4 BUILDING SERVICES

PREAMBLE

General

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 ECU Project Manager and the appropriate Services Manager:

- Scope document which clearly indicates intent. Preferably in diagrammatic format.
- Equipment Schedules where appropriate.
- List of suggested tenderers

Specification

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 standards.

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 to be aligned to GDA94 Coordinates to allow insertion into the University Master Site Services Plan.

4.1 Access, Maintenance & Manuals

4.1.1 General

Maintenance of the University's facilities is funded from its recurrent resources and normally bears little relation to the capital programme. It is therefore imperative to ensure that all facilities are constructed bearing in mind life-cycle costs and maintainability.

Designs will be rejected which make inadequate provision for:

- servicing and maintenance;
- easy removal and replacement of plant and equipment;
- access;
- durability;
- those which opt for minimising capital cost at the expense of on-going maintenance.

4.1.2 Operating and Maintenance Manuals

Shall be provided prior to Practical Completion for every building project and is to 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 shall be complete with terminal numbers corresponding to wiring ferrules and shall be cross referenced as necessary;
- commissioning data, set points, flow rates, timer settings etc.
- two hard copy manuals and one electronic copy.

4.1.3 Access for 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 plantroom or plant area.

"Adequate access" for routine servicing means the 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 ECU Project Manager.

Mechanical and Electrical Plant and equipment, particularly those requiring manual operation such as electrical control panels, or routine maintenance such as pump, fans, etc. 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 co-ordination 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.

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.

4.1.4 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 Operations Branch.

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

It is preferred that plant rooms be located at roof top or basement level rather than in the body of the building. Provision shall be made in elevated plant rooms for hatches and lifting equipment to facilitate conveyance of equipment to ground. Where plant rooms are built in tier fashion within the building, access ladders shall be provided between levels within the plant room.

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

All pipework penetrations to be bunded.

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

Plantrooms floors shall be designed to be washed down for maintenance and cleaning and shall be provided with water taps

4.2 Mechanical Services, Heating , Ventilation & Air Conditioning

4.2.1 General

This section of the Design Standards 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, particularly in relation to controls.
- Accessibility, ease of operation, simple maintenance, combined with minimal maintenance frequency.
- Whenever possible, life cycle cost analysis shall govern the selection of systems and equipment and the University may call for calculations on competing systems.
- Chilled water systems are preferred in areas that are in close proximity to existing or planned chilled water reticulation systems. It is

accepted that chilled water systems may initially require a higher capital cost than DX systems, but, on a life cycle cost analysis, may be preferable.

- Allowance for adequate space for installation and maintenance of machinery whether it be in designated plantroom, ceiling spaces 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 "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.
- System must have economy cycle where systems are greater than 20KW(R).
- Proposed system must be low maintenance and energy efficient.
- Sensors are to be located 1200-1500mm from the outside wall and on the room dividing wall where the whiteboard/pin board is located.

4.2.2 Preferred Contractors

Contractors either tendering or working on projects at Edith Cowan University must be approved by the manager Mechanical Services.

4.2.3 Sustainability

All utility consumption is to be metered and data from meters presented in a form to allow comparison against historical data to enable fine tuning of systems to achieve maximum efficiency. Current strategy is to aggregate all utility meter data under the BMS system.

Metering proposal to be approved by the Manager, Mechanical Services prior to implementation. Data gathering and reporting systems must be fully operational before practical completion.

4.2.4 Design Conditions

Careful consideration should be given to the design conditions for various areas.

(i) **External Design Conditions - Summer**

(a)	Teaching Areas	37°C DB 24°C WB
(b)	Office & Research Areas	36°C DB 24°C WB

(ii) **External Design Condition - Winter**

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

4.2.5 Performance Standards

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

(i) **Internal Design Conditions - Summer**
22.5 ^{0}C DB +/-1.5 ^{0}C
55% RH +/- 5% RH
unless specifically nominated otherwise.

(ii) **Internal Design Conditions - Winter**
Internal Winter Design Conditions shall be:
22.5°C +/- 1.5°C

4.2.6 Room Occupancy Number

Can be taken to be approximately equal to those shown below:

- General Office 5.0m^2 /person
- Library Reading Rooms 2.5m²/person
- Laboratory - Undergraduate (1st Year) 3.7m²/person Labs will be variable. Note that utilisation of some labs will be low. Configure for energy efficiency
- Laboratory - Undergraduate (other years) 4.7m²/person
- Laboratory - Postgraduate 12.0m²/person
- Seminar Rooms 2.0m²/person
- Lecture Theatres 1.1m²/person
- Lecture Class Rooms 2.0m²/person

Where room usage and corresponding population levels are not listed, forward a request to ECU for the relevant information. Where this information is not available, conform to AS1668 Part 2 as nominated by the Building Code of Australia.

4.2.7 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 d determined
- Computer Terminal Rooms 100 W/m² To be individually determined

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

4.2.8 Fresh Air Rates

Shall be in accordance with AS 1668 Part 2 as nominated by the Building Code of Australia.

4.2.9 Ventilation Requirements

Shall be in accordance with AS 1668 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 change over on fault, are required as stipulated by the Health Act.

4.2.10 Ventilation in Photographic Darkroom Areas

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

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.
- Tricholoroethane (such as Kodak Film Cleaner) allow 10 air changes per hour general room ventilation.

Local exhaust required where the following are used:

- Ethoxyethanol, Hydroxylamine Sulphate, p-Phenylene-Diamene, Tertiary Bulylamine Borane, Selenium Oxide, Platinum Chloride, Potassium Oxalate, Potassium Sulphide, Potassium Permangenate, Potassium Cyanide, Potassium Dichromate, Ammonia, Mercuric Chloride, Acetic Acids, Catechin.

4.2.11 Fire & Smoke Control

Shall be in accordance with AS 1668 Part 1 and as nominated by the Building Code of Australia. Certification and commissioning documentation, maintenance and testing procedures are all to be included in the operating and maintenance manuals. Fire/smoke separation to be clearly indicated in documentation.

4.2.12 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.

4.2.13 Chilled Water Temperatures

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

Supply Water Temperature	$7.0^{o}C$
Return Water Temperature	$14.0^{o}C$

Leaving chilled water temperature set point shall be re-scheduled from 7.0 ^{0}C to 12.0 ^{0}C based on outside air temperature. Refer to Air Conditioning Control Functionality.

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 normalized to meet the current design standard for the site and that the piping and valve configurations for the system are in accordance with the design intent of the system.

4.2.14 Heating Water Temperatues

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

Supply Water Temperature	75.0^{O}C
Return Water Temperature	55.0^{O}C

Leaving heating water temperature set point shall be re-scheduled from 75.0^{0}C to 55.0 ^{0}C based on of outside air temperature. Refer to Air Conditioning Control Functionality.

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 normalized to meet the current design standard for the site and that the piping and valve configurations for the system are in accordance with the design intent of the system.

4.2.15 Condenser Water Temperatues

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

Supply Water Temperature	29.5^{O}C
Return Water Temperature	35.0^{O}C

Leaving condenser water temperature set point from the cooling tower shall be re-scheduled from 29.5^{0}C to 21.5^{0}C based on a combination of outside air temperature, time of day and charge mode of chilled water storage tank. Refer to Air Conditioning Control Functionality, Section 11.28.

4.2.16 Noise and Vibration Control

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

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

4.2.17 Air Handling Systems

Air-conditioning shall normally be provided by the use of air-handling equipment using chilled water supplied from the University's Central Chiller 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 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 University Project Manager.

To achieve better control over operation, unitary type air-handling systems serving a single room or small number of similar rooms are preferred over 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 shall not be used. Floor mounted console style chilled water FCU's shall not be used.

All air conditioning systems shall have adequate fresh air (in accordance with current Code requirements of AS 1668 Part 2) drawn from outside the building at locations well away from discharges from cooling towers, fume exhausts, traffic, cooking areas, chemical storage areas (in accordance with current Code requirements of AS3666).

The minimum and maximum outside air dampers shall be motorised.

All air handling systems to be of Fan Coil Industries, G.J Walker Air Handling Systems , Airwise Engineering,Carrier 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 plantrooms to manoeuvre equipment and carry out maintenance. Access to fire dampers shall be provided.

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

Where appropriate, air handling systems shall be configured to allow for economy cycle, warm up cycle and night purge control routines to minimize 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 heaters at VAV boxes shall be provided for trim heating to obtain approval to use heating water pipework to VAV. The consultant will need to prove the economic/running cost viability.

Consideration should also be given to the use of heating water for trim heating at VAV boxes where cost justification based on ongoing energy and maintenance demonstrate savings. 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. Similarly, the use of variable volume fan assisted VAV boxes with electric reheat may be used on perimeter zones, 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 ECU's Manager – Mechanical where fan assist VAV boxes are proposed.

4.2.18 Chilled Water Systems

Joondalup Campus

The existing chilled water system has the following characteristics:

- Central chilled water plant located in Plantroom 2 in Building 16, consists of 3 off water cooled chillers and 1 off 2.2 million litre chilled water storage tank
- The chilled water storage is discharged during the day as a "phantom" chiller in order to reduce peak demand. The storage tank is charged by the chillers at night utilising the TAC digital control system
- The chilled water storage tank stores chilled water at approximately 5.0 ^{0}C and mixes it with return water as required to achieve desired supply water temperature set point
- Another central chilled water plantroom is located in building 24 consists of 1 off water cooler chiller and a space for a future water cooled chiller to be installed.
- Chilled water supply temperature is reset from 7.0 ^{0}C to 12.0 ^{0}C, based on variation of outside temperature
- The chilled water systems are a decoupled primary water systems at the central plants with secondary variable speed pumps utilised for chilled water distribution to the Campus
- A reticulated chilled water distribution system across the campus serving most buildings utilising a two way control valve arrangement with 3 way valves on index legs

The secondary chilled water pumps are controlled via differential pressure sensors located in Buildings 1, 2, 8, 18, 19, 21,23,31 & 32. Consideration for an additional differential pressure sensor to form part of the chiller plant control logic shall be assessed for each new building.

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- A cooling call is generated from each building which enables the chilled water plants. The cooling call is typically generated via any chilled water valve that opens more than 70% and the cooling call is disabled when all chilled water valves for that building is closed less than 20%
- The chilled water system utilises a pressurised expansion tank located in Building 16. The original site chilled water header tank located in Building 18 is isolated now that the thermal storage facility has been installed.
- The chilled water plant in building 16 utilises the TAC INET Building Management Control System which interfaces with the Andover Building Management Control System (BMCS),The chilled water plant in building 24 utilises the Andover Continuum Building Management Control system(BMCS).
- There is a smaller chilled water plant located in Building No 4 which is used as a back up for Building 4, 5 & 6 and 30, in the event that chilled water conditions are lost from the central plant. The chiller and dedicated boiler plant are located in lower level plantroom in building 4. The expansion tank for this chilled water system is located in Building 6 air handling plantroom. This chiller and boiler plant operates under an Andover control System.
- All new buildings Chilled water supply for cooling shall be provided from the Campus existing Chilled water ringmain,the designer must comply with the existing Campus Chilled Water master plan and design principles and consult with the University's Manager of Mechanical Services for any proposed system.The designer must check the existing Chilled water plantrooms capacities and establish if there is a need to increase these centralised capacities inline with the Chilled water master plan when designing a system for any new buildings.

Mt Lawley Campus

The existing chilled water systems have the following characteristics:

- Central chilled water plant located in Plantroom 6 in Building 19 consists of 3 off water cooled chillers with a fourth chiller located in Building No 3, Plantroom No 1
- There is another stand alone chilled water plant:
  (Trane Chiller in Plantroom 4) Serving Part Building 1
- Chilled water supply temperature is reset from 7.0 ^{0}C to 12.0 ^{0}C, based on variation of outside temperature
- The chilled water system is a decoupled primary water system at the central plant with secondary variable speed pumps utilised for chilled water distribution to the Campus
- A reticulated chilled water distribution system across the campus serving most buildings utilising a two way control valve arrangement with 3 way valves on index legs
- The secondary chilled water pumps are controlled via differential pressure sensors located in Buildings 3 (Plantroom 2 tunnel) Building 1 and 8.
- A cooling call is generated from each building enables the chilled water plant. The cooling call is typically generated via any chilled water valve that opens more than 70% and the cooling call is disabled when all chilled water valves for that building is closed less than 20%
- The chilled water system utilises an expansion tank located in Building 19 Plantroom 6 in the cooling tower compound.
- The chilled water plant utilises the TAC INET Building Management Control System which interfaces with the Andover Continuum Building Management Control System (BMCS).

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 control system for the plant. Consideration for an additional differential pressure sensor to form part of the chiller plant control logic shall be assessed for each new building.

4.2.19 Heating Water Systems

Joondalup Campus

The existing heating water systems have the following characteristics:

- Two boilers in Building 1B plantroom provide for space heating requirements to Buildings 1 and 2.
- One boiler in Building 4 Plantroom 1 provide for space heating requirements to Buildings 4, 5, 6 and 30.
- A single boiler located in Building 8 and one in Building 8A provide for space heating requirements to each building.
- A single boiler provides for space heating requirements in Building 17.
- A single boiler provides for space heating requirements in Building 18
- A single boiler provides for space heating requirements in Building 23..
- A single boiler provides for space heating requirements in Building 19.
- A single boiler provides for space heating requirements in building 31
- A single boiler provides for space heating requirements in building 21
- A single boiler provides for space heating requirements in building 32
- Coil control valve arrangement is based on a two way valve system with system differential pressure controlled by a single bypass valve located in

each plant room.

Mt Lawley Campus

The existing heating water systems have the following characteristics:

- A boiler located in Plantroom 7B of Building 1 provides for space heating requirements to part of the eastern end of building 1 while a boiler located in Plantroom 3 Building 4 provides space heating to the remainder of Building 1.
- Two boilers in Building 3 Plantroom 1 provides for space heating requirements to Buildings 3, 4, 5 and 6.
- A single boiler located in Plantroom 5 of Building 12 provides for space heating requirements to Building 8 and 12 and domestic hot water to Buildings 12, 14 and 15.
- Two boilers in Building 19 Plantroom 6 provides for space heating requirements to Buildings 13, 16, 17 and 18.
- A single boiler located in Building 15 provides for space heating to Building 15.
- A single boiler provides for space heating requirements in building 10

Coil control valve arrangement is based on a two way valve system with system differential pressure controlled by a single bypass valve located in each plantroom.

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 boiler have the capacity, existing expansion tanks are suitable in height and size and that the new control system interfaces with the existing control system for the plant. Consideration for an additional differential pressure sensor to form part of the boiler plant control logic shall be assessed for each new building.

4.2.20 Ductwork and Registers

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

Where variable Air Volume systems are deemed appropriate to provide zoning flexibility, then ductwork shall be designed to limit air velocities to 10.5 m/s in riser ducts and a maximum of 8.5 m/s at VAB 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. The use of rigid fibre glass ductwork will not be accepted. Where alternatives are available, they shall be used upon ECU's approval.

All flexible ductwork used for supply air or return air shall be externally insulted to reduce heat transfer. Flexible ductwork shall be in accordance with AS 1668 Part 1 and shall have early fire hazard properties not exceeding the following indices when tested in accordance with AS 1530 Part 3 and AS 4254:

Spread of Flame	0
Smoke Developed	3

Heater bank linings shall be in accordance with AS 1668 and be constructed

from "Harditherm 700" or approved equivalent.

Ceiling diffusers shall be of the square louvre faced type for typical applications and shall be of Variflow, Harts, Dragon or other approved manufacture. Circular Krantz diffusers are acceptable however correct engineering and selection as prescribed by Krantz PTY LTD is to be adhered too. Additionally, where motorized Krantz diffusers are installed, access to the diffuser motor for servicing is to be provided to the acceptance of ECU. Ceiling diffusers shall be retained in position by a threaded screw/bolt arrangement. Where it is proposed to use an alternative arrangement, approval from ECU's Manager – Mechanical Services is required. All diffusers shall incorporate insulated cushion heads with flexible ductwork to spigot takeoff from 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. Front set of blades are to be horizontal. Maximum blade spacing shall be 20mm.

Toilet exhaust grilles shall be of disc or eggcrate type.

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

4.2.21 Piping, Valves and Fittings

In general, chilled water, heating water and condenser water lines within buildings shall be of Type B Copper. Underground pipework shall be suitably protected copper type B and or ABS laid direct in the ground unless laid in close proximity to heating water pipework. Pipe installed underground at a depth of less than 1200mm shall be insulated type B copper pipe. Galvanised pipe or other material shall not be used unless approved by ECU's Manager - Mechanical Services.

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

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

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 from 50 mm to 500 mm diameter Gate valves from 300 mm diameter
Throttling Plus Isolation	Double regulating valves from 15 mm to 65 mm diameter (for bypass legs across coils at index runs only) Wafer type butterfly valves from 50 mm to 300 mm diameter

Modulating Control Valves
Belimo Pressure Independent Characterised Control Valves (PICC valves) only (with manual over-ride capability)

Stabilising Differential Pressure Valves (for each building only)
Tour & Andersson

Non Return Valves
Swing Check Valves

Gauge Cocks
Ball Valves

Pressure / Temperature Test Points
Binder Double Seal Type

Belimo Pressurised Independent Characterised Control valves with associated strainers shall be used for all water balancing and control of cooling and heating coils and the like, in lieu of the traditional double regulating valves. All valves shall be labelled and clearly identify their flow control setting. Stabilising Differential Pressure valves shall be used for all branch take off from mains serving each building to provide a second tier of automatic balancing for both the chilled water and heating water systems.

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

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

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

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

Any variation of valve types / applications from the above shall be notified in writing to ECU Architectural and Buildings and Services Branches of ECU prior to ordering of equipment.

Where existing chilled / heating water system is to be extended, the consultant shall check and verify the capacity of the existing piping mains and plant to ensure that they are capable of meeting current and future demands. The consultant shall advise both the Architectural Branch and the Buildings and Services Branch of ECU of the current and future system characteristics.

4.2.22 Insulation to Pipework

Insulation shall not be mineral wool or fibre glass. Polystyrene insulation complete with vapour seal shall be specified. Insulation for valves, flanges and fittings shall be arranged for easy removal for maintenance purposes and shall be provided with hinged and clipped casings. All exposed pipework which is insulated shall be metal sheathed in plant rooms, ducts and where exposed and sisalation wrapped where concealed. Metal straps shall be provided to both metal sheathing and sisalation. Sisalation shall be continuous over all wooden insulation blocks at hangers. Blocks shall be turned from solid timber.

4.2.23 Underground Services

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

All pits laid in paving are to be trafficable to medium standard.

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

4.2.24 Plant and Equipment

Pumps
Close coupled pumps shall not be used. 50mm suction and over shall be Ajax I.S. "Back End Pull Out Type". Under 50mm suction they shall be Ajax "Vertical Split End Type". Impellers shall be bronze; casing above 25mm: gunmetal, below 25mm: bronze; shafts shall be stainless steel. All seals shall be mechanical seals.

Motors
Shall be totally enclosed fan cooled and normally be limited to 1450 rpm maximum. Motors for variable speed to 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.

Fans
Where they are centrifugal fans they are to be of approved manufacture with backward curved aerofoil shaped blades.
Air flow switches are to be piped across the suction and discharge ends of fans

Variable Speed Drives
Variable Speed Drives (VSD) shall be of Danfoss, ABB or Zenner manufacture or approved equal.

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

VSD shall have a mains supply isolation contactor installed before the VSD. The contactor shall, at all times, be sized sufficiently to allow the controlled motor to operate Direct On-line (DOL) should the VSD be removed for service.

The intent is to allow conversion to DOL operation as a contingency in instances where failure of a VSD occurs and it is necessary to keep the facility in service. In such instances, temporary "soft starting" may be required where motor size does not allow DOL starting, however it is important that the isolation contactor is of sufficient size to operate in conjunction with soft starting.

Edith Cowan University's Building Automation 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 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% 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.

Roof Mounted Exhaust Fans
Roof mounted exhaust fans shall be direct drive type and utilise speed controllers or variable speed drives as required depending on the fan motor size. The use of belt driven fans is not the preferred option. If a belt driven fan is proposed, then it shall be subject to approval by ECU.

Heater Banks
Heater banks may be electric but only to be used where other alternatives are cost prohibitive. Utilise pulse width modulation for the staging of the heater banks as described under Controls

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

Air handling plant above 3,000 L/s	Pyracube, Four Peak or deep bed type
Air handling plant under 3,000 L/s	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. Prefilters shall be of Email SP panel type filter with KO type media or approved equivalent, to achieve a minimum of 75 % efficiency at AS1132 Dust Test No 4.

Magnahelic gauges shall be provided to sense filter bank pressure drop. Engraved labels secured adjacent to magnahelic gauges shall state the pressure at which filters shall be cleaned/replaced.

VAV Boxes

VAV boxes shall be Johnson, Airwise Engineering or approved equivalent. Depending on the design, variable volume boxes utilising a single primary air system is preferred. Subject to justification to and approval by ECU, the use of series or parallel type fan assisted VAV boxes may be considered. Where fan assisted VAV boxes are utilised, they shall incorporate a fan air flow or pressure switch which shall be suitable for low air pressure at minimum airflow. The airflow / pressure switch shall be interlocked with any electric trim duct heaters.

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 QAQC checks shall be included in the Operating & Maintenance Manuals.

Chiller Sets

Existing chillers are of York, Trane or Luke manufacture. Water cooled helical screw type chillers are the preferred option. Requirements other than water cooled helical screw require clearance by the University Project Manager and Buildings and Services Branch of ECU. Additional chillers should be compatible. Where practical, chillers are preferred to be low speed multi-stage type with no gear box.

Chiller condenser vessel tubesheets shall preferably be constructed from stainless steel. Where mild steel tubesheets are supplied with new chillers, the tubesheet shall **NOT** be treated with a protective coating such as “Corocoate” or like epoxy coating. Cathodic protection shall be provided with the application of sacrificial anodes in condenser end caps as a minimum along with “Best Practice” application of anti-corrosion water inhibitor treatment.

Treatment of tubesheets and cathodic protection type, along with maintenance requirements, shall be documented in plant “Operation 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, that allow chiller plant management and monitoring. Control functions shall include 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 BacNet or other high level interface is provided, the control system shall be configured to:

- Monitor refrigerent temperatures and pressures
- Monitor % compressor loading
- Monitor compressor Amps and run times
- Allow variation of % 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.

Chiller enable, chilled water reset and any other critical command from the BMCS to the chiller shall be hard wired, all BACnet or HLI is to be utilised for monitoring only. 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 COP's at part load, varying chilled water supply temperatures and varying condenser water temperatures. Life cycle costing of operating and maintenance profiles over 20 years shall be forwarded to ECU for verification prior to the consultant issuing tender specification.
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 manufacturer's recommendation.

Cooling Towers
Cooling towers shall be constructed of fibreglass or non-corrosive material and be in accordance with 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. Where new cooling towers are provided they shall incorporate an automatic type flushing system to the approval of ECU.

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 setup to provide for rotation of biocides. Biocide chemicals shall be injected into the condenser water entering side of chiller condensers. All condensers, pipework and cooling tower wetted surfaces shall be treated by biocides including potential "dead-legs" such as condenser by pass pipework;
- Where a BMS is available within a condenser water system plantroom, automatic time scheduling of biocide dosing shall be achieved via the BMS.

The selection of a cooling tower shall be undertaken in conjunction with the selection of the associated chiller to ensure COP's at design and part load conditions are achieved. Cooling tower fans should incorporate variable speed drives, suitably controlled to maintain design condenser water temperature to each cooling tower basin.

Cooling towers shall be of B.A.C. (Baltimore Aircoil) manufacture or approved equal. Disposal of cooling tower waste water is to be to approval of ECU. ECU sustainability objectives require the consideration of reuse of waste water. The option of discharge to sewer as trade waste must be maintained.

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.

Pressure Vessels
All equipment supplied to the University that contains pressure vessels shall be registered in accordance with relevant Australian Standards, legislation and

Worksafe WA.

In addition to statutory requirements, copies of registration certificates and inspection reports/datasheets shall be included in "Operation and Maintenance" manuals with a separate copy issued to ECU's 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; and
- Vacuum systems.

Inspection, certification and maintenance requirements of pressure vessel shall be detailed in "Operation and Maintenance" manuals.

All 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 pulleys shall be equivalent to Taperlock.

Air Handling Plant
Refer filters, motors and fans under items 11.15 and 11.22. Air handling plant associated with variable air volume boxes shall incorporate variable speed drives to control supply air fan speed to suit 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 economy cycle in trying to modulate to achieve 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.

Air handling units shall incorporate a motorised minimum outside air damper which shall close on warm up cycle. Economy cycle damper which could also be utilised in night purge control routine should also be provided where appropriate.

All sensors and relief dampers locations are to clearly shown on the Building Management and Control systems (BMCS)graphics

All related DDC points on a related system must be located on the same physical controller,e.g a heating water system differential pressure must be on the same controller as the heating water bypass valve.

Heating Water Boilers
Shall be forced draught type.

Evaporative Coolers
Shall be constructed of aluminium similar to "Bonaire" or approved equivalent.

Plantroom Floor Waste Charging System

A solenoid valve to be provided to charge the plantroom floor wastes. These solenoid valves are to be controlled to come on once a week by the Building Management System.

4.2.25 Instruments

All instruments shall be calibrated to read in the S.I. system of units. Dial gauges shall be 100mm 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% of full scale deflection.

4.2.26 Air Conditioning Electrical System

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

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

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

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

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

Hours run meters shall be provided on all items of equipment which are duplicated or run in parallel, and where else considered necessary, unless controlled by a direct digital control system, in which case the control system shall record operating hours. Strategy for measuring and tracking energy use by mechanical services systems will require greater detail.

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

Polyphase Kilowatt-Hour Meters shall be provided to main A/C Switchboards to meter the consumption of the switchboard and all its sub-boards. Where sub-metering of mechanical service switchboards is being picked up under the Electrical Services element, this requirement is not applicable.

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 heated air systems.

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

4.2.27 Identification of Equipment

All items of equipment shall be identified with engraved trefelite labels, in accordance with the University's Computerised Maintenance Management System QFM Coding structure. Contact the Buildings and Services Branch for details. Thermometer bulbs, pressure gauge tapings and remote sensing points shall be labelled to indicate their function.

4.2.28 Identification of Pipework

All pipes shall be identified in accordance with AS 1345 - 1972 for the Identification of Piping, Conduits and Ducts and AS 1318, Industrial Accident Prevention Signs. "Safetyman" adhesive labels are an acceptable method for identification of pipework. Flow direction arrows shall be provided to all pipework. All exposed pipework in plant rooms and risers and wherever else exposed to view shall be fully painted in accordance with the University's "Colour Schedule for Plant and Equipment" (Section 24.0). Colours standards shall be in accordance with AS 2700.

4.2.29 Future Air Conditioning

All buildings are to be designed to have sufficient capacity to allow for extension or expansion of the air conditioning systems with in the building design for future buildings proposed for the site. The designer should reference the master plan and discuss the options with ECU to consolidate the design intent. All chilled water and heating pipe systems to each building shall, as a minimum, be designed to have 20% spare capacity throughout.

4.2.30 Building Management System (BMS)

The University's buildings are controlled and monitored through an Andover Continuum or TAC INET system located in the Maintenance office with Data Gathering Panels (DGPs) in each building. The Contract shall allow for the supply and installation of a system in the building connected back to the CPU by the University's ethernet communications network and to any relevant points in the building to be determined in conjunction with the University. The new Building Management and Control Systems(BMCS) shall be Andover Continuum.

Interconnection between DGPs within the building and between buildings shall be DEKORON cable 1.5mm², twin, terminated through a lightning protector at the DGP.

Power to the DGPs shall be 240V/24V with capacity to operate the maximum relays controlled by the DGP. All controls emanating from the DGP to external devices shall be 24V A.C. originating from a 240V/24V transformer mounted within the DGP cabinet or in external switchboards and switched by the internal relays within the DGPs.

Relays shall be IZUMI, RY4S, 24V D.C. Typical control drawings are available from Asset Delivery Branch.

Programming of system shall be part of the contract and group point numbering shall be determined in conjunction with ECU's Buildings and Services Branch. Provision for system graphics to also be included in accordance with current methodology.

All the BMCS and Mechanical services switchboards to have 25% spare capacity for future expansion, the spare capacity shall include but limited to ,Hardware, software and spare DDC points capability.

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

4.2.31 Air Conditioning Controls – General

(i) Refrigeration plant shall be fully automatic and shall normally respond to a call for cooling from the air-handling unit.

(ii) Local exhaust fans (other than toilet exhaust) shall be provided with local manual controls.

(iii) External and/or remote temperature and pressure sensors and recorders should be specified on any installation of 100 kW or over.

(iv) Provision should be made on all controls and sensors for connection to a Central Control and Monitoring System (BMS) - Andover or CSI.

(v) Control and monitoring systems for air-conditioning plant shall be determined in consultation with staff of ECU's Buildings and Services Branch prior to finalisation of specification.

4.2.32 Air Conditioning Control Functionality

Occupied (Master) Setpoint
Occupied Setpoint is an internal numeric point which floats over a temperature range range of 22.5°C to 23°C and is established once on each air handling/fan coil unit. The Occupied Setpoint represents the room or space temperature setpoint under active push button control. The floating Occupied Setpointis reset according to ambient temperature in accordance with the following paramenters:

- If the ambient temperature is below 17°C then OSP = 22.5°C
- If the ambient temperature is above 25°C then OSP = 23.0°C
- When the ambient temperature is between 17°C and 25°C, OSP will be proportional between 22.5°C and 23°C

Mode	***Set-point***
Occupied Set-Point	22.5°C
Setback Cool Mode	OSP + 2°C
Setback Heat Mode	OSP – 2°C

- Where a globalised campus Master (Occupied) Setpoint is already established providing alternative functionality relating to previous approaches in control strategy, the above approach will take precedence. To this end, the control strategy shall be updated to reflect current control requirements.

Air Conditioning Run Times
Air conditioning systems shall be time scheduled to operate in core hours. Core hours for the purpose of air conditioning run times is from 8:00am to 5:30pm Monday to Friday.

Once air conditioning units start in core hours, systems shall operate in a

"setback mode". Setback shall be in accordance with the following parameters:

Setback cool mode	=	OSP + 1.5°C = SBCSP
Setback heat mode	=	OSP – 2.5°C = SBHSP

Upon the occupant activating an A/C push button, the active zone shall revert to "occupied mode". "Occupied mode" shall provide system control to Occupied Setpoint. In core hours, occupied mode shall be for a duration of four (4) hours. Outside of core hours, an initial activation of the A/C push button shall start the air conditioning system with the active zone operating in "occupied mode" while inactive zones operate in "setback mode". Out of hours run time is for a duration of two (2) hours.

A/C push button control stations shall utilise a "rocker" style switch (not depression type as used previously) 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. All inactive zones shall remain in "setback mode". The push button control logic shall be set up where the push button has to be depressed for a period of not longer than 3 seconds to enable occupied mode. A further 30 seconds needs to elapse before the bush button can be depressed for a period of not longer than 3 seconds to enable setback mode in core hours and turn the AHU/FCU off in an "out of hours" condition.

Where there is a group of staff studies, the A/C push button control station shall be located most conveniently in the main access way at 900mm above floor level. Where tutorials or classrooms are encountered, separate push button control stations for each area located adjacent to the light switch shall be provided.

Some areas, such as Auditoriums, Theatres and the like, do not operate on core hours. The air conditioning plant is initiated when the push button is activated and then controls as required to achieve OSP. However, if the area is not occupied and the room temperature exceeds 28.0 ^{0}C or is lower than 19.0 ^{0}C, then the air conditioning plant shall start automatically and run until the room temperature falls below 26.0 ^{0}C or rises above 20.0 ^{0}C.

There is existing air handling plant that, due to their configuration, does not follow the above control logic to the letter. In the event that there are modifications to an existing air handling or distribution system, the designer shall identify the control logic employed and modify as required, subject to ECU approval, in order to provide a plant that operates effectively and is energy efficient. The control logic finally employed should be similar in intent to the design intent of the control logic described herein.

Room Sensing

Normal location of sensors for room temperature sensing shall be:

- For perimeter zones, 1500 – 2000 mm from the outside wall, 1500mm to 1700mm above the floor, out of direct sunlight and adjacent return air path if possible
- For internal zones, 1500mm to 1700mm above the floor and adjacent return air path

VAV Operation

VAV operation shall be in accordance with control functionality for occupied and setback modes as outlined under section titled "Air Conditioning Run Times". This means that only the VAV in the activated push button area is to commence full control function - all other VAV's are to remain in setback mode as indicated.

Where more than one VAV Box service a common area a common push button is to be installed and programmed to start all the VAV Boxes serving that area.

VAV electric re-heat shall be enabled and allowed to operate to maintain OSP or SBSP whenever the following calculation below is true.

SAF Status = On & (SAT < RAT)
SAF Status = On & (RT < OSP or SBOSP)

where

SAF = Supply Air Fan
SAT = Supply Air Temperature
RAT = Return Air Temperature
RT = Room Temperature
OSP = Occupied Set Point for occupied
SBSP = Set Back Set Point for unoccupied mode

Note:
Refer to item (v) in Warm Up Section under the heading of "Note" for VAV operation during warm-up mode.

VAV heater banks shall have a mains power supply isolation contactor located in the air conditioning unit plantroom mechanical services switchboard that is energised based on fan status that is derived from an air flow switch located in the supply air duct.

VAV heater bank trip indication shall be by way of monitoring a hardwired status point typically associated with the heater isolation contactor/relay and is to be displayed on the BMS graphic page for VAV boxes.

Economy Cycle Operation
AHU start up
On AHU start up hold chilled and heating water valves closed for 2 minutes.
Check for viability of economy by
OA < RA and SA > SA_SP and Enthalpy < 48 for economy cool
OA > RA and SA < SA_SP for economy heat
If economy is viable modulate economy dampers to control supply air temperature to supply air temperature set point. (Hold chilled and heating water valves closed)

If on economy cool
Where economy dampers = 100% and SA > SA_SP for a period greater than 2 minutes, then modulate CHWV to maintain supply air temperature. (Economy not able to meet demand)

If OA > RA or Enthalpy > 52 then close economy dampers. Modulate the Chilled Water Valves to maintain supply air temperature. (Economy is no longer viable).
While AHU is running when no economy is in use, check for cooling economy viability by OA < RA and Enthalpy < 48 for economy cool. Where this is true, open economy dampers to 100%. Continue to modulate CHWV until valve = 0%. Then modulate economy to maintain supply air temperature.

If on economy heat
Where economy dampers = 100% and SA < SA_SP for a period greater than 2 minutes, then modulate HWV to maintain supply air temperature. (Economy not able to meet demand)

If OA < RA then close economy dampers. Modulate Heating Water Valves to maintain supply air temperature. (Economy no longer viable).
While AHU is running when no economy is in use, check for heating economy

viability by OA > RA for economy heat. Where this is true, Open economy dampers to 100%. Continue to modulate HWV until valve = 0%. Then modulate economy to maintain supply air temperature.

Variables
Where SA temperature is not used replace SA and SA_SP with chilled and heating water control points (e.g. Room temperature and room temperature set point)

Where OA > SA_SP -0.5 and OA < SA_SP +0.5 and Enthalpy < 48 then Economy = 100% (OA is very close to SA_SP so economy is used to provide 100% fresh air).

OA = outside air temperature
RA = return air temperature
SA = supply air temperature
SA_SP = supply air temperature set point
CHWV = chilled water valve
HWV = heating water valve

Note: Enthalpy is not used for heating

Night Purge
Night purge shall be incorporated and initiated when:

- The air handling system incorporates an economy cycle and does not operate 24 hours a day
- The average space temperature for all zones exceeds 24.0 ^{0}C
- Outside air temperature less than 22.0 ^{0}C
- Outside air enthalpy less than 52 kj/kg
- Time of day between midnight and core hours start time

Night purge shall be terminated on commencement of core hours of operation, when outside air temperature greater than return air temperature or outside air enthalpy exceeds 52 kj/kg. During night purge operations, all VAV boxes shall open to 100% design airflow until OSP + 2.0^{0}C is achieved, whereupon the night purge cycle shall terminate

Early Morning Warm Up Operation
Initiation
Warm up cycle will not be initiated unless the average room temperature is less than 20.0ºC, outside air temperature is less than 14.0ºC and time of day is less than two hours before core hours (i.e. Monday to Friday). This is illustrated in the following equation.

(ART < 20ºC) & (0AT < 14ºC) & (TOD = Core Hours Start < 2 hours)

where:	ART	=	Average Room Temperature
	SAF	=	Supply Air Fan
	OAT	=	Outside Air Temperature
	TOD	=	Time Of Day

The warm up cycle shall be enabled two hours before core hours commences, subject to operating parameters being met. When the warm up cycle is enabled the heating water valve will modulate to maintain a supply air temperature of 35.0°C. This will be held until the average of all room temperatures is equal to OSP – 1.0^{0}C or Core Hours commence.

ie. cold morning OSP = 22.5°C - 1 .0 ^{0}C = 21.5°C

Note:

(i) 22.5°C – 1.0 ^{0}C is needed to overcome building inertia. This control logic is aimed at being both energy efficient (i.e. not overheating the space) and mindful of reducing operating costs (i.e. minimising the need for electricity consumption during on-peak periods) as the central heating is typically a gas boiler with no on peak periods, it is prudent to maintain the operation of the warm up cycle until specified conditions are achieved. Variation of parameters for activation and termination of warm up cycle may be required to suit building characteristics and plant performances over varying ambient conditions.

(ii) The economy cycle will need to de-energise while warm up is in operation.

(iii) The minimum outside air will need to be closed off and in the case of air quality control, will need to be overridden so as to move to its closed position.

(iv) During warm up, an AHU localised point will be recognised by each VAV so that the VAV will drive to its maximum design volume (i.e. reverse acting mode) and also lock out any VAV re-heat.

(v) The duration of the warm up cycle is nominal only.

(vi) After the warm up cycle has terminated, a period of 15 minutes (variable) air circulation is required before ECU standard mechanical services control is enabled. The air handling unit shall continue to operate until core hours of operation are initiated however, the minimum outside air damper would open to preset (normal open) position, the VAV boxes would return to normal control of airflow and the leaving supply air temperature would be reset to normal operation. The outside air economy dampers would be held closed 100%

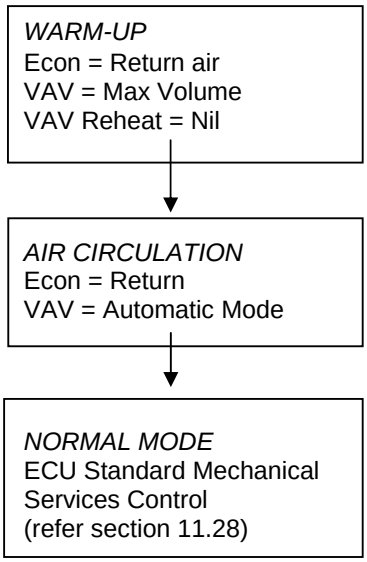
(vii) In the event that the warm up cycle is terminated prior to 7.30 AM, the air handling unit shall be switched off until either the parameters for warm up cycle allow it to be enabled or core hours of operation were reached.

(viii) Ensure that the warm up cycle utilises the gas boilers and central heating water systems in lieu of electric reheat.

(ix) Consideration should also be given to day warm up cycle routines where the building or air handling systems experience a cold thermal change during the day.

The warm up sequence is illustrated below in Figure 4

Figure 4



Day Warm Up Operation

The day warm up cycle is enabled from the following parameters:

Enabled	**Disabled**
Average Room Temperature < OSP – 1.5 ^{0}K **or**	Average room temperature > OSP -1.0 ^{0}K
All AHU VAV heater positions >50%	Outside core hours (0800 – 1730)
Core hours (0800 – 1730)	Monday to Friday
Days of week is Monday to Friday	

Whilst the day time warm up cycle is enabled, the operation of the VAV boxes is then reversed such that it will control to maximum air volume as the temperature in the room falls below the heating set point and will control to minimum air volume as the room temperature rises above the heating set point.

eg.

Warm Up
S/A = 32.0 ^{0}C
Econ = Return Air
Min O/A = Open
VAV Airflow = Reverse
VAV Reheat = Nil

Once warm up cycle is disabled a period of 15 minutes is elapsed to allow for the air circulation. During the air circulation cycle the supply air temperature resumes normal control, the economy cycle dampers remain in full return air mode, the minimum outside air dampers operate and VAV boxes operate as below:

Early Morning Air Circulation
S/A = Normal Control
Econ = Return Air
Min O/A = Open
VAV Airflow = Automatic
VAV Reheat = Nil
P/R SAF = Normal

Day Time Air Circulation
S/A = Normal Control
Econ = Return Air
Min O/A = Open
VAV Airflow = Reverse
VAV Reheat = Nil

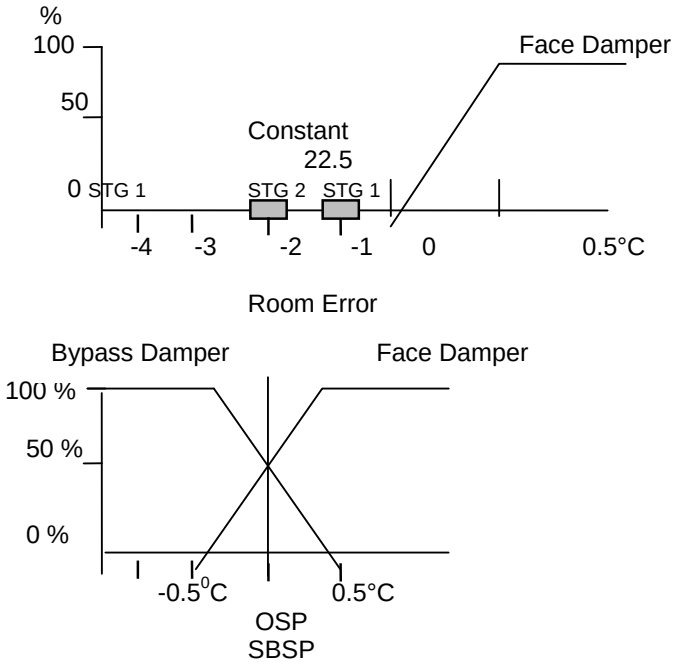
AHU Static Pressure Control
Air handling unit air volume will be controlled by sensing system static air pressure with the sensor located at a distance 60% down stream of the AHU in the supply air duct index leg. The static pressure sensors locations are to be Shown on the Building Management and Control System Graphics, sensors must be located in locations that can be accessed for future maintenance. (Variations to this will need special arrangement through ECU Buildings and Services Branch). The static air pressure will be maintained by modulating a variable speed drive controlling the AHU supply air fan motor speed.

The static pressure set point shall be determined in conjunction with the consultant and the commissioning personnel such that the static pressure set point shall be measured at simulated diversified airflow for the air distribution system.

Chilled and Heating water pressure transducers shall be provided with isolation and bypass valves, binder points to be installed in close proximity to the transducers to allow commissioning, calibration, replacement and zeroing of the transducer.

AHU Zone Control (Face & Bypass)
Face / Bypass control achieved by taking the highest average value of any space temperature sensor on that zone and comparing to OSP for each zone sensor to determine set point deviation.

Figure 5



Deviation of Room Temperature Against OSP / SBSP

Supply Air Temperature Cooling and Heating Reset
The chilled and heating water valves will be modulated to maintain supply air temperature sensed by a supply air temperature sensor according to the reset schedule as illustrated in Figure 6. Room error referred to in Figure 6 is obtained by utilising the highest average of zone temperatures compared to the master set point (or room set point) in occupied mode or the "setback mode" set point when no zones are active. If operating in the unoccupied mode and the after hours push button was activated for one or more VAV boxes or areas, then the highest average room error would be calculated using only the activated VAV boxes or areas, with the unoccupied areas excluded from the calculation.

An example of the calculation of the highest average is provided as follows:

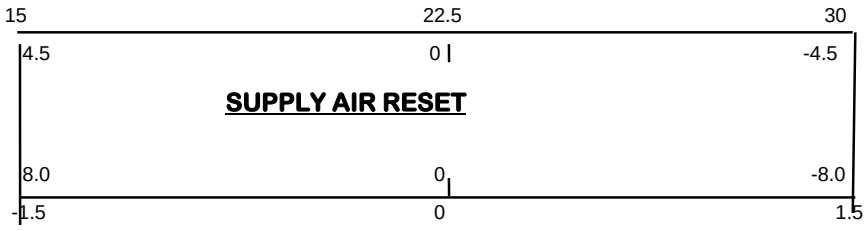
VAV No	SP	Actual Temp	Occupied / Unoccupied
1.1	23.0	23.8	Occupied
1.2	23.3	25.0	Occupied
1.3	23.0	25.5	Unoccupied
1.4	23.0	23.7	Occupied

Calculated Average Room Error = (0.8+1.7+0.7)/3 = 1.06ºC
Calculated Highest Average Room Error = (1.7+1.06)/2 = 1.38ºC

Figure 6

A

OUTSIDE AIR TEMP



B

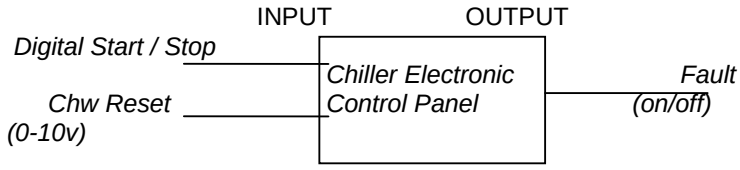
SUPPLY AIR RESET = 22.5 + (A + B)

Toilet Exhaust Control
Toilet exhaust fan will operate during core hours plus 1 hour or whenever toilet zoned AHU is running plus one hour. The duty / standby fans shall be step start controlled based on accumulated run hours for each fan.

Chiller Control
Interface and Reset
The chiller selected by ECU will have either an electronic control panel or a full direct digital control panel.

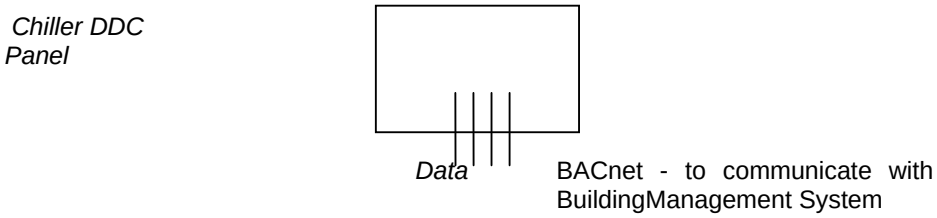
- **Electronic Control Panel**
  Control interface to Edith Cowan University's Building Management System where an electronic control panel is used will be as indicated in Figure 7a.

Figure 7a



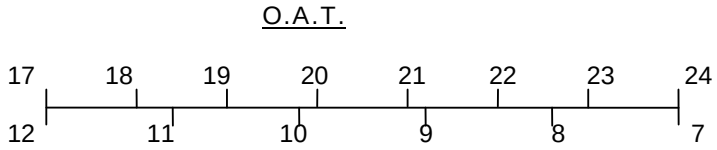
- **Direct Digital Control Panel**
  Control interface to ECU's Building Management System where a direct digital control system is used will be as indicated in Figure 7b.

Figure 7b



Chilled Water Control
Chilled Water Temperature Reset
The chilled water system is to be provided with setpoint reset according to the schedule in Figure 8

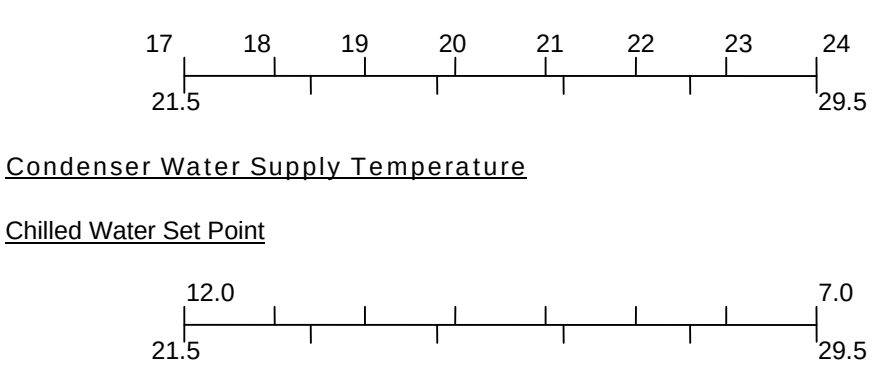
Figure 8



The staging up of the chillers on return chilled water temperature shall have the staging set points offset to match the variation in leaving chilled water temperature setpoint such that, for example, set points of 7.0 ^{0}C / 14.0 ^{0}C would change to 10.0 ^{0}C / 17.0 ^{0}C.

Condenser Water Reset
Provide condenser water temperature reset for screw type chillers based on the following parameters:

Figure 9



Use highest of the two values above.

Screw chillers shall incorporate condenser water flow control, either via the use of throttling valves or variable speed pump operating controlled by refrigerant differential pressure sensor, in accordance with manufacturer's recommendations.

Reciprocating chiller sets shall incorporate condenser water bypass in accordance with manufacturer's recommendations. Unless centrifugal chillers are to be utilised for lead start, these chillers would not require condenser water throttling control. However, where a chiller plant has more than 2 chillers, and depending of the configuration of the condenser water pipework, condenser water throttling valves or automatic regulating valves may be necessary to limit excess condenser water flow through each vessel.

In resetting condenser water supply temperature set point, the operation and staging of the cooling tower / fans must follow suit. Utilise free cooling across all cooling towers where possible.

Chilled Water Differential Pressure Control

Where a de-coupled chilled water system is in use, the chilled water system differential pressure will be maintained by a variable speed drive attached to the secondary chilled water pump. The variable speed drive will respond to variations in system pressure as read by a differential pressure transmitter. The transmitter is to be installed at a point approximately 60% down stream of the chilled water pump in the index leg of the chilled water system.

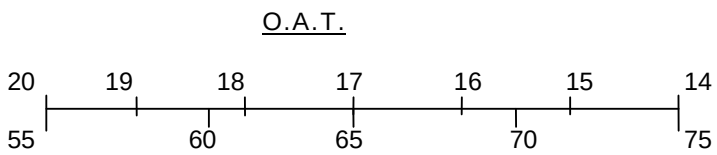
Where the system is not de-coupled, chilled water system differential pressure will be maintained by a bypass valve which will respond to variations in system pressure as read by a differential pressure transmitter across the chiller vessel. The transmitter shall measure differential pressure across the chiller to ensure minimum chilled water flow rates are maintained while providing full flow out into the field as required.

With respect to the Joondalup campus, the operating pressure and pressure range for valves to the expansion tank and system differential pressure have been set against the Science and Health Building No 19, which represent the index leg of the system, including the static head exerted on the system.

For all new projects on Joondalup Campus, it is important that the engineer checks and ensures that the static head of new buildings does not exceed that of the Science and Health Building. This will generally be achieved by locating chilled water plant on levels below the Science and Health plant room levels. In the event the levels of Science and Health Building plant are exceeded the engineer is to check and calculate all system pressures which may then require some adjustments to be made to the pressure settings relevant to the thermal storage system and expansion tank in the central plant room.

Heating Water Control
Heating Water Temperature Reset
The heating water system is to be provided with setpoint reset according to the schedule in Figure 10

Figure 10

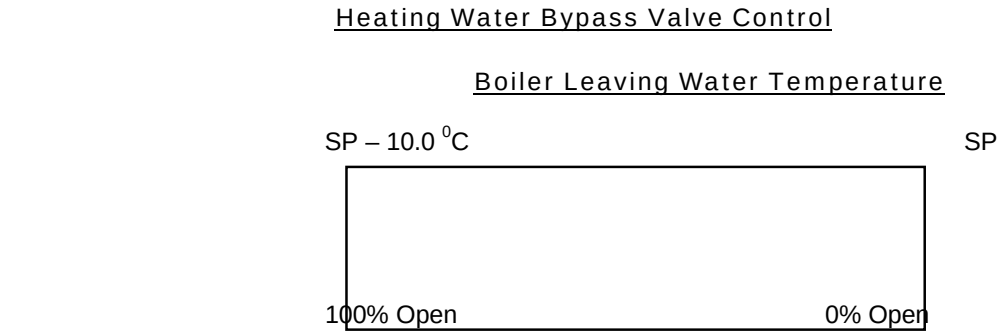


Heating Water Temperature Setpoint

Heating Water Differential Pressure Control

The heating water system will have a Bypass Valve that is to maintain the boiler water temperature as illustrated in Figure 11.

Figure 11

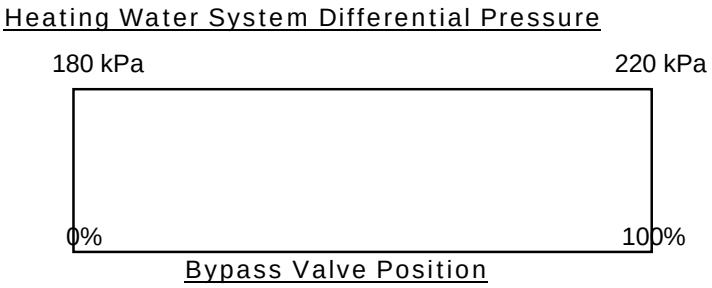


The boiler operation shall be interlocked with a heating water flow switch, to be located on the leaving water side of the boiler, suitably calibrated to de-ergise the boiler at minimum flow rate.

Heating Water Over Pressurisation

The bypass valve will be programmed to open in accordance with the schedule illustrated in Figure 12, should over pressurisation of the system occur.

Figure 12



4.2.33 Load Shedding

Where load shedding control sequences are utilised, they shall be incorporated where site maximum demand is monitored. Load sheding shall have the following priorities:

- Increase of chilled water supply temperature from 7.0 °C to 8.0 °C
- Increase in OSP and SBSP by 1.0 °C
- Isolation of operation of all electric duct heaters

4.2.34 Energy 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 the ECU Project Manager Buildings of the estimated energy consumption profiles over a 12 month period and the energy modeling scenarios. The consultant is to identify, nominate and / or investigate all scenarios for limiting energy consumption and greenhouse gas emissions.

The consultant shall be responsible for monitoring the operation and control of the air conditioning plant for a period of 24 months after practical completion. This work shall form part of the consultants brief for the design and documentation of the project. This shall include regular site visits or remote dial in to the site to observe operation and performance of plant, make modifications to the control logic of the plant and equipment to improve efficiency and reduce operating costs. The consultant shall instruct the contractor to make all necessary changes at no cost to ECU, as required to achieve efficient operation of the plant. The consultant shall submit energy consumption profiles and sign off on the operation and control of the plant and equipment every 3 months, to the approval of ECU.

The consultant shall also specify energy monitoring equipment to be provided for all forms of energy consumed for the building. This shall be achieved via monitoring points on the digital control system. 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

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

4.2.35 Gas Meters/BMS Connection

All wiring connected to all gas meters to be installed as per Standards Association of Australia requirements for electrical circuits in a Zone 2 environment. Protection is required to enable the circuits to be rated intrinsically safe.

4.2.36 Practical Completion

The consultant is encouraged to discuss the design and development of the mechanical services and the selection of equipment with ECU's Manager – Mechanical Services, at an early stage of the project to ensure that the systems proposed meet with ECU approval.

Prior to issuing out to tender, the consultant shall issue to ECU's 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 ECU's Manager – Mechanical Service, for approval. The consultant shall also co-ordinate the defects inspection to be carried out with a representative of the

consultant, the contractor, ECU's Asset Delivery Branch, ECU's Building Buildings and Branch, and ECU's facilities Manager.

4.2.37 Defects Warranty Period

The consultant and contractor shall ensure that all new plant and equipment is serviced monthly for a period of 12 months after practical completion and that maintenance service sheets for all items of equipment are reviewed by the consultant before being forwarded to ECU for their verification.

At the end of the 12 months defects warranty period, a final inspection shall be carried out by the consultant, contractor, ECU's Manager, Mechanical Services and ECU representatives. A copy of all service sheets shall be forwarded to the ECU's Manager, Mechanical Services for their records.

After the defects warranty period, the consultant will 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 ECU Asset Delievery Manager. ECU's Manager, Mechanical Services shall also be advised of any changes to the operation of the plant and equipment and the Operating & Maintenance manuals shall be upgraded accordingly, on a regular basis.

4.2.38 Operating & Maintenance Manuals

The Consultant shall ensure that one complete set of Operating & Maintenance Manuals are checked, complete and approved by the consultant before being forwarded on to ECU for acceptance. Upon approval and subject to changes identified by the consultant and ECU, The consultant shall ensure that 2 off full and complete sets of operating and maintenance manuals are forwarded to ECU, for their records. We will require one electronic copy

The Operating & Maintenance manuals for mechanical services shall:

- Be a three ringed binder, navy blue in colour and A4 in size
- Consist of one or more binders as required to accommodate all the information on the project services
- Identify the Campus, building name and number on the binding and front cover with lettering being in gold leaf lettering. The layout of the titles and headings for the manuals shall be obtained from the Architectural Branch of ECU.
- Identify the Builder, Architect, Consultant & mechanical contractor
- Identify the date of Practical Completion
- Incorporate a description of the works undertaken, description of operation, equipment schedules, functional description of the control system including flow diagrams and point schedules, manufacturers data, commissioning data, maintenance procedures, fire testing procedures and as constructed drawings
- The control system documents may be provided in a separate volume to match the project manuals.
- Incorporate one set of hard copy and one electronic copy of "as constructed" drawings per set of Operating & Maintenance Manuals
- Set of As Constructed Drawings in appropriate cabinet located in main plant room.

4.3 Hydraulic Services

4.3.1 Preferred Contractors

Contractors either tendering or working on projects at Edith Cowan University must be approved by the project manager, Asset Delivery.

4.3.2 Piped Pressure Services

4.3.2.1 General

This section of the standards outlines the minimum requirements for the following pressure services:

- cold water;
- hot water;
- reverse osmosis water system
- natural gas;
- LP Gas (liquified petroleum gas);
- Specialist gases e.g nitrogen, oxygen, CO^2, etc;
- compressed air;
- vacuum.

For Fire Service, refer section 4.8.

In general, each riser shall be fitted with isolating valves at the bottom (or top in cases of downfeeds) and each multi storey circulating stack shall be isolated at top and bottom as appropriate. Branch lines serving an outlet or groups of outlets shall be provided with isolating valves at the riser. To laboratories and ducts to ablution blocks there is to be a main isolating valve. In all cases, isolating valves shall be readily accessible in ducts or valve boxes. For water supplies, compressed air and natural gas, ring main distribution systems should be used wherever possible and these rings should be broken down into minimum of three sections per ring by clearly marked isolating valves in the ring system. In the case where a building is supplied by a ring main, then the main shall be capable of being isolated on either side of the tee-off position. Isolation valves are to be clearly identified on As Constructed drawings, for clarity it may be necessary to include a schematic layout.

All pressure pipework shall be tested to a minimum pressure of not less than 50% above Manufacturer's design working pressure for the pipe or twice the working pressure whichever is the greater when no other relevant testing standard exists. Allow to isolate fixtures during pressure testing.

4.3.2.2 Water Supply

Materials

***Pipework*.** Reticulation within buildings shall be seamless tested copper tube type "B" as described in Australian Standard AS1432.

Fittings. Shall be silver soldered capillary fittings, taper/taper threaded inhibited brass fittings, flared fittings, inhibited brass fittings or flanged connections. For connections to fixtures and fittings use flared and/or brass barrel unions for up to and including 50mm diameters. Flanges to be used for sizes above 50mm diameters. *Compression fittings (Kingco, Conetite, etc) shall not be used under any circumstances*. Silver solder shall contain at least 15% silver in all instances.

Valves. *All valves shall be suitable for Perth water with particular regard to dezincification*. Isolating valves may be dezincification inhibited bronze gate valves or stop cocks up to and including 50mm diameter. For sizes larger than 50mm diameter, flanged valves are to be used with flanges and valve body designed for the test pressure of the service. Balance valves shall be globe valves. All valves to be suitable for pressure testing of both body flanges and disc to 2100 kPa.

(Valves 80mm diameter and larger may be cast iron or steel body, bronze trimmed with DR stem.).

Butterfly valves are acceptable for isolating purposes only and are to be stud fitted (between flange models are not acceptable). Spindle to be stainless steel and seals to be rubber or plastic appropriate to fluid being transported, likewise valve discs are to be stainless steel, brass, aluminium or aluminium bronze as recommended by the valve manufacturer for fluid being transported.

Taps. Taps shall be of brass construction with jumper valves except where lever action valves are used and these are to be fitted with 90° or 180° ceramic seats. Handles shall be brass or ceramic vandal-proof. All standard taps, outlets and fittings shall be of approved manufacture.

Cold Water

Branch lines shall be of the following minimum sizes to domestic type outlets, unless the occupancy or use is such that normal diversity factors are not appropriate:

Serving one outlet	-	15mm min. not exceed 10m
Serving three outlets	-	20mm min.
Serving seven outlets	-	25mm min.
Above seven outlets	-	as required.

All external hose cocks to have a minimum branch size of 20mm and where branch serves more than one hose cock it is to be appropriately sized to suit the low diversity factor.

Direct mains water connected external wall mounted, or hot dipped galvanised steel post mounted, 20mm polished brass hose cocks on 50mm flanged polish brass extensions for washing down shall be located around the external surfaces of all buildings. Hose cocks shall be located approximately 600mm above ground and positioned such that a 20 metre length of 15mm nominal bore garden hose can be fitted to the hose cocks for the washing down of all external surfaces and windows of the building, ie. Maximum spacing of hose cocks to be 35 to 40 metres centre to centre. All such hose cocks shall be fitted with lockable polished brass backflow prevention hose connectors.

Minimum outlet running pressure shall be 100 kPa. Where this pressure is not available, the above minimum pipe sizing is to be reconsidered.

Hot Water

Hot water services shall be minimum of 15mm N.D. up to 10m to individual outlets, local electric units are acceptable under some conditions where the number of outlets is small, however when electric water heaters are used, their size and location is to be brought to University Project Manager's notice prior to the design being completed.

In general, the hot water supply should be centralised using a number of natural gas fired Mains Pressure HWS in parallel with an insulated flow and return system incorporating a circulating pump plus a manual change over

stand-by pump.

Dead legs should be restricted to 10m maximum except to cleaners' rooms where the dead leg may be up to 20m.

Hot Water Points. In addition to areas specifically mentioned, hot water shall be provided to the following areas:

Showers

- Showers are to be provided in all buildings as directed with water outlets to be positioned on side walls. These outlets are not to discharge towards the change area of the cubicle. Thermostatic temperature control mixing valves and lever action taps to be fitted in facilities for people with disabilities and child care areas.

Common Room Kitchen

- Hot water service shall be provided to kitchen and teas areas. Appropriately sized boiling/ chilled water units to match staff numbers are required for tea making.

Toilet Hand Basins

- Are not to be provided with hot water unless specifically called for in the brief. Where required they are to have one or three tap hole mixer sets. Individual hot and cold water bib cocks are not acceptable.

Basins for Persons with Disabilities

- To cubicles for persons with disabilities basins are to be provided with controlled temperature water and lever action taps with mixer sets. Controlled temperature adjustable valves to be located above 2100mm above floor level.

Cleaners' Sinks

- Are to be provided with hot water with mixed outlet and aerator (located maximum 450mm above sink).

Hot water units must be located in easily accessible locations for maintenance and access must not be compromised by location of other services, etc.

Minimum outlet pressure shall be equivalent to cold water.

Insulation of Hot Water Lines

All hot water lines shall be insulated in material appropriate to the project and circulating loops shall be fitted with Mechanical thermostatic control valves to maintain temperature at all points in the flow loop with a minimum flow. The use of pre-insulated copper pipe is permitted up to 15mm diameter only. Hair, felt and paper insulation shall not be used. Sectional insulation such as Ensolex or Armaflex may be used up to the appropriate temperature rating. For hot water distribution, ring mains shall be insulated with 25mm thick sectional fibreglass (or the equivalent thermal rating using multiple layers of Ensolex or Armaflex) aluminium wrapped and taped. Where exposed to view or subject to damage and in all plant rooms and ducts, pipe insulation shall be sheathed in 0.9mm aluminium.

4.3.2.3 Reverse Osmosis Water System

A commercial reverse osmosis plant "Millipore" or similar approved should be used.
Reticulation shall be by means of ABS, polythene or PVC piping, the choice of reticulation material being confirmed with the users prior to design commencing.

4.3.2.4 Natural Gas

Pipework external to buildings to be approved yellow colour coded PVC, type 2 class 100 to AS1464 or polyethelene or similar approved plastic pipe. Isolating valves may be gate, quarter turn ball or studded butterfly. Pipework (internal to the building) shall be seamless tested copper tube as described for water supply and sized as required for loads but not less than 6mm diameter for up to 1m (serving individual laboratory outlets) and not less than 15mm diameter elsewhere.

All joints shall be silver soldered as for cold water. Isolation valves within buildings shall be of the Diaphragm or quarter turn ball valve type and each laboratory, kitchen area, plant room, etc, will be fitted with main isolating valve conveniently located for emergency access. All rooms with gas fittings or fixtures are to be provided with an emergency shut off button located adjacent to entry. A gas meter shall be provided to the building main supply.

4.3.2.5 LPG

LPG shall be copper pipework throughout all as described for natural gas with pipe sizes adapted appropriate to the higher calorific value of the LPG.

4.3.2.6 Inert Gases

Inert gases such as nitrogen should be supplied from the bottles located within a ventilated storage space which is easily accessible to the service road.

Cylinders shall be supported in racks and shall be manifolded with non return valves in such a way that any cylinder can be removed and still allow the effective operation of the remainder of the bank.

There is to be rack storage space for standby bottles.

A pressure relief valve and pressure gauge should be fitted to the low pressure manifold, relief to discharge to atmosphere clear of all walkways, building openings, etc.

Pipe work shall be copper and shall be silver soldered, all as described under water services. Isolation valves may be diaphragm, quarter turn ball, globe or needle type.

4.3.2.7 Oxygen

Oxygen shall be supplied from bottles located within an easily accessible, well ventilated storage space (accessible to delivery dock). Cylinders shall be manifolded with non return valves in such a way that any cylinder can be removed and still allow the effective operation of the remainder of the bank.

A pressure relief valve and pressure gauge should be fitted to the low pressure manifold, relief to discharge to atmosphere clear of all walkways, building openings, etc.

Pipe work shall be copper and shall be silver soldered as described under cold water. Pipework to be fully degreased prior to installation. Isolation valves may be diaphragm, quarter turn ball, globe or needle type. Oxygen lines shall be adequately drained and kept at least 150mm clear of pipes carrying gas.

4.3.2.8 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 Client Department).

Pipe work shall be copper and shall be silver soldered all as described for cold water and shall grade to automatic drains with collection tundishes. Isolation valves shall be of the Diaphragm, quarter turn ball, globe or needle type.

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 drain 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 fit water traps having automatic discharges similar to Spirax, Norgen or SMC and complete with collection tundishes.

4.3.2.9 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 pump 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.

Pipe work shall be solvent joint Class 18 PVC pressure pipe or Type "B" copper depending on 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 fit glass removable catch pots with full pipe diameter inlet valves. 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 pipe work to grade to liquid collection catch pots.

4.3.3 Identification of Pipe work

All pipe work shall be identified with their names and colour codes as listed in Section 24.6.

The ground colour shall be applied over the full length of the pipeline or over a

length of pipeline of not less than 450mm where adhesive labels are used. The location of identification marking shall be at intervals of not more than 3m (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 200mm 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.

4.3.4 Underground Pipe Work

All underground pipework shall have a minimum of 600mm cover to topmost surface of pipe or pipes. Pipes shall be buried in sand with a minimum of 150mm sand above, to side and below (or on a bed of crushed diorite where base of trench is clay or rock) pipe. Pipes shall be laid in a horizontal plane and not one above each other.

Rubber ringed jointed pipe work is not permitted under buildings or within 3m of building perimeter or external columns. All rubber ringed jointed pipework to be fitted with concrete anchor blocks in accordance with pipe manufacturer's requirements sized to reflect test pressure.

All underground pipe work shall be identified by laying continuous PVC marker tape not less than 300mm above the pipe. The marker tape shall be colour coded, magnetic and be printed with the identification of the pipe contents.

All external hose cocks shall be capable of isolation for servicing either individually or in groups. Valvebox lids are to be hot dipped galvanised hinged cast iron lid and frame set on pressed bricks and cement mortar and are to be identified and colour coded to reflect service involved.

4.3.5 Pumps (where required to achieve nominated pressures or flows)

General
Pumps complete with switch and control gear should preferably be provided and installed by the Hydraulics Services Sub-Contractor to ensure correct installation and control. Pumps shall be of an approved centrifugal either multi stage or back-end-pull-out type. All seals shall be mechanical seals.

Cold Water Booster Pumps.
A minimum of Dual cold water pumps shall be provided. One pump shall be capable of providing the flow and pressure required. The other pump shall act as standby, however control circuits are to enable pumps to run together during periods of concentrated load. Facilities shall exist for manual changeover for duty and standby pumps together with individual manual test stop/start switches to all pumps. Hours-run meters shall be provided for each pump. Pressure gauges of the bourdon-tube type, nominal 100mm face, with inlet union and isolating valves for servicing shall be provided on each side of the pumps. Pumps shall be activated by a drop in system pressure. A system pressure tank or tanks shall be provided with gauges fitted to tank input to enable checking of pressure system.

Hot Water Pumps
Where a central system is installed, hot water circulating pumps shall be provided in the hot water loops to minimise dead legs.

The hot water circulating pump shall be installed in the return water loop. Care shall be taken to ensure that pressure in the hot water circuit is not greater than the pressure in the cold water main. Pumps shall be of the "in line" type with totally enclosed motor. Pump casings shall be bronze with stainless steel or bronze impellers and stainless steel shafts and mechanical seals.

Circulating pumps to be single phase 250V with one metre of flex and 3 pin GPO plug. GPOs to be mounted in tandem with individual switching. Pumps to be individually isolated and fitted with unions so they are readily removable for servicing.

4.3.6 Inspection and Testing

4.3.6.1

Contracts shall provide to carry out all commissioning of equipment and required tests including the payment of fees, provision of labour and test equipment. All tests shall be carried out to the applicable Australian Standard, the requirements of any Act or Authority having jurisdiction or these Standards as set out in this specification, whichever is the greatest.

No piping work, fixtures or equipment shall be concealed or covered by any means before they have been pressure tested, flow tested and inspected by the Superintendent. All works shall be completely installed and tested as required by this Section and the Code requirements and shall be leak tight before inspection of the particular works is requested. Tests shall be repeated to the satisfaction of the authorities having jurisdiction.

All defects shall be remedied immediately and the tests reapplied to the satisfaction of the Superintendent and the Authorities.

At least 72 hours notice shall be given prior to the carrying out of tests. Where construction vehicles or similar equipment is used on the site allowance shall be made for retesting pipelines under concrete slabs on ground immediately prior to placing membrane and reinforcing steel or in the case of roadways, builder's tracks, etc, immediately prior to practical completion.

4.3.6.2 Test Pressures

Gravity pipelines including soils, waste and vent piping shall be tested to maximum flood conditions for three hours.

Water supply pipelines including Fire Mains and Services: 2.1mPa for twelve (12) hours and generally kept charged thereafter.

Drainage Rising Mains: 1 mPa for 3 hours or 1.5 times pipe manufacturer's designed maximum operating pressure for 3 hours, whichever is the greater pressure.

Fire Hydrants and Fire Hose Reels shall be tested for pressure of flow as required by the Fire Brigade. Such tests to be witnessed by the Hydraulics Engineer.

Fixtures to be filled to spill level with water after installation and visually checked for leaks.

Internal downpipes to be hydrostatically tested to the maximum head possible for a minimum of 24 hours.

Pipework for gases shall be tested in accordance with the relevant code or standard or twice the working pressure or 1.5 times the pipe manufacturers' maximum recommended working pressure, whichever is the greater.

Gravity sewers shall be water tested as for (1) above, but with maximum hydraulic pressure plus 2m or air tested to 50kPa (both tests being conducted for a minimum of 3 hours).

4.3.7 Sanitary Plumbing

4.3.7.1 Materials

Shall be U.P.V.C., cast iron, copper or brass subject to:

- The effluent being discharged (urinals shall not discharge into copper soil drains, sewerage effluent rising mains shall be PVC or similar approved plastic material).
- Australian Standard AS 3500, Building Code of Australia and WAWA Bylaws.

4.3.7.2 Pipe work

Shall be concealed where possible in accessible ducts and ceiling spaces.

4.3.7.3 Plumbing Ducts, Access Panels, False Ceilings etc.

Architectural drawings shall be checked to ensure all sizes and clearances etc. to conform with the Authorities' minimum requirements.

4.3.7.4 Design

Design of sanitary plumbing is to be in accordance with the WAWA Bylaws and AS 3500.

No toilets or waste facilities shall be provided below the level of main sewer lines.

4.3.7.5 Trade Waste

Generally all waste lines from laboratories shall be U.P.V.C. unless the effluent is incompatible. Underground drainage shall be U.P.V.C. with solvent joints. Neutralising traps shall be installed if required by regulations. Grease traps shall be installed from all commercial kitchen areas. All trade waste installations shall be subject to Health Department & WAWA approval. WAWA approval is required prior to construction commencing.

4.3.7.6 Sewer Drainage

Design
Generally the drainage system shall be designed in accordance with the W.A. Sewerage and Water Supply Regulations and AS 3500.

Materials
Shall be U.P.V.C. pipes and fittings complete with solvent joint where minimum required cover is available. Otherwise mechanically jointed cast iron or reinforced concrete encased vitrified clay pipe with neoprene rings shall be used.

Pipe Sizing
To minimum Authority requirements.

Filled Ground
Where pipes are laid in filled ground the use of a concrete mat, crushed rock bed in lieu of pier and beams is to be investigated and discussed with the University.

Inspection Chambers
Shall be pressed clay bricks in cement mortar installed in accordance with Local Authority requirements. Gas air tight covers to be used throughout. Medium duty covers shall be used externally except in roadway (where heavy duty circular covers are to be used). Light duty covers shall be used internally. Brass edged covers are to be used where particular floor or paving finishes are to be used.

4.3.8 Stormwater Drainage

4.3.8.1 Design

Calculations from Moores Tables N = .013.

Pipe Sizing
Flooding frequency shall be decided for each project after considering the damage or inconvenience flooding would cause.

For building drainage	-	once in 50 years;
For site works	-	once in 20 years.

Assessment of possible damage implication to be undertaken.

4.3.8.2 Materials

Tested soil weight U.P.V.C. or V.C.P. for 100 and 150 diameter. R.C.P. for 225 diameter and over (class to be consistent with traffic loads).

4.3.8.3 Inspection Pits

At major changes of direction and junctions. Precast pits with silt traps external to buildings. Stamp S-W into covers. Medium duty covers shall be used externally and light duty covers shall be used internally. Brass edged covers are to be used where particular floor or paving finishes are to be used.

In paved areas, lids are to be buried but manhole covers and/or grates are to be visible at paving level.

4.3.8.4 Fittings

Generally sumps with silt traps shall be located so as to avoid the use of pits or fittings. Overflow gutters or sumps to be provided on drains from downpipes.

4.3.8.5 Discharge

All stormwater lines shall discharge directly into the closest existing pits, lines or soakwells. The route, point of outlet, and method of discharge is to be approved by the University. Provide a means of dispersal and water energy reduction.

4.3.8.6 Agricultural Drains

Shall be 100mm dia (min) slotted tested UPVC pipe and fittings with lines extended to surface and fitted with brass clear-outs in finished paving. Alternatively, Nylex or similar approved strip drain can be used.

4.3.8.7 Soak wells

Shall be culvert pipes classes S, X or Y depending on traffic loads. Tops to soakwell to have removable manhole covers and 100mm diameter sighting and inspection access openings extended up to ground level.

Soak wells with slotted walls are to be wrapped with geo fabric to prevent sand from collapsing into well. Tops and manhole covers are to suit traffic loads.

4.3.9 Backflow Prevention

All mains water services to new or altered existing buildings will be fitted with Backflow Prevention Equipment in conformity with the requirements of AS 3500 and the Water Corporation of W.A. regulations.

The basic design and installation criteria to be applied to the backflow prevention equipment are that of “containment” generally as described below:

The individual non-potable water supply connections to buildings are to be isolated from the mains water distribution network of the campus by installing in the buildings connection main an approved Reduced Pressure Zone backflow prevention device (an RPZ valve). The RPZ’s are to be installed to form containment zones for the buildings concerned.

The protection of the individual internal services of a building which is within a containment zone formed by the fitting of an RPZ valve in the incoming supply is not necessary, except for those services supplying items of equipment whose usages are specifically listed as requiring particular consideration under AS 3500. However all laboratory taps, and mixed water outlets, including those in Fume Cupboards, are to be fitted on their outlets with high operating temperature approved DR. C.P. brass dual check valves with 316 S.S. springs. Dual check valves are to be fixed tightly to the outlets to prevent accidental removal by staff or students and “non-potable” water warning sign is to be mounted adjoining all such outlets.

All potable water outlets are to be supplied directly fro the campus mains water distribution network, ie. From the upstream side of the “containment RPZ” valve.

Whilst only a single RPZ valve is to be installed in each water service between the internal distribution mains of the campus and those of the building, pipework and isolating valves for a duplicate RPZ valve set will be installed. Prior to Practical Completion, the contractor is to supply to the University, for stocking purposes, a second separate tested approved stand-by RPZ valve of identical size and model to that installed. The stand-by RPZ valves to be held by the University for use in the event of a service emergency.

To conform to AS 3500 it is necessary to fit all RPZ’s above the surrounding ground or surface level with their discharge orifices being at least 300mm above the ground or surface. Generally the RPZ valves are to be fixed unobtrusively on stand off brackets to the external face of the wall of the building to which they are protecting.

Labelling of all internal water service pipework shall be carried out, however, it is difficult and expensive to label external buried pipes whose service duty

changes from Potable to Non-Potable water due to the fitting of backflow prevention devices. To overcome the difficulties and costs associated all isolating valves on all external Non-Potable services are to be painted bright purple, whilst all new service pipework will be sleeved or wrapped in bright purple wrap to alert tradespersons that the service they are isolating, or connecting to, is a non-potable service.

The existing inverted hose cocks and garden strip sprinklers around the existing or new buildings which are connected to mains water are to be connected via RPZ valves whilst above ground wash down hose cocks connected to mains water are to be installed as per hydraulic services briefing note for external hose cocks, no new inverted hose cocks will be installed.

A separate allowance is to be made for the installation and fitting of water meters to all potable and non-potable water services directly feeding buildings.

A recording and maintenance schedule following the system set out by the Water Corporation for recording the need to test and service all testable devices and setting out the results of all testing and servicing shall be formulated and activated.

4.3.10 Fixtures

4.3.10.1General

Selection of fixtures to satisfy the following criteria:

- Ease of maintenance
- Availability to allow quick replacement of components.
- Standardisation across the campus where possible.
- Satisfy University sustainability objectives.

Where fixtures vary from University standard samples to be provided and approval to be sought from the Project Manager Asset Delivery.

4.3.10.2Fixtures

Cisterns

Half and full flush cisterns to be used. Care to be taken in the design of drainage from fittings served by low flush cisterns to avoid frequent blockages.

Recessed cisterns located in ducts are required except in staff toilet areas but only when so approved by the Project Manager.

Waterless Urinals

Current standard utilised by the University is the Urimat type. Prior to specification check University service agreements for these fixtures.

Taps

The University objective is to save water by the elimination of waste. Taps to be selected for low flow.
Frequent failure of nylon operating pins to ceramic discs has been experienced with taps from one manufacturer. Care should be taken with tap selection.

Taps are to be fitted with flow restrictors with the following general flow rates limits:

- Taps general 3-5l/min
- Showers 8.0 l/min

Flow restrictors to be hydromisers or approved equivalent.

Chilled Water Drinking Fountains

Allow in the Contract for the supply and installation of Chilled Water Drinking Fountains with cup filler to each floor level. Each unit is to suit people with disabilities.

4.3.11 Tanks and Hot Water Systems

4.3.11.1Tanks

General

In general, buildings other than laboratory buildings shall be supplied from mains pressure. Where water pressure is insufficient, tanks and booster pumps shall be specified. In laboratory buildings all laboratory fittings shall be supplied through a buffer storage tank of suitable capacity fitted with discharge pressurising pumps. All laboratory water outlets to be labelled "non potable". Other fittings within the laboratory building shall be fed from the mains. All tanks shall be fitted with a strainer to the inlet.

Cold Water

Cold water tanks shall be appropriate to the projects. Tanks shall be welded, 1.2mm, type 316 stainless steel or fibreglass , circular, corrugated. Minimum tank size shall be of suitable capacity but in no case shall the stored volume plus make up be less than 50 litres per hour per fixture. The tank shall have a lid complete with access manhole and internal/external ladder. Internal ladder to be in stainless steel. Tanks to be fitted with full height transparent indicator tube.

Demineralised Water

Demineralised water tanks shall have a minimum capacity of 2000 litres and shall be welded, 1.2mm, type 316 stainless steel or fibreglass circular, corrugated. Tanks shall have a lid complete with access manhole and if necessary internal and external ladder, all in stainless steel.

Hot Water

Mains pressure electric units if used shall be "Rheemglass". Preferably hot water to be mains pressure natural gas pressure fired units either "Rheemglass" or mains pressure Calorifier type

Overflows

Overflows shall be capable of discharging the full inlet water quantity. Copper safety trays shall be provided to all tanks and hot water units and tanks shall be mounted on painted jarrah bearers within the tray.

Alarms

All tanks shall be provided with high, low and extra low level alarms. Float switches shall be of Mobrey or Flyght manufacture. In addition a pressure switch shall be provided to sound an alarm should the system pressure fail. Both tank and pressure alarms are to be connected via a Data Gathering Panel to the BMS (see Section 13.16). Pressure pumps shall be de-energised when the extra low level alarm is actuated.

Solar Hot Water Systems

Consideration shall be given to the installation of electrically boosted "solar" hot water units. In all cases the consultant should check that the flows and temperatures available are suitable to the application.

4.3.11.2Electric Hot Water Systems

Hot water may be provided by single or multiple electric hot water units of Rheem Mains Pressure glass lined type with 3.6 kW elements. Sufficient capacity and storage shall be provided to enable supply of hot water for a minimum of four (4) hours when heating elements are shed for energy management by the BMS. Provide electric control systems to enable load shedding via BMS of all electric elements (see Section 13.16).

Where demand is large then gas heating is to be used.

4.3.12 Water Meters

Provide water meters to master supply of all buildings. Strategy for metering and managing of consumption of hydraulic services to be established.

4.3.13 BMS Control Points

Allow for the following alarms, controls and monitoring points to be connected to the BMS via a DDC in the building:

- Electric Hot Water heaters for load shedding
- Cold Water Tank - high, low and extra low level alarms
- Demineralised Water Tank - high and low alarms
- Fire Main - low water pressure alarm
- Booster Pump(s) alarms - failure
- Fire Pump Alarm - failure and run
- Compressed air alarms - compressor overload
- Low oil pressure
- Low air pressure
- Vacuum alarms- overload
- High vacuum
- Water seal failure
- Hot water circulating pumps - failure.

4.4 Lift Services

4.4.1 Preferred Contractors

Contractors either tendering or working on projects at Edith Cowan University must be approved by the manager Electrical Services.

4.4.2 Lift Contracts

Tenders from lift contractors are to be considered on the basis of:

- Initial capital cost;
- Annual maintenance costs.

Details of maintenance contracts should be submitted for evaluation with the tender and the supplied lift must be able to be maintained by the nominated University annual maintenance contractor who may not be the supplier of the lift. The supplied lift must not contain components/controls etc. that cannot readily be obtained by the University's nominated annual lift maintenance contractor. Lift contractor must supply a statement to this effect with the Tender.

4.4.3 Lift Dimensions

Lift car dimensions and requirements should be checked with the University. Lifts should be suitable for persons with disabilities access and use and at least one lift in the building should be of size to accommodate stretcher access. Minimum clear door opening width shall be 900mm x 2000mm high (but to be in accordance with AS1735.12-1986 relevant to access).

4.4.4 Types of Lift

SECTION UNDER REVIEW.
VF-LRV (electronically controlled lift valve) Bucher Hydraulic Unit. Due to energy consumption and location of lift motor room Drive with Bucher Hydraulic Unit. Due to energy consumption and location of lift motor room, the hydraulic range is more suited. Lifts shall have a minimum capacity of 1156kg.

Hydraulic lifts to have a maximum and minimum rated speed of 0.75m/s and 0.5m/s respectively.

Traction type lifts to have a minimum rated speed of 1.0m/s.

4.4.5 Security

The facility shall be provided in all lifts to park the lift at the ground floor and to lock off access to and from any floor by means of key switches keyed to the University's master keying system.

Include all necessary wiring and control logic to allow access control of lift cars.

In the event of fire alarm programme lift to go down to level 1, open doors and stop.

4.4.6 Facilities for Persons with Disabilities

Lifts shall be designed for use by people with disabilities and shall be constructed such that operating controls, telephone etc. are easily accessible with all to be located on the side wall.
Operating controls are to be arranged horizontally 900 above lift car floor
A handrail shall be provided internally and shall be positively fixed such that it is not subject to vandalism. Facilities must be in accordance with the requirements of the Building Code of Australia. Provide tactile/braille labelling of lift buttons including voice activation to floor level and on fire alarm activation.

4.4.7 Lift Car

4.4.7.1 Internal Finishes

Lift doors and frames shall be finished satin stainless steel for both car and landings. Internal car finish shall be such as to minimise the possibility of damage.
Provide vandal resistant buttons and fixings.

4.4.7.2 Car Protection Blanket

Each lift shall include a protective blanket for the walls of the car.

4.4.7.3 Car Operating Panel

The following shall be provided on the panel faceplate:

- Illuminating car call buttons
- Emergency stop button
- Alarm button
- Door open button
- Door close button
- "Car overloaded" illuminating indicator
- Engraved load notice
- Illuminating direction of travel indicators
- Digital car position indicators
- Exclusive service key switch
- Light key switch
- Fan key switch
- Arrangement of controls horizontally to comply with ECU accessibility requirements.

4.4.7.4 Signage

Allow for installation of following signs

- "No dialling required, lift handset and await response".
- Identification of car by Building Number and Lift Number.
- The carrying capacity of the car shall be engraved on the car operating panel faceplates.
- Lift Car Number to be fitted to the inside of the car and to match ECU's numbering system.

4.4.7.5 Telephone

Telephone to be provided and will be "hot keyed" (automatically connected) to security (out of normal hours) and to the switchboard (during normal office hours). Programming will be organised by the University's Telecommunications Officer. Handset underside to be located 900mm above car floor level.

4.4.7.6 Lift Indicators

Indicators are required at each floor to indicate position of lift. Provide a digital car position indication in the car.

4.4.7.7 Car Exhaust Fan

An extractor fan is required on the car enclosure complete with sound isolated supports. Fan to be a 150mm diameter propeller fan connected to an isolating switch plug unit.

4.4.7.8 Car GPO

Allow for a single phase GPO in the telephone recess of the lift car. Outlet is to have a stainless steel fascia plate and fixing screws.

4.4.8 Lightning Surge Diverters

Allow for installation of lightning surge diverter protection.

4.4.9 Emergency Lighting

Provide an emergency light unit in accordance with the code with the power supply provided by a continuous trickle charged battery system mounted on the roof of the car.

Emergency car lighting shall be supplied from an invertor power supply and it shall illuminate the fluorescent light nearest the car operating panel together with the panel in the telephone cabinet door.

4.4.10 Lift Machine-Room

The design shall comply with the following requirements:

- The Sub-contractor shall provide a clean, completed machine with a 2 hours fire rated door. Lighting, power points and adequate ventilation, in compliance with S.A.A. Lift Code and building regulations.
- The machine-room access door, closer and notice shall comply with S.A.A. Lift Code. The machine-room access door shall swing out.
- Fire extinguishers, or a sprinkler system in compliance with S.A.A. Lift Code, shall be supplied.
- Provision of a key-safe adjacent to the lift motor room entry door.
- Filtered fresh air intake and exhaust shall be installed.
- Where possible, finishes to walls, floor and ceiling shall be durable and painted in full gloss enamel for easy cleaning. Where possible, the ceiling colour shall be white and walls off-white. Floors shall be properly sealed and receive 2 coats of grey coloured paving paint.
- Control and hoisting equipment shall be well lit by room lights, which shall be twin 36 watt fluorescent reflector-type fittings with protective guards. Lighting shall be positioned so that Maintenance Technicians are not working in their own shadow.
- The control gear shall be illuminated by emergency lighting.

4.4.11 Keys

Provide a set of keys to the ECU so that in case of a fault the Lift can be Parked.

4.4.12 Manual

Provide drawings of system and Maintenance Manuals in both hard copy and CAD format.

4.4.13 Maintenance & Warranty

The complete installation is to be guaranteed for 12 calendar months from date of practical completion and is to be fully serviced and maintained for that period.

During defects period, regular weekly servicing of equipment is required and a 24 hour call out service is to be provided.

During defects period completion of on-site log books provided under the contract are to be maintained.

4.5 Electrical Services

4.5.1 Preferred Contractors

Contractors either tendering or working on projects at ECU must be approved by the Manager Electrical Services.

4.5.2 Sustainability

All utility consumption is to be metered and data from meters presented in a form to allow comparison against historical data to enable fine tuning of systems to achieve maximum efficiency. Refer mechanical services for linking to the BMS. In addition to the BMS electrical meter data directed to the University Wonderware system metering proposal to be approved by the manager, electrical services prior to implementation. Data gathering and reporting systems must be fully operational before practical completion.

4.5.3 Scope

This section of the Standards outlines the University's minimum requirements for electrical services including telephone block wiring.

4.5.4 Flexibility of Design

The layout of light fittings, Telecom outlets and power outlets should allow flexibility such that spaces can be subdivided into separate areas. Where island rooms exist, these shall be conduited to allow for the installation of power and telephone outlets from the relevant sub-board or F.D.P. where these are not installed in the first instance. At least 2 x 32mm conduits shall feed each section of the skirting ducts in these areas.

Island floor outlets are not permitted as they present a trip hazard.

4.5.5 Lighting

4.5.5.1 Performance Standards

Lighting levels on the working plane shall be in accordance with the requirements of AS 1680 Series of Standards. *The defined level shall be minimum with calculated levels being no greater than plus 10%.* Over-illumination shall be discouraged. Particular areas nominated for specialised requirements will be identified by the user and the appropriate lighting levels recommended, however, at no times are these to be less than code requirements.

Options available for the control of lighting to be reviewed to ensure optimum cost effective energy management solutions are incorporated including:

- *Motion detection/occupancy sensors.*
- *Daylight/level sensors.*
- *Time schedules.*
- *Manual switching and grouping.*
- *Dimming*.

Such controls should be achieved by further development of existing lighting control systems on the campus.
Light fittings are to be accessible 3 metres from finished floor level so as not to necessitate the need to use scaffolding

4.5.5.2 Design Requirements

Lighting fittings should be manufactured from Australian made components and be approved by Western Power. The fittings are preferable to be manufactured within Australia. Downlights shall be of the LED type, to be approved by the Electrical Manager ECU. No compact fluoro's shall be used in any situation. If the fitting is not available in Australia then they may be sourced from abroad provided the quality is acceptable to the University . Light fitting selection to be approved by the University Electrical Manager, in general lamp types to conform to University standard selection.

Fluorescent fittings shall incorporate power factor correction (except fluorescent lighting controlled through dimming units which may have power factor correction capacitors at the dimmer unit) and be of the switch start type *and* low loss or *electronic* ballasts*. The final determination of ballast types shall be reviewed with the University.* Spring loaded tombstone lamp holders shall not be used.

All fittings should be adequately ventilated *or designed to ensure excessive temperatures within the fittings does not result*. Temperature rise in the fittings should be restricted to 50^{O}C above ambient.

Where recessed Downlighters are installed they shall have non flammable ceiling guards installed to prevent the insulation from encroaching on the fitting causing overheating and the opportunity of a fire commencing. Similar or equal to Ceiling Light Guards supplied by Thorn Lighting for LEDs lights.

Diffusers shall be easily removable and all components shall be easily accessible. Fittings which have to be dismantled in order to replace lamps shall not be used. Standard diffusers shall be *as a minimum K12 prismatic in general service areas, Louvered Style Diffusers in general office areas* Separate whiteboard illumination using fluorescent tube lighting or similar *shall be provided*. *The lighting design in Teacher areas, where multimedia presentations are accommodated is to incorporate greater flexibility and control of lighting than normal conventional designs. Design solutions should incorporate dimming of all lighting with flexibility to allow switching off of light fittings that adversely affect presentations on projection screens.*

Light fitting design and layout should satisfy the intensity requirements for open offices but should have sufficient flexibility to enable partitioning of individual perimeter or island offices.

The length of fitting should suit the ceiling module.

The fluorescent tubes shall be "T5 Cool White, 4000^{O}K 85 RA" *Philip Alto low mercury, or Osram Eco equivalent* a minimum of 20,000Hrs operation in all areas unless specified differently in the Building Brief for a particular purpose. Retaining lanyards for the diffuser shall be stainless steel wire. Plastic lanyards are not acceptable. All fluorescent fittings shall incorporate their own fuse (Pierlite PT505 fuseholder fitted with a F5 fuse). Prismatic diffusers are not to be used unless the environment requires dust proof fittings.

External lighting of buildings shall be discussed with the University Manager and *Manager, Electrical Services.* The external paths associated with a particular building project shall be illuminated as part of that building. All external lighting shall be consistent with that of existing buildings. External lighting control shall be through the use of BMS and *building lighting control system where provided.*

Where false ceiling exists, fluorescent fittings shall be connected to the wiring loom by means of a three-pin plug and *2000mm* of flexible lead. *Suspend/secure cabling within building spaces of removable tile ceilings in such a manner and spaced above ceiling to ensure cables do not interfere with removal and reinstallation of tiles, or maintenance of in ceiling equipment. A Maximum fixing distance of no more than 900mm apart.*

Unless otherwise approved by University all wiring, including sheathed cables and conduiting, shall be concealed within or by the building structure in a manner that can be replaced without damage to the completed building finishes.

Where no false ceilings exist, consideration *may* be given to running all services exposed. Conduit runs in this case are to be carefully worked out prior to installation.

Starters shall be of the electronic type equivalent to WOTAN DOES ST171 except for 20W fittings where 20W starters shall be used. Non-flickering electronic starters shall be used in all areas.

Downlights shall not be used for general illumination. *Dimmable fluorescent or* LED downlights in conjunction with fluorescent lighting *shall be used in teaching spaces where directed* to provide dimmable lighting for video projection requirements.
Metal halide type fittings shall NOT be used in teaching or office areas due to the minimum of the 15 minutes strike up time and the fitting being susceptible to loss of function due to power disturbances.

Light fittings in store areas or libraries shall be located at least 400mm away from shelving in order to comply with the University's Fire Insurance Requirements. Ensure lighting layout indicates final position of shelving and that fittings are dimensionally located to avoid shelving conflict.

4.5.5.3 Works of Art

In the public areas of the building and in all meeting rooms within the building, ensure the spaces are able to be used to display the University's Art Collection. Liaison should occur at an early date in the development of the plans with the Project Manager and Art Curator to identify "gallery" areas.

The following guidelines apply in such gallery areas:

- Designated walls in gallery areas should receive no direct sunlight.
- Lighting in designated gallery areas should provide an even illumination of the wall.

Where incandescent lighting, such as spotlights or wall washers are used, they should be dimmable LED to allow adjustment of the lighting level between 50 lux for works on paper and 150 lux for works on canvas. Where spotlights are used, they shall be LED and at least 2 metres from wall.

Where fluorescent lighting is used, such lighting shall use low UV fluorescent lamps or have lamps fitted with UV absorbing polyester sleeves.

4.5.5.4 External Lighting Poles & Bollards

Lighting Poles & Bollards shall be "Avenue" model manufactured by Thorn preferred on all campuses.

External lighting. Control of external lighting to be through the BMS. External

lights consist of grounds circuits and security circuits. Inline circuit breakers/fuses will be installed to each light pole supply. A balanced supply load to each circuit and that grounds and security lighting are evenly distributed around external areas. Typically 50% of each.

4.5.6 Switching

Switches should wherever possible be located on permanent walls or columns. Switches are to be 900mm above the finished floor level. Block switching should not be used except where special circumstances dictate. Intentions to block switch areas should be discussed with the *Manager, Electrical Services,* prior to final design. Switching and dimming in all teaching spaces shall be in accordance with requirements for Lecture Theatres. All switch plates shall be identified with IPA studs as to circuit and switchboard of origin.

Light switches are to be rated at 15 amps (not 10 amps) and to have heavy-duty mechanism for fluorescent loads (Clipsal 30 FLM15 or equivalent).

4.5.6.1 C-Bus Lighting Control

General
Provide a lighting control system complete with all switching modules, dimmers, switches and other control devices, control panels, power supplies, wiring and other equipment necessary to provide a complete and operational installation.

C-Bus Lighting Control **is the preferred lighting control system for all campuses.**

The ECU Electrical Manager must be notified prior to any additions or alterations to the C-Bus System/Network.
Once the additions or alterations have been made the contractor must submit the changes to the Electrical Manager or his Deputy, for Sign-Off, before they are saved to the Network Data Base.

Personnel carrying out works on the Clipsal C-Bus ALCS are required to have undertaken the Basic and Intermediate C-Bus Training Course carried out by Clipsal Integrated Systems and attained an 'Approved Installer' and / or 'Point One Accredited Integrator' qualification for the Clipsal C-Bus ALCS. A list of suitable qualified personnel shall be submitted.
Installation, Testing and Commissioning of the Clipsal C-Bus ALCS shall be carried out in conjunction with Clipsal Integrated Systems and an approved commissioning technician.

System
The Clipsal C-Bus ALCS shall be microprocessor based and utilise Category 5E Unshielded Twisted Pair (UTP) cable with 240V AC insulation rating as the communication medium between intelligent network nodes to control lighting.
The system shall comprise modules with in-built microprocessors, which can be programmed via both learning the relationships between input and output devices without the use of a personal computer or at a higher level with a personal computer using a Microsoft Windows based application software.
All hardware shall meet the requirements for electromagnetic compatibility for certification with the CE mark.
The devices shall maintain programmed parameters during power failures with Non Volatile Random Access Memory (NV-RAM). The control system shall remain fully functional in the event of supervisory computer shut down or failure.
The Clipsal C-Bus ALCS shall use high speed, full duplex communications protocol. The system shall provide constant feedback on the operational status

of inputs and outputs and have the ability to interrogate the status of specific modules.
The Clipsal C-Bus ALCS protocol shall implement the International Standards Organisation (ISO) Open Systems Interconnection (OSI) seven-layer reference model for communication protocol.
The Clipsal C-Bus ALCS protocol shall provide transmission error checking for all information passed over the network.
The C-Bus Automatic Lighting Management System shall incorporate the following facilities:

- Time based scheduling for energy management control of lighting.
- Photoelectric cell dimming control of the open plan area artificial lighting and lumen depreciation compensation.
- Occupancy sensors for energy management control of lighting.
- Be an easily programmable energy management and time control, using PC and Windows XP™ based configuration software.
- Have the ability to interface with the Building Automation System at high or low level.
- Automatic OFF control of lighting if required.
- Automatic ON control of lighting if required.
- Automatic On and OFF control of lighting using occupancy sensors.
- Manual ON/OFF control of lighting at all times.
- Provide an easily configurable logic engine to enable implementation of network logic functions and control scenarios.
- Provide a full range of plastic, stainless steel and glass faced switch panel options.
- Provide the option for 'Dynamically Labelled*' switch identification using DLT technology.
- Be compatible with luminaire control gear generally available.

4.5.6.2 Electrical

The Clipsal C-Bus ALCS shall use an extra low voltage (less than 36V DC) bus to interconnect all control and switching units. Cat 5E UTP cables shall be used as the wiring medium for this bus. Shielded communication cables shall not be used due to the risk of group loop interference.
Input and output units shall be connected on the system bus in parallel.
The Clipsal C-Bus ALCS shall be powered by a two (2) wire network, superimposing data and unit DC power supply onto one pair of data wires avoiding multiple connections of the networked devices.
Short circuit of the network power supply shall have no long-tern effect on the system once the fault is repaired.
Each unit shall have a unique serial number embedded in firmware for ongoing product traceability and warranties, be individually programmable and be identified by a unique network address code.
The Clipsal C-Bus ALCS bus shall be electrically isolated to 3500V AC RMS for one (1) minute from the mains wiring.

4.5.6.3 General Lighting Control System Functions

The general function of the C-bus ALCS to included but not be limited to the following general scenarios:

Offices / Administration Open Plan Areas:

- Local switch On/Off, with daylight sensing
- Provide intelligent programmable light level sensors, to measure the natural day light levels and according to a predetermined lux level to intelligently monitor and dim various circuits depending on these factors.

- 360 deg Occupancy sensors to be located within these areas as depicted on plans and setup to automatically turn lighting off for after hour operation.

Security, Corridor and Foyer Lighting

Internal and external security lighting shall be provided to operate during normal hours of darkness. Corridor and foyer lighting shall also be provided throughout all buildings. The lighting shall be switched in the following groups:

- Group 1: External Security Lighting
- Group 2: Internal Security Lighting
- Group 3: Corridor/Foyer Lighting

These lighting groups shall each be contactor controlled at the local sub-board with switch control also available in corridor/foyer for use by cleaners. A master / slave or contactor system shall be used where the master contactor is controlled by the time switching function of the BMS. This shall apply to all external lighting.

External security lighting to be controlled in conjunction with the BMS incorporating PE Cells and time clock function. Information relevant to types and source of external lighting shall be discussed with University Project Manager and the Manager, Electrical Services. Designated "safe lit corridor/safe lit car park" are to be identified by the University Project Manager and such designated areas to be totally controlled by BMS.
Each external lighting group shall have a manual override system provided at the local supply distribution board in addition to the BMS system.

For corridor lights provided in addition to the above a local override at each entry to the corridor to allow for out -of hours- use. (Alternatively occupancy sensors to be installed in the corridor areas for out-of-hours use.)

Corridors

- Light switch panel to be located at the entry to the corridor to allow for out-of hours use.
- Occupancy sensors to be installed and programmed as a re-trigger able timer to automatically turn lights On / Off after 60 minutes if no movement is detected.

Store Rooms/ Cleaner Rooms

- Switch On/Off, with occupancy sensor, sensors to be programmed as a re-trigger able timer to automatically switch lights On / Off after 15 minutes, if no movement is detected.

Offices

- Controlled by a local switch and a PIR occupancy sensor.
- Switch in the On position sets the system in Auto mode turning the lights On and enabling the occupancy sensor, occupancy sensor to be programmed as a re-trigger able timer to switch lights Off after 20 minutes if no movement is detected.
- With the switch in the Off position this disables the occupancy sensor and the lights remain Off.
- Alternately a PIR occupancy sensor only (no local switch panel) may be programmed as a re-trigger able timer to switch lights On/Off with a 20 minutes re-trigger time delay.

Plant Rooms and Service cupboards

- Local On/ Off switch

Toilets

- Controlled by PIR occupancy sensor to be programmed as a re-trigger timer to turn lights On / Off after 30 minutes if no movement is detected.

- Occupancy sensors to be located in both the Air lock and toilet cubicle area.

Stairs

- All windowless fire escape stairs and internal stairs shall have circuits controlled only at the distribution board.
- Stairs which have sufficient natural lighting shall have lights controlled by PIR occupancy sensor to be programmed as a re-trigger able timer to automatically turn lights On / OFF after 10 minutes if no movement is detected. Care to be taken in locating occupancy sensors to ensure safe use of stairs

Staff / Meeting Conference / Board Rooms

- Lighting to be controlled via a local light switch panel and PIR occupancy sensors.
- The light switch panel will have the ability to turn the lights On/Off and dim.
- Occupancy sensor to be programmed as a re-trigger able timer set to 30 minutes, when no occupancy is detected the lights to fade Off over 30 seconds.
- Dimming facility via the light switch panel with the ability to turn the lights Off adjacent to the projector screen.

Laboratory / Teaching / Prep Areas / Foyers / Study Areas / etc

- Lighting to be controlled via a local light switch panel and PIR occupancy sensors.
- The light switch panel will have the ability to turn the lights On/Off and dim.
- Occupancy sensor to be programmed as a re-trigger able timer set to 30 minutes to turn lights Off after 30 minutes if no movement is detected.
- Dimming facility via the light switch panel with the ability to turn the lights Off adjacent to the projector screen / white board.

Perimeter dimming

- The luminaries on the perimeter of the building shall generally be controlled such that in the event of there being sufficient natural light from the windows, the luminaries shall be dimmed in response to the available natural illumination by the lighting control system.
-

4.5.6.4 C-Bus Control Modules

C-Bus control modules shall be located in an accessible location within a locked cupboard. Preferably adjacent to an electrical distribution board. Location to be approved by Manager Electrical Services.

Under no circumstances will the location of controls in ceiling spaces be permitted

4.5.6.5 Touch Screen

- The colour touch screen must be capable of controlling and monitoring the lighting control system.
- A programmable Touch screen device connected to the data network shall provide Scheduling and Scene management. Obtain an IP address from the Manager Electrical Services
- Touch screen to be located in a room/ service cupboard not accessible by the general public. Location to be approved by Manager Electrical Services
- Pages to be set up to mimic inputs and outputs to individual areas as nominated.

- Real time clock display and setting facilities from the touch screen.
- Touch screen to provide scheduling function for internal, external and security lighting.
- Schedules shall be able to be modified by the user without the use of any programming tools or devices

4.5.6.6 Ethernet Interface

Provided a C-Bus Ethernet interface part number 5500CN located in the communications room and patched back to the communications cabinet. Network the system **and connect** to the lighting control maintenance PC at the Joondalup campus administration building.

IP address will be provided by the Manager Electrical Services.

Request ECU IT patch interface to C-Bus VLAN with its static IP Address

4.5.6.7 Network Bridge

Network bridges shall be allowed for the building as required. Limit each network to a maximum of 70 devices and 700 meters of network cabling to allow 30% expansion for future use. If this is to be exceeded the project must be split into multiple networks and then joined via a 5500B Network Bridge. A backbone network topology for the project is to be submitted to Clipsal Integrated Systems for approval prior to construction.

4.5.6.8 Relay and Dimmer Controllers

The relay, dimmer and DSI gateway modules shall be housed in an approved enclosure adjacent the floor distribution switchboard within the electrical riser. Alternatively an extension to the floor distribution switchboard can be provided to house the modules.

4.5.6.9 System interface:

The lighting management system shall have the ability to interface to the building management system at various levels.

- Volt free contact.
- BACnet IP Gateway
- OPC Server software

4.5.6.10 Naming Convention

The C-Bus lighting control system is installed across multiple buildings. A naming convention is required to:

- Ensure consistency in the naming of various projects, networks, devices and load groups in each building.
- Provide a mechanism to easily identify where the device is located and what area it controls.
- Minimise the use of cryptic acronyms wherever possible.

General Format

General Format for naming of a point shall be:
Project>Network>Application>Group Address
Where:

Project	Describes the name of the building and site (up to 8 characters)
Network	Describes the vertical or horizontal location as a floor level.
Application	Describes the control system application
Group Address	Describes the controlled load type and location. Include ipa\ circuit# if a relay

Example:

Project	**Network**	**Application**	**Group Address**
Building 21	Level 2 East	Lighting	Rm 2.01 front W1

- The concept is that a programmer or maintenance staff person is able to identify the group address or tags with minimal reference to drawings or documentation.
- Project identifier can only have 8 character; all other identifiers have up to 32 characters.

Device Identification

All units on a C-Bus network have a unique identity code called a unit address, this identifies a specific device connected to the C-Bus network. A reserved unit address approach should be taken when designing the project.

Following format shall be followed:

Unit Address	Unique code that identifies each unit on a single network.
Part Name	Tag to identify unit. Restricted to 8 characters.
Tag Name	Tag to identify unit, up to 32 characters.

Example:

Unit address	**Part Name**	**Tag Name**
052	Rm 508	Rm 508 switch 1

Note:

- Reserved address approach should be used where the outputs start an unit address 001 and input devices from unit address 020 and above.
- Unit address 255 is reserved as a default for new units, no C-Bus device with this address should be left connected to the network once commissioning and handover has been completed.
- Abbreviations should only be used where the C-Bus system cannot accommodate the full text description.

4.5.6.11 Documentation

The Installing Contractor shall provide a complete set of 'as installed' drawings and an end user instruction booklet
Label all C-Bus distribution board schedules internally include C-Bus unit number on module.
Include secure copies of electronic databases of all programmed devices including C-Bus Tag database, C-Touch Project file xml, PAC xml file or any other files needed.

4.5.6.12 Warranty

The Clipsal C-Bus will carry a two-year warranty; the installer to provide proof of installed dates and is subject to manufactures conditions of Warranty.

4.5.7 Power

4.5.7.1 Socket Outlets

Unless specific requirements are detailed, allow two double Socket outlets per *workstation* or 10m^2 of net useable space. All *socket* outlets shall be identified by means of circuit identification I.P.A. red, white and blue studs as to the circuit on which they are installed and the switchboard of origin. In the case of the Clipsal 2000 range socket outlets the IPA shall be installed under grid plates and an adhesive label to the face between the socket outlets.

All three phase outlets shall have 5 round pins.

Emergency power isolation is required for all power outlets in each laboratory, machine room *that are considered to be hazardous areas but such rooms do not include computer teaching rooms where general teaching in computing is carried out,* and is to be located at the lecturer's bench or in locations approved by the University Project Manager and *the Manager, Electrical Services. All services emergency stop control for an area shall be grouped together for easy, convenient access.*

All socket outlets (1 phase and 3 phase) shall be protected by devices incorporating 30mA RCD Protection (Residual Current Device).

All Socket outlets protected by RCD's shall be engraved in 5mm high green filled lettering "RCD PROTECTED".

Unprotected power may only be provided when written permission has been given by the Maintenance Manager, Electrical.

All Socket outlets not protected by RCD's shall be engraved in 5mm high red filled lettering "Not RCD Protected" with the name of device under, ie "NOT RCD PROTECTED BOILING WATER UNIT ONLY".

Engraving of removable surrounds is not acceptable.

Provide dedicated Socket outlets for cleaners (engraved accordingly) at appropriate locations throughout the building, catering for vacuum cleaners, etc. These outlets are to be installed 600mm above floor level.

All socket outlets are to be switch operated.

4.5.7.2 Switch Boards and Sub-Boards

Main Switchboard. Regardless of the initial requirements, the main switchboard shall be designed to Form 3B and be able to withstand the maximum prospective fault level *for the maximum design capacity of the sub station*. All switchboards will be fitted with smoke detection. The main switchboard shall be of type tested construction, floor mounted, free standing compartment cubicle type construction ("dead front" type and fitted with circuit breakers or switch fuse units to control outgoing circuits).
The unimpeded space around a Main Switchboard shall not be less than 1.2 Metres where the panels are removable either with or without tools to permit the tradesperson enough exit space.
The switchboard is required to be approved prior to manufacture by the *University Manager, Electrical Services. All such switchboards are to be of steel construction*.

Building main switchboard shall incorporate Shunt Surge Diversion to the incoming supply. In addition inline surge reduction filtering shall be provided to "clean power" supply to boards serving Teaching and Laboratory areas as directed by University.

All switchboards shall be provided with an individual feed to a 10A Socket Outlets incorporated into the switchboard *or in an easily accessible location on the wall within the cupboard*, for test equipment use.

Provision shall be made to extend the main busbar systems in either direction. At least 25% spare space shall be provided as an absolute minimum. Main switchboard shall have capacity for additional switchgear and sub mains for future expansion. Mains cables shall be sized accordingly to take account of the full expansion potential of the board.

All Switchboards shall have Isobars fitted.

Generator Supply *Where specified a Generator Supply inlet socket shall be fitted to the outside of the Building Main Switchboard, Sub Board or Switchroom or as specified by the ECU Electrical Manager. An electrically interlocked changeover switch shall be installed on the switchboard and labelled accordingly.* Key access to switchboards is to comply with the University's Keying System.

The main switchboard shall be designed in accordance with AS 1136 "Switchgear and Control Gear Assemblies for Voltage up to 1000V AC".

Following full load being applied to board, typically mid way through the defects liability period, condition monitoring of switchboards to be carried out using thermal imaging. Report on thermal imaging to be included in electrical manual.

Sub-Distribution boards, lighting and power supply. Sub-boards shall be *of steel construction and* arranged for *floor or* wall mounting unless circumstances dictate otherwise. At least 30% spare capacity shall be provided on all sub-boards. Sub mains cables shall be sized to take account of the full expansion potential of the board. Escutcheons shall not be interlocked with switches, isolators or circuit breakers.

Key access to switchboards is to comply with the University's Keying System.

Lighting, power and 3 phase circuits shall have clearly defined separate areas on the sub board with each having it's own isolator in addition to the *distribution* board *main switch*. A separate mechanical services switchboard (MSSB) or separate section on the board shall be provided for air conditioning feeds. *Boards servicing Teaching and Laboratory areas may also require separate "clean power" chassis section and isolator*.

Vermin Protection. All switchboards and sub-boards shall be designed to be vermin proof.

Fuse Cartridges. All fuses shall be HRC cartridge type conforming to AS2005 and AS3135. A minimum of six (6) spare cartridges for each rating shall be supplied at each switchboard position. Spare fuse cartridges shall be mounted on a suitable rack, easily accessible without removing escutcheon plates. At the main switchboard, in switch rooms or substations, spare fuses shall be located in a wall mounted enclosure. At distribution boards, cupboards, the fuses shall be mounted internally on rear face of door. In special circumstances DIN fuses may be acceptable up to 32 amps.

Sub Metering. *Metering shall be provided by microprocessor based networked monitoring devices providing complete electrical metering and indication Cutler-Hammer IQ4000 (master) and IQ200 (slave) units.*

Master meters shall be provided in each building main switchboard to register building consumption and consumption for each of the main building services emanating from the board including, but not limited to Air conditioning and Mechanical Services, Hydraulics and Hot Water *with slave meters for submains to selected distribution boards.* The main meter for the building *provide* Pulse kWhrs output to the BMS.

Push Buttons. Shall be of the shrouded type.

KW Transducers. Shall not be used without prior approval from the *Manager, Electrical Services.*

Indicating Lights. Shall be of the integrated LED lamp type with a minimum life of 100,000hrs . ***Meters***. All *non digital* meters shall be selected such that the normal deflection is 80% of the full scale range. A voltmeter with selector switch and 3 Ammeters with M.D.I. shall be provided on each main switchboard. Use one set of CT's.

Metering test link. Shall be provided for all current transformer sensing metering complete with voltage isolating links and current shorting links.

Labelling. Each and every control, switch etc. on main switch-boards, sub-boards etc. shall be clearly labelled. All labels shall be engraved traffolyte*, and attached to the switchboard by means of non self tapping type screws.*

Circuit Schedules. Shall be typed and be provided at all switchboard positions. The information contained on the schedules shall consist of circuit breaker identification number, phase colour corresponding with type and location of each circuit. This information shall incorporate room number and whether it serves power, lighting, mechanical services, etc. The switchboard schedule to indicate where supply is fed from, cable type and size to be laminated and fixed to inside of switchboard door and shall also contain the switchboard sub-main size and point of origin.

Colour. All switchboards shall be colour orange X15 (AS2700-1996).

Circuit Breakers. To final sub-circuits shall be Merlin Gerin type miniature circuit breakers and shall have individual RCD protection for all power circuits and lighting circuits. Other circuit breaker types may be submitted to the University for approval.

Discrimination. *Prior to selection of switchgear a supplier, the switchboard manufacturer must ensure discrimination can be achieved as follows.*

Co-ordinate the protection equipment on all main and distribution switchboards such that in the event of any condition of over-current or short circuit occurring at the load side of terminals of any submain protective device or final subcircuit equipment isolator/connection device:

- *Sub-mains protection effectively discriminates.*
- *All lighting circuits continue to operate apart from any lighting which is supplied by the faulty circuit.*

Short circuit calculations shall be for all faults up to and equal to the prospective fault current at each distribution switchboard.

Certify compliance with the above in writing to the Principal, including fault and discrimination calculations for switchgear used prior to submission of switchboard shop drawings for examination.

Submission of equipment list and manufacturer's discrimination and enhanced selectivity charts are acceptable in lieu of individual calculations, where these are available.

All Neutrals, Earths and Active Cables. Shall be number ferruled to correspond to the circuit breaker number. All circuit breakers shall be numbered consecutively on the *escutcheon plate* and on the circuit breaker mounting bracket for ease of identification once the *escutcheon plate* has been removed.

All active cables entering circuit breakers shall be via cable lugs. All control wiring shall have number ferruled with numbers as indicated on as constructed drawings.

Neutral bars shall have the same number of terminations as there are circuit breakers and holes for main neutral and MEN connection. Earth bars to have terminations equal to the number of circuit breaker positions. Blue point connections shall not be permitted within switchboards and sub-boards without prior approval from *the Manager, Electrical Services.* System of earthing shall be MEN system.

Standard Equipment. For all switchboards and sub-boards for light, power, air-conditioning or other building services shall be as follows:

Alarm Relays	*Releco MR-C 11 pin base*.
Time Relays	*Releco MR-C 11 pin base*.
Auto/Off/Manual Switches	*Kraus and Naimer*.
Active Links	*Blue Point or Busbar System*.

A sample of the contactors shall be submitted for University approval prior to their installation in switchboards.

Inspection and Testing
The University reserves the right to inspect during the course of construction. The sequence of inspections is as follows:

1. Approval of switchboard drawings prior to commencing manufacture.
2. Factory inspection when the switchboard is assembled prior to painting.
3. Factory inspection after ductor, primary/secondary current injection and hi-pot tests have been carried out prior to leaving the factory.
4. During the warrenty period, the highest load time frame to be agreed with the university for a thermograhic and Power quality analyse be carried out and a written report be submitted to Building and Services .

4.5.7.3 Quality of Power Supply

At the point of attachment to any new building, the Power Factor shall be less than 0.85 during ON PEAK hours at normal running load. If the Power factor is not less than 0.9 then Automatic Power factor correction equipment shall be installed at no cost to the University.
The Currents across the three phases shall be balanced within plus or minus 10% of each other.
The quality of the power at the point of supply to a new building shall conform to AS2279 and Western Power Technical Requirements. A power quality audit shall be carried out prior to tenant's occupation and after during the peak load period to verify it conforms to the standards specified. If the supply is non conforming due to tenants equipment then the University shall cover the cost of filtration but if the source the distortions are for example from a Variable speed drive on the Air conditioning plant then the contractors will be responsible to cover the cost of installing Filtration or rectifying. The reports of Quality Audit are to be provided for inclusion in the Electrical Maintenance Manual for the Building.

4.5.7.4 Sub mains.

Underground sub mains *shall* be in PVC conduits, via cable pits (*Gatic lid and brick construction* trafficable *type* where in paths). *Where fibro cement or similar pits are used they shall be installed with 100x100mm concrete collar to strengthen lid support lip.* Provide adequate spare conduits for future use. *Pits shall be drilled for conduit access and gaps around conduits filled to approval.*

4.5.7.5 Earthing

Provide all Earth Testing data of the total installation to indicate compliance with regulations.

4.5.8 General Wiring

Power and 240V control cable shall not be less than 2.5mm^2 stranded copper, 240 volt control cable shall be not less than 1.5mm^2 stranded copper conductors. Lighting circuits shall be wired using not less than 1.5mm^2 stranded copper conductors. Colour coding shall be in accordance with AS 3000 part 3.2. Control wiring shall be white with a minimum size of 1.5mm^2 stranded copper cable. Single core copper cables shall not be used.

Colour differentiate power from light cables. Black TPS for power and white for light.

Install and conceal all wiring, including sheathed cable, within or by the building structure in a manner that can be easily replaced without damage to the completed building finishes.

Suspend/secure cabling within ceiling spaces of removable tile ceilings in such a manner and spaced above ceiling to ensure cables do not interfere with the removal and reinstallation of tiles, or the maintenance of in ceiling equipment.

Loop cables from point to point with joints and connections only at switches or outlets.

Seal cabling passing through a roof with a mechanical screw-up gland and apply an approved non hardening UV resistant sealant.

Do not install cables in any area until all construction work which is likely to damage cable is completed.

Group and install all cabling in straight runs parallel with line of building. Refer to AS3000 Wiring Rules regarding derating factors for cables. Cable sizes specified have not been derated for grouping of multiple circuits unless otherwise noted. Where derating is necessary due to installation method/grouping, increase cable sizes as specified in AS3008.1.

Cable entries to switchboards or equipment shall be via gland plates or through panels shall be made using circular, orange-sheathed, cable and suitable compression glands. Double insulated flat cable may be used if entering through ducts or conduits.

All metal Cable Trays, Ducting, Trunking, Cable Enclosures and conduits shall be bonded to earth, back to the nearest switchboard.

Portable electrical equipment and heaters used in hazardous areas to comply with AS3000 and AS1076.

Cable trays, conduits and conduit saddles shall have the following colour coding throughout the entire installation:

- Orange for power, lighting and 240V controls.
- Grey for Data or Extra Low Voltage or Low Voltage Controls.
- White for Telephones (and data where combined in same cable).

Conduit saddles shall be of type to ensure conduits are installed flush with wall/ceiling surface. Ducts and cable trays shall be fully galvanised where

exposed to the weather and colour banded to the above schedule every 3 metres (to all locations). All cable trays shall have *15*% spare carrying capacity.

4.5.9 Emergency Lighting

Emergency lighting shall be provided in accordance with the requirements of the Building Code of Australia and the Australian Standards.

Careful selection of emergency lighting shall be made so that the lighting meets the University's statutory obligation in a discrete way, particular attention to this issue must be made when emergency lighting may impact on architecturally splendid areas such as building entry points or architectural areas of importance.

Where existing Nexus monitored emergency lighting systems exist those systems shall be added to and extended as necessary. All systems shall be fully tested and commissioned to the supplier's and ECU's satisfaction.

All new buildings shall have Nexus monitored emergency lighting systems installed to match the existing systems on ECU campus. Any such new system shall be networked back to the head end PC on Joondalup campus as part of the project.

Emergency exit lights shall be of a Cold Cathode type or LED type. Battery types shall be of the highest quality and designed to provide the longest possible life for the battery. Where access to emergency lighting is at normal ceiling height battery pack shall be mounted local to each fitting. Where situations with high ceilings or difficult to access areas exist other options may be considered in consultation with ECU. Surface mount type fittings shall not be used.

As constructed data for emergency lighting systems shall include fully documented drawings including type and locations of fittings. Where computerised systems have been provided emergency lighting database reference information shall also be contained on the drawings.

Refer to AS 2293 "***Emergency Evacuation Lighting in Buildings***".

Emergency lights shall only be decommissioned with ECU approval prior to any work being carried.(We are have a lot of faults on the Nexus system, due to contractors disconnecting Lights and not recommissioning them)

4.5.10 Exit and Stair Lighting

Exit and stair lighting shall be in accordance with the requirements of the Fire Safety Act. Exit and stair lighting in enclosed stairs shall be designed to be "ON" at all times. Switching therefore shall be provided only at the circuit-breaker. In non-enclosed stairs, or stairs where natural light is sufficient for day time use, stair lighting shall be switched by the external lighting program of the BMS and *energy management lighting control system when applicable*. Emergency lighting to these areas shall be installed. Provide exit and stairway signs to comply with relevant codes. *Emergency lighting system shall be monitored by the emergency lighting control systems, referred to in clause 15.6. All light fittings to be installed no more than 3 metres finished floor level.*

4.5.11 Lightning Protection

Lightning protection shall be provided, if required, to all buildings in accordance with AS 1768-1991. *Lighting protection is required on all Joondalup Campus Buildings due to the high "strike" incidence on the campus.*

4.5.12 Electric Fans and Fan Heaters

In non air-conditioned offices where fixed electric heater with a push button on-off switch is provided, an overriding control through the BMS, for load shedding purposes shall be provided as follows:

All heaters in common designated area shall be wired on circuits controlled by a contactor which is controlled through the BMS for load shedding purposes. When the contactor energises the circuit(s), occupants can then operate heaters via push button control.

4.5.13 Toilets

Allow *for one socket outlet* adjacent to the mirror in toilet *areas*. No *socket outlets* for general use shall be installed within the restricted zones as defined by AS 3000.
Disable Toilet alarms shall be fitted with a remote alarm to a staffed position occupied during the normal operational hours of the Building.

4.5.14 Tea Rooms

Allow for sufficient power for briefed equipment including general power outlets for general use.
3 phase power to be provided for water heater where specified.

4.5.15 Gas Meters

All wiring connected to all gas meters to be installed as per Standards Association of Australia requirements for electrical circuits in a Zone 2 environment protection is required to enable the circuits to be rated as intrinsically safe.

4.5.16 Distribution System

Distribution of power and telephone/data wiring may be by means of a two channel perimeter aluminium skirting *of colour as directed by the consultant architect.*

In large open areas, in-floor, two channel duct with floor boxes and sealed cover plates should be considered as well as service poles. Where island rooms exist, these shall be conduited to allow for the installation of power and telephone outlets from the relevant sub-board or F.D.P. where these are not installed in the first instance.

Floor outlets for power and telephone outlets shall be of Clipsal manufacture or equal, however floor outlets are not recommended as they present a "trip" hazard.

All ducts shall have a minimum of 2 x 32mm feeds from the sub-board to each section of the duct.

4.5.17 Clock System

Battery operated 305mm dia. clocks shall be standard and shall be provided at the front of all lecture theatres,all teaching spaces, laboratories, common rooms, general offices, foyers, and lift lobbies.

4.5.18 Electric Water Heaters and Circulating Pump

Water heaters and circulating pump shall be controlled through the BMS with over-riding control at the distribution board supplying the circuits.

4.5.19 Underground Services and Pits

All underground services shall be installed in accordance with the requirements of AS 3000 shall be colour coded as follows:

Gas Services = yellow painted lid
Fire = red
Water = green
Electrical = orange

and shall be laid in sand with 75mm below and 150mm above and to sides and shall be identified by laying an approved continuous PVC marker tape 300mm min. above the conduits.

Only selected backfill shall be used and shall be compacted in layers not exceeding 200mm to a density of 90%. Compaction Standard achieving a standard penetrometer reading of 8 min blows per 300mm. The minimum cover shall be in accordance with AS 3000 and in any case, not less than 600 mm to top of conduit. Concrete cover to conduits to a lesser depth will be allowed only after written approval from the *Manager, Electrical Services*.

Minimum size of underground conduit shall be *32mm*. Underground cable shall be *PVC/PVC* cable, not less than 2.5mm^2.

Underground cable joints are not acceptable on sub mains. Maximum distance between pits on underground cable runs shall be 60m.

All underground pits shall have their lids marked indicating the service installed and pits shall be adequately drained.

All cable passing through pit shall be permanently tagged to approval indicating point of origin and termination.

Provide clearance between services as required by relevant Acts, Regulations.

All underground electrical services are to be laid in straight, direct lines.

All external cable Pits are to be trafficable.

4.5.20 Substations

Where required, provide new substation, new boundary switch room or modify existing substations as required.

Electrical feed to be a ring main type system to new buildings.

Allow for new switchboards, transformers, switchgear as required. Substations to be 2 hour fire rated and comply with requirements of Western

Power and AS 3000.
Transformer size to be determined and to be part of the contract.

Provide spare FCUs for future use.

All high voltage switching shall be performed by Western Power trained staff having the required certification. No work shall commence on high voltage network without an Access Permit in place and signed by all parties who will be carrying out the works.

Where any high voltage cable is to be cut, altered or moved, the Contractor shall arrange with the Consultant and *Manager, Electrical Services* to test and mark the cable to ensure that it is the correct cable and that it is not "live" before work commences.
Once the cable is proved DEAD it shall be "Spiked" with the approved equipment before any work is commenced.
All work shall be checked and tested as appropriate before the switching is carried out. Final approval for energising of a new sub station lies with the supply authority. No switching shall be carried out without their approval.

The Contractor shall meet all costs associated with switching and commissioning.

4.5.21 As Constructed Documentation and Manuals

Consultant approved "as constructed" documentation shall be submitted, in manuals, **prior to practical completion** and shall cover all electrical services. These manuals shall include but not be limited to the following:

- Complete set of "As Constructed" hard copy drawings and disks (complying with ECU requirements-Autocad and REVIT format)
- *shall include dimensioned and surveyed location of items as well as full details on services installed.*
- Details on all equipment and appliances.
- Equipment or plant operational instructions.
- Maintenance literature for all equipment and appliance including spare parts listings.
- Equipment supplier's details.
- Commissioning figures including all electrical test readings, lighting levels achieved, fire alarm audible levels on room by room basis for EWIS, complete set of fire alarm tests, *earth loop impedance figures, Harmonic Analyse, all three phase are balanced within Plus or Minus ten percent,* etc.

Manuals to be provided as 2 hard copy sets and one complete manual in electronic form.

4.5.22 Regulatory Authority Notices

For all electrical installation work Electrical contractor shall submit a Minor Works or a Preliminary and Completion Notice to the supply authority and at the same time a copy to the *Manager, Electrical Services*.

Contractors shall also complete an entry in the *campus* site electrical record book detailing:

- the location and nature of works;
- the number of the notice;
- Contractor's name, name of person carrying out work and their license number.

Any Electrical Work and or equipment that does not conform to these Planning and Design Guidelines shall be removed and reinstated to the appropriate standard, at the Contractors expense.

4.5.23 Auto Doors

4.5.22.1 Operator

Operators for auto doors to be Dorma EL301 and be complete with:-

- Separate entry exit sensors.
- Electric constant rated stall proof capacitor start squirrel cage motor.
- Battery back-up for a minimum 300 operations.
- Photo-electric cells across doorway.
- Controls to be interfaced with the buildings Fire Alarm and Security access control systems.
- Switches and push buttons shall be mounted 900mm above finished floor level.

4.5.22.2 Operation

Normal Hours
The doors shall allow free access and exit via local movement sensors.
Close after time delay
Fire Alarm condition – Doors operate as normal.

After Hours
The doors shall be controlled via the Security access system. Only a valid card holder is permitted.
Exit via Exit push button or in secure areas via a card reader with a back-up break glass. Close after time delay.
Fire Alarm condition – Doors open and remain open until the fire alarm is reset.

4.5.22.3 Request to Exit Button

The request to Exit (EX) push button shall be momentary bell press switch. The push button shall be a Clipsal prestige series P30MBP or equivalent in the same orientation to other fittings.
The push button shall be engraved in red “PUSH TO EXIT in capital letters a minimum of 8mm in height and centrally located above the button. All “End of Line Resistors” shall be located on the rear of each plate and securely fixed.

4.5.22.4 Key Switch

Dorma key switch is SK. Allow to replace lock barrel with ECU standard barrel

4.6 Communications

4.6.1 Generally

Contractors

Any work carried out on the University Communications cabling and systems can only be done by contractors approved by the ECU Manager IT Infrastructure Services.

ACA Specifications, Approval and Australian Standards

This work shall be carried out strictly in accordance with the current ACA specifications and appropriate Australian Standards by an appropriately registered cabling contractor. The cabling installation shall comply with the current issue of AS3080, "Integrated Communications Cabling Systems for Commercial Premises", unless this brief specifies otherwise.

Equipment to be Provided

The cabling contractor to supply and install data/telephone cabling system complete with all equipment racks (unless directed otherwise), patch panels, terminal blocks, connectors, cables, patch leads, records, jumpers, accessories and consumables. All projects shall be ACA approved and clearly marked as such. Cabling Contractor to install conduits and wiring access for facility cabling. All cable trays and supports for block wiring shall be supplied and installed by contractor.

Telephone/Data Backbone Cabling

Telephone and data backbone cabling shall be included in the contract.

Telephone Handsets and Final Connection

Telephone handsets will be supplied and installed by the University. Final connection of the telephone i.e. jumpering on the IDF/MDF and connection of the patch lead in the Communications Cupboard/Room shall be carried out by the University.

Earthing

Provide a complete earthing system to ACA approval for telephone and data distribution system, including connection to the main earth.

Locks and Handles

All locks on Communications Rooms and Cupboards shall use an "AS2" cylinder in the University's standard lock series unless otherwise specified. Doors shall only be able to be opened with a key and be self-locking on closing, but shall have a handle on the inside or be arranged to prevent persons being trapped. Doors shall open outwards and shall have a fixed handle on the outside.

4.6.2 Cabling Provisions

4.6.2.1 General

Provide for communications cable distribution by the use of either two or three channel skirting duct mounted either at skirting level or bench height depending on application. In staff offices the ducting is to be at skirting level. Ensure duct has adequate conduit entries for cabling requirements.

Provide a detailed block diagram for each building specifying:
Cable type
Outlet type
Origin
Destination
Termination connection points/Number off

Provide lightning surge diverters to data/telecommunications lines.

All cabling to be as per ACA TS 102-1998 (Australian Communications Authority Technical Standard Customer Equipment and Cabling) and the other applicable Australian Standards. All cabling contractors shall be registered with the ACA as accredited registrar.

4.6.2.2 Site Cabling

Special Services Cable
Provide special services cabling in conduits between the building's main data frame and the Special Services Frame in each building. Terminate on Krone frames at each end.

Fibre Optic Cable
Specification for fibre optic cabling to be determined by the ECU Manager IT Infrastructure Services. Leave a five (5) metre loop of cable at each end for future connection by the University.

Where fibre optic cables pass through underground cable pits provide cable loop (≈ 300 dia) and cable tie to prevent loop uncoiling. Indelibly label all underground cables within pits clearly notating where the cable originates, type of cable and where it terminates.

Cabling Requirements
Check with the ECU Manager IT Infrastructure Services for exact requirements of data cabling as requirements may vary from one project to another.

All copper cabling entering a building shall be provided with line protector surge arrestor units at both MDF and IDF ends, Critec SLP 10-K4 or equal approved to TS009.

4.6.3 Detailed Requirements

4.6.3.1 Server Room

Server rooms are critical infrastructure. Brief for design must be approved by the ECU Manager IT Infrastructure Services. In general the following to be considered:

- Heat loads of equipment to be accurately determined.
- Plan for heat dissipation must be based on a clear understanding of air flow.
- Power supply to be uninterruptible.
- Air conditioning systems to be fully backed up.
- Facility to be fire protected and include a fire suppression system.
- Facility to be secure and have access control.
- A risk assessment to be prepared and signed off by the ECU Manager IT Infrastructure Services
- Access for delivery and installation of equipment.

4.6.3.2 Communications Room

General

Each building shall have at least one Communications Room, preferably centrally located on the ground floor, to securely house equipment to provide communications and computing services for general use in the building. The Communications Room is the hub for the communications wiring for the building and shall be directly connected to the underground service duct network.

The room shall be sized to accommodate a minimum of 2 APC Net shelter type racks with adequate space to install and service equipment. Details of the layout to be confirmed with the ECU Manager IT Infrastructure Services Floor covering shall be anti static vinyl and room to be dust free.

Environment

The room shall preferably not have any windows, but must be air conditioned to specifications supplied by the ECU Manager IT Infrastructure Services. Generally:

- To dissipate equipment heat loads.
- Full back up.

Electrical Requirements.

Room lighting shall be provided.
Equipment power supply to be uninterruptible. Unless otherwise directed UPS to of Emerson Network Power manufacture. System to have the ability to monitor power consumption both at the UPS and at each individual rack (metered power rail).

Ducting Requirements

All ducts shall enter the room adjacent to the communications rack. The room shall be directly connected to the underground communications duct network by at least two 100mm ducts in each direction. The rooms shall be connected to building communications cupboards by ducts with easy access for future modification of cable infrastructure

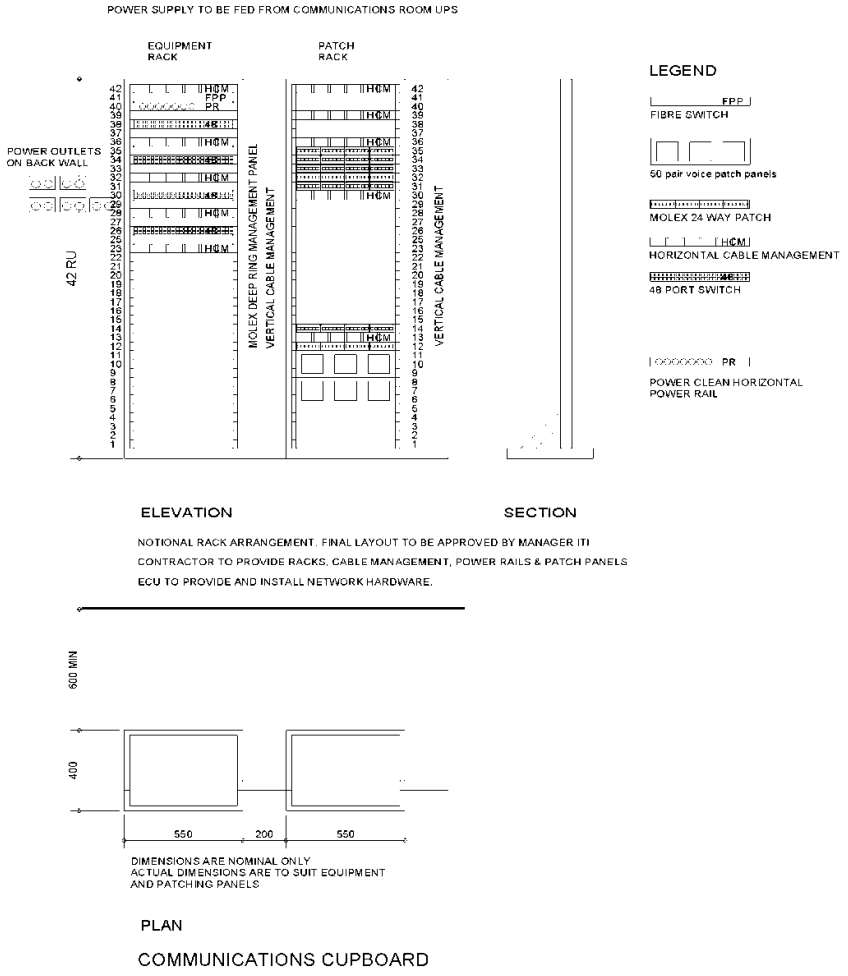
4.6.3.3 Communications Cupboards

General

Each cupboard shall be sized to accommodate 2 of 19 inch racks with adequate space for the installation and servicing of equipment .

There shall be at least one Communications Cupboard on each floor from which there shall be access by conduit or via the ceiling space to run cable to all rooms on the floor. Cupboards shall be vertically aligned one above the other.

The cabling run from any outlet to a communications rack shall not exceed 90m. No Communications cupboard shall be more than 180m wiring run from the Communications Room. Additional Communications cupboards and rooms shall be provided, where necessary, to ensure that these lengths are not exceeded. Specification of cable links between cupboards and Communications Room to be determined by the Manager IT Infrastructure Services.



Environment

Equipment heat loads to be determined and appropriate solution for the dissipation of heat determined. At a minimum cupboard to be provided with an exhaust system triggered by an over temperature alarm.

Cupboards to be dust free and include finished ceiling and sealed floor.

Electrical Requirements

Internal lighting shall be provided. There shall be a double socket outlet adjacent to each rack. Power to each rack is to be provided with a Power Clean LF-8 horizontal power rail having 8 outlets, fixed horizontally on the middle of each rack.

Power outlets in riser/cupboards shall be supplied directly from UPS installed in Main Communications Room.

Ducting Requirements

Where there is more than one floor, cupboards shall be vertically interconnected by conduits or wiring access with the equivalent space of not less than three 150mm conduits.

Where more than one cupboard is provided on the same floor, cupboards shall be horizontally interconnected by conduits or wiring access with the equivalent space of not less than two 100mm conduits.

Where additional cupboards are provided on the same floor as the Communications Room, the cupboards shall be horizontally interconnected by conduits or wiring access with the equivalent space of not less than three 150mm conduits.

4.6.3.4 Outlets at the Workplace

All outlets shall be provided in sets consisting of 2 RJ45 terminated CAT6UTP cabling. These outlets shall be assumed to be one for data and one spare Each set of outlets shall have an adjacent double GPO unless specified otherwise.

Outlets other than those for workstations will be project specific and are to be individually determined.

4.6.4 Facility Cabling and Patch Leads

4.6.4.1 Cabling to Outlets

Provide the appropriate number of Krone Highway 32 panels (or equivalent) on the rack and an RJ45 termination per wall outlet. Copper cabling shall be category 6UTP cable from each RJ45 outlet located around the building in accordance with the plan. Outgoing cables shall be installed in conduit or in the ceiling space and dropped down to the skirting ducts at suitable locations. Termination of wires at the outlets shall use the pin/pair assignments specified in AS3080 Section 6.3 and Figure 3 as TS568A.

Colour code shall be as specified in AS3080 para. 6.2 and Table 2; for clarity this is shown in Table 17.1 below:

RJ45 Pin	Pair Colour (base/band)
1	White/Green
2	Green/White
3	White/Orange
4	Blue/White
5	White/Blue
6	Orange/White
7	White/Brown
8	Brown/White

Data and VoIP Patch Leads

For each data outlet provide one 3 metre lead for the connection from the wall outlet to a computer, one 2 metre lead for patching (unless required to be longer because of the size of the patch field) and one 1.5 metre lead for patching from VoIP Telephone to computer. All patch leads to be of Molex manufacture, certified UTP category **6** with appropriate ACA approval. All leads to be left unconnected in the appropriate Communications Room/Cupboards at the completion of the contract. Length of leads may vary due to location on rack, hence length of leads to be discussed with The Manager, IT Infrastructure (IT Services Centre) prior to manufacture of leads.

Analogue Telephone Patch Leads

For each analogue telephone outlet provide one 2 metre white Cat 6 lead due to the backbone cable terminating on 50pr voice panels. (Unless required to be longer because of the size of the patch field). All leads to be left unconnected in the appropriate Communications Room/Cupboards at the completion of the contract. Provide one 3 metre lead for the connection from the wall outlet to a phone. This lead to have a RJ45 connector on one end and a RJ12 on the other.

4.6.4.2 Data Distribution Cabling

Patch Panels

Provide a data distribution panel on the equipment rack below the facility patch panel in each Communications Cupboard and Communications Room and fit with one RJ45 data connector per data distribution cable.

Data Distribution Cabling

Provide additional cables between the Communications Cupboards and the Communications Room and provide additional cables between Communication Cupboards as specified, by Manager, IT Infrastructure (IT Services Centre).

4.6.4.3Telephone Distribution and Backbone Cabling

Intermediate Distribution Frame

On one of the racks in the Communications Room, mount the required number of 100 pair Krone terminal blocks to provide backbone cabling to the campus Main Distribution Frame (MDF) and distribution cabling to each Communications Cupboard that is fitted with a "Telephone" block. Mark the backbone block "Telephone Backbone". Mark the distribution blocks "Telephone CCXX", where CCXX is the Patch Panel identification in the

appropriate Communications Cupboard as specified in Paragraph 17.8. Blocks to be electrically insulated from the rack in accordance with ACA specifications. Refer Clause 17.10 diagram for location of Krone terminal blocks on the rack.

Final Distribution Frame

Mount the required number of 50 pair Krone terminal blocks on one of the racks in each Communications Cupboard or Room as required for telephone distribution cabling. Mark the blocks "Telephone". Blocks to be electrically insulated from the rack in accordance with ACA specifications. Refer Clause 17.10 diagram for location of Krone terminal blocks on the rack.

Telephone Distribution Cabling

Install a suitable size telephone pair cable from "Telephone" terminal blocks located in the equipment rack in each Communications Cupboard to the appropriate "Telephone CCXX" terminal block located in the equipment rack in the Communications Room.

Telephone Backbone Cabling

Mount the required number of 50 pair Krone terminal blocks and any associated hardware on the campus MDF in the PABX room. Location on the MDF to be agreed with the University Telecommunications Officer. Install a suitable size telephone pair cable from "Telephone Backbone" terminal blocks located in the equipment rack in the Communications Room to the terminal blocks on the MDF.

Telephone Jumpering

Jumpering to be provided in the Communications Room between the "Telephone Backbone" terminal blocks and the "Telephone CCXX" distribution terminal blocks.

4.6.5 Labelling and Documentation

O ***Labelling***

Outlets on the patch panel shall be identified using the following convention:

PP« Patch Panel »-P« Panel »-« Outlet » eg. PP25-P2-10

The Patch Panel number to be obtained from the Senior Voice Communications Officer, IT Infrastructure (IT Services Centre). Number the Panels downwards from the top. Number the outlets from the top left hand of the panel across then downwards. On the Patch panel: label the top of the patch panel with the Patch Panel number; label each panel with its panel number; label each outlet with the outlet number. All labels to be engraved lettering on traffolyte hard plastic strip or a suitable alternative approved by IT Infrastructure (IT Services Centre). Labels to be permanently attached to the panel.

Label each combined wall outlets with the full identification of the corresponding patch panel outlet.

Patch Panel Documentation

Documentation to be provided at each Patch Panel using a form supplied by the Senior Voice Communications Officer.

Provide a CAD plan to the University Project Manager with a copy to the Manager, IT Infrastructure (IT Services Centre), of the building with the full identification marked on the plan against each wall outlet.

Three hard copies of the documentation shall be provided. One shall be placed in a clear A4 plastic envelope to be provided and secured to the rack. One copy shall be provided to the Senior Voice Communications Officer, IT Infrastructure (IT Services Centre) and one copy shall be provided to the University Project Manager.

As Constructed Plans

Contractors shall provide CAD presentation of information on building and site plan disks to be provided by the University, the following "as constructed" information :

- Exact location, number off, and identification (specified in 17.8 above) for each wall outlet.

- An indication of the route between outlets and the communications room/cupboards.

- The route of any cable runs between communications cupboards and to the communications room where these are not vertically one above the other.
- For any cabling exterior to a building, the type of cable, the exact route taken, the method of construction, eg overhead, in duct or direct buried, and if ducted, which duct bores used.

"As constructed" plans in CAD and hard drawing format shall be available when the installation is inspected and shall be submitted to the University Project Manager on completion of the work.

4.6.6 Acceptance, Testing Certification and Warranties

Acceptance

On completion of the installation of the Voice/Data Cabling System check test all Voice/Data Cabling System outlets and confirm that the equipment has been installed and interconnected in accordance with the Specification and drawings and that the specified performance is achieved.

Testing of all UTP cabling shall be carried out using Level 3 handheld testers Omniscanner 3, HP wirescope, Philips fluke DSP4000 or equal approved, complete with system compatible test probe/s.

All UTP cabling shall be tested and be compliant to TIA EIA 568 Draft 6 Category 6 specifications and retested and be compliant to ISO/IEC 11801 Category 5 (enhanced).

Provide both Channel and component Cat 6 and 5E compliant test results.

Test all UTP cable pairs and check for:

- Continuity;
- Correct Sequence;
- Reversed Pairs;
- Transpositions;
- Split Pairs;
- Pin Assignments;

- DC resistance and continuity for each pair;
- Return Loss (must meet the Category **6** (enhanced) minimum requirement);
- Capacitance for each pair;
- Active ACR;
- Compliance to ISO/IEC 11801 Category 5E (pass or fail) utilising Cat 6 patch leads.
- Compliance to TIA/EIA 568 Draft 6 Category 6 (pass or fail)

Test all outlets for compliance utilising Cat 6.

Testing of all multimode fibre optic cabling shall be carried out using Optical Light Loss testing except where cables are installed such that the installer has no visual confirmation of the cable route or optical light loss test are in excess of the recommended losses. In these situations Optical Time Domain Reflectometer testing shall be carried out.

Testing of all single mode fibre optic cabling shall be carried out using Optical Time Domain reflectometry.

Test all fibre optic cabling and check for:

- End to end continuity.
- Correct core sequence at both ends (White-White, Blue-Blue, etc).
- Cable free from kinks and strain.
- Cable has sufficient clearances at bends.
- Cable has been supported to manufacturer's recommendation and specified.
- Cable jacket maintained as close to the point of termination as possible, within the termination unit (box, tray, etc).
- Through Couplers are secure in termination units.
- Connectors are standards compliant and free from discrepancies, prior to termination.
- Cable has been properly stripped and prepared, all jelly cleaned from the cores, all supports removed from the inner tube, and the cores cleaned and freed from grease oils and any other impediments.
- Light losses at both ends of the terminated cable. This test must be conducted from both ends, ie test all cores from end 'A-B'. Then test all cores from 'B-A'. Results must be recorded for each test sequence.
  Losses must not exceed 3.0Db for the overall length of each individual core and 2 connectors.

Provide a 'Drum Test Certificate' for all fibre optic cabling from the cable supplier to prove continuity and quality assurance of the unreeled cable.

Sufficient advance notice of testing is required to allow for the witness of tests. Complete all tests prior to Practical Completion.

All cables failing specified testing shall be replaced at no cost to the contract. Submit two disk copies of test results.

Certification and Guarantees

Provide a performance certification and guarantee on all installed cables and connectors. The guarantee shall confirm satisfactory operation of the cabling system for the application.

The complete voice/data cabling system shall have a minimum warranty of ten (10) years, with respect to all components of the system, from the time of practical completion.

Acceptance of the installation is conditional upon testing and certification as specified below and the telephone work being inspected and tested by ACA and a Certificate of Acceptance being issued by ACA. Acceptance of the installation is also conditional upon the work being inspected by the Communication Branch of Information Technology Division of Edith Cowan University and completed to their satisfaction.

4.7 Media Services

4.7.1 General

Media services and the manner that media is employed for teaching is a rapidly changing environment. Standards therefore will be established on a project specific basis.

Designers should be aware that provision for media should be grounded on education and information need. Very broadly media services consist of display systems and audio systems. In some situations these system have to work in conjunction with whiteboards. Location of display system and controls must take into consideration size of facility and the manner in which the facility is to be used.

Trailing cables which result in trip hazards are to be avoided.

In general media services are user driven with minimal support, user friendliness is an imperative. In situations such as general teaching area and bookable meeting spaces help is provided via telephone. Ensure a telephone outlet is provided for these facilities.

4.7.2 Contractors and Equipment

Any work carried out on University Media Services can only be done by contractors approved by the ECU Manager IT Support Services.

All equipment and cabling specification used must be approved by the ECU Manager IT Support Services.

4.7.3 Antennae

In general all buildings are to be fitted with a free to air antennae system with the ability to connect at each floor provided in nominated communications cupboards.

4.7.4 Security of Equipment

All media hardware to be provided with adequate physical security – padlocked cages for projectors; lockable tethers for LCD screens; lockable cupboards for equipment etc.

In designing lockable cupboards for equipment consideration to be given to the need for access to DVD and VCR drives. In general equipment to be housed in racks specifically designed for the purpose. Housing for equipment to allow for the dissipation of heat generated by the equipment.

4.7.5 Media Installations

4.7.5.1 Student Information Screens

Standard

- LCD screen on appropriate wall or ceiling bracket
- Starbak Display Engine

Alternative

- LCD screen or screens
- PC to provide video feed to screens

4.7.5.2 Standard Install Meeting/ Conference Rooms

Standard:

- JED AV control device
- Lap top plate
- Ceiling mounted projector
- Motorised drop down screen
- DVD/ VCR combo mounted in an equipment rack
- Powered Speakers

Optional:

- TV antenna point
- Video conferencing facility

4.7.5.3 Computer and Teaching Labs

Standard:

- JED AV control device.
- Lap top plate
- Ceiling mounted projector
- Motorised drop down screen
- DVD/ VCR combo mounted in an equipment rack
- Powered Speakers.

Optional:

- Additional display devices

4.7.5.4 Specific Need

To be determined on a project basis with the support of the ECU Manager IT Support Services.

4.7.6 Flexi Lecture

Flexi Lecture is the ECU system for the video and audio capture of Lectures and the streaming of this captured information to students via the Web.

The system has variants ranging from full video and audio capture with video conferencing facility to audio capture only.

This facility can only be provided with the approval of the ECU Manager IT Support Services. Detailed specification and selection of contractors qualified to carry out installation to be approved by the ECU Manager IT Support Services.

4.7.7 Media Services Help

All rooms containing multimedia equipment are to be provided with a telephone point configured for direct connection to security and MMR help.

4.8 Fire Services

ECU – Standard for Fire Indicator Panels and Fire Plans

FIB display – eg
Top Line – Bldg 4 Level 2 West Zone 5
Bottom Line – Zone 5 Loop 3 S24

Fire Plans
- Must be colour.
- Show each Zone in different colours (same colours can be used on a different floor).
- Fixed to wall and laminated.
- Minimum size – A3.
- Electronic version .DWG to be provided.

Password - 3333

4.8.1 General

Each building shall be provided with a system of fire protection in accordance with relevant codes and standards. Each individual system shall be designed and installed in such a way as to guarantee the maximum insurance rebate allowable for that system.

The Project Architect shall consult with the Fire Brigade at the earliest possible stage in the design process so that the Fire Brigade's requirements are met and delays will not be experienced at the building occupation stage.

This section of the Engineering Standards outlines the University's minimum requirements for the following types of Fire Protection Systems:

- Automatic Fire Alarms.
- Hydrants and Hose Reels.
- Hand Extinguishers.
- Automatic Fire Sprinklers.
- Special Systems as required *e.g*. gas extinguishing systems, high velocity water sprays.
- Lightning surge diverter protection required to fire alarm lines.

Note code requirement for Public Building exhaust to outside air in event of fire.

4.8.2 Preferred Contractors

Contractors either tendering or working on projects at Edith Cowan University must be approved by the manager Electrical Services.

4.8.3 Fire Alarms

4.8.3.1 General

Generally, a fire alarm system is required to all buildings with independent FIBs connected back to the main site FIB and to the Fire Brigade. This requirement also applies to refurbished buildings.

All fire alarm systems shall be provided with a fire plan drawing adjacent to the fire panel. The drawing shall be to scale and of a size that can be easily read from 1m away. Any alterations to the building or fire system to be recorded on the fire plan.

Fire panels to be changed to show new or additional room numbers.

4.8.3.2 Emergency Warning and Intercommunications Systems (EWIS)

For each project, an Emergency Warning and Intercommunications system shall be installed subject to funds being available.

The system shall be in accordance with AS 2220.1 and .2 "***Engineering Warning and Intercommunications Systems for Buildings***". The EWIS panel shall be located next to the fire indicator board in the entry foyer and connected to every warden intercom point and to be a system for distributed loudspeakers on every level. The EWIS system shall be activated to the alert mode on the occurrence of all or any of the following:

Activation manual call point
Activation of smoke/thermal detector.

Facility such that the operator can override the system and include any of the following functions to all or any part of the building by using one specific button for each function:

Alert tone
Evacuate tone
Public address systems.

The EWIS panel shall have illuminated push/hold and push/release button for each intercom point on every level of the building.

Intercom points shall be installed in the immediate vicinity of the fire stair exit and in all fire hose reel cupboards.

On commissioning, sound level readings shall be taken for all rooms including plant and associated areas. A minimum sound level shall be attained for each room of 75Db. Note strobe lights to be used in conjunction with audible alarms in areas with equipment which require occupants to use hearing protection.

4.8.4 Automatic Fire Alarms

4.8.4.1 General

In general all buildings shall be equipped with automatic fire alarms connected via the building's Fire Indicator Board, to the local Fire Brigade.

4.8.4.2 Detection

In general the buildings shall be protected with *ceiling mounted smoke detectors and* thermal alarms *in ceiling spaces or harsh environments* in accordance with the requirements of AS 1670, Automatic Fire Detection and Fire Alarms.

Thermal alarms shall be of the electro-pneumatic, compensating rate of rise type. Thermo-pile and solid state alarms are also acceptable. Detectors shall be in accordance with the requirements of AS 1603.

Smoke detectors (combustion type) should be used where early warning is required in areas such as sub-stations, switch rooms, P.A.B.X. and M.D.F. rooms.

Smoke detectors (obscuration type) should be used in air-conditioning systems in supply and return air systems to comply with the requirements of AS 1668 - Part 1 - 1979 Fire Precautions in Buildings with Air Handling Systems.

Consideration should be given to an intermixing of smoke detectors of both types in areas such as computer rooms or rooms containing sophisticated electronic equipment particularly where air movement is considerably high. All detectors shall be provided with neon or L.E.D. indicating lamps.

Note: Break glass alarms are also required in all laboratory areas, corridors and foyers. Concealed space detectors shall be equipped with remote neon or L.E.D. indicators labelled with the type and location of the detector.

4.8.4.3 Sub Fire Indicator Board

Each building shall be equipped with its own Fire Indicator Board showing all alarm circuits. Allow on each Sub Fire Indicator Board a minimum of 25% spare space. A maximum of 30 thermals or 15 smoke detectors shall be provided on any circuit.

It is essential that all fire indicator panels on each campus be configured identically. Unless otherwise directed fire panels to be Ampac Fire finder fully addressable analogue type.

The building shall be connected via the Special Services Cable to the Site Fire Indicator Board/*Fire Alarm Multiplexers* from which an alarm will be transmitted to the Brigade. Provision shall be made for all connections fees etc. and modifications necessary to the site plan forming part of the Site Fire Indicator Board. Each F.I.B. shall also be linked via a DGP point in the building to indicate an alarm on the BMS.

Fire Indicator Boards shall be placed in a position easily accessible to the Fire Brigade from vehicular access and the position of the F.I.B. should be checked at documentation stage with the relevant parties. The University has generally standardised on F.I.Bs being located behind an unlocked door sign written in accordance with the code. Signs on the doors are provided by the University.

All to the requirements of AS1603 "Control Indicating Equipment".

4.8.5 Hydrants and Hose Reels

Hydrants are to be provided to serve all buildings in accordance with the BCA and appropriate Australian Standards. In General each level of a building shall have sufficient unequipped Brigade landing valves such that no portion of that level is more than 30m from a hydrant. Hose reels should be placed at or adjacent each hydrant and should be a minimum of 36m x 20mm I.D. hose. Hydrant systems shall be designed to provide water within the range of pressures specified by the BCA and Australian Standards. Brigade booster connections, if required, shall be provided in accessible locations for all buildings. Pumps shall be provided if required to meet design pressure. The system is to be subject to a Fire Brigade test for approval.

Provide signs (coiled hose reel design) mounted at right angles to the wall to signify location of hose reels and hydrants.

Fire hose reel nozzles, etc., to comply with the following:

- Hose reel gate valve must lock end of hose nozzle to hose reel and retain it in that position when not being used.

- To permit hose nozzle to be detached from hose reel gate valve, the gate valve must be released which will at the same time allow water to flow into the hose. When the hose is unravelled and taken to the fire, water is released upon turning on of the hose nozzle.

- Hose reel cupboard doors to be painted a distinctive colour which is different to all the other doors.

- Consultants are to organise formal certification from the Fire Brigade that location of units and operation of system is in accordance with Regulations.

4.8.6 Fire Extinguishers

Fire extinguishers shall be provided to all areas in accordance with Fire Services requirements. In general the following extinguishers should be used for standardisation and shall be provided under the contract:

• General office areas	2kg carbon dioxide extinguishers to be located in reception or office areas where photocopiers, facsimile machines, multiple computers occur.
• Cooking areas	4.5kg dry chemical powder (B.E. Powder) extinguisher plus blanket 1200 x 1800
• Switchboards and/or Transformer rooms	Carbon dioxide or dry chemical (4.5kg)
• Laboratories	Carbon dioxide (4.5kg) plus Dry chemical (4.5kg) and 1200 x 1800mm fire blanket
• Computer rooms	3.4kg carbon dioxide
• Computer laboratories	3.4kg carbon dioxide
• Plantrooms	Carbon dioxide (4.5kg) and dry chemical (4.5kg)
• Student Housing kitchens	Dry chemical (2.5kg) and fire blanket

Floor area per extinguisher to be as follows:

• Water extinguishers	Offices, teaching area, assembly halls	$300m^2$
	Display areas, workshops	$200m^2$
	Bulk storage areas, woodworking areas, processing areas	$150m^2$
• Chemical extinguishers	Refer AS 2444 Generally, in the office or laboratory situation where flammable liquid containers not exceeding 5 litres (total not exceeding 25 litres in the areas) provide 1 extinguisher per $80m^2$ each within 15 metres walking distance.	

Other extinguishers should be used where the risk so demands. All extinguishers shall be provided with coded location signs and usage signs in accordance with the requirements of AS 1851 - Part 1 - 1989, (maintenance code) and AS 1841 - 1850 as applicable.

Maximum size of extinguisher (excluding water storage type is to be 4.5kg and minimum size to be 2.2kg.

In general only extinguishers approved by the SAA will be acceptable.

Extinguishers which require inversion for operation shall not be specified.

Extinguishers shall be installed in accordance with the requirements of the Fire Brigade, installed at a height of 1000mm above floor level and in accordance with the requirements of AS 2444 (Portable Fire Extinguishers - Selection and

location).

Provide signs at right angles to the wall to signify location of fire extinguishers.

Maximum walking distance between water extinguishers to be 15 metres.

Where deep fryers are installed, extinguisher to be located next to exit from the room.

Carbon dioxide, foam and dry chemical extinguishers are preferred for flammable liquid fires (BCF is deprecated for this purpose on environmental grounds).

Water extinguishers are not to be used on fires associated with electricity/electrical equipment nor on flammable liquids.

Foam extinguishers, being water based, are not suitable for use on electrical equipment.

4.8.7 Fire Blankets

In cooking areas and laboratories, provide and install under the contract a 1200mm x 1800mm fire blanket.

4.8.8 Automatic Fire Sprinklers

Sprinklers must be installed in areas where required by Australian Standards, building codes or Authority requirements. Refer to AS 2118, etc. In general, any area should be considered individually and a proposal for Sprinkler Protection should be discussed with the University prior to documentation.

4.8.9 Special Systems

In certain applications consideration may be given to special systems such as:

- BCF, carbon dioxide, BTM gas extinguishment systems.
- High velocity water spray systems.
- High expansion foam systems.
- Tail end dry pipe.
- Pre-action systems.

Any proposal for any of the above systems should be discussed with the Project Manager Buildings prior to documentation.

4.8.10 Diagram of Exits

Provide a permanent engraved floor plan *letter cut vinyl behind perspex cover set off face of and* fixed to the wall on each level showing location of exits. *Allow also for similar sign of campus showing fire assembly points for campus including for new building.*

4.9 Security Services

4.9.1 General

4.9.1.1 Preferred Contractors

Contractors either tendering or working on projects at Edith Cowan University

must be approved by the Manager Security Services.

Security Consultant/Lead Consultant to develop a comprehensive Security Management Plan in conjunction with ECU Manager Security Services, Project Manager Asset Delivery and relevant Campus Manager.

Security Plan to:

- Provide access control all to ground level access points thereby securing the perimeter.
- Compartmentalise building into manageable portions and allow for access control to these portions.
- Identify any security risks and provide access control to these areas.
- provide access control to any area or room which would require the issue of more than 6 keys.

4.9.1.2 Preamble

Designers interpreting these guidelines are to understand that changes to technology and policy may outpace the content of these guidelines. Prior to calling of tenders for any work related to ECU Security the following must be approved by the Manager Security Services:

- Access control/ security management plan. Plan must clearly indicate strategy for prevention of unauthorised entry and the access paths for users who would enjoy access to defined areas only.
- Schedule of equipment. Door locking devices; door closing devices; card readers; control buttons; CCTV cameras and enclosures; DVR.
- Location of security phones.
- Schematic wiring diagrams and cable specification.
- List of potential tenderers for access control.
- List of potential tenderers for video surveillance.

All facilities that require 24 hour access and contain equipment of high value must be provided with CCTV surveillance and access control. Rooms or areas which would require controlled access for a large number of people are to be provided with access control

4.9.1.3 Equipment to be Provided

The security contractor is to supply and install the security system complete with all cabling, documentation, operational equipment, required software, fittings, finishing, and appropriate connection to existing systems. Consultants and contractors shall abide by the relevant legislation and Australian Standards. The security contractor is to install all necessary conduits and wiring access for facility cabling.

4.9.1.4 Systems Integration

All electronic security systems shall be fully integrated through the utilisation of the existing TAC Integrated Security Management System (ISMS) and CCTV digital surveillance network. The ISMS's primary function is to integrate all access control systems, intrusion alarm systems, future security systems and future Intelligent Building Systems. The ISMS and the digital surveillance systems communicate with sub-systems and field equipment over the existing Security Systems' Virtual Local Area Network (VLAN).

4.9.1.5 Licensing

The designers of the University's security systems shall be licensed security consultants and the employer of the designers must be a licensed security agent. Similarly security installers must be licensed. Copies of the employer's Security Agent's licence and the actual designer/specifier's licence and

installers licence shall be forwarded to the University's Security Manager prior to commencing work. Please note that it is illegal in Western Australia for a company or individual to design, specify, or install security measures without the relevant licence. Unlicensed personal and companies will be barred from security design and installation work at ECU.

4.9.2 Crime Prevention through Environmental Design

4.9.2.1 General

The University requires attention towards the environment to complement and enhance the security of the campuses. Crime Prevention Though Environmental Design is an approach to preventing crime where its objective is to improve security by limiting criminal opportunity through the use of natural barriers and natural surveillance. Where possible, the University prefers CPTED to be used in conjunction with traditional electronic, mechanical, and structural crime prevention techniques. When conducting security related work, consideration shall be given to the following:

4.9.2.2 Territoriality

Territorial reinforcement of an area is the physical design that helps develop a sense of territoriality by the user that produces a perceived risk to an intruder. This shall be achieved through the use of clearly defined perimeters by way of barriers (fences, hedges or rows of trees) and other visual indicators (changes in ground lay material, lighting levels or wide-open spaces). Where applicable, the security designer shall demonstrate territoriality in instances that require the restriction of individuals.

4.9.2.3 Natural Surveillance

Keeping intruders under observation will result in a higher perception of detection. This shall be achieved by techniques that minimise the opportunities for intruders to conceal themselves and their actions. Large glass windows, well kept gardens, lighting and wide-open spaces will increase the natural surveillance of an area. The effectiveness of electronic CCTV systems is further increased when natural surveillance techniques are employed. Where applicable, the security designer shall demonstrate natural surveillance particularly in the vicinity of CCTV cameras.

4.9.2.4 Natural Access Control

The prevention of access to an area and the creation of the perception of detection and increased effort required by an offender constitutes Natural Access Control. Lighting can be employed to control the movements and concentrations of people. Individuals will be attracted to brightly-lit areas at night. Natural Access Control shall be utilised to provide an increased level of safety for authorised individuals.

4.9.3 Electronic Access Control Systems

All future electronic access control systems shall be compatible with the existing University Integrated Security Management System through the use of the University's Security Systems' VLAN and contactless smart cards. The University's *Manager, IT Infrastructure* must be consulted to ensure appropriate ports and IP addresses are available for access to the network.

4.9.4 Electronically Operated Door Locks & Hardware

Unless otherwise approved. Configuration of hardware to be restricted to the

following:

Auto Door – Card Reader, auto door interface card, door release and break glass.

Swing Door – Electric Lock, card reader, reed switch, DOTL and door sounder.

4.9.4.1 Electro-Mechanical Mortise Locks

Unless otherwise specified, all new doors requiring electronic access control shall be fitted with electro-mechanical mortise locks from the Lockwood 3570 series, configured for fail safe but with an internal free handle to allow egress; and external locked handle for entry. Mechanical key override is not required for electric locks.

Door furniture shall be from the Lockwood 3580 series and the handles shall be model number 1070 with a square end and radius corners.

A “request to exit” push button is required for exit. A break glass is required for emergency egress.

Provision of door sounder to be confirmed.

Purpose designed concealed door loops type DL-400, an equivalent approved, shall be utilised and where practicable doors shall be pre-wired for the locks, or wiring channels shall be utilised. The conduits and termination boxes shall be purpose designed for this application and shall be as small and secure as practicable. General-purpose conduits will not be acceptable.

4.9.4.2 Electromagnetic Locks

In cases where it is not practicable to install an electric mortise lock (eg. some existing doors) an electromagnetic lock may be utilised. The holding mechanical force of each electromagnetic lock shall be a minimum of 2000N. Some doors may require 4000N. The designer shall determine the force required and make calculations available to the University’s Security Manager. The lock shall be suitable for installation on glass frame doors where applicable. The contractor shall provide all necessary rigid metal supports to ensure that the locks are secured firmly at all times.

Locks installed below the minimum doorway height specified by the Building Code of Australia or relevant legislation will not be acceptable.

All surface mounted electromagnetic locks shall incorporate a concealed built-in door status sensor.

Doors that are installed with electromagnetic locks shall also be fitted with a mechanical key lock. The mechanical lock shall be installed with a lock cylinder on the insecure side of the door plus a holdback cylinder for retracting the bolt by key operation. While the electromagnetic locks are operational the holdback feature would be in use. However during times when electromagnetic locks are without power, the holdback cylinder on the mechanical lock shall be released by keyholders to allow operation of the mechanical lock as an automatic deadlatching lock. A free handle shall be utilised on the secure side of the door. The handle on the insecure side shall be key lockable. The cylinders shall be keyed to match the existing master key system.

A ‘request to exit” pushbutton is required for egress. A breakglass is required for emergency egress.

4.9.4.3 Electric Strikes

Electric strikes are not to be used unless the University Project Manager or Security Manager specifically requests this type of locking mechanism on a particular door. Electric strikes shall be from the Padde ES2000 series with compatible mortise locks from the Lockwood 3500 series, or similar, and shall be fail safe.

The cylinder shall be keyed to match the existing master key system. The key override shall be monitored in a manner that generates an alarm at the integrated security management system (eg. using a tongue sensor in the strike).

A 'request to exit" pushbutton is required for egress. A breakglass is required for emergency egress.

4.9.4.4 Door Openers and Closers

Where the University Project Manager requires an auto-door opener for a swing door it shall typically be a Dorma ED 200 or equal. All other electrically operated swing doors must be fitted with a good quality hydraulic door closer. The closer should be mounted on the secure side of the door. The closing power shall be sufficient to consistently and reliably close the door sufficiently for the electric locking device to engage and secure the door.

In the case of an existing door closer, it may need to be replaced to ensure sufficient closing power and it must be located on the secure side of the door.

4.9.4.5 Reed Switches

Each door controlled by the electronic access control system shall be monitored by a reed switch. Reed switches may be incorporated into the electric locking mechanism. In this case the reed switch must be installed and wired in accordance with the manufacturer's instructions. If an integral reed switch is not available then a separate reed switch shall be installed at the head of the door and be recess mounted in the door frame. The magnet shall be mounted in the top edge of the door. In the case of an integral reed switch in an electro-mechanical mortise lock, the magnet for the reed switch shall be mounted in the doorframe at the position recommended by the lock manufacturer.

4.9.4.6 Push/Pull Labels

Where required by the University Project Manager, the door pull plate shall be labelled "PULL" and the door push plate shall be labelled "PUSH". The labels shall be manufactured from brass with a satin chrome finish and etched with 19mm high letters.

4.9.5 Card Control

4.9.5.1 Contactless Smart Card

The access control card shall be a multi-application contactless smart card incorporating MiFare hardware technology. It shall be fully compatible with existing smart cards in use at the University. The smart card must incorporate access control and identification technology, which utilises radio frequency (RF) circuits in microchip form. The microchips shall be encoded and transmit the encoded information when activated. The thickness of the smart card shall be similar to a bank/credit card.

The suitable contactless smart card shall have the following characteristics:

- The smart card shall be capable of operation with any of the existing university smart card readers. It shall be a polycarbonate or PVC based card.
- The smart card shall have the facility to allow direct printing on one surface using the existing card printer.
- Card identification must be consistent with the existing series in use at ECU and must utilise ECU's existing facility code.

The card shall comply with ISO 14443 for contactless transmissions. For most projects, contact cards are not required. However should there be a specific requirement for contact cards they shall comply with ISO 7816 parts 1-10.

4.9.5.2 Card Readers

The access control card readers shall be used for access to certain rooms. As a general rule egress readers are not to be utilised. However where the University Project Manager or Security Manager specifically requests an egress reader for a room it shall be similar to an access reader. Card readers shall possess the following minimum features:

- The card readers shall support contactless smart card technologies and be resistant to tampering.
- All card readers shall display at least two separate and distinct visual signals to indicate to the user, whether access is granted of denied and whether the door is locked or unlocked.
- Card readers shall have a built-in antenna providing a read range of at least 5cms.
- Where required by the University Project Manager, card readers shall be of a design that may be hidden behind a panel. Where mounted on dark timber panels, card readers shall have brushed aluminium surround to make them obvious.

Card readers shall be mounted 900m above floor to allow easy access for people standing or siting in a wheelchair.

4.9.5.3 Egress Control

Unless otherwise directed by the University Project Manager or the University Security Manager, normal egress control through doors fitted with either automatic opening operation, electromagnetic locks or electric strikes shall be effected by the use of a simple "request to exit" push-button. The push-button shall be black with a white surround and be large enough and conveniently positioned to be operated by persons with disabilities and able-bodied persons.

On doors controlled by automatic opening operation electromagnetic locks and fail-safe electric strikes it will be necessary to install an emergency breakglass release pushbutton on the secure side of the door. This break glass shall be used to disconnect the electrical power to the local fail-safe electric door lock, bypassing the control circuit. The surround for the breakglass shall be white and be suitably labelled. Configuration of break glass on auto doors. If activated external PIR disabled however door to be able to be manually operated. Internal PIR to remain enabled.

Request to exit buttons and emergency egress breakglass buttons shall be mounted at 900m above floor level in a position easily accessible to people standing or sitting in a wheelchair.

In a fire alarm situation the power to electric locks within the alarm zone shall

be cut.

4.9.5.4 Field Controllers Panels

Existing field controller panels shall be utilised wherever possible. If a new field controller is necessary it shall be installed at a position to be approved by the University Project Manager, Security Manager and *the Manager IT Infrastructure*. *The Manager IT Infrastructure* must be consulted to arrange for provision of a suitable port, IP address and connection to the Security Systems VLAN.
Field control panels shall only be installed in secure areas. Typically communications cupboards.

4.9.6 Closed Circuit Television

4.9.6.1 General

The University is moving away from video based CCTV to a digital internet protocol (IP) system. Various systems will be trialled, current choice is Indigo Vision.

Depending on scale and location of projects, Manager Security Systems will determine what system will be utilised

4.9.6.2 IP Based System

Network Video Recorders (NVR).

NVRs are to be located in a secure area accessible by security personnel only. NVRs to be Indigo Vision with minimum 2 TB removable hard disk drive.

NVRs shall:

- Utilise a decompression algorithm suited to codec type used by the cameras (MPEG4/H.264)
- Incorporate separate host processors to perform video operations and other necessary options ensuring that video performance is not affected during processor loading, including during playback of stored video streams.
- Support analogue inputs and outputs with appropriate interfaces/encoders to enable legacy support for existing devices.
- Incorporate Windows based architecture for incorporation into the existing system and shall include security to prevent hacking.
- Have the capacity for up to 64 devices but shall have a maximum of 20 connected devices to allow storage management and future capacity.
- Be supplied with support for RAID technology.
- Locally and automatically perform disk space management.
- Be fully configurable via the connected network utilising administration credentials.

Movement Detection

The system shall have the ability to detect movement and be programmable to record at a higher resolution when movement is detected. Movement detection shall be performed at source on the host processor to ensure scalability and reliability. The system shall be fully configurable, including five modes of operation, sensitivity and delay time. Any movement detected after hours shall initiate an alarm signal. Alarm information shall activate corresponding camera or cameras to view alarm area or area most relevant to alarm area.

CCTV Cameras and Lenses

Cameras to be Indigo Vision fixed type and shall incorporate a ratified form of video compression being MPEG4/H.264 codec guaranteeing full frame video under SIF, 2SIF or 4SIF resolution as applicable.

Lens specification such as focal length, aperture, field of view, to suit particular application and to be confirmed by the manager security operations.

All cameras shall support Capped Bit Rate (CBR) and Activity Controlled Frame rate (ACF) options allowing for minimal storage and network utilisation whilst maintaining full rate video and adjusting the quality dependant on level of motion being viewed.

Tamper alarms shall be active twenty four hours per day regardless of other timed settings.

4.9.6.3 Video Based System

NVR to be INDIGO 8000 series or newer (latest model).

The existing CCTV workstations and digital video recorders (DVR) may need software and/or hardware upgrades to accommodate additional cameras. The designer shall determine the specific requirements.

The designer must seek approval from the University Security Manager for the location (and type) of proposed CCTV cameras, DVRs, monitors (where required) and workstations. All camera applications shall comply with the requirements of relevant legislation and be employed in such a way that the opportunity for abuse is minimised.

Cameras and lenses

All CCTV cameras and associated lenses shall be of the Panasonic brand or equal. All applications of cameras within the University shall utilise the standard Panasonic colour dome cameras, WV-CW494 and WV-CF294 (or equal). In applications where cameras are facing windows or areas where there is expected to be large differential changes in the ambient light levels, the super dynamic WV-CW474 (or equal) camera shall be used. In all other installations where the light levels are to be more consistent, the standard WV-CW224 camera (or equal) shall be used.

Matching Panasonic (or equal) lenses shall be used on the selected cameras at all times. All applications of lenses in the University shall utilise the 1/3 type High Speed Aperture Lenses, WV-LA210C3, WV-LA408C8 or WV-LA908C3 (or equal). The security designer shall determine the appropriate focal length and field of view required for each application.

Ensure lighting control is compatible with camera selection. In areas where motion detectors are used to control lights critical lights should not be able to be isolated by the light switch.

Outdoor mounting brackets shall be of a heavy-duty construction suitable for supporting the combined weight of camera, lens and housing. The brackets shall be suitable for wall and/or pole mount applications.

Under no circumstances shall CCTV cameras be installed in either indoor or outdoor applications without an appropriate housing. The final selection for camera housing and mount shall be made with consideration towards the field of view, vandalism/tamper and the prevention of moisture and dust penetration. The final selection must be approved by the University Security

Manager.

Recording and Archiving

All images captured from CCTV cameras shall be recorded on a digital video recorder located in the immediate building (typically in a communications room or cupboard). This recorder shall have the function to simultaneously record images from at least 16 cameras and provide playback over the Security Systems' VLAN. The security contractor shall provide all cabling between the DVRs and cameras and for the connection of the DVR to the Security Systems' VLAN. However the connection to the VLAN may only occur after express approval of the University *Manager, IT Infrastructure* and after the necessary network connection fees have been paid (ie. port provision plus rack space in existing racks). Existing DVRs may be utilised if spare channels are available. However, in this case the DVR hard disk may need upgrading.

DVR disk sizes shall be determined using a "Storage Requirement Calculator". The parameters to be used for the calculation are:

Frame rate = a minimum of 1.5 fps per camera (ie. 16 cameras at 1.5 fps = 24fps)
Frame size = a minimum of 35kb
% of storage saving through use of video motion detection = 60%
Storage time = minimum of 5 days

Archiving of recorded images will be achieved remotely by way of an existing DVD-RAM backup drive located in the CCTV workstation in the *Joondalup* campus security *management* office.

4.9.6.4 Housings and Mounts

All CCTV cameras installed within the University shall be appropriately mounted and contained in housing suitable for the immediate environment.

Housings installed in indoor environments are to be of the plastic dome type. Individuals in the camera's field of view must be able to clearly see the camera through the housing. Unless determined otherwise by the University Security Manager, housings installed in outdoor environments are to be of a weatherproof metal and plastic construction with fitted sunshield. The housing shall be a size that will fit the selected camera and lens with room for necessary cabling.

4.9.7 Intrusion Alarm Systems

4.9.7.1 General

Intrusion alarm systems must only be used for a specific purpose and approved by the Manager Security Services. Where possible system is to be integrated with the access control system - use of key pads to arm and disarm intrusion alarm system is to be avoided.

Intrusion alarm systems shall be managed by the Integrated Security Management System (ISMS) by way of an existing alarm workstation on each campus. However it is a policy at the university that intrusion alarm systems be monitored by ECU Security via a GSM dialler located in the monitored building which will transmit SMS text messages to 3 nominated ECU security mobile phones. Liaise with ECU Security regarding the phone numbers. ECU to provide SIM cards for each of the GSM diallers. Each GSM dialler to have 10 inputs. The dialler shall be configured so that it is not possible for anyone to *gain unlawful entry* into the VLAN by dialling the phone number of the dialler. The design must be approved by the University Security Manager and

the *Manager of Information Security*.

4.9.7.2 Alarm Devices

The nature of the integrated system shall allow intrusion alarm devices to be either dedicated or incorporated into other security devices. For example, dedicated alarm devices may comprise of volumetric intrusion detectors, and integrated alarm devices may constitute CCTV motion detection.

The University has a preference for Passive Infrared (PIR) detectors for the detection of volumetric movement. The success of these detectors, measured in terms of low false alarm rates and nuisance alarm rates, is dependent on the manner in which the detectors are installed. To maximise the effectiveness of these detectors, consideration shall be given to the following:

- PIR detectors shall not be positioned towards direct sunlight, objects of high temperature or where there is likely to be rapid changes in ambient temperature.
- Where possible, PIR units shall be positioned so that people in the field of view are forced to walk across the face of the unit, instead of towards it.
- PIR detectors shall not be installed in outdoor environments (unless it is a type especially designed for outdoor use).
- Where possible, PIR units shall be installed in a way that they are less vulnerable to tamper and vandalism. This includes the use of tamper alarm circuits.

Video and data projectors that are permanently mounted in rooms shall be protected using a vibration sensor fixed to the projector. The vibration sensor selected should be suitable for the immediate environment – that is, the designer must consider any noise or vibrations in the area. The design should ensure that any attempt to remove or damage the projector (or sensor) should generate an alarm.

All alarm cables from the field controller to the alarm device shall be monitored using dual end-of-line resistors. The end-of-line resistors shall be installed in each alarm device housing and configured to sense current and voltage changes on the alarm signal and the tamper signal wires. Any change in voltage or current shall initiate an alarm at the field controller and the operator station.

The University Security Manager reserves the right to reject any design or device that is deemed to be of an inadequate security standard.

4.9.8 Field Hardware Communications

Field hardware communications between TCP/IP addressable security devices and workstations shall be via the existing Security Systems' VLAN. The University *Manager, IT Infrastructure* will make available a reasonable number of Ethernet RJ-45 ports at each campus to enable the connection of the contractor's equipment to the Security VLAN (typically achieved in a communications room). There is a charge for this connection. Similarly, if the designer proposes to use existing IT rackspace (eg. for DVRs) then the University's IT Network Infrastructure Manager will also charge for the space used. The designer should consult with the University *Manager, IT Infrastructure* to determine the current charges. It is also very important that the designer ensures that IP addresses are made available for access to the Security VLAN. The IP addresses are available from the University *Manager, IT Infrastructure*.

The contractor shall be responsible for the supply and installation of any additional networking equipment necessary to interface to the security VLAN. The security contractor shall be responsible for all cable terminations necessary to make the security system fully functional.

4.9.9 Power

4.9.9.1 Main Power

Unless noted otherwise in the contract documents, the security contractor shall supply and install all necessary power cabling, trunking, circuit breakers and distribution boards, necessary to make the security systems operational.

All vertical cables shall be installed in risers or ducts unless otherwise approved.

The security contractor shall install all necessary power circuits from the existing distribution board to suitably placed power outlets in the communications room, cupboard or riser.

4.9.9.2 Uninterruptable Power Supply

All security systems shall continue to be fully operational for at least two hours after mains power failure.

4.9.10 Documentation

Project Documentation
Consultants and Contractors shall provide the University with all relevant documentation. Provide an AutoCAD plan of the building to the University Project Manager detailing all specifications of the security work performed.

As Constructed Plans
Contractors shall provide to the University AutoCAD drawings indicating project information in the following manner:

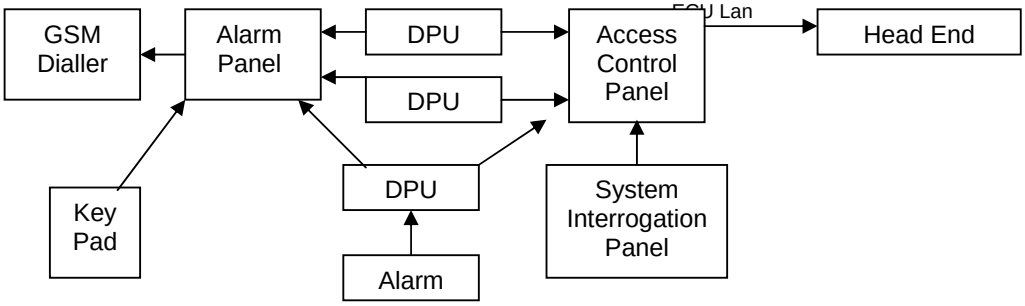
- Exact location, number of, and identification of each security component. In the case of CCTV cameras, an indication of the direction to which they point, and their field of view shall be included.
- Actual cable routes between the security components and the controlling system shall be indicated and detail of these provided.
- For any cabling exterior to a building, the type of cable, the exact route taken, the method of construction (eg. overhead, in duct or direct buried), and if ducted, which duct bores.

"As Constructed" plans in CAD and hard drawing format shall be available when the installation is inspected and shall be submitted to the University Project Manager on completion of the work.

4.9.11 Acceptance Testing and Certification

An acceptance test and performance demonstration program shall be developed and documented by the security contractor under the direction of ECU or its agents for all security projects. These requirements shall apply to all system components and software. The contractor shall perform the tests and document the results under the supervision and witnessing of ECU or its agents. Operational scenarios shall be developed and used by the security contractor to simulate the actual use of the system in the normal environment

of ECU. Acceptance of the installation is also conditional upon the work being inspected by Edith Cowan University's security consultants (ie. the designers) and completed to their satisfaction.



4.10 Colour Coding – Plant and Equipment

NOTE: Where colours are not specified for particular items of plant, the University shall be consulted before colours are nominated. All plant and equipment shall be painted to the following colour scheme. 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.

NOTE: Colours are selected from
- AS 2700 - Colours for General Purposes
- AS 1345 - The identification of piping Conduits and Ducts.

4.10.1 Pumps

Domestic Cold Water Pumps		***AS 2700 Colour***
Motor	Orange	X15
Pump	Canary	Y11
Coupling Guard	Golden Yellow	Y14 with black stripes
Base		Black

Domestic Hot Water Pumps		
Motor	Orange	X15
Pump	Pumpkin	X12
Coupling Guard	Golden Yellow	Y14 with black stripes
Base	Black	

Fire Service Pumps		
Motor	Orange	X15
Pump	Signal Red	R13
Coupling Guard	Golden Yellow	Y14 with black stripes
Base	Black	

Chilled Water Pumps		
Motor	Orange	X15
Pump	Canary	Y11
Coupling Guard	Golden Yellow	Y14 with black stripes
Base	Black	

Condenser Water Pumps		
Motor	Orange	X15
Pumps	Pumpkin	X12
Coupling Guard	Golden Yellow	Y14 with black stripes

Base	Black	

4.10.2 Air-Handling Plants

Fan Coil Units

& Conditioners:	Deep Cream	Y25
External Motors	Orange	X15
Belt Guards	Golden Yellow	Y14 with black stripes

Toilet Exhaust Systems

Fans	Pumpkin	X12
Motors	Orange	X15
Coupling Guards	Golden Yellow	Y14 with black stripes
Base	Black	

Supply Air Systems

Fans	Straw	Y24
Motors	Orange	X15
Belt Guard	Golden Yellow	Y14 with black stripes
Base	Black	

Fume Exhaust Systems

Supply Air Fans	Pumpkin	X12
Exhaust Fans	Pumpkin	X12
Motors	Orange	X15
Belt Guards	Golden Yellow	Y14 with black stripes

Miscellaneous Exhausts (other than those above)

Fans	Pumpkin	X12
Motors	Orange	X15
Guards	Golden Yellow	Y14 with black stripes
Base	Black	

4.10.3 Air-Compressors and Vacuum Pumps

Air Compressors:

Motors	Sapphire	B14
Compressor	Aqua	B25
After Cooler	Sapphire	B14
Air Receiver	Sapphire	B14
Guards	Grey Blue	B43
Belt Guards	Golden Yellow	Y14 with black stripes
Base	Black	

Vacuum Pumps:

Motors	Sapphire	B14
Vacuum Pump Aqua		B25
Silencer	Sapphire	B14
Vacuum Tank	Sapphire	B14
Guards	Grey Blue	B43
Belt Guards	Golden Yellow	Y14 with black stripes
Base	Black	

4.10.4 Refrigeration Systems

Centrifugal Chillers:

Compressor/ Motor	Orange	X15
Condenser Vessel	Pumpkin	X12
Chiller Vessel	Canary	Y11
Oil Pump Vessel	Orange	X15
Frame	Black	

Pipework Tubing	Raffia	X31

Condensing Units (DX system)

	Lettuce	G33

4.10.5 Electrical

Main Electrical Switch Board	Orange	X15
Sub-Boards Switchboard	Orange	X15
Mechanical Service Switchboard	Orange	X15
Power Load Centres	Orange	X15
Cable Trays, Ladders, Ducts & Conduits	Orange	X15
Fire Alarm Cable Trays, Ducts & Conduits	Signal Red	R13

4.10.6 Pipework, Valves and Fittings (not Outlets)

Service	**Pipe**		**Valves**	**Valve Tops**	
Domestic Cold Water	Mid Blue	B15	Signal Red	R13	Black
Domestic Hot Water	Jade	G21	Signal Red	R13	Black
Chilled Water			Signal Red	R13	Black
Fire Services Water Mains	Signal Red	R13	Signal Red	R13	Black
Condenser Water			Signal Red	R13	Black
Drains	Black	-	-	-	
Gas LP	Raffia	X31	Pumpkin	X12	Black
Compressed Air	Aqua	B25	Ultramarine	B21	Black
Vacuum	Ultramarine	B21	Black		
Oxygen	Raffia	X31	Pumpkin	X12	Black
Acetylene	Pumpkin	X12	Black		
Other Gases	To Approval				
Demineralised Water	Palm Green	G44	Signal Red	R13	Black
Internal Downpipes & Stormwater			Mid Grey	N52	- -
Natural Gas	Canary	Y11			

4.10.7 Supports

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