guidelines under the Reference Documents folder where *000311 PDG Mechanical Services Guidelines* (this document) is located. Archibus equipment labelling codes shall be referenced on all as-constructed drawings. The labelling standard must be adhered to.

To obtain Archibus equipment codes for the labels, the consultant/contractor will need to submit an equipment list in Microsoft Excel to the Technical Officer for allocation of codes from which the contractor can then have the labels made.

Thermometer bulbs, pressure gauge tapings and remote sensing points shall be labelled to indicate their function.

3.2.31 FUTURE AIR CONDITIONING

All buildings are to be designed to have sufficient capacity to allow for extension or expansion of the air conditioning systems, either within the building or in adjacent buildings and vacant land plots i.e. chilled and heating water pipe sizing to, past and within buildings. The designer should reference the Curtin University Master Plan and discuss issues and options with Curtin University to consolidate the design intent that addresses future development requirements. All chilled water and heating pipe systems to each building shall, as a minimum, be designed to have 20 per cent spare capacity throughout.

3.2.32 ENERGY AND WATER MANAGEMENT

At preliminary design stage, subject to the extent of works to be carried out, but where new plant is proposed to be installed, and as part of the life-cycle costing of the selected plant, the consultant shall advise Curtin University's Responsible Officer of the estimated energy consumption profiles over a 12-month period and the energy modelling scenarios. The consultant design engineer is to identify, nominate and/or investigate all scenarios for limiting energy consumption and greenhouse gas emissions. Options, as a minimum, shall be considered best practice with a proven track record.

On all new buildings and major and complex projects, the consultant shall be responsible for monitoring and reporting on the operation and control of the air conditioning plant for a period of 24 months after practical completion. This work shall form part of the consultant's 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 Curtin University, as required to achieve efficient operation of the plant. The consultant shall submit plant performance reports, energy consumption profiles and sign off on the operation and control of the plant and equipment every three months throughout the 24-month tuning period, to the approval of Curtin University.

The consultant, contractor and BMS contractors shall work collaboratively to achieve energy performance and operational performance improvements. Performance analysis reports shall be submitted one week prior to the anniversary of the reporting period from the date of practical completion at monthly or quarterly intervals as required to suit specific project needs.

The consultant will arrange for Performance Review meetings which shall include Curtin University, consultant, contractor and BMS contractors as a minimum. Review meetings shall occur no later than one week after the anniversary of the reporting period from the date of PC at monthly or quarterly intervals as required to suit specific project needs.

The contractor and/or the consultant shall develop the template for the performance reports and submit the template for approval within two weeks of practical completion.

In developing the information for the templates required the consultant/contractor must consider key performance indicators and the means to test and validate performance improvements.

Reports must be analytical in nature and not just a presentation of data without any meaningful analysis. The performance reports will by necessity require involvement of consultant, contractor and BMS contractor to develop and implement.

The mechanical design engineer shall work with other engineering/design consultants to ensure that all energy and water monitoring equipment is suitably specified and installed to provide for all forms of energy and water consumed for the building and is reported upon using the University's standard reporting system for energy and water (iEnergy). 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
- hot water consumption
- energy consumption/production from miscellaneous sources such as bore water, geothermal, solar hot water, wind, photovoltaic, etc.

Throughout the 24-month 'tuning' period, the consultant shall ensure that the operations and maintenance manuals are upgraded to reflect any changes that have been undertaken since project Practical Completion. This will include the insertion of an Issues Register that forms a log of the issues and actions taken over the course of the tuning period.

CENTRAL ENERGY PLANT (CEP) – ENERGY AND WATER MANAGEMENT AND BMS

GENERAL

Any work being undertaken on Curtin central energy plant (CEP) on any campus must ensure that existing energy and water management graphics and data are integrated, updated, validated and certified by the Consulting Engineer, Contractor and BMS Contractor.

ENERGY AND WATER MANAGEMENT ARRANGEMENTS

The types of energy management arrangements can include but are not necessarily limited to:

- co-efficient of performance (COP)
- 'Authority' level meter gas and electrical (if dedicated to the plantroom)
- plantroom-level gas, electrical and thermal energy metering required for COP

- component/equipment-level gas, electrical and thermal energy metering required for COP
- campus power as integrated to the Struxureware Metering system
- water use
- waste discharge
- BMS alarms on out-of-range or mismatch between recorded data, e.g. boiler has thermal output, but no gas being recorded and vice versa.

CONSULTANT

The Consulting Engineer shall:

- clearly specify the works to be integrated and any amendments to the graphics, programming and reporting
- review contractor submittals prior to construction to validate the BMS Contractors amendments
- undertake a thorough BMS review and validate that the works have been undertaken and are correct and provide certification of it.

CONTRACTOR

The Contractor shall check the BMS contractor's works prior to requesting consultant review of the works. The Contractor shall provide a copy of their validation process and certification of BMS oversight to the Consulting Engineer prior to the request or as part of the request.

BMS CONTRACTOR

The BMS Contractor, as custodian of the BMS system, shall ensure that the BMS systems are:

- upgraded
- clearly document the changes via updated functional descriptions and operation and maintenance manuals
- validated
- programmed
- have graphics complete and correct
- have test data and information supplied.

The BMS Contractor shall attend reviews by both the Contractor and the Consulting Engineer and do all things required to ensure that the Energy and Water Management systems are fully functional, irrespective of the project specifications and shall allow to do so as part of their tender.

Prior to commencing work on site, the BMS Contractor shall submit:

- QA documentation demonstrating the processes for capturing, modifying and recording BMS amendments in general and specifically for the energy and water management
- functional description documentation that clearly highlights amendments

- reporting documentation that clearly highlights amendments
- any other submittals required by the Consulting Engineer or Contractor.

DEFECTS LIABILITY PERIOD

During DLP, issues with metering and data shall be attended to as a Priority 2 alarm and be attended to in accordance with Priority 2 alarm requirements.

OPERATIONS AND MAINTENANCE

When engaged for operational changes and maintenance the above processes shall also be followed to ensure that the systems are kept in operational condition and documentation is kept current. Where there is no consulting engineer or contractor involved, the BMS Contractor will assume those roles.

During maintenance, issues with metering and data shall be attended to as a Priority 2 alarm and be attended to in accordance with Priority 2 alarm requirements.

RETURN TO SITE

Should there be corrupted or unusable data as a result of failure in the above, the Consultant, Contractor and BMS Contractor shall return to rectify and backfill the corrupted data at their own expense, even if it is discovered outside of a nominated project DLP.

3.2.33 PRACTICAL COMPLETION

The consulting engineers shall ensure that representatives from Curtin University's PF & D Mechanical Engineering Department are included in the project Technical Review Group and that design and development of mechanical services and the selection of equipment is undertaken in conjunction with these University representatives.

Prior to issuing to tender, the consultant shall issue to Curtin University's Infrastructure Manager Mechanical Services one set of preliminary tender drawings and specifications for review and comment.

At practical completion, the consultant shall forward all commissioning data to Curtin University's Infrastructure Manager Mechanical Services for review and comment by the University. The consultant shall also coordinate the defects inspection to be carried out with a representative of the mechanical consultant, the mechanical contractor and Curtin University's Mechanical Engineering section.

3.2.34 DEFECTS LIABILITY PERIOD

The mechanical consultant and mechanical contractor shall ensure that all new plant and equipment is serviced throughout the duration of the defects warranty period in accordance with the plant and equipment's specified maintenance requirements. The mechanical consultant shall stipulate maintenance requirements, including frequencies, in the project specification. Maintenance service sheets for all items of

equipment are to be reviewed by the consultant before being forwarded to Curtin University for its review and comment.

The mechanical consultant shall specify that the contractor is to deliver maintenance reports when they are due for each month or quarter. The consultant, after review, shall submit these reports to Curtin University. This ensures that maintenance is conducted when it is due and not left unattended.

At the end of the 12-months defects warranty period, a final inspection shall be carried out by the mechanical consultant, mechanical contractor and a representative from Curtin University's Mechanical Engineering section. A copy of all service sheets shall be forwarded to Curtin University's Infrastructure Manager Mechanical Services for its records one week prior to the scheduled final inspection meeting.

On applicable projects and on completion of the defects warranty period, the consultant shall continue monitoring the operation and performance of the air conditioning plant and initiate improvements and modification as required up to the end of the 24-month energy reporting period that commences from Practical Completion, to the approval of Curtin University's P F& D Mechanical Engineering Department.

3.2.35 OPERATIONS AND MAINTENANCE MANUALS

The Mechanical Design Consultant shall ensure that one complete set of electronic operations and maintenance manuals are checked, completed and approved by the consultant before being forwarded on to Curtin University for review, comment and acceptance. Upon acceptance and subject to changes identified by the consultant and Curtin University, the consultant shall ensure that two full and complete electronic sets of the project operations and maintenance manual is forwarded to Curtin University for its records. One of the two copies of the manual shall be provided in PDF format with the second copy in an editable version in Microsoft Word. In addition to PDF versions, drawings shall be provided in AutoCAD in DWG format. All documentation shall be compiled in accordance with the University's protocol for AutoCAD drawings, as described in the *Documentation Deliverables Guidelines*. BIM models shall be provided as agreed with Curtin's Drawing Management office at the time of project schematic design.

The operations and maintenance manuals for mechanical services shall be formatted as follows such that if it was to be printed, it would be representative of a traditional hard copy operation and maintenance manual:

- be a three-ringed binder, navy blue in colour and A4 in size
- have a manual front cover and spine title and associated detail that shall be printed in gold leaf lettering. (See Appendix 3 for the typical layout of the titles and headings for the manual front cover and spine. Note that there is a standard layout for all projects, with the exception of site in-ground chilled and heating water projects. These projects have a specific requirement as illustrated in Appendix 3.)
- consist of one or more binders as required to accommodate all the information on the project services and identified accordingly as Volume 1, Volume 2 etc.

- identify the Builder, Architect, Consultant and 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. As a minimum this detail shall be set out in sections as follows:

Contents

*Used in Chilled and Heating Water in ground pipework projects only.
Makes reference to Operation and Maintenance Manuals in terms of the number of volumes (see Appendix 3)*

Index

Contains index detail

Introduction

A brief commentary on what the project intent is

Description of Installation

A detailed description of the scope of work

Functional Description

A detailed description explaining the sequence of events that demonstrates how each element of the project operates and achieves its intent

Fire Mode Functional Description

A detailed description explaining the sequence of events that the system is required to operate in, during a fire alarm. It must include a cause and effect matrix, architectural plans and sections showing fire/smoke compartmentalisation.

Building Management System

Includes control logic diagrams, I/O schedules, alarming detail, graphic page detail where required etc.

Manufacturers' Literature

Includes manufacturers' product manuals and the like that contains the specification detail relevant to ALL plant, equipment and instruments installed on the project

Maintenance

Maintenance schedules relating to installed equipment/systems as recommended by the manufacturer

Commissioning Data

Contains all 'as installed' performance data relating to the project such as chilled and heating water flow rates, air balancing figures, pump and fan curve data, certificates and plant registration data etc.

As-constructed Drawings

A1 printed capable copies of all drawings taken from project AutoCAD files representing 'as installed' mechanical services, mechanical electrical wiring diagrams and electrical schematic drawings incorporating control system interface.

Include the building management control system (BMS) documentation, which shall be incorporated into the operations and maintenance manual. A separate control manual will result only where a project is solely a controls-based project and upgrading an existing building operations and maintenance manual is not practical. A separate controls manual will only be approved by the project consultant and once Curtin's Infrastructure Manager Mechanical Services has been consulted.

3.3 PIPED PRESSURE SERVICES

3.3.1 INERT GASES

While gas services are typically delivered by the mechanical consultant, this will be undertaken in close consultation with and direction from the project dangerous goods and hazardous substances consultant. Refer to the Guidelines and associated Reference documents in the Hazardous Substances and Dangerous Goods section of the University's online Project Delivery Guidelines portal.

3.3.2 COMPRESSED AIR

Compressed air shall be supplied from air compressors within the building. Compressors shall be oil-free, of Broomwade manufacture (or other approved equal), liquid ring or screw to suit University service requirements.

They shall be mounted, together with their motor, on an integral steel base and shall be effectively isolated from the structure. Tank-mounted compressors are also acceptable.

The compressor shall be effectively silenced. Air cleaners shall be substantially mounted. Unless otherwise called for, compressed air shall be supplied at 200 kPa at the bench outlet (confirm requirements with the client department).

Pipework shall be copper and shall be silver soldered and shall grade to automatic drains with collection tundishes. Isolation valves shall be of the diaphragm, quarter-turn ball, globe or needle-type and they shall be a standard product freely available in the marketplace.

An air receiver shall be provided to limit the number of starts per hour of the compressors. The receiver shall be provided with all necessary gauges, safety valves, pressure stats and automatic drains for automatic operation. The compressed air system shall be complete with mains-to-system air regulators. At the base of all risers and low points in the distribution system water traps shall be fitted having automatic discharges similar to Spirax, Norgen or SMC and complete with collection tundishes.

The complete installation is to comply with relevant Australian standards.

3.3.3 VACUUM

Vacuum shall be supplied by means of vacuum pumps within the building. Vacuum pumps shall be Nash or Dynavac or equivalent manufacture, water ring pumps capable of passing fluids from the system without damage to the pump, fitted with bacteria filters where appropriate.

Vacuum pumps shall be mounted, together with their motor, on an integral steel base mounted on an inertia base equal to 1.5 times the weight of the vacuum pump and its ancillaries and shall be effectively isolated from the structure. Water seals with safety interlocks shall be provided to each pump.

Pipework shall be solvent joint Class 18 PVC pressure pipe or Type B copper depending on the service. Plugged tees shall be used in place of bends to allow for cleaning of piping, however at the base of all droppers and at the low points in graded horizontal pipework glass removable catch pots with full pipe diameter inlet valves shall be fitted. Isolating valves shall be of the diaphragm or quarter-turn ball type.

A vacuum tank shall be provided to limit the number of starts per hour of the vacuum pump(s). The tank shall be provided with all necessary gauges, safety valves, pressure stats for automatic operation.

All pipework is to grade to liquid collection catch pots.

The complete installation is to comply with relevant Australian standards.

3.3.4 IDENTIFICATION OF PIPEWORK

All pipework shall be identified with their names and colour codes as listed.

The ground colour shall be applied over the full length of the pipeline or over a length of pipeline of not less than 450 mm where adhesive labels are used. The location of identification marking shall be at intervals of not more than 3 metres (not less than 1 per floor in vertical pipework) and preferably adjacent to branches, junctions, valves, walls and control points. Such markings shall be placed so that they are easily seen from all approaches.

Service labels, where applied, shall be over a length of not less than 200 mm at locations and intervals as specified for ground colours.

The direction of the flow shall be indicated by an arrow adjacent to each service label. An approved adhesive label shall be used for identification and indication of the direction of flow of pipework.

3.4 COLOUR CODING – PLANT AND EQUIPMENT

3.4.1 GENERAL

Where colours are not specified for particular items of plant, the University shall be consulted before colours are nominated. All pipework, valves and fittings in plant rooms, ducts and wherever exposed to view shall have the colours applied over their entirety. Pipework identification shall be achieved throughout by use of Safetyman pipe markers and labels to indicate contents and flow.

Colours are to be selected from:

- AS2700 – Colours for General Purposes
- AS1345 – The Identification of Piping Conduits and Ducts.

SUPPORTS

Ace Unistrut Mounting Brackets, MS Angle Supports and Hanger Rods are to be painted 'Black' where exposed.

3.5 BUILDING MANAGEMENT CONTROLS (BMS)

3.5.1 GENERAL

Building Management System (BMS) direct digital control system shall be fully 'native' BACnet-compliant and shall be structured to provide seamless communication and access via Curtin University's existing WAN across the existing Schneider Electric StruxureWare or Johnson Metasys LANs.

The new control system shall be Microsoft Windows-based and be compatible with the current version used by Curtin University. The control program software and associated graphics shall be loaded onto Curtin BMS servers and workstations as required and as determined for each project by Curtin University. All user program licences and rights shall be provided.

Provide an Ethernet TCP/IP and/or BACnet IP communication network via the WAN between controllers and all communications cabling and repeaters as necessary for the installation specified and to maintain the integrity of the existing BMS LANs.

Controllers for the connection of field inputs shall be field-mounted, in new control panels or in existing control panels if suitable, generally adjacent to the existing mechanical services switchboards. Provide new power supply to the controllers with dedicated circuit-breaker and controls transformer per control panel, to suit the installation. Controllers shall be fully BACnet compliant and shall have standalone capabilities capable of continuing on last set of instructions should the communications trunk be cut. Controllers shall incorporate battery backup for 72 hours without loss of program or trend data. On restoration of power, the controllers shall be sequentially restored automatically and provide any automatic downloading of information by way of duplex communication between the controller and the operator's terminal. The controls contractor shall allow spare capacity and flexibility of the control system by providing an additional 20 percentage points for each analogue and digital input and output over and above all utilised control points together with additional memory capacity to suit. Each installation shall cater for a minimum 20 per cent spare capacity on conclusion of the installation.

Each group of controllers shall be provided a 240-Volt power supply from the adjacent switchboard and shall incorporate an isolating transformer, filters and under voltage/over voltage protection to prevent equipment failure due to power supply disturbances. Provide lightning protection of the communications cables where copper LAN cable is run between buildings.

Provide point controller manual overrides for the manual operation of chillers, cooling towers, condenser fans, cooling towers, pumps, air conditioning units, ventilation fans and the like.

All communication cabling shall be a minimum of 0.8 mm² multi core twisted and shielded cabling to eliminate interference

Provide all interface cabling and conduits from controllers to terminal devices, between controllers and from controllers to terminals in the mechanical services switchboards, all in accordance with AS3000.

The DDC software shall be specifically designed for the HVAC control functions as specified and operate in a Microsoft Windows environment. The software shall include:

- communications software
- software control logic as specified
- time and event functions
- multi-level password access
- alarm display
- automatic dial out on receipt of high priority alarms to any or all of six telephone numbers in rotation
- colour graphics package and edit tool for presentation of plant mimic diagrams with dynamic display of parameters
- trend logging
- graphic display of logged data via bar charts, graphs, etc.
- full mathematics functions.

Provide graphics pages to represent the installation, control and monitoring of the mechanical services plant, which shall include 3D-type graphics representing the air conditioning and mechanical ventilation plant and live schematic DDC logic diagrams to represent the installation. The graphics shall identify alarm points and manual override points. The graphics shall be 'drill down' from a state map, campus plan, building plan/levels, air handling unit, etc. to the approval of Curtin University, prior to installation.

Graphics for air handling equipment shall identify the operating mode (occupied, unoccupied) of the plant and also identify the last time economy cycle, warm up, night purge or air quality control routines were last utilised.

Always provide a functional description and points schedule to Curtin University for approval prior to installation.

Always provide control valve selections to Curtin University for approval prior to installation.

Identify the location of all TO connections required to interface with the University's Ethernet system prior to commencing works on site.

Always provide training to Curtin University staff to familiarise staff to the new mechanical services plant and its controls system.

Always provide 12 months free labour and warranty on all new equipment.

Tune the control system and modify control routines to provide efficient and effective operation of the mechanical services plant to the approval of Curtin University.

All works associated with the Campuses shall be completed to the approval of nominated mechanical services consultant and Curtin University.

3.5.2 CONTROL SYSTEM DESIGN

The consultant shall, in consultation with Curtin and a BMS vendor, determine an appropriate BMS hardware topology design that addresses:

- the critical nature of the systems being controlled or monitored
- redundancy requirements addressing power failure, controller failure and IT or communications failure
- prevention of systems cascade failure issues relating to multiple mechanical system points residing on the same controller(s)
- segregation of building floors or large floor plate spaces
- spare space provisions.

Topology designs shall not be left to the BMS contractor to determine during construction, as it is too late and potentially costly to address the above issues at that point of the project.

3.5.3 CONTROL DEVICES

3.5.3.1 General

Typically, air handling plant shall utilise the following control and monitoring points, which shall be presented on their associated graphics page:

- start/stop
- fault (via differential pressure switch)
- supply air temperature
- supply air temperature set point (depending on type of air conditioning plant)
- space temperature
- space temperature set point
- return air temperature
- outside air temperature (global)
- outside air humidity (global, if specified)
- occupied/unoccupied mode and time left to run
- economy enable/disable
- date/time economy was last enabled
- night purge enable/disable mode

- date/time night purge was last enabled
- warm-up mode enable/disable
- date/time warm-up was last enabled
- air quality control enable/disable
- date/time air quality control was last enabled
- date/time stamp to be printable for each page
- DX fault (via interface card)
- safety tray moisture alarm (comms and AV room CHW FCU and/or DX FCU)
- filter differential pressure (SP: 50–125 Pa depending on filter type).

3.5.3.2 Occupied/Unoccupied Switches

Occupied/unoccupied switches shall utilise a rocker- style toggle switch with spring return (not depression type) and shall incorporate a green neon indicator light that provides the occupant with an indication of air conditioning status and that the zone is active.

The occupied/unoccupied switches shall be engraved to identify:

- 'Air Conditioning'
- VAV or fan coil unit served
- room number(s) that the switch serves.

3.5.3.3 Control Valves

Control valves for chilled water and heating water services to air conditioning units shall be Belimo Characterised Control Valves or approved equivalent to provide equal percentage flow to percentage open valve position. Control valves shall be a minimum of 1.5 times the pressure drop of the device being controlled including pipework valves and fitting pressure losses compared to the index leg.

Where the design pressure drop of existing water coils is unknown, the control valves shall be sized to meet the following criteria:

- for chilled water valves, to achieve a pressure drop at full design flow between 25 kPa and 60 kPa
- for heating water valves, to achieve a pressure drop at full design flow between 10 kPa and 30 kPa
- for chilled water and heating water valves, the valves to be typically be one size smaller in diameter than the pipework line size.

3.5.4 CONTROL LOGIC

The objective of control strategy outlined in this document is to set a minimum standard with consistency in programming for typical type HVAC systems in use across Curtin campuses. There may be instances where there is a need to move away from

these control standards. Examples of such instances could be related to specific requirements of laboratories, process control cooling systems or where specific temperature/relative humidity control is required. In such circumstances, the control logic needs to be developed in association with the project mechanical engineering consultant and Curtin's Infrastructure Manager Mechanical Services.

3.5.4.1 Time Schedules

Time schedules shall be provided for each item of air conditioning plant regardless of the item of equipment actually utilising the time schedule, unless the equipment was ever to be manual operation-based.

Curtin University core hours of operation are from 8:00am to 5:30pm Monday to Friday, except public holidays and University holidays. The core hours shall be used in most instances unless the operation of the mechanical services plant warrants an alternative time schedule to suit (e.g. Library.)

The time schedules shall be user friendly and allow full access to users to vary public holidays and University holidays and non-working days. Stage the scheduled start times to avoid all the plant being enabled at the same time. The activation of the occupied/unoccupied switches shall override the associated time schedule.

The comms room duty/stand-by arrangement utilises the following peak/off-peak hours of the University for change-over operation:

- Peak 8.00am – 10.00pm weekdays
- Off-Peak 10.00pm – 8.00am weekdays and 24 hrs weekends

During peak hours the duty unit shall be the CHW FCU.

During off-peak hours the duty unit shall be the DX system.

Where there is a duty unit only, the equipment shall run 24/7.

The duty unit shall swap at either the designated time or on mismatch alarms (as indicated above) after time delay.

3.5.4.2 Occupied/Unoccupied Mode

When enabled via the time schedule, the air conditioning plant shall operate in the unoccupied mode until the occupied/unoccupied switch for that air conditioning plant is activated, upon which the air conditioning plant shall operate in the occupied mode.

For a single zone air conditioning unit, if the occupied/unoccupied switch was activated during core hours, then the air conditioning plant shall operate in the occupied mode for a period of four hours.

For a single zone air conditioning unit, if the occupied/unoccupied switch was activated outside core hours, then the air conditioning plant shall be enabled in the occupied mode for a period of two hours.

For a multi-zone air conditioning unit, if the occupied/unoccupied switch was activated during core hours, then that zone shall operate in the occupied mode for a period of four hours, while the remaining zones shall operate in the unoccupied mode.

For a multi-zone air conditioning unit, if the occupied/unoccupied switch was activated outside core hours, then the air conditioning unit would be enabled and that zone shall operate in the occupied mode for a period of two hours, while the remaining zones shall operate in the unoccupied mode.

For variable air volume (VAV)-type air conditioning, if the occupied/unoccupied switch was activated during core hours, then that VAV shall operate in the occupied mode for a period of four hours, while the remaining VAV boxes shall operate in the unoccupied mode.

For VAV-type air conditioning, if the occupied/unoccupied switch was activated outside core hours, then the air conditioning plant shall be enabled and that VAV box shall operate in the occupied mode for a period of two hours, while the remaining zones shall operate in the unoccupied mode.

If the occupied/unoccupied switch was activated outside core hours and the air conditioning unit was operating in warm-up mode or night purge mode, these modes shall be cancelled.

The afterhours switch control logic shall be set up where the toggle switch has to be depressed for a period of no longer than three seconds to enable occupied mode. A further 30 seconds shall elapse before the toggle switch can be re-depressed for a period of no longer than three seconds to enable unoccupied mode in core hours or to turn the AHU/FCU off in an out-of-hours condition.

3.5.4.3 Standby Mode

Standby mode shall be a nominated timeframe before the start of core hours and is used to enable either night purge or warm-up cycle control routines for the nominated air conditioning plant able to utilise these control routines.

Depending on the thermal mass of the building, the standby mode nominal time frame shall be set at one hour for both night purge or warm-up cycle control, however if the building had a high thermal mass, the time frame for warm-up cycle may need to be extended, which would warrant a separate standby mode time schedule for each control routine.

3.5.4.4 Space Temperature Set Point

For space temperature requirements for comms and AV rooms see the space temperature control section under Section 3.2.16.

The space temperature set point control shall utilise three parameters to determine set point, these being ambient temperature, heat/cool mode and occupied/unoccupied mode, as illustrated in the table below.

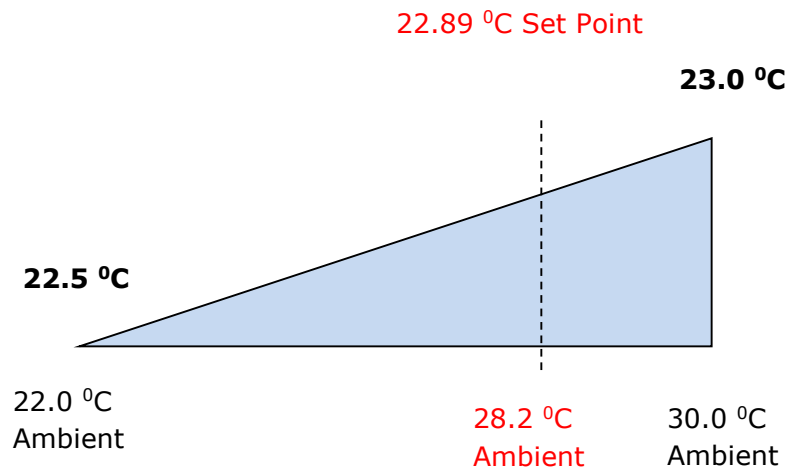
Mode	Occupied	Unoccupied
Cool Mode	22.5–23.0 °C	25.0 °C
Heat Mode	22.0 °C	20.0 °C

In the occupied mode, the control system shall control to achieve set point. In the unoccupied mode, no heating or cooling would be provided between the Unoccupied Cool Mode set point and the Unoccupied Heat Mode set point.

For example, if in the unoccupied mode, if the space temperature was less than 22.0 °C but greater than 20.0 °C then the space temperature control set point would be 20.0 °C, but no heating would be provided. If the space temperature increased above 23 °C but less than 25.0 °C then the space temperature control set point would be 25.0 °C, but no cooling would be provided. If the space temperature increased above 25.0 °C (or below 20.0 °C), then the control system would operate using PID control to provide cooling to maintain the cooling set point of 25.0 °C (or heating set point of 20.0 °C).

3.5.4.5 Space Temperature Cooling Set Point Rescheduling Control

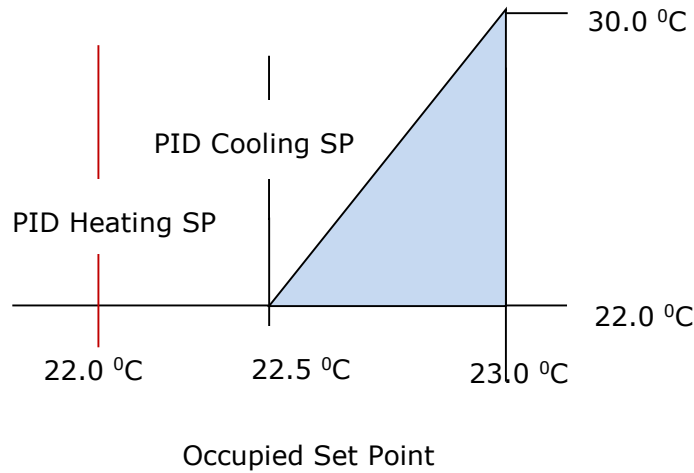
Space temperature set point shall be allowed to reschedule the occupied cooling mode set point such that the set point will vary on a sliding scale from 22.5 °C at an ambient temperature of 22.0 °C to a set point of 23.0 °C at 30.0 °C.



3.5.4.6 Space Temperature Control – Constant Volume Single Zone Chilled and Heating Water Systems

When operating in the Occupied Mode and the system is in Cool Mode (see 3.5.3.4), modulate the chilled water valve using Proportional Integral Derivative (PID) control to maintain the Occupied Cooling Set Point. Note that the PID loop will control to the specific set point as it re-schedules off outside air.

When operating in the Occupied Mode and the system is in Heat Mode (see 3.5.3.4), modulate the heating water valve using Proportional Integral Derivative (PID) control to maintain the Occupied Heating Set Point.

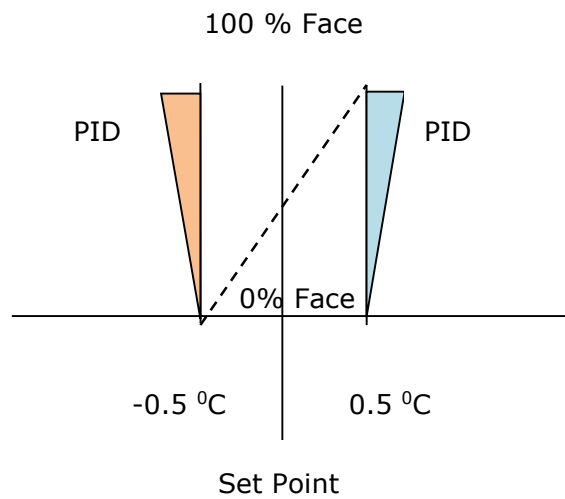


3.5.4.7 Space Temperature Control – Constant Volume Multi Zone Face and Bypass Hot Deck/Cold Deck Chilled and Heating Water Systems

When in the occupied mode, provide face/bypass damper control for each zone to modulate its face/bypass damper using PID to maintain the set point.

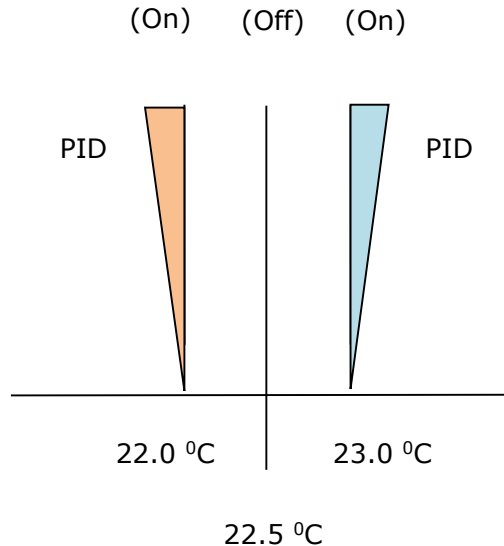
In Cool Mode the chilled water valve for the air handling unit shall modulate based on the greatest positive deviation from set point of any zone. The chilled water valve shall modulate using PID control to maintain space temperature equal to $SP + 0.5\text{ }^{\circ}\text{C}$.

In Heat Mode the heating water valve for the air handling unit shall modulate based on the greatest negative deviation from set point of any zone. The heating water valve shall modulate using PID control to maintain space temperature equal to $SP - 0.5\text{ }^{\circ}\text{C}$.



3.5.4.8 **Space Temperature Control – Constant Volume Single Zone Single-stage DX Systems**

When in the occupied mode, provide a 0.5 °C dead band either side of set point and then use PID either side of the dead band for enabling heat or cooling. Disable at set point.



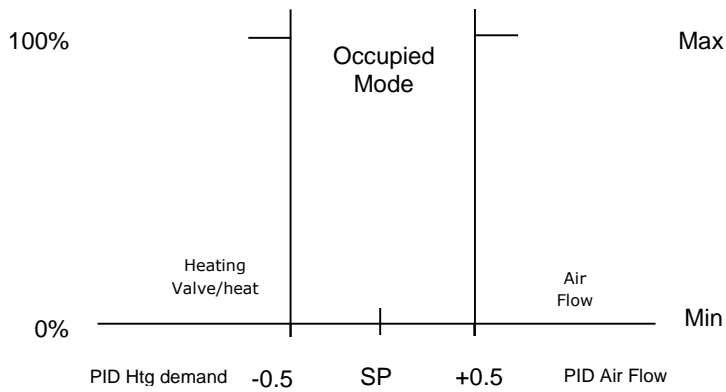
3.5.4.9 **Space Temperature Control – Constant Volume Single Zone Two-stage DX Systems**

When in the occupied mode, provide a 0.5 °C dead band either side of set point and PID control either side of the dead band for sequentially enabling the two stages of heat or cooling as indicated for the Single Stage DX System above.

3.5.4.10 **Space Temperature Control – Variable Air Volume System**

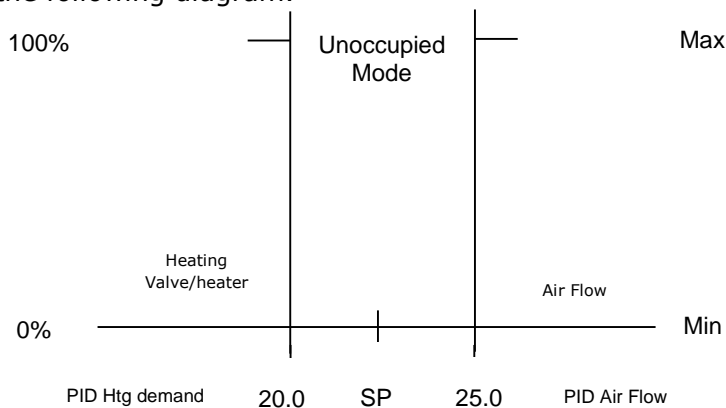
When in the occupied mode, each VAV box shall modulate the supply air flow rate from minimum design airflow to maximum design airflow to maintain space temperature set point using PID control as per the diagrams below.

VAV boxes with heating water coils shall modulate their heating water valve using PID control such that the valve modulates to maintain the space temperature set point as per the diagrams below. VAV boxes with electric heaters shall regulate the heaters using Pulse Width Modulation (PWD) to maintain space temperature set point as per the diagrams below. Air handling units containing electric heaters shall utilise an electric heater isolation contactor located in the MSSB that electrically isolates the power supply to the heaters when the air handling unit air flow status is off.



Occupied VAV Space Temperature Control

When in unoccupied mode the VAV box damper and heating valve/electric heater will modulate in sequence to maintain the required space temperature set point as indicated in the following diagram.



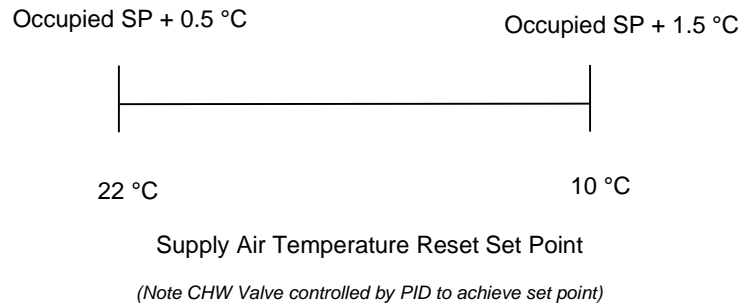
Unoccupied VAV Space Temperature Control

3.5.4.11 Leaving Air Temperature Reset Control – Variable Air Volume Air Handling Units

Temperature control is disabled if no fan status has been established or if the supply air temperature sensor is in fault. Note that Curtin University utilises hot water re-heat so air handling unit heating water valves are generally not used on VAV systems.

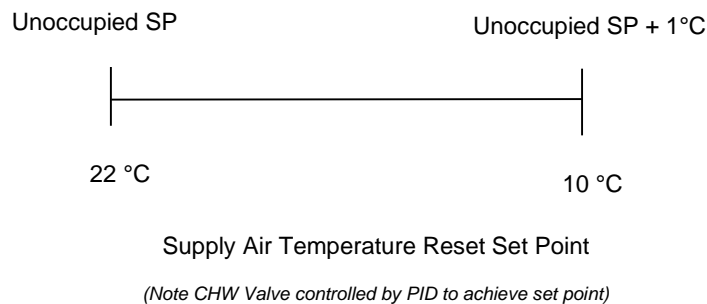
Variable air volume air handling units operating in cooling mode shall utilise leaving air temperature reset control incorporating chilled water valve control via its own PID loop to achieve supply air set point. Supply air temperature reset is determined utilising the highest average deviation from set point across all VAV boxes operating in the occupied mode. (Highest average is the average of the sum of all the deviations from set point added to the highest deviation from set point, which is then averaged again. This limits the effect of any rogue VAV boxes. If no VAV boxes are in the occupied mode, then leaving air temperature reset control shall be based on the highest average deviation from set point across all VAV boxes operating in the unoccupied mode. Cooling mode leaving air temperature set point shall reset proportionally to a nominal 10.0 °C, subject to the coils design leaving dry bulb temperature as illustrated in the following diagrams.

Highest Average Deviation



Occupied VAV Leaving Air Temperature Reset

Highest Average Deviation



Unoccupied VAV Leaving Air Temperature Reset

Where the VAV air handling unit is a direct expansion (DX) refrigerant system, the compressors shall be staged based on the highest average deviation from set point using PID control as described for Space Temperature Control – DX Systems. Ensure that a leaving air temperature control routine is provided to disable the lag compressor if supply air temperature falls below 5.0 °C. Resume normal operation if the supply air temperature is greater than 9.0 °C.

3.5.4.12 Minimum Outside Air Damper Control

Where the air conditioning unit incorporates an economy cycle, the economy outside air damper shall be separately controlled from the economy return air damper and the economy relief air damper such that when the economy mode is disabled, the economy return air damper and the economy relief air damper close fully while the outside air damper shall close to the minimum outside air set point position. The minimum outside air set point position shall be determined by commissioning the minimum outside airflow rate as part of the project scope of works. When operating in economy cycle (or night purge), the outside air damper shall modulate from minimum outside air set point position to 100 per cent open as specified under Economy Cycle Control. When in warm-up mode, the outside air damper shall modulate to the fully

closed position. The graphics shall display the outside air damper at its minimum outside air position as being at 0 per cent open.

3.5.4.13 Economy Cycle Control – Constant Volume Single Zone Systems

Enable the economy cycle if the space temperature is above space temperature set point and the outside air temperature is less than return air temperature by 0.5 °C for 600 seconds (adjustable). Modulate the economy dampers from 0 per cent open at SP and the damper opens as determined by the PID loop when space temperature is greater than SP. Disable the economy cycle if any of the above parameters are not achieved.

The economy cycle shall operate as the first stage of cooling, with the chilled water valve operating as the second stage of cooling.

3.5.4.14 Economy Cycle Control – Constant Volume Multi Zone Hot Deck/Cold Deck Systems

Enable the economy cycle if any zone space temperature is above set point and the outside air temperature is less than the return air temperature by 0.5 °C for 600 seconds (adjustable). Modulate the economy dampers using the greatest positive deviation from set point of any zone from 0 per cent open at SP and the damper opens as determined by the PID loop when space temperature is greater than SP. Disable the economy cycle if any of the above parameters are not achieved

The economy cycle shall operate as the first stage of cooling, with the chilled water valve operating as the second stage of cooling.

3.5.4.15 Enthalpy Control

Where enthalpy control has been provided/specified, it shall be applied to the economy and night purge control routines.

If enthalpy (determined by dry bulb temperature and humidity sensor or by an enthalpy sensor) is located in the return air and another enthalpy sensor has been provided for outside air, the additional parameter for enabling the economy and night purge shall be that the outside air enthalpy shall be less than the return air enthalpy for more than 600 seconds. If this parameter is not achieved, then the economy/night purge cycle shall be disabled.

If only an outside air enthalpy sensor is specified, then the additional parameter for enabling the economy and night purge shall be that the outside air enthalpy shall be less than 48 kJ/kg for more than 600 seconds. If this parameter is not achieved, then the economy/night purge cycle/air quality control routines shall be disabled.

3.5.4.16 CO₂ Air Quality Control

If CO₂ monitoring for air quality control has been specified, then on air quality exceeding 500 (adjustable) part per million (ppm) and the air conditioning system is not in warm-up mode or night purge mode, the economy dampers shall open on a proportional scale between 500 ppm and 750 ppm (adjustable), until the chilled water or heating water valves are open 100 per cent whereupon the economy damper

operating in air quality control shall modulate to maintain space temperature or leaving air temperature set point.

When designing the air conditioning plant intending to utilise air quality control, the consultant shall ensure that sufficient heating/cooling capacities are incorporated into the design and specification to allow for lower and higher 'air on coil' conditions due to increased proportions of outside air being introduced under this control routine.

3.5.4.17 Night Purge Cool-down Cycle (where economy cycle provided)

Enable night purge cycle if the average space temperature is greater than Cool Mode Occupied SP + 1.0 °C and the ambient temperature is less than Cool Mode Occupied SP - 2.0 °C and the time of day is less than one hour before core hour start time (Standby Mode).

When night purge is enabled, open the economy cycle dampers 100 per cent and run the supply air fan until the average space temperature achieves set point whereupon the air handling unit shall continue to operate and the economy dampers shall modulate as described for economy cycle control.

For VAV systems operating in night purge mode, the VAV boxes shall open to 100 per cent of design airflow until the associated space temperature achieves set point whereupon the VAV box shall modulate to maintain space temperature set point without the use of trim heating.

The night purge cycle shall be terminated at the commencement of core hours while the supply air fan shall continue to run and normal temperature control shall be enabled. The heating water and chilled water valves shall be held closed during night purge operation. If the occupied mode is enabled, then night purge cycle shall be terminated.

3.5.4.18 Warm-up Cycle

Enable the warm-up cycle if the average space temperature is less than Heat Mode Unoccupied SP - 2.0 °C and the time of day less than 1.5 hours before core hour start time (adjustable subject to the size of the heating water system and delay of enabling the heating water boiler) and ambient temperature is less than 16.0 °C (adjustable).

When warm-up is enabled, disable the economy cycle, fully close the minimum outside air damper, enable the supply air fan and open the heating water valve 100 per cent until Occupied mode space temperature set point is achieved or start of core hours, whereupon revert to normal operation. The chilled water valve shall be held closed during warm-up mode.

If the air conditioning system incorporates a motorised minimum outside air damper, then close the minimum outside air damper when the warm-up cycle is enabled.

If the variable volume air handling unit has a heating coil installed as part of the unit, then only this heating coil shall be used when operating in warm-up mode and the leaving air temperature set point shall be set at a nominal 32.0 °C, adjustable subject to building inertia and thermal mass. Where the variable volume system has heating coils at the VAV boxes, then these coils' heating water valves shall be utilised only where the AHU does not have a primary heating coil.

For VAV boxes operating in warm-up mode, the VAV boxes shall open to 100 per cent of design airflow and the heating water valves shall open to 100 per cent until the associated space temperature achieves set point whereupon the VAV box shall modulate its airflow and heating water valve normally to maintain space temperature set point minimizing the use of trim heating or cooling.

When operating in warm-up mode, the supply air temperature delivered into the space shall be between 28.0 °C and 32.0 °C. If the air handling unit base heating coil does not have sufficient heating capacity at 100 per cent design airflow, it may become necessary to control the VAV boxes towards a pre-set warm-up minimum airflow and/or possibly utilise any trim heating available (taking into account the impact on the site heating water system DP).

Disable the warm-up cycle when the time of day is greater than core hours start time less 15 minutes. Maintain supply air fan operation (and return air fan if applicable) with both the chilled water and heating water valves closed until the commencement of core hours. If prior to warm-up cycle commencing, the occupied mode is enabled, warm-up cycle shall not start. If during warm-up cycle, the occupied mode is enabled, then the warm-up cycle shall be terminated.

3.5.4.19 Cooling Call

A cooling call shall be generated if any chilled water valve is open more than a set percentage, typically 70 per cent, and shall be disabled when all chilled water valves are typically less than 20 per cent open, but these percentages may change depend on the type of air conditioning plant being controlled and system response.

3.5.4.20 Heating Call

A heating call shall be generated if any heating water valve is open more than a set percentage, typically 70 per cent, and shall be disabled when all heating water valves are typically less than 20 per cent open, but these percentages may change depend on the type of air conditioning plant being controlled and system response.

3.5.4.21 Duty/Standby Toilet Exhaust

The toilet exhaust shall be enabled via a time schedule or when the associated air conditioning unit is enabled. The toilet exhaust shall be disabled one hour after the associated air conditioning unit has been disabled.

In a mismatch alarm between the airflow differential pressure switch and the lead exhaust fan, the lead exhaust fan shall be disabled, an alarm fault generated and the lag exhaust fan shall be enabled.

The lead/lag of the duty standby exhaust fans shall change weekly on a Wednesday at 10.00 am unless there was a fault from the lag exhaust fan.

3.5.4.22 Alarms

Provide mismatch alarms and critical alarms and transmit the alarm to the front end PCs of the Curtin Bentley Campus Operations and Maintenance Office and any other nominated PC, via the University's WAN.

Provide automatic dial out for the nominated critical alarms and transmit the alarm in text format to the mobile telephones, pagers and email as nominated by the Curtin Bentley Campus Operations and Maintenance Office.

3.5.5 BMS GRAPHICS

Graphics are a fundamental criterion for the use and application of the controls systems at Curtin University. This section of the design guidelines outlines the approach and standards that apply to the design and creation of BMS graphics. Any deviation from these guidelines requires the specific approval by Curtin's Manager Infrastructure Manager Mechanical Services.

The desired outcome of these guidelines is to provide a uniform method of addressing and formatting graphics pages to provide a system 'drill down' approach to navigating around the graphics. This will assist maintenance staff to interrogate the control system using the main graphics page, rather than using cumbersome index trees and the like.

Graphics will generally be 3D-type graphics pages that utilise 'hot spots' (hyperlinks) to navigate between pages to allow forward and reverse movement from one graphics page to another. Where index trees exist, they will be turned off by default so that they are not visible. The use of proprietary forward/back arrows on the graphics pages shall not form part of the system for accessing the various graphics pages. Graphics will include Campus Summary Pages, Building Home Pages and Building Summary Pages for each building, as specified further in this document. Where some graphics pages have been set up specifically for faculties, these will need to reflect the specific needs of the faculty without them being able to view/access the remainder of the campus.

The entry point to the BMS when logging on shall be at a map of Western Australia that is in sufficient detail to identify the Bentley (including Technology Park), Murray Street, Shenton Park and Kalgoorlie campuses and any other remote locations as specified. From the map of Western Australia, a click on the hot spot associated with a campus location will take the user to a campus map of that particular campus. The buildings on that map shall be identified by their building number. Those buildings that have the relevant BMS contained within shall have the building number bolded (highlighted and contain a hot spot) while those buildings without a BMS will not be bolded (highlighted). The campus maps shall be in sufficient detail to identify the building layout. The 'building' hot spot shall take the user to a Building Home Page. Each building shall use a photograph of that building as the background wallpaper, with the photo being submitted to Curtin's Mechanical Engineering Services Department for approval prior to its use.

Uploading of the new graphics pages (and programs) onto the BMS server shall be conducted out of normal hours to minimise disruption of the operation and control of the various mechanical services systems and general user access.

3.5.6 DATA MANAGEMENT AND LOGGING STANDARDS

It is imperative that data management within Curtin University's building management systems is managed in a formalised structured manner with the objective of

minimising the volume of data traffic over the various BMS virtual networks. This is vitally important in ensuring the smooth operation of the BMS with response times maintained and, above all else, no loss of data. To assist BMS providers in achieving these objectives the following table constitutes Curtin University's data logging standard and has been established in consultation with Curtin's BMS suppliers.

These standards are to be applied to all works undertaken on University facilities unless otherwise specified. Ad-hoc trends required for troubleshooting can deviate from these standards however they shall be removed from the system on resolution of issues.

System	Point Description	Frequency	Trend Type	Duration Held
	Non Critical Plant Points			
A/Cs/FCUs	Zone Air Temperature	15 Mins	Database	12 Months
	Supply Air Temperature	15 Mins	Database	3 Months
	Return Air Temperature	30 Mins	Controller	5 Days
	Outside Air Velocity	30 Mins	Controller	5 Days
	Supply Air Static Pressure	30 Mins	Controller	5 Days
	Carbon Dioxide ppm	30 Mins	Database	12 Months
	Set Points (General)	30 Mins	Database	3 Months
	Chilled Water Valve	30 Mins	Controller	5 Days
	Heating Water Valve	30 Mins	Controller	5 Days
	Economy Output	30 Mins	Controller	5 Days
	VSD Speed	30 Mins	Controller	5 Days
	Non Critical Plant Points			
VAVs	Zone Air Temperature	15 Mins	Database	3 Months
	Set Points (General)	15 Mins	Database	3 Months
	Critical/Research Area Plant Points			
A/Cs/FCUs	Zone Air Temperature	15 Mins	Database	12 Months
	Supply Air Temperature	15 Mins	Database	12 Months

System	Point Description	Frequency	Trend Type	Duration Held
	Return Air Temperature	15 Mins	Database	12 Months
	Outside Air Velocity	15 Mins	Database	12 Months
	Supply Air Static Pressure	15 Mins	Database	12 Months
	Carbon Dioxide ppm	15 Mins	Database	12 Months
	Set Points	15 Mins	Database	12 Months
	Chilled Water Valve	15 Mins	Database	12 Months
	Heating Water Valve	15 Mins	Database	12 Months
	Economy Output	15 Mins	Database	12 Months
	VSD Speed	15 Mins	Database	12 Months
	Critical/Research Area Plant Points			
VAVs	Zone Air Temperature	15 Mins	Database	12 Months
	Set Points (General)	15 Mins	Database	12 Months
Common	Ambient Temperature	30 Mins	Database	1 Year
	Ambient Humidity	30 Mins	Database	1 Year
Metering	Electrical Metering	5 Mins	Database	1 Year
	Gas Metering	5 Mins	Database	1 Year
	Water Metering	5 Mins	Database	1 Year
	Thermal Metering	5 Mins	Database	1 Year
Main Plant	Chiller Entering Temp	15 Mins	Database	12 Months
	Chiller Leaving Temp	15 Mins	Database	12 Months
	Chiller Differential Pressure	15 Mins	Database	12 Months
	Main ChW Flows	15 Mins	Database	12 Months
	Boiler Entering Temp	15 Mins	Database	12 Months
	Boiler Leaving Temp	15 Mins	Database	12 Months
	Boiler Differential Pressure	15 Mins	Database	12 Months

System	Point Description	Frequency	Trend Type	Duration Held
	Main HtgW Flows	15 Mins	Database	12 Months
	Thermal Tank Entering Temp	15 Mins	Database	12 Months
	Thermal Tank Leaving Temp	15 Mins	Database	12 Months
	Thermal Tank Flow	15 Mins	Database	12 Months
	Domestic HtgW Leaving Temp	15 Mins	Database	12 Months
	All of these types of points below are captured in the events database.			
AHU/FCUs	Fan Enable	Change Of State	Event Database	12 Months
	Fan Status	Change Of State	Event Database	12 Months
	Occupied/Unoccupied Mode	Change Of State	Event Database	12 Months
	Warm-up Mode	Change Of State	Event Database	12 Months
	Night Purge Mode	Change Of State	Event Database	12 Months
	Cooling Call	Change Of State	Event Database	12 Months
	Heating Call	Change Of State	Event Database	12 Months
	Ventilation Mode	Change Of State	Event Database	12 Months

The following outlines the graphical profiles and arrangements required of the graphics pages compiled for all Curtin University Campuses. Essentially the graphics pages shall be compiled in a drill-down arrangement from State map, Campus plan, building etc. down to devices such as fan coil units and variable air volume boxes. Navigation through the graphics pages shall be via the graphics pages themselves, by cursor clicking on an item within the graphics page, known as a 'hot spot', to move forward or backward, rather than using the index tree. The Index Tree, should it be currently displayed, shall be disabled.

Graphics Level	Description	Requirement
1.0	Campus Location Map	Map of Western Australia titled Curtin University – Western Australian Campuses. The map will identify the location of each of the Curtin Campuses (Bentley, Murray Street Perth, Shenton Park and Kalgoorlie) and other locations as specified.
		This level in the Log On page and also display the name of the control system that is being logged on to, either Johnson or StruxureWare, utilising a User ID and a Password for access that is unique to the user.
		Each campus location would be a 'hot spot' to move forward to a Campus Site Plan (Graphics Level 2). Where a site plan was not warranted (e.g. Murray St), then the hot spot would jump to the Building Index Home Page.
		Each campus location would flash red if there was an active high level alarm, regardless of being logged on or not.
2.0	Campus Site Plan	Applicable for Bentley and Kalgoorlie campuses. The site plan shall identify all Curtin University buildings regardless of if they are on the Johnson or StruxureWare control system, but highlight the building or building numbers applicable to the control system in use. The highlighted building numbers shall be a hot spot to provide direct access to that building's home page. Each building shall flash red if there is an active high level alarm.
		The Campus Site Plan will also identify:

		<ul style="list-style-type: none"> • Campus ambient temperature/humidity/enthalpy (identified on all graphics pages for that campus) • Campus cooling call (enabled/disabled) (for each cooling plant as applicable for each campus) • Campus heating call (enabled/disabled) (for each heating plant as applicable for each campus) • List in table format at the bottom of the Site Plan any unacknowledged high level alarms
	Campus Site Plan (Continued)	<p>Each Campus Site Plan would also have hot spots to forward to:</p> <ul style="list-style-type: none"> • Campus Building Cooling Summary • Campus Building Heating Summary • High Level Alarms • Low Level Alarms • Lighting Control
		<p>Each Campus Site Plan will also have a hot spot to move backwards to:</p> <ul style="list-style-type: none"> • Campus Location Map
3.0	Campus Cooling Calls	<p>List all buildings and their cooling calls. List all the applicable buildings regardless of if they generate a cooling call. For Bentley Campus, this page would also identify if the cooling call has been relayed from the Schneider Electric StruxureWare control system to the Central Chilled Water Plant Johnson Metasys control system and also identify if the cooling call has been generated by the Johnson Metasys control system:</p> <ul style="list-style-type: none"> • Hot spot to move forward to each building's Building Index Home Page • Hot spot to move back to Campus Site Plan • Hot spot to move sideways to Building Summary Page
3.1	Campus Heating Calls	<p>List all buildings and their heating calls. List all the applicable buildings regardless of if they generate a heating call. For Bentley Campus, this page would also identify if the heating call has been relayed from the Schneider Electric StruxureWare control system to the Central Heating Water Plant Johnson Metasys control system and also identify if the heating call has been generated by the Johnson</p>

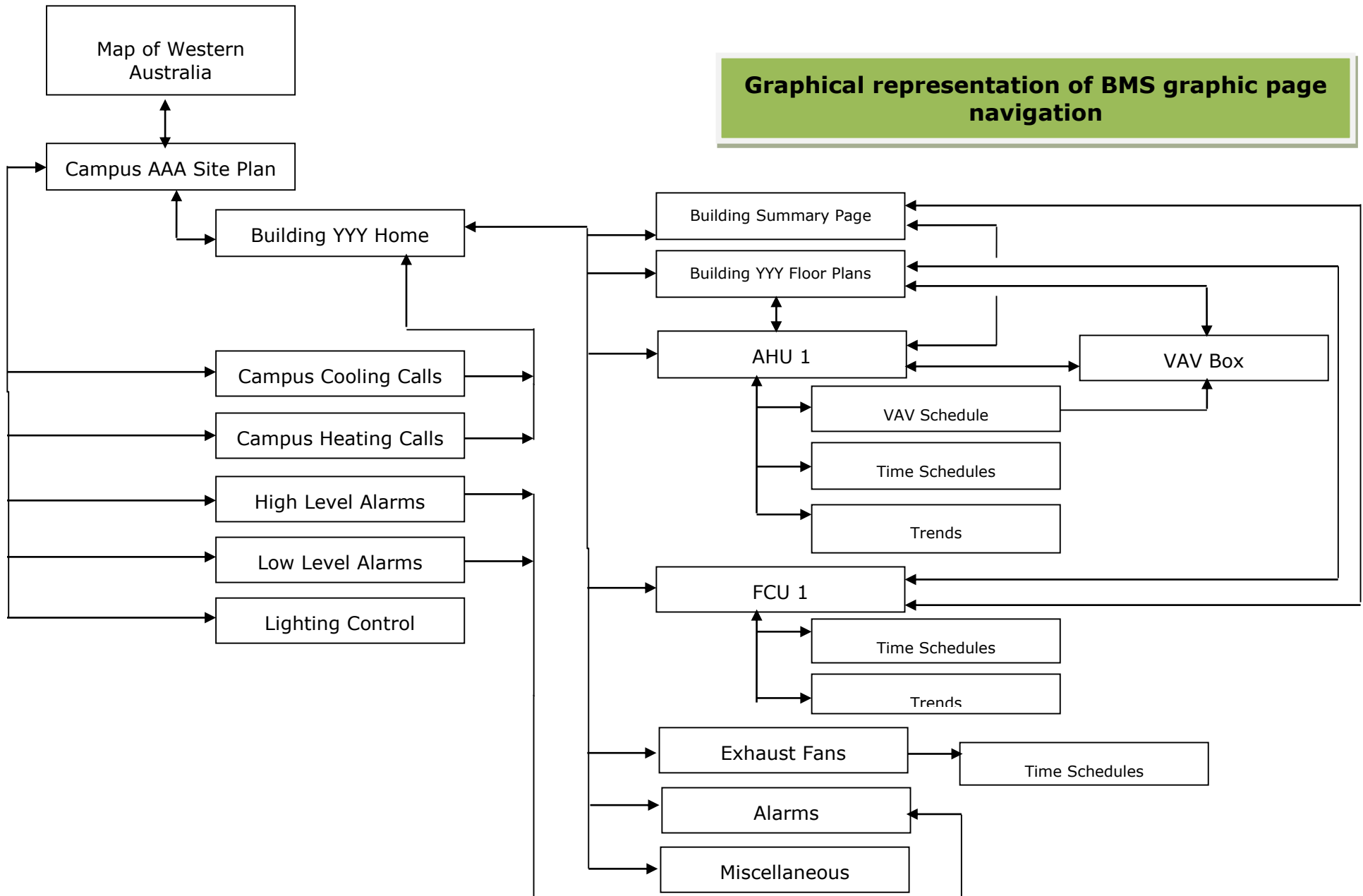
		<p>Metasyscontrol system:</p> <ul style="list-style-type: none"> • Hot spot to move forward to each building's Building Index Home Page • Hot spot to move back to Campus Site Plan • Hot spot to move sideways to Building Summary Page
3.2	High-level Alarms	<p>Lists a description of all unacknowledged and acknowledged high-level alarms , time/date when the alarm was generated and when/who acknowledged the specific alarm:</p> <ul style="list-style-type: none"> • Hot spot to move to move back to Campus Site Plan
3.3	Low-level Alarms	<p>Lists a description of all unacknowledged and acknowledged low-level alarms , time/date when the alarm was generated and when/who acknowledged the specific alarm:</p> <ul style="list-style-type: none"> • Hot spot to move back to Campus Site Plan
3.4	Lighting Control	<p>Where is controlled by the BMS, list lighting schedules for the Campus's external lighting control, as applicable:</p> <ul style="list-style-type: none"> • Hot spot to move back to Campus Site Plan
4.0	Building Home Page	<p>Background wallpaper to be a photo of the actual building.</p>
		<p>Displays a list of all floor plans, items of equipment, miscellaneous information and time schedules associated within each building (e.g. A/C units, FCUs, VAV box schedule, alarms), each with a hot spot to move forward.</p>
		<p>Shall also indicate a hot spot to Building Summary Page, which shall list in table format:</p> <ul style="list-style-type: none"> • Building Cooling calls and Building Heating calls • AHU/FCU cooling and heating calls

		<ul style="list-style-type: none"> • AHU/FCU chilled and heating water control valve positions • AHU/FCU space temperatures • Building alarms • Building chilled and heating water temperatures, water flow rates, calculated thermal consumption • List all points that have been manually overridden or disabled.
		Each Building Index shall have a hot spot tag 'Campus Site Plan' to move backwards.
4.1	Building Floor Plans	<p>Floor plan of each level identifying:</p> <ul style="list-style-type: none"> • Room layouts and room numbers • North point • Space temperature and space temperature set point for each sensor • The associated FCU, AHU, VAV box or zone number shall also be identified (colour-coded) • Ambient temperature/humidity/enthalpy (for all graphics pages for the associated campus)
		Each space temperature shall have a hot spot to jump directly forward to the associated end device e.g. VAV Box.
	Building Floor Plans (Continued)	The floor plan shall be colour coded to identify the zone of the VAV, FCU or AHU and a legend or list provided to identify each area.
		Each floor plan shall have a hot spot tag 'Building Home Page' to move backwards.
4.2	Building Equipment (AHU/FCU)	Each AHU/FCU graphics page shall have a hot spot to move forward to the associated VAV box schedule, time schedule and trends.
		Each AHU/FCU graphics page shall have a hot spot to move back to the associated floor plan and back to the Building Home Page.

4.3	Building Equipment (VAV Box Schedule)	Each VAV Box Schedule graphics page shall identify the area they serve and shall have a hot spot to move forward to the associated VAV box.
		Each VAV Box Schedule graphics page shall identify the area they serve and shall have a hot spot to move back to the associated AHU/FCU, back to the associated floor plan and back to the Building Home Page.
4.4	VAV Box	Shall identify the area it serves and shall have hot spots to move backwards to VAV Box Schedule, AHU and Building Floor Plan.
4.5	Building Equipment (Exhaust Fans)	Shall list all exhaust fans with equipment name tags and identify the area they each serve.
		Hot spot to access the time schedules for each exhaust fan as applicable. If not operating on a time schedule, identify means of operation in text on the graphics page (e.g. "Manual operation", "Operates with AC 2", etc.).
		Hot spot back to Building Home Page.
4.6	Building Equipment (Miscellaneous)	<p>This graphics page shall list an index or item of equipment each with a hot spot to move forward and may include equipment such as :</p> <ul style="list-style-type: none"> • Exhaust Fans • CHW/HTGW secondary pumps • CHW/HTGW thermal consumption data (flow, temperatures, thermal consumption, thermal consumption rate)

		<ul style="list-style-type: none"> • Building Cooling Calls • Building Heating Calls
		Hot spot back to Building Home Page.
4.7	Alarms	Shall lead to an active list of the most recent acknowledged and unacknowledged alarms register for the building.
		Hot spot back to Building Home Page.
4.8	Time Schedules	Hot spot access forward to a list of all time schedules for each item of equipment.
		Hot spot back to Building Index
4.9	Miscellaneous	List or display each of the miscellaneous items (exhaust fans, chilled water and heating water flow, temperatures and thermal consumption, etc.
		Hot spot back to Building Index.

Graphical representation of BMS graphic page navigation



In terms of provision of BMS graphics for Curtin University, the following shall be adhered to.

1. Graphic pages shall generally comply with the following points to standardise graphics types and styles across campuses:
 - a) shall be 3D
 - b) shall navigate by way of 'hot spots' (hyperlinks)
 - c) shall be of standard layout for similar types of equipment (FCUs, VAVs, etc.) to allow ease of navigation and 'look and feel' of the system
 - d) shall utilise light coloured backgrounds to reduce consumption of printer ink
 - e) shall utilise the full screen size of the VDU
 - f) shall be legible with minimum 10pt font and constant theme font throughout
 - g) shall incorporate side and bottom scroll bars only if the graphics page is larger than the screen and only in cases where it is absolutely unavoidable to fit onto the full screen of the VDU
 - h) shall be configured to be printed on A4 landscape in colour, where connected to a printer and display the time/date of the graphics page when printed.
2. All graphics pages except the Map of WA shall display:
 - a) ambient temperature, humidity and enthalpy for the relevant campus location
 - b) A time/date stamp that is displayed on the graphics page when printed
 - c) identify any point that has been manually overridden.
3. All Building Home Page graphics pages shall:
 - a) have a picture of the respective building as background wallpaper
 - b) have a hot spot index of all main items of plant.
4. All AHU and FCU graphics pages shall identify:
 - a) chilled water and heating water supply temperature into the building
 - b) if their time schedule has been enabled or disabled
 - c) if after hours of occupied/unoccupied operation has been activated, the duration and the elapsed time
 - d) AHU/FCU fault status
 - e) date and time of last economy, warm-up or night purge operation as applicable
 - f) the mode of operation the unit is currently utilising (economy, warm-up or night purge operation) as applicable
 - g) if the unit has generated a cooling call or heating call
 - h) for a VAV type AHU, identify

- I. the cooling demand and the heating demand
 - II. leaving air temperature upper and lower limits (adjustable)
 - III. leaving air temperature set point
 - i) for an FCU, identify the active space temperature set point
 - j) provide text to identify that 0 per cent represents closed and 100 per cent open (e.g. economy dampers fully open at 100 per cent).
5. All VAV box graphics summary pages and VAV graphics pages to identify:
- a) VAV space temperature set point (adjustable)
 - b) VAV maximum/minimum design airflow set points
 - c) VAV box airflow set point
 - d) VAV box airflow
 - e) calculated cooling or heating demand
 - f) occupied/unoccupied mode, time period and lapsed time
 - g) AHU supply air temperature.
6. For the Building's thermal consumption identify:
- a) Heating water and chilled water EWTs and LWTs
 - b) Heating water and chilled water flow rates
 - c) Calculated heating water and chilled water thermal consumption.

High-level alarms are those alarms that utilise automatic dial out to a pager and email the maintenance office on fault activation. Low-level alarms are non-critical alarms such as mismatch alarms for non-critical equipment or systems. The list of high-level alarms shall be reviewed by Curtin University from time to time.

3.5.7 PROCUREMENT OF IP ADDRESSES FOR NETWORK DEVICES

The issuing of IP addresses for any BMS device should be a very simple and quick process if proper protocol is followed. The following information is required. If all information is not supplied, IP addresses will not be issued so it is important all information is provided.

Required information:

- TO outlet number: Must include alpha character if present
- TO outlet colour: All Cat 6 are green outlets
- MAC address of the device being installed: 12 alpha/numeric characters
- Device Type/Model: Brand, Make and Model
- Building/level/room: Follows Curtin's naming convention. Building/ level and plant room is OK as numbering of plant rooms occurs later in projects.

This information is to be provided by the Project Manager directly to the Senior System Support Engineer within the Business Support Portfolio of the Properties, Facilities & Development area of Curtin University.

The application process for an IP address and associated interface by the Senior System Support Engineer with CITS is as follows:

1. The Project Manager provides the required IP address information to the Senior Systems Support Engineer.
2. The Senior Systems Support Engineer requests a service request (SR) through the CITS Service Desk.
3. The CITS Service Desk issues a Service Request (SR #nnnnn).
4. CITS Networks actions the Service Request and returns it to the Senior Systems Support Engineer on completion.
5. The Senior Systems Support Engineer informs the Project Manager and provides the IP Address and any other relevant information.

In managing the use of IP addresses for BMS devices, ensure the following:

- IP address: Ensure IP addresses are not swapped between like devices.
- IP Gateway address: Configure devices exactly as given. An incorrect number will prevent the device from working.
- SubNet Mask: Configure devices exactly as given. An incorrect number will prevent the device from working.
- Note that CITS will not patch a TO Outlet until test results for that circuit have been received. This however, does not prevent the issuing of IP addresses.

4 APPENDIXES

4.1 APPENDIX 1

ADDITIONAL EQUIPMENT DATA COLLECTION SHEETS – TEMPLATES

- 1) Chilled and Heating Water Connected Load
- 2) Chilled Water Flow Meters
- 3) Heating Water Flow Meters
- 4) Electric Meters
- 5) Gas Meters
- 6) Water Meters
- 7) Chilled Water Supply and Return Temperature Sensors
- 8) Heating Water Flow and Return Temperature Sensors
- 9) Chilled Water Supply Pressure and Pressure Difference Transmitters
- 10) Heating Water Flow Pressure and Pressure Difference Transmitters

4.2 APPENDIX 2

OCCUPANT INFORMATION BROCHURES

1. Air Conditioning Push Button Control Information Brochure

Operation of the Air Conditioning System

Buildings at Curtin University are air conditioned to allow a set point of approximately 22 °C to be achieved all year around. The systems are automatic and set to operate typically between the business hours of 8.00 am and 5.30 pm Monday to Friday.

Those areas that have local A/C push buttons will allow air conditioning to operate in a slightly relaxed mode of temperature control when the local push button is not activated, i.e. slightly above set point in summer and slightly below set point in winter. If occupants feel that they are a little uncomfortable and would like tighter temperature control, the local A/C push button can be activated by depressing the button until the indicator light illuminates. During business hours the push buttons will provide a four hour control time.

If air conditioning is required outside of these hours the push button can be depressed until the indicator light illuminates. This will turn on the air conditioning and automatically allow it operate at approximately 22 °C for a duration of two hours.

The provision of controls that allow variations to the set points via the use of push button operation provides a good blend between providing comfort conditions when required and energy conservation.



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4.3 APPENDIX 3

OPERATIONS AND MAINTENANCE MANUALS

Front Cover and Spine Detail

1. Standard Operations and Maintenance Manual layout.
2. Specific Operations and Maintenance Manual layout for a site Chilled and Heating Water Pipework project

Standard Operation and Maintenance Manual front cover and spine layout.

**OPERATIONS
AND
MAINTENANCE
MANUAL**

FOR

**MECHANICAL
SERVICES**

AT

**CURTIN
UNIVERSITY**

**(NAME OF
CAMPUS)**

**(PROJECT
NAME)**

Volume # of #

**OPERATIONS
AND
MAINTENANCE MANUAL**

FOR

MECHANICAL SERVICES

AT

**CURTIN UNIVERSITY
(NAME OF CAMPUS)**

BUILDING ###

(ROOM ### IF APPLICABLE)

(PROJECT NAME)

Volume # of #

**OPERATIONS
AND
MAINTENANCE
MANUAL**

FOR

**MECHANICAL
SERVICES**

AT

**CURTIN
UNIVERSITY**

**(NAME OF
CAMPUS)**

Volume #

**OPERATIONS
AND
MAINTENANCE MANUAL**

FOR

MECHANICAL SERVICES

AT

**CURTIN UNIVERSITY
(NAME OF CAMPUS)**

**CHILLED & HEATING WATER
PIPEWORK UPGRADES**

Volume #

(Sample contents page to be used in all Chilled and Heating Water in ground pipework based projects only)

CONTENTS

Volume/s	Project Number	Project Title
1 – 3	UPJ000204	B402 to B407 CHW and HTGW installation
4 – 5	UPJ000353	B105 Fibro Pipe Replacement & HTGW Expansion Line
6 – 9	UPJ000432	B205/B206 CHW & HTGW Pipe Replacement

4.4 DEFINITIONS

A/C	air conditioning
AHU	air handling unit
AV	audiovisual
BMS	building management system
CCV	characterised control valve
CHW	chilled water
CITS	Curtin Information Technology Services
comms	communications
CRAC	computer room air conditioner
CT	Current Transformer
DB	dry bulb
DDC	direct digital control
DOL	direct online
DX	direct expansion
EC	Electronically Commutated
EWT	entering water temperature
FCU	fan coil unit
HLI	High Level Interface
HTGW	heating water
HVAC	heating , ventilation and air conditioning
Infrastructure Manager Mechanical Services	university representative charged with the responsibility for the university's mechanical fixed plant and equipment and associated infrastructure
LWT	leaving water temperature
Mechanical Services Contractor	an external company engaged by the university to deliver construction and maintenance services for mechanical fixed plant and equipment and associated infrastructure
MSSB	mechanical services switch board
NCC	National Construction Code
NR	noise rating
OBD	opposable blade dampers
OPSO	over-pressure shut-off
PF&D	Properties, Facilities and Development

PI	proportional integral
PID	proportional integral derivative
POT	A variable potentiometer or rheostat
Practical Completion	Issued to a Contractor acknowledging completion of works to a stage where the works have been completed as per the contract documents and are "reasonably fit for occupation or their intended use".
Project Manager	The person managing the project on behalf of the University
PWD	pulse width modulation
RAC	room air conditioner
Responsible Officer	The University's representative on projects, nominated by the Portfolio Manager, as the person responsible for the project and may be CU Portfolio Manager, CU Project Manager, CU Project Officer, University Associate Lead Consultant
RH	relative humidity
SP	set point
TO	Telecommunications Outlet
UPS	uninterruptible power supply
VAV	variable air volume
VDU	video display unit
VSD	variable speed drive
WB	wet bulb