

THE UNIVERSITY OF WESTERN AUSTRALIA

PROJECT MANAGEMENT AND DESIGN GUIDELINES

HANDBOOK

SECTION C. ELECTRICAL SERVICES GUIDELINES

CONTENTS

1 0 INTRODUCTION

- 1.1 Purpose of the handbook
- 1.2 Facilities Management to nominate power supply point
- 1.3 Contract documents to be submitted to Facilities Management
- 1.4 Enquiries

2.0 DRAWINGS AND SPECIFICATIONS

- 2.1 List of drawings required
- 2.2 Submission of "as-constructed" information on project completion
- 2.3 "As-constructed" drawings
- 2.4 Energy conservation

3.0 ELECTRICITY SUPPLY

- 3.1 Approval of installation
- 3.2 Power supply on main campus
- 3.3 Interruption of power supply
- 3.4 Temporary supply for building operations
 - 3.4.1 Connection of power to building site
 - 3.4.2 Approval of installations for building site
 - 3.4.3 Charges for electricity consumed on building site
- 3.5 Power factor
 - 3.5.1 Main incoming supply
 - 3.5.2 Mechanical services
- 3.6 Quality of power supply

4.0 ELECTRICAL SUB-STATIONS

- 4.1 Inclusion of sub-stations in new buildings
- 4.2 Use of sub-stations
- 4.3 Access permit for high voltage work
- 4.4 Ventilation of high voltage transformers
- 4.5 High voltage transformers
- 4.6 High voltage switchgear
- 4.7 Approval of sub-stations
- 4.8 Hydraulic Services
- 4.9 Cables

5.0 MAIN CABLES

- 5.1 Main cable connection to buildings
- 5.2 Allowance for future cable access to switchboard
- 5.3 Size of access conduits
- 5.4 Underground Services

6.0 MAIN SWITCHROOMS

- 6.1 Responsibility for switchroom design
- 6.2 Switchroom - general
- 6.3 Size
- 6.4 Position
- 6.5 Locks and keys
- 6.6 Light and power
- 6.7 Cable access
- 6.8 Cable trenches
- 6.9 Protection
- 6.10 Labelling

7.0 MAIN SWITCHBOARD

- 7.1 General comments
- 7.2 Metalwork
- 7.3 kWh meters
 - 7.3.1 Master meter - type
 - 7.3.2 Sub-meter - type
 - 7.3.3 Provision for expansion of switchboard - effect on metering
 - 7.3.4 Transformer types
 - 7.3.5 Calibration of electro mechanical kWh meter
 - 7.3.6 Standard method of connection of transformers
- 7.4 Metering test link
- 7.5 Busbars
- 7.6 Distribution pillars
- 7.7 Essential services
- 7.8 Earthing
- 7.9 Main switch
- 7.10 Switchboard wiring
- 7.11 Finish
- 7.12 Labels
- 7.13 Fuses
- 7.14 Inspection and testing

8.0 EARTHING

- 8.1 Electrical earth
- 8.2 Technical earth

9.0 SUB-MAINS

10.0 SUB-DISTRIBUTION SWITCHBOARDS

- 10.1 Sub-switchboards to serve defined building areas
- 10.2 Size of sub-switchboard
- 10.3 Master isolating switch
- 10.4 Distribution boards in series
- 10.5 Numbering of sub-distribution switchboard
- 10.6 Installation of circuit schedule
- 10.7 Externally-mounted switchboards

11.0 CONDUIT, DUCTING AND WIRING

- 11.1 Flexible designs
- 11.2 Conduit – installation
- 11.3 Conduit colours
- 11.4 Wiring types
- 11.5 TPS cables

12.0 LIGHTING

- 12.1 Types of lighting
- 12.2 Lighting levels
- 12.3 Emergency and exit lighting
- 12.4 Fluorescent lighting
- 12.5 Components
 - 12.5.1 Ballasts
 - 12.5.2 Capacitors
 - 12.5.3 Fuses
 - 12.5.4 Wiring
 - 12.5.5 Lampholders
 - 12.5.6 Lamps
 - 12.5.7 Maintenance
- 12.6 External lighting
 - 12.6.1 Lighting of access or escape-ways
 - 12.6.2 Campus security lighting
 - 12.6.3 Switching on security lighting
 - 12.6.4 Lighting around buildings
 - 12.6.5 Position of security lighting
- 12.7 Light switches
- 12.8 Lighting requirements for dark rooms

13.0 POWER OUTLET

- 13.1 Distribution of power outlets
- 13.2 Standard RCD power outlet
 - 13.2.1 (a) 240 Volt 10 amp socket outlet
 - (b) 240 Volt 10A plug top
 - (c) Moulded cord on plug top
 - 13.2.2 (a) 240 Volt 15 amp heavy
 - (b) 240 Volt 15 amp heavy-duty plug top
 - 13.2.3 (a) 240 Volt stabilised voltage outlet
 - (b) 240 Volt surge-protected outlet
 - 13.2.4 Isolated supply fed from its own transformer
 - 13.2.5 240 volt standard power outlet supplied from stand-by generator in case of mains failure
 - 13.2.6 (a) 240 volt outlet for low-current use equipment
 - (b) 240 volt plug top for low-current use equipment
 - 13.2.7 Outlet for 240 volt equipment with removable cord
 - 13.2.8 Outlet for 240 volt equipment with -
 - removable cord made up in University workshop
 - equipment with removable cords delivered with unsatisfactory equipment plugs where power cord is not an integral part of the equipment

- 13.2.9 (a) 110 Volt 10 amp socket outlet
- (b) 110 Volt 10 amp plug top
- (c) Corresponding male pin equipment socket is Clipsal 435/110
- 13.2.10 D.C. outlet
- 13.2.11 250 Volt 15-30 amp heavy-duty outlet
- 13.2.12 500 Volt 3 phase 20 and 30 amp outlet
- 13.2.13 External weatherproof outlet
- 13.3 Circuit arrangements for power outlet

14.0 MARKING OF LIGHT SWITCHES AND POWER OUTLETS

- 14.1 All light switches and power outlets to be identified
- 14.2 Standard method of marking
- 14.3 Marking code

15.0 ELECTRIC HEATING

- 15.1 Space heating
- 15.2 Water heating

16.0 ELECTRIC MOTORS AND MOTOR CONTROL EQUIPMENT

17.0 TOILET VENTILATION SYSTEMS

- 17.1 Lighting and Ventilation
- 17.2 Toilet hand dryers

18.0 CLOCK SYSTEMS

- 18.1 Master clock
- 18.2 Connections
- 18.3 Indicating clocks
- 18.4 Positioning of indicating clocks
- 18.5 Maintenance
- 18.6 Installation
- 18.7 Connection of telephone line to clock relay
- 18.8 Battery-operated clocks
- 18.9 Telchron satellite-operated clocks

19.0 MECHANICAL PLANT ROOM (Refurbished and new)

- 19.1 Electrical Power Point
- 19.2 Electric Wiring
- 19.3 Light

APPENDICES

- C1** Communications and Audio-Visual Installations
- C2** Lift Installations
- C3** Fire and Emergency Services Installations
- C4** Automatic Doors

SECTION C: ELECTRICAL SERVICES GUIDELINES

1.0 INTRODUCTION

1.1 The purpose of the handbook

This handbook has been prepared for the guidance of commissioned architects and consultants of the University. It brings together the standard or preferred details and installation methods developed for electrical installations at The University of Western Australia. All aspects of electrical installation are included except those dealing with audio-visual teaching aids which are published separately.

1.2 Facilities Management to nominate power supply point

Where an architect or engineering consultant is detailing electrical work University Facilities Management should be kept informed of progress. Any queries arising from this document should be referred to Facilities Management which will nominate how and from where power will be supplied to any particular project.

1.3 Contract documents to be submitted to Office of Facilities Management

Contract documents must be prepared in sufficient time for Facilities Management staff to examine and comment on them before tenders are called. (Allow 2 weeks minimum.)

1.4 Enquiries

Enquiries in respect of interpretation, amendment or correction of electrical section should be directed to:

Graham Wright
Senior Technical Officer - Electrical
Tel: 6488 20316
Fax: 6488 1038
Email: gwright@admin.uwa.edu.au

2.0 DRAWINGS AND SPECIFICATIONS

2.1 List of drawings required

Accurate record drawings are essential for the proper functioning of Facilities Management. For electrical installations these drawings should consist of :

- (a) a block plan showing all access cables to a building, including pipes, pits and conduits. Spare conduits should be clearly shown.
- (b) building layout plans for the whole electrical installation. Separate plans are usually required for :
 - power and communication
 - lighting and fire detection
 - special services

- (c) building mains and sub-mains line diagram showing all protection and metering devices.
- (d) detailed drawings of main and sub-distribution boards.
- (e) site plans indicating sub-stations and cable routes only.
- (f) any other special drawing of the electrical installation.

2.2 **Submission of "as-constructed" information on project completion**

Within four weeks of Practical Completion provide all information pertaining to the completed project to the Project Manager.

Consultants are to allow for the provision of these under the scope of their fee agreements. Final payment of fees will not be authorised until all the information has been received.

The information may be prepared by subcontractors, but it is the responsibility of the consultant to deliver it to the University and guarantee its reliability.

2.3 **As-constructed drawings**

Documents include: Drawings-Specifications - Operational/Maintenance Manuals.

Consultants must provide accurate drawings of the completed project. These are designated "As-constructed" drawings in CAD format. The OFM Drawing Office being a CAD based FM system require all graphical data to be correctly positioned and orientated in relation to the site plans. The electronic data shall be pictorially and dimensionally accurate. Not to scale drawing are unacceptable.

Drawing Standards

All plans are to be provided with North up the page and drawn at a scale of 1:100 (actual CAD scale) including the site plan. Unless building plans are drawn to represent their site location angle, all plans are to be drawn normal to drawing sheet axes. Layers must be used to clearly identify elements within the drawings with like elements on the same layer to allow subsequent segregation of required data. Differing linestyles are to be used to designate services. Continuous lines with text notes added to designate services are an acceptable alternative. Where symbol fonts are used to designate graphical items, the font libraries are to be included with the supplied data.

File Reference Numbers

OFM Drawing Office uses an electronic drawing register that can be searched using various fields. The drawing/data is then retrieved by reference to a '**Registered Drawing Number**'.

Drawings provided by outside consultants are to have an OFM Drawing Office '**Registered Drawing Number**' attached prior to *As Constructed* issue to UWA.

The format of the number will be: **123A123**

123- 3 digit UWA building asset number

A - discipline reference ..A - Architectural M - Mechanical etc.

123 - 3 digit Drawing number allocated by OFM.

A group of numbers for each discipline (Architectural - Mechanical etc.) is to be obtained from the OFM Drawing Office. 9380 1866.

Required Data Format

Drawings are to be supplied in **MicroGDS** or **AutoCAD** format. Any specific line - character style files and pen tables used to plot files are to be included. A text file is to be included that references Registered Drawing number to file title.

One bound copy of all Specifications - Schedules - Operational manual are to be supplied.

They are also required in electronic format on CD.

These files are to be on a separate CD from any CAD data.

The format of the text files to be either text or pdf.

Data Supply Process

Refer to flow chart (Attachment 5) for additional explanation.

Architects/Consultants/Contractors are to supply to OFM Project Manager: -

2 paper copies of all final drawings and ONE unbound copy of specifications and manuals for "As Constructed Approval".

The documentation will be checked by OFM. Any discrepancies will be referred back for correction and the approval submission repeated.

The Project Manager will give written confirmation of approval.

Once approval has been given the Architect - Consultant - Contractor will supply electronic and printed data as noted above.

All data must match previously approved prints.

The data will be verified by OFM and any discrepancies referred back to the Architect/Consultant. To conserve disk space files/folders may be compressed using "WinZip".

Any queries about the above should be directed to the OFM Drawing Office 9380 1866.

2.4 Energy conservation

In line with UWA General Environmental Policy on energy management, and in the spirit of the Commonwealth Greenhouse Challenge, energy conservation must be considered in all University activities, projects and systems.

All consultants/contractors involved in University projects must be cognisant of, and plan for energy-efficient equipment and systems. Reduction in greenhouse emissions will be considered equal in importance to energy cost reduction.

Consultants must be able to show that equipment and systems have viable energy-efficient capabilities even though original capital costs may be greater than considered alternatives. In most cases a simple payback calculation will provide savings estimations over a period of time.

For cash flow consideration and larger projects the Net Present Value (NPV) method which takes into account the time value of money should be used.

The checklist below provides some guidance in identifying the potential benefits for an energy project.

- lower energy consumption, fuel and water costs
- lower labour requirements, reduced overtime
- reduced maintenance
- higher product quality from fewer rejects and reduced re-work
- environmental benefits from less greenhouse emissions and heat discharge
- improved processes for plant bottlenecks and extra market demand
- integration with existing safety and health systems

Below are some general guidelines to be considered in consultation with the appropriate Senior Technical Officers or nominated Project Officers/Managers.

(Relevant manuals will outline the energy reduction specifics for system application and equipment installation.)

- a) Electrical Services
 - energy-efficient services to standard building electrical services
 - lighting codes adhered to (AS 1680)
 - systems compatible with existing systems
 - equipment selected on maintenance of Power Factor (PF)
 - knowledge of high efficiency lamps, sensors, etc
- b) Mechanical Services
 - knowledge of DDC system
 - equipment selected on maintenance of Power Factor (PF)
 - high efficiency motors
 - systems compatible with existing systems
 - motors selected on correct load needs
 - a comprehensive maintenance plan
 - awareness of coefficient of performance in HVAC systems

3.0 ELECTRICITY SUPPLY

3.1 Approval of installation

The University purchases power in bulk from Western Power and provides for its distribution around the campus. All electrical sub-contractors must place the normal notice with the University and have their work approved by the University before power is connected to new buildings.

3.2 Power supply on main campus

The power supply on the main campus of the University is 415/240 volts 50HZ. The campus is the area bounded by Gordon Street, Hampden

Road, Clifton Street, Stirling Highway, Mounts Bay Road in the north, Fairway, Myers Street and Parkway in the west and Hackett Drive on the east and south.

Off-campus power supply is generally the same as the Western Power grid system but may be high or medium voltage depending on the location.

3.3 Interruption of power supply

Electrical supply shall not be disconnected without prior reference to Facilities Management. Normally a minimum of 48 hours notice is required before a power supply interruption can be organised.

3.4 Temporary supply for building operations

The temporary supply of electricity to a building site on the campus is the responsibility of the building contractor.

3.4.1 Connection of power to building site

The University will nominate the point at and the method by which electricity supply can be obtained for building purposes. At this point a weatherproof meter box will be provided by the builder. It will be the builder's responsibility within the site area to construct a power line or install underground cables to the points at which power is to be used.

3.4.2 Approval of installations for building site

The builder's electrician shall place a photocopy of the completion notice with the University. After the installation has been inspected and approved, a meter will be provided and final connections made.

3.4.3 Charges for electricity consumed on building site

Power consumed for building purposes will be metered and the building contractor charged.

All electrical work must comply with Worksafe requirements.

3.5 Power factor

3.5.1 Main incoming supply

At the point of attachment to any new building, the Power Factor shall not be less than 0.85 during ON PEAK hours at normal running load. (ON PEAK hours are 08:00hrs until 22:00hrs weekdays). If a Power Factor of less than 0.85 is present, then Automatic Power Factor Correction equipment shall be installed at no cost to Facilities Management.

3.5.2 Mechanical services

The incoming supply at the main mechanical services switchboard shall have a Power Factor of not less than 0.85 during ON PEAK hours at normal running load. (ON PEAK hours are 08:00hrs until 22:00hrs weekdays). If a Power Factor of less than 0.85 is present, then Automatic Power Factor Correction equipment shall be installed at no cost to Facilities Management.

3.6 Quality of power supply

The currents across the three phase shall be balanced within 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 occupation and after, to verify it conforms. If the source of the harmonics is not conforming and generated by the tenant's equipment, then the University of Western Australia shall cover the costs of installing the required filtration. If the harmonics are from building services such as a variable speed drive on the mechanical services, then the project shall cover the cost for filtration.

The results of the Power Quality Audits are to be incorporated into the project Electrical Maintenance Manual.

4.0 ELECTRICAL SUB-STATIONS

4.1 Inclusion of sub-stations in new buildings

Sub-stations are located to serve a particular area of the campus. If a sub-station is required in a new building complex the fact will be incorporated in the brief. The commissioned architect will be required to consult with Facilities Management staff who will make available critical dimensions, suggested layouts and details of facilities required.

4.2 Use of sub-stations

Sub-stations are used to house cast-resin transformers, high (6300 volt) and low (415 volt) switchgear, cables and ancillary electrical equipment. They are an integral part of the University power distribution network. The network has the capability of being upgraded to 11,000 volts in the future.

4.3 Access permit for high voltage work

High voltage work or switching shall not be carried out without the prior knowledge of the nominated authorised electrical officers in Facilities Management. These officers will issue an access permit.

Note: Contractors nominated switching officers must have completed the Western Power High Voltage Approved Switching Course and must submit switching programmes for approval.

4.4 Ventilation of high voltage transformers

High voltage transformers which are installed shall have adequate ventilation, which shall be monitored by the associated Building Management System.

4.5 High voltage transformers

High voltage transformers shall be the air-cooled cast-resin type, thereby reducing maintenance and installation costs. Primary voltages to be 11/6.3KV dual tap.

4.6 High voltage switchgear

High voltage switchgear is to be rated at 11KV and manufactured by ABB SAFEPLUS Type CTC-F equipment.

4.7 Approval of sub-stations

Sub-stations shall conform to the Office of Energy WA Electrical Requirements and be approved by Western Power. Approvals shall be submitted by a Chartered Engineer.

4.8 Hydraulic Services

Only electrical services are permitted to be installed in Sub-Stations/Switchrooms and Distribution Boards. Consultants and Architects shall ensure that no other services such as Water, Gas etc. pipework is in these areas.

4.9 Cables

All network cables H.V. and L.V. shall be termite protected.

5.0 MAIN CABLES

5.1 Main cable connection to buildings

Main cable connections to a building will normally be carried out on the direction of Facilities Management staff and will be financed from the project budget. The cost would normally be included in the building contract or financed from other building funds.

5.2 Allowance for future cable access to switchboard

Adequate allowance is to be made for future cable access into main switchboards. Main switchrooms may be used as distribution centres for the University medium voltage power distribution network, in which case access will be provided for cables from 2 sub-stations.

The point of and method of connection of the mains cables to the installations, normally at the mains switchboard, will be the subject of discussions between the electrical consultants and Facilities Management.

5.3 Size of access conduits

Consultants should ensure that the size and type of access conduits, their positions and the size and position of cable trenches are such as will permit the installation of heavy mains cables. Normally access conduits should be of minimum 100mm diameter - larger buildings 150mm diameter.

Access conduits must be straight. Bends are not permitted. Cable pits must be of sufficient size to accommodate the turning radius of cables and permit cable jointers to work within them. The minimum turning radius for cables is to be taken as per "Guide to Installation of U.G. Cables ESA of Aust. 1989".

5.4 Underground Services

Buries services shall be compacted to comply with compaction tests achieving a standard penetrometer reading of 8 minimum blows per 300mm and in the presence of our representative.

6.0 MAIN SWITCHROOMS

6.1 Responsibility for switchroom design

As main switchrooms are structurally part of the building they are the commissioned architect's responsibility. Consultants shall adhere to the following guidelines.

6.2 Switchroom - general

For large buildings a separate main switchroom will be required. For smaller buildings a cupboard-type installation may be sufficient.

E6.3 Size

The switchroom must comply with all aspects of the AS3000-2000 wiring rules pertaining to accommodation of main switchboards, safety access to front and rear of switchboards etc. If the building is to be extended in the future the switchroom must be of adequate size to enable the switchboard to expand. Space must be allowed for any ancillary equipment such as clock relays or external lighting controls that may require accommodation.

E6.4 Position

For preference main switchrooms should be accessible to workshop staff without their having to enter the security keying system of the building. This enables staff to enter the switchroom in an emergency without obtaining a building key. Access from ground-level covered-ways is ideal. Access doors must be large enough for the switchboard to be installed or removed in the future. Two fire exits should be allowed wherever possible from main switchrooms.

6.5 Locks and keys

The switchroom door must be locked with a master lock on the University E & M system and keyed alike to the particular building E & M number. Any power distribution frames or cubicles within the switchroom must be separately locked on the ED Master Series. Lock cylinders on the ED master system are supplied by Parker Black Pty Ltd in Osborne Park. Lift motor rooms shall be keyed to the EML System, not the EMA System.

6.6 Light and power

Main switchroom light and power shall be separately supplied from the essential services section of the main switchboard which is on the live side of the building main switch so that power and light is available in the room when the building main switch is off. Fluorescent lights should be positioned so that meters can be clearly read. At least one socket outlet should be provided. The switchroom should be ventilated.

6.7 Cable access

Adequate spare cable access sufficient for the life of the building, both to outside the building and to the building internal distribution must be provided. Direct duct access to building basements or tunnels, central rising shafts and roof spaces must be provided, even if not required in the first instance. Attention to manufacturers' cable bends specifications must be observed. All pipe ducts must be straight. Adequate turning radius must be provided in trenches.

6.8 Cables trenches should be longer or wider or both than switchboards to enable worker access to them when the main switchboard is in place. Top edges of concrete trenches should be protected with 25mm angle set to form a space for the trench covers. Trench covers should be 25mm thick hardwood timber. Steel plate is not an acceptable cover near electrical switchboards unless covered with a suitable insulative matting. All underground trenches are to be tanked to prevent the ingress of ground water. Cable entry ducts shall be sealed after cables have been installed.

6.9 Protection

A CO₂ fire extinguisher should be installed in the switchroom near each entry door. If the building is equipped with a fire alarm system, detector heads must be installed in the switchroom.

6.10 Labelling

- a) The door to the main switchroom shall bear a University standard door nameplate bearing the room number and the name. Additional signage as per AS3000 clause 2.9.8.3 may be required.
- b) In the case of high voltage switchrooms the label shall comply with AS1319- 1994 regulatory signage, "DANGER" symbol in Landscape version with "High Voltage" and 'Authorised Persons Only' message.

7.0 MAIN SWITCHBOARD

7.1 General comments

The main switchboard shall be a metal-enclosed dead-front cubicle. It may have either front or back access as the situation dictates. It shall contain a section for essential services fed from the live side of the main switch even if these are not required in the first instance. Such items as lifts, fire alarms etc which must be supplied from essential services, may be added during the life of a building.

Generally each sub-distribution board in the building would be supplied from a separate switch on the main switchboard. When University buildings are extended, as the occupying department expands, the main switchboard should also be capable of extension.

Main switchboards on the University campus shall be designed for a fault level of 46.5kA and comply with separation Form 3B AS3439.1 - 1993.

The main switchboard should generally not double as a final sub-circuit distribution board.

7.2 Metalwork

A high standard of metalwork is required. The following points concerning the metalwork should be noted.

- a) The thickness of metal used will depend on the size of the board. For large free-standing switchboards the minimum metal size for major components is 2mm thick furniture quality bright steel sheet. Smaller components may be of reduced gauge.
- b) All hinged panels are to be suitably stiffened and fitted with lift-off hinges.
- c) Large lift-off panels are not favoured, but if unavoidable they must be equipped with a means of handling them such as fitted D handles. Such panels must have a means of support, such as studs or a supporting ledge, for use while the fixing screws are being installed.
- d) Escutcheon plates and hinged panels shall be fixed in place with a fixing which can be undone without the use of tools. Dzus Adjustable Panel latches are favoured.
- e) The metal cabinet is to be mounted on a welded channel, steel frame predrilled, to take holding-down bolts.

7.3 kWh Meters

Energy consumed in a University building must be accounted for. To achieve this each main switchboard will have a master electricity meter fitted and where required, sub-meters for mechanised and special services.

7.3.1 Master meter-type

The master meter in major buildings will be a Satec 290-A power meter with RS485 communications card for interface to the campus LAN. This unit can be sourced to the switchboard manufacturer from Protection and Monitoring Systems PO Box 101, Kurrikurri NSW 2327 : 02 4936 4900, Fax : 02 4936 4800.

7.3.2 Sub-meter : type

Sub-meters will be Email digital register and depending on load may be secondary-rated CT type or for small loadings direct-connected either 10-60 amp or 30-125 amp rating. Din rail mounted modular systems can be offered for sub-metering. All sub-meters shall have a pulse voltage -free contact output.

7.3.3 Provision for expansion of switchboard – effect on metering

Although a main switchboard may be constructed to accommodate future building expansion, metering must be installed to account for the present maximum demand conditions to achieve maximum accuracy.

7.3.4 Transformer types

Current transformers for all kWh recording will be class 0.5 accuracy and may be selected from ratios of either Type "S" 200/5 extended range, 150/300/600-5 or 400/800/1200-5 type instruments.

7.3.5 Calibration of electro-mechanical kWh meter

An electro-mechanical kWh meter must be checked and calibrated by the Western Power Meter Branch before installation. The fees for this test should be incorporated into the contract documents.

7.3.6 Standard method of connection of transformers

For the standard method of connection of current transformers and meters refer to Standard Drawing 206/E/24.

7.4 Metering test link

A GEC metering strip shall also be incorporated behind the front of the switchboard with the meter wiring passing through it for simple attachment of recording instruments. The GEC test Terminal Blocks will be supplied to the switchboard manufacturer from University stocks.

Connection of the test link shall be in accordance with University Standard Drawing 206/E/24.

The end, face or top of the switchboard cabinet shall be fitted with a swing-open cover approximately 100 mm square situated close to the test link to allow access for cables between recording instruments and test links.

E7.5 Busbars shall be of adequate dimensions to accommodate the power to be carried by the switchboard throughout the anticipated life of the building. Larger bars installed in the first instance may save a costly rebuild of the switchboard if the building is ever extended.

Care should be taken to ensure that the busbars are rigidly supported. All bolts on busbar systems should be correctly tightened and checked by the Contractor. A University staff member will check all busbar bolts and connections before the switchboard is energised. Loose bolts may be cause for rejecting the switchboard. All bolts must be high tensile strength.

Busbars enclosed in a designated busbar zone which cannot be entered without de-energising the board shall remain bare copper. In such a busbar zone the bars are to be phase-colour identified once in each isolated section of the cabinet.

Busbars in open sections of a board such as the connections to the rear terminals of switches or CFS units shall be insulated with phase-coloured insulation either by taping or PVC-dipping the bars. If PVC-dipping is used, busbar joints are to be left uninsulated until after the board has been approved when they shall be taped.

Busbars shall not alter in CSA along the entire length on installation.

7.6 Distribution pillars

Where Facilities Management requires a distribution pillar for use on the campus low-voltage distribution system to be incorporated as part of the main switchboard, it shall be constructed in accordance with University service detail drawing No. 206/E/51/1-4. "ABB" 3 pole tier fuse switch disconnect type SLBM is the preferred manufacturer.

This section of the switchboard shall be separately locked with a Lockwood night latch and keyed alike to the University sub-station master key, Key No. ED. The lock cylinder can be supplied by Key West of Inglewood.

Sufficient space must be allowed in front of the distribution pillar for the distribution cables to be worked on whilst being terminated.

7.7 Essential services

A section of the main switchboard shall be designated for supplying power to essential services. These services shall be connected to the live side of the main switch.

Essential Services include lifts, fire alarms, security lighting, power and lights within the main switchrooms and any other service which may be declared of an essential nature in an emergency.

Even if such services are not required when the main switchboard is first installed, a section of the switchboard shall be left free for the later addition of such services.

7.8 Earthing

The MEN system of earthing is used throughout the University. The connection between the earth and neutral bars should be at the main switchboard only and in such a fashion that it may easily be removed for testing the earth and clearly labelled MEN link.

Adequate earthing and neutral connections are required on each switchboard. Sufficient connections shall be allowed for the design capacity of the switchboard. All neutral and earth connections shall be identified with the phase and circuit number.

Where bare copper bar is used as neutral or earth bars it shall be predrilled with an adequate number of holes for the board. Each hole must be numbered.

7.9 Main switch

The general rule for the selection of main switches is :

- up to 150 amp supply – manually-operated 150 amp slow break switch
- 150-600 amp supply - moulded case circuit-breaker (electronic)
- over 600 amp supply - air break withdrawable switch with electronic protection

The minimum interrupting rating for the main switch in major buildings shall be 50 kA.

7.10 Switchboard wiring

Switchboard wiring shall be neatly and securely carried out. Channels, ducts or other supports shall be provided in clearly-defined access-ways for sub-main cabling.

The minimum size of switchboard metering instrumentation wiring shall be 4mm² (7/0.85) cable, phase coloured and numbered as shown on the

appropriate University standard drawing. All other control wiring 1mm² (7/0.85).

7.11 Finish

All metal work etc is to be thoroughly cleaned, descaled, derusted with a phosphoric rust remover and given one coat of self-etching rust-inhibiting primer. It should then be filled, rubbed down and painted with a suitable undercoat. Final external finish is to be provided by two coats of gloss enamel paint in a colour similar to Australian Standard 2700 Colour No Y44 "Sand". Internal finish colour shall be gloss white.

If a distribution cabinet is fitted the doors are to be labelled with the following legend in 50mm high letters, in red "DANGER" followed by the words "415 VOLT ELECTRICITY SUPPLY". Alternatively an approved danger notice bearing a similar legend may be accepted.

7.12 Labels

All components on the switchboard shall be clearly labelled with the labels fixed to the face of the switchboard. In addition the rear of all outgoing units shall have an identical label to the front, affixed close to the outgoing cable connections. The main labels shall have 25 mm high letters.

In addition all outgoing combination switch fuse units shall be clearly labelled with similar labels in 5mm high letters. Labels shall be fixed to the switchboard or escutcheon plates with zinc-plated metal thread screws.

7.13 Fuses

Any switchboard, main, sub-distribution or control, to which HRC fuses are fitted, must also contain or have installed adjacent to it, a fixture in which spare fuse cartridges can be stored. Three cartridges for each size of cartridge used on the switchboard should be accommodated in the fixture and supplied with the switchboard.

7.14 Inspection and testing

The University reserves the right to carry out inspections during the course of construction and to undertake tests on the completed switchboard. A statement to this effect is to be included in all specification documents. The following sequence of inspections and tests is to be carried out by University staff :

- a) Approval of switchboard drawings after selection of switchboard manufacturer but prior to commencement of manufacture
- b) One factory inspection when the switchboard is substantially assembled but before painting and finishing has been started
- c) One factory inspection before the finished switchboard leaves the works including ductor, primary and secondary current injection and hi-pot test of all automatic equipment on the switchboard

- d) A thorough on-site inspection of the whole switchboard including all connections to it before the board is energised
- e) During the highest load time-frame of the warranty period a thermal graphic survey shall be carried out and a written report shall be submitted to Facilities Management

8.0 EARTHING

8.1 Electrical earth

University buildings are connected on the multiple-earth neutral system. From the earth bar at the main switchboard an earth cable of a size required by the SAA wiring rules shall be connected to an earth electrode or electrodes driven adjacent to the building and to the incoming water main.

Because of the type of water piping now being installed the water main must be considered an unreliable earth. Therefore earthing electrodes shall be driven deep and should normally be of the steel core copper-clad type capable of being joined in lengths. Sufficient electrodes should be driven to satisfy the Wiring Rules requirement that the –

- Resistance to Earth < 4ohms

(Typically 15m of rods required to achieve this on main campus)

Certification of Earth Resistance is to be supplied to Facilities Management prior to the installation being made "live".

The earthing cable shall be clamped to the earth electrode by an approved clamp. This shall be sufficiently below finished ground-level as to remain undisturbed. The head of the earthing electrode and clamp shall be covered with a galvanised iron valve box with a lid. The lid shall have securely attached to it a brass plate engraved "MAIN EARTH".

Certification of the resistance of the installed earth shall be provided by the contractor to Facilities Management.

All metallic pipe in the building shall be equipotential bonded to the electrical earth.

8.2 Technical earth

Close-circuit TV installations require a separate earthing system usually referred to as a "Technical Earth".

These systems shall be installed quite separately from the electrical earthing system of the building. All earthing conductors shall be green/yellow PVC-insulated. All earthing conductors in the Technical Earthing system shall be installed in screwed steel conduit or galvanised water pipe when used underground. The minimum size of main technical earthing conductor is 120mm².

The earthing conductor must be run continuously into and out of each connection. Care must be taken to ensure there are no loops in the system. The Technical Earth must have its own earth electrodes similar to, but separated from the electrical earth electrodes. Minimum distance

of separation shall equal the depth of the longest driven rod. Resistance to earth < 4 ohms.

These earth electrodes are also connected to the earth bar of the main switchboard. This earth cable shall be clearly labelled "Technical Earth".

The lid of the valve box covering the technical earth electrode shall also be labelled with an engraved brass plate "Technical Earth".

9.0 SUB-MAINS

Sub-mains cables between protection switches or combination fused switches on the main switchboard and sub-distribution switchboards shall be adequately sized to cater for internal load growth in the area they serve.

The cables shall be installed in tunnels, rising shafts, roof spaces, etc where they are accessible over their whole length.

Such cable routes should be clearly defined so that additional cables can be added.

Earth sheath return cabling is not permitted in University buildings.

10.0 SUB-DISTRIBUTION SWITCHBOARDS

10.1 Sub-switchboards to serve defined building areas

Sub-switchboards shall be installed to serve clearly-defined building areas or functions. It may be necessary for each special purpose laboratory to have its own switchboard.

Particular care should be taken in siting sub-switchboards. They should generally be accessible only from public areas such as passageways and foyers. It should not be necessary for service personnel to enter teaching areas (class rooms or lecture theatres), laboratories (teaching or research) or private offices in order to work on sub-switchboards. In situations where the switchboard is in an area open to the general public it must have a lockable door or be in a lockable cupboard. Keys must comply with the University EM system. The lock cylinder can be supplied by Key West of Inglewood.

10.2 Size of sub-switchboard

Each sub-switchboard must be generously sized. The number of power circuits continually grow as departments purchase additional equipment. New sub-switchboards therefore should have at least 50% additional spare capacity when installed.

10.3 Master isolating switch

Each sub-switchboard shall have a master isolating switch capable of handling the total anticipated load. The main isolating switch shall not interlock with the escutcheon of the board. The Surge Suppression shall be installed to protect the equipment connected to the board. Surge Suppression shall be installed with the indicators visible through the escutcheon or neon indicators showing suppression healthy.

A preference is stated for miniature circuit breakers to protect final sub-circuits. These should be Westinghouse Quick-Lag type or similar approved which can be installed mounted in one of the standard metal switchboards produced by this firm.

Sub-switchboards are to be supplied from the main switchboard.

10.4 Distribution boards in series

The practice of supplying a series of distribution boards, one after the other, is discouraged. This practice should only occur in specific limited situations such as a small specialist laboratory switchboard supplied from a larger distribution board. If permitted to happen this should be limited to 1DB in series between a final DB and the main switchboard. In such a situation an "Origin of Supply Label" must be fitted to the final distribution board.

10.5 Numbering of sub-distribution switchboard

Each sub-distribution switchboard should be clearly numbered. The numbering system to be applied shall be as follows :

- a) All distribution boards on any one level, supplied with power directly from the main switchboard, are to be consecutively numbered, the switchboard number following a decimal point after the level designation, viz. B.1, B.2, G.1, G.2, 1.1, 1.2 etc.
- b) Where a building has a separated wing or a number of wings, a wing, rather than a level designation may be used, viz A1, A2 or LT.1, LT.2 etc.
- c) Where a sub-distribution board is supplied with power from another sub-distribution board it shall bear the originating switchboard's designation followed by its own identifying numeral, viz G.1.1 or 1.2.1. By this means the number of the switchboard will describe the origin of supply. This rule will be used even if a sub-distribution board on one level supplies power to a board on another level.

Both the phase and circuit numbers of each circuit breaker should be clearly shown on the sub-board. The numbering system required is Red 1, White 1, Blue 1, Red 2, White 2, Blue 2 etc not consecutive numbers. This system should be numbered consecutively on any one floor level irrespective of the number of distribution boards on the floor.

This can best be achieved by coloured indicating buttons (IPA markers) mounted adjacent to each circuit breaker.

10.6 Installation of circuit schedule

A clear, legible, typewritten circuit schedule on stiff white A4-size cardboard shall be installed in a metal holder either adjacent to or attached to the inside of the door of each sub-switchboard. In a new building the room numbers and designations should be checked as these may change during the course of construction.

10.7 Externally-mounted switchboards

Where switchboards are mounted external to buildings and subject to weather conditions, the outer case shall be fabricated from 3mm gauge marine aluminium with a sanded finish. The design of this item should be discussed with Facilities Management.

11.0 CONDUIT, DUCTING AND WIRING

11.1 Flexible designs

As a result of staff changes and work requirements in University buildings the numbers and positions of outlets are frequently changed.

Consideration should therefore be given to flexible forms of installation. Passages could utilise a central distribution duct while in laboratories surface conduiting, ducting under benches or back of bench service rails are useful.

Skirting ducts are usually provided in offices while workshops benefit from either overhead busbar distribution or under floor distribution.

Computer areas are occasionally provided with raised floor distribution. However, they may also be provided with under bench ducting or back of bench service rails.

Where such a system is installed, adequate provision must be made in the way of spare conduits or access to ducts and ceiling spaces to bring additional circuits from the near distribution board to the wiring ducts. In addition it is essential to be able to pass from room to room via the duct system.

Lighting and power circuits will not be permitted in the same conduit.

Phases should be kept apart. No dissimilar phases should terminate in the same outlet box unless to a 3-phase switch plug outlet or appliance.

11.2 Conduit - installation

The standard installation method preferred in the University is PVC insulated cables installed in Class B heavy-duty PVC conduit. PVC conduit must be used in areas where corrosive gases may be present. Where PVC conduits are installed in service areas or accessible roof spaces they should be neatly racked and fixed to walls or structural members. They should not be installed without further protection in areas where they can be damaged by traffic. Conduits should be so installed that they do not obstruct access to roof or similar spaces.

However PVC conduit must not be used where exposed to excessive temperatures, where exposed to direct sunlight i.e. in glasshouses or in the Physics building or any other area where radio shielding of the power cables is necessary.

Where PVC conduit is not used, heavy-gauge screwed steel conduit is to be used.

Conduits should have a minimum size of 20mm. A maximum of 2 circuits only will be allowed in conduits on this size.

Conduits should not be installed through the walls of cool or cold rooms. Connections to power and light and refrigeration equipment should be by some form of self-contained cable - either MIMS or Circular TPS.

11.3 Conduit colours

Orange-coloured conduit and fittings should be used underground and where exposed in plant and switchrooms, service ducts and roof spaces. Grey conduit should be used where the conduits are exposed in occupied areas. Fittings should match conduits.

11.4 Wiring types

Wiring enclosed in conduit shall be new and delivered to the site in unbroken reels. It is to be 250 volt grade with minimum V75 insulation. Single strand cable is not to be used.

Minimum sizes are :

- a) Lighting circuits - 1.5 mm² stranded 7/0.5 PVC-insulated and 2.5mm² stranded 7/0.67 green/yellow PVC-covered earth wire.
- b) Power circuits - 2.5mm² stranded 7/0.67 PVC-insulated and 2.5mm² stranded 7/0.67 green/yellow insulated earth wire.

Colour coding is to be in accordance with SAA wiring rules and with the following:

- a) Final sub circuits - Red active, Black neutral, White switch wire.
- b) 3-Phase circuits and sub-main - Phase colours of Red, White, Blue, Black neutral, Green/Yellow earth.

Where required, mineral-insulated copper-covered cable, installed strictly in accordance with the manufacturer's recommendations, may also be used.

11.5 TPS cables may be used without conduit in the following situations if approval is obtained from Facilities Management :

- a) In accessible roof spaces where the cables are securely attached to structural members or cable trays or are totally enclosed in cable ducts. Cables must not be installed in position where they obstruct or impede free movement in the roof space.
- b) In plant rooms, service ducts or tunnels where the cables are securely mounted throughout their length on a custom-made cable tray or trough.
- c) As droppers in building cavities. However this would not normally be permitted in new buildings.

TPS cables may not be plastered into walls or cast in concrete without conduit or similar protection. Nor may they be surface-mounted in an exposed position in public or occupied areas.

Single-stranded cable is not permitted in any installation.

12.0 LIGHTING

12.1 Types of lighting

Incandescent lighting should only be used for special purposes. If incandescent lights are used they shall be fitted with 260V lamps. Energy-saver fluorescents should be considered ahead of incandescent. Refer to the Senior Technical Officer, Electrical.

Area lighting will generally be with fluorescent lights. It is most important that the type of fluorescent fitting selected should allow for easy repairs and maintenance.

Bare fluorescent tubes are adequate in places where glare does not present a problem. If diffusers are essential they must be simple and easily removed or replaced. For large fittings, hinged diffusers are preferred.

12.2 Lighting levels required will be defined during the initial planning stage of the building.

For academic purposes the lighting levels given in the tables in Australian Standard 1680 1/2-current edition entitled "Code of Practice for Interior Lighting and the Visual Environment" shall be taken as minimum standards which must not be reduced. Experience has shown that if the recommended levels are treated as maximum at time of installation, the University is involved in either excessive maintenance costs or the provision of additional lights as the installation ages.

12.3 Emergency and exit lighting is to be provided in all academic buildings as per Code AS2293 and is required in the following locations :

- a) all areas requiring emergency lighting under the Public Health Act
- b) stairs
- c) internal passageways
- d) exits from the building
- e) large lecture rooms, classrooms and laboratories
- f) any windowless internal area where people work

Lights shall be able to be tested from the Local Distribution Board push button and timer as per standard or via a computer controlled system for existing buildings. New projects - Stanilite Nexus computer monitored systems. Emergency lights to be separate from light fittings.

12.4 Fluorescent lighting

Fluorescent fittings shall be selected for their ease of maintenance as well as their light output qualities. With this in view the lighting design should be based on pre-manufactured units, completed samples of which can be inspected during the design stage. Past experience has shown that fittings especially made for a building are seldom cheaper and are usually not as well made or planned for maintenance as standard fittings. In addition such qualities as materials and finish can be inspected at the time of specifying the fittings.

Notwithstanding the above, the specification should cover the delivery to site of a sample fitting for Facilities Management staff to inspect prior to the contractor placing an order.

Light fittings shall be selected with some upward component of light in order to throw some light back on to the ceiling. It has been found that this gives a better light distribution and a lighter, brighter aspect to rooms. This is particularly important in offices and study areas.

All metal, open-louvre fittings are preferred and have been found to give the best long-term performance. Most plastic diffusers and grilles used have deteriorated over a period of years. This has resulted in discolouration and loss of light-transmission characteristics.

The metalwork of the fittings should allow for spacing the components to prevent hot spots developing and for adequate ventilation of the fittings.

When specific brands of fittings are being nominated they should be discussed with Facilities Management staff. Diffuser plastic retaining straps are not acceptable due to their rapid deterioration. Only stainless-steel wire retainers will be approved.

12.5 Components should be rated for 240 volts 50Hz operation.

12.5.1 Ballasts are to comply with AS2643-1991 and AS3168-1991 and AS3168-1983. Their maximum watt loss at the fitting operating temperature and 240 volt supply voltage should be :

5 watts for	20 watt tubes
5 watts for	40 watt tubes
8 watts for	65 watt tubes
12.5 watts for	80 watt tubes

They are to incorporate a separate winding for each lamp and are to be mounted not less than 50 mm from each other.

All ballasts are to be fitted with quick connect terminals.

Noisy ballasts will not be tolerated and specifications must be stringent on this point. Care should be taken in choosing electronic ballasts as they might not be suitable for laboratory or experimental-type buildings due to magnetic noise generation interfering with experiments.

Electronic ballasts are preferred to magnetic ballasts.

12.5.2 Capacitors

All fittings should be equipped with capacitors to correct the power factor to 0.9 lagging. The capacitors shall be in accordance with AS3168-1991 and stamped as such.

12.5.3 Fuses

All fluorescent fittings shall incorporate their own fuse. This fuse shall be a Pierlite PT 505 fuseholder fitted with an F5 fuse.

Starters to be electronic pulse type only - to provide a soft start and flicker-free start

12.5.4 Wiring

Interconnecting wiring within the fitting shall be 250 volt grade high-temperature PVC cable capable of withstanding 85°C continuously and all wiring shall be clearly marked as such.

A separate earth stud firmly bolted to the bottom of the fitting should be provided and fixed in such a way that it should not be necessary to loosen the bolt to attach the earth wire.

All fittings shall be equipped with a fixed terminal block for the termination of the external wiring. Recess fittings shall be installed complete with a length of 3-core PVC insulated and sheathed 24/0.20 flexible cable and a 3 pin plug top. Connection to the building wiring shall be to a 3- pin outlet mounted on a draw in box.

12.5.5 Lampholders shall be firmly fixed in position on brackets to ensure that the holders are maintained in their correct location and plane.

12.5.6 Lamps

All lamps throughout a building shall be of the same make, type and colour. The colour is to be white 16mm diameter T5 4000°K with rendering index of Ra 84 (Triphosphor). "Long Life" tubes shall be lamps of a type guaranteed by the manufacturer for a minimum 13,000 hours life.

12.5.7 Maintenance

Light fittings shall be handed over in an as-new condition and not be used during construction of the building. Any lamps or tubes which do not give their rated life during the maintenance period are to be replaced by the contractor.

12.6 External lighting may be fixed to the building or other structure or mounted on separate posts. The type of external lighting selected is to harmonise with the building decor and conform to the pattern in the general area. Facilities Management is to be consulted on the selection of fittings.

All external lights are to be numbered. Numbers will be allocated by Facilities Management and are to be marked on the fitting or its support by stencilling in 25mm high letters.

12.6.1 Lighting of access or escape ways shall be on at least two circuits as required by the Public Health Department.

12.6.2 Campus security lighting is to operate from dusk until dawn.

12.6.3 Switching on security lighting

Building security lighting shall be switched by a photo-electric device on each building. The photo-electric device is to be positioned in an accessible position and to be fitted with a manual override switch at the associated Distribution Board.

12.6.4 Lighting around buildings should be installed to give clear safe access and exit from buildings. Particular care should be taken to illuminate steps and other changes in level. Lighting should be placed in conjunction with the landscaping plan with reference to future tree and shrub growth.

The building external name or names should be illuminated. It will be necessary for the commissioned architect to clarify with the Manager, Planning and Design section the position and size of this name during the design to enable the best position for the light to be obtained.

12.6.5 Position of security lighting

Security lights shall be positioned to illuminate each entry door of the building, fire escape stairways and the main approach for security staff and cleaners.

All post-top lanterns shall be fused.

12.7 Light switches

The preferred light switches are the Clipsal Series 30 range. They are to be positioned on the latch side of doors and at a height 1,000mm that complies with AS1428.1 - 1993.

In the case of rooms where natural light is available and two or more light fittings are installed, consideration should be given to individually switching the light fittings nearest the source of natural light.

All light switches shall be a minimum of 15A rating and capable of switching on capacitive loads. Clipsal 30 FLM15 light switch operators i.e. buttons or switches shall be retained with fixing screws to prevent the operators being pushed through the switch plate. Two-way switching shall be used along corridors, stairways, etc and in rooms with more than one entrance

Multi-gang switches may be used providing not more than one phase is connected to them. Where adjoining switches on different phases have to be installed they shall be positioned at least 150mm apart.

12.8 Lighting requirements for dark rooms

Photographic dark rooms require special care in their lighting layout.

Where a light trap entry to the dark room is built, this should be equipped with a simple batten holder so that a red or white light may be installed.

The white lights inside the dark room should be switched at the door as for a normal room. This switch should be series-switched with one pole of a two-pole double-throw switch mounted on the forward edge of the work bench at a suitable point remote from the door. The second pole of this switch should be wired to bring on a warning light over the entry to the dark room.

The warning light should glow red and read "Darkroom in Use". A Sedco ND 2 has been satisfactorily used for this purpose.

The action should therefore be that on entering the darkroom the user can switch on the lights at the door. When preparing to work in the dark the lights must be switched off at the bench. This switching off automatically isolates the white lights from the door switch and at the same time brings on the warning light outside.

Dark room safe lights should be either chain-hung from the ceiling or wall-mounted. In either case they are to be a standard photographic dark light capable of taking a standard Wratten photographic filter. The type of Wratten Filter is to be nominated by the darkroom user. Photographic

dark lights should also be switched on the forward edge of the work bench. See Standard Drawing No 206/E/27.

13.0 POWER OUTLET

13.1 Distribution of power outlets

Adequate power outlets are to be provided in all buildings. All plugable power outlets, where practical, shall be RCD-protected. The following is a list of the areas where experience has shown a requirement for power :

- a) **Private offices** - one double outlet for a fan or radiator, plus one double outlet available from the desk position for computing or dictation machines.
- b) **Store rooms** - A double outlet for duplicator or similar machine.
- c) **Open areas under stairs** - these are frequently used for photocopiers, refrigerators, etc. If a photocopier is required a 15 amp outlet is needed.
- d) **Foyers** - outlet for display lighting, displays etc.
- e) **Corridors** - adequate cleaning outlets and outlets adjacent to telephone distribution frames and electrical switchboards. RCD-protected and separated circuitry to offices and laboratory teaching facilities.
- f) **General offices** - at least two double outlets adjacent to each desk for computers and printers etc. Photocopiers require a 15 amp outlet. All socket outlets to be RCD-protected.
- g) **Cleaner's socket outlets** shall be engraved "CLEANERS" if a large quantity is required and labelled if a only a small quantity is required.
- h) **Laboratories** - Emergency isolation of all electrical supplies within a Laboratory shall comply with AS2243.7. The emergency stop button (Clipsal Cat. No. 56PBSI) requires to be fitted with a 180° shroud (40mm Dia. S & S Cat. No. D5/AMRG) to prevent accidental operation. Each contactor's control circuit shall have individual isolation via fuses or removable links. The release of the Emergency Stop Button shall not re-energise the relevant circuit, only the action of a separate manual key- operated reset button (Cutler-Hammer Cat No. T15712/T53P keyed H661). This reset button should be sited so it is accessible to the Laboratory Technician or other authorised person e.g. Facilities Management Workshop staff. Refrigerators and freezers may be hardwired to bypass RCD and/or Emergency Isolation System.
- i) **Neons** - All domestic, industrial, suspended or fixed-socket outlets of single or three-phase shall have Neons fitted to indicate power available, except where outlets are installed in dark rooms.
- j) **Refrigerators** - if required, can be direct connected via a 3 gang plated fitted cable grip, Neon and a 15A switch operator

Heavy-duty (15 amps) outlets should normally be provided for urns, stills, room air-conditioners and photocopiers, or any other known item whose demand exceeds 10 amps.

13.2 Standard RCD power outlet connections

The following requirements apply to electrical supplies except those for air-conditioners or fume extractors.

13.2.1 a) 240 volt 10 amp socket outlet

Any standard brand/make of approved socket outlet to take 3 flat pin plug tops - Colour - White Electric, Brown or Black and inscribed "RCD PROTECTED" in green letters may be selected in consultation with the commissioned architect.

To be wired with:

- Top left pin - brown active wire
- Top right pin - blue neutral wire
- Bottom vertical pin - green/yellow earth wire

Viewed from front

The preferred type of general-purpose outlet is the Clipsal or HPM range.

Power outlets for strip heaters and similar switched semi-permanent installed appliances are to be of the automatic type similar to Clipsal 10 "Plugmatic" or Ring Grip 303.

b) 240 volt 10A plug top

Plug tops with 3 flat pins preferably of the type with unbreakable nylon base, soft transparent PVC top and external cord grip.

i.e.	Clipsal	Cat. No. 439D
	Ring Grip	Cat. No. PTI
	H.P.M. Industries Pty.Ltd.	Cat. No. 100L

Wiring code to conform to socket outlet.

c) Moulded cord on plug top

Wiring code to conform to socket outlet.

13.2.2 a) 240 volt 15 amp heavy-duty socket outlet

Any standard brand make of 15 amp rated socket outlets to take 3 flat pin plug tops including special 15 amp plugs with large earth pin. Colour - "Dove Grey".

Wiring code as for 13.2.1 a).

The preferred type of Heavy Duty Outlet is the Clipsal 15/15N.

b) 240 volt 15 amp heavy-duty plug top

Any standard brand make of rated 15 amp plug tops with 3 flat pins but with the earth made too large to fit a standard 10 amp socket outlet.

Wired as for 13.2.1 b) but with terminals large enough to take a minimum of 30/0.25 tinned copper wire.

i.e.	Clipsal	Cat. No. 439D15
	Ring Grip	Cat. No. PTI/15

13.2.3 240 volt stabilised voltage outlet

As for 13.2.1 a) or 13.2.2 a) Colour "Beige"

13.2.4 Isolated supply fed from its own transformer

Pin arrangements according to the secondary voltage.

Colour of Plate - "Pale Salmon"

13.2.5 240 volt standard power outlet supplied from an emergency stand-by generator in case of mains failure

As for 13.2.1 a) or 13.2.2 a) Colour "Red"

13.2.6 a) 240 volt outlet supplied from lighting fuses for items with low-current use

i.e. desk lamps, microscope lamps, etc.

or

240 volt outlet supplied from power mains for items of equipment with low-current drain whose use it is desired to restrict to a particular point

e.g. some slide or film projectors

Any standard brand make of approved socket outlet with 2 flat pins for active and neutral connections and a round pin earth, in any colour except those prescribed for special purposes.

Wiring code as for 13.2.1 a)

Preferred outlet type Clipsal 15LN or for a permanently-connected appliance such as telephone battery eliminator - Clipsal 10 Series "Plugmatic"

b) 240 volt plug top for low-current use equipment

2 flat pins for active and neutral wires and round pin earth.

Wiring code as for 13.2.1 b)

Preferred plug type Clipsal Cat No 439L

13.2.7 Outlet for 240 volt equipment with removable cord

Cord to be fitted with standard plug top as required in 13.2.1b), 13.2.2b) or 13.2.5b) above.

Plugs on equipment end of cord may remain as supplied providing they are 3-pin female plugs with shrouded terminals. If not, both plug on cord and socket in equipment must be changed to comply with paragraph 13.2.9 below.

13.2.8 Outlet for 240 volt equipment with -

- removable cord made up in University workshop
- equipment with removable cords delivered with unsatisfactory equipment plugs
- where power cord is not an integral part of the equipment.

For supply end of cord use standard plug top as required in 13.2.1 b), 13.2.2 b) or 13.2.6 b)

For light duty below 5 amp for equipment end of cord use Cannon Cat No XLR - LNE - 11C plug.

For socket in equipment use Cannon Cat No XLR - LNE - 32 receptacle.

For standard and heavy duty up to 15 amps. For equipment end of cord use a 3-pin industrial cord extension socket.

Clipsal 436/15

For socket in equipment use.

Clipsal 435/15

or 435V/15

or 435VF/15

13.2.9 a) 110 Volt 10 amp socket outlet

(Generally required by equipment of U.S.A. manufacture).

Socket outlets to take plugs with 2 round 3/16" diameter live pins with standard flat earth pin.

Clipsal Cat No 415/110

or 412/110

b) 110 volt 10 amp plug top

Plug top with 2 round 3/16" diameter live pins with standard flat earth pins.

Clipsal Cat No 439D/110

Wiring as for 1 b)

c) Corresponding male pin equipment socket is Clipsal 435/110

13.2.10 D C outlet

2-pin polarised outlet.

Clipsal 40 for 250 Volt DC

Clipsal 402/32 for 32 Volt DC or less

13.2.11 250 volt 15-30 amp heavy duty outlet

a) 30 amp rated Hi-Impact PVC socket outlet to take 3 round pin 30 amp plug.

WILCO Cat No Clipsal 56C332

b) 30 amp plug top with 3 round pins.

WILCO Cat. No. Clipsal 56P332

NOTE: The 20 amp combination outlets are NOT acceptable. The equivalent ROWCO outlet is acceptable.

13.2.12 500 volt 3 phase 20 and 30 amp outlet

NOTE: It is anticipated that only in exceptional circumstances will equipment in excess of 30 amps be connected by a socket outlet. Such equipment will normally require fixed connection.

Where socket outlets are required each case must be considered on its merits. 5 pin outlets are preferred.

a) Socket outlets to be 20 or 30 amp-rated, 5-pin (3-phase, neutral and earth) outlets fitted with triple pole switch.

Make	20 Amp	30 Amp
WILCO	WICM520	WIC530
Clipsal	56C520	56C532
or Clipsal	56C510	

For flush mounting the appropriate insulated flush plate is to be fitted.

b) Plug tops to be 500 volt 30 amp 5 pin suitable for socket outlets.

Make	20 Amp	30 Amp
WILCO	WIPM520	WIP530
Clipsal	56P520	56P532
or Clipsal	56P510	

13.2.13 External weatherproof outlet

The appropriate pin arrangement for the particular current and voltage condition required from the above standard is to be selected, installed in an appropriate weatherproof enclosure and shall be RCD-protected.

13.3 Circuit arrangements for power outlet

Because of the ever-changing requirements for power in University buildings, reserve capacity should be left in all new power circuits.

In the older, existing buildings in which 16 amp cable was used for final sub-circuits, protected by a 16 amp circuit-breaker the maximum number of outlets allowed was 8. The University recommendation for new installations is 6 doubles. In computer laboratories which have permanent air conditioning, the installation is 6 doubles.

To allow a reserve on all new circuits the following limitations on numbers of socket outlets shall be maintained.

Air-conditioned offices	6 doubles
Laboratories	5 doubles

In addition for laboratories generally each laboratory should have more than one circuit irrespective of numbers of outlets. No circuit should extend into more than one laboratory.

A schedule giving the make and type of accessories (socket outlets, switches etc) mounting height and other details should be incorporated in each specification. This schedule should be approved by Facilities Management before the specification is issued.

Voltage stabilisers will usually be required for electronic and scientific measuring equipment. The type and size of stabilisers selected should be carefully investigated and discussed with Facilities Management before final selection is made.

Stabilisers should be installed in accessible positions where they can be easily maintained. They should be complete with all necessary indicating instruments such as Voltmeter, Ammeter etc and secondary circuit protection.

All fixed appliances such as electric stoves, hot water systems etc must have the fixed wiring terminating in an isolating switch situated close to the unit before the unit is connected.

Power outlets for use of equipment in fume cupboards must be RCD-protected. Refer to AS2243.7 1991.

14.0 MARKING OF LIGHT SWITCHES AND POWER OUTLETS

14.1 All light switches and power outlets to be identified

It is of considerable assistance particularly in emergencies, to be able to quickly locate the fuse or circuit breaker controlling a particular light or power outlet.

To achieve this end, every light switch and power outlet should be marked with the number and phase colour of the originating fuse or circuit breaker.

14.2 Standard method of marking

The standard method of marking the plates or switches of power outlets is with coloured and numbered plastic buttons (IPA markers) fixed to the plates. For the 2000 Clipsal range fit adhesive label to face of the socket and IPA to the plate grid.

All light switches, power outlets, and the outlets to fixed electrical equipment are to be numbered in this fashion.

In the case of the Clipsal 2000 range socket outlets the IPA shall be visible without removing the cover.

14.3 Marking code

The code shall be the same as that described in paragraph E10.5 for sub-distribution switchboards, i.e. Red 1, White 1, Blue 1, Red 2, White 2, Blue 2, etc.

Note that the numbers on any one floor run consecutively from one distribution board to another, although blocks of reserved numbers may be allocated to each distribution board.

15.0 ELECTRIC HEATING

15.1 Space heating

The policy for heating buildings in the University is that in non air-conditioned or controlled-temperature areas, heating will be achieved by using plug-in portable fan heaters. Allowance should therefore be made for all offices and similar work spaces to be heated by this method.

It has however been found that tutorial rooms, seminar rooms, general offices and similar places where a group of people gather are unsuitable to be heated by this method as furniture may be scorched by low level heaters. These areas will therefore be heated by wall-mounted strip heaters according to the size of the room. The heating is invariably not needed when the room is crowded, therefore the size of the heater may be calculated on a minimum basis.

All heaters are to be fitted with timers that provide for a maximum of one hour.

Outlets for wall-mounted strip heaters should be Clipsal 10 "Plugmatic" or similar automatic outlets, positioned at one end of the heater and switched adjacent to the door.

Heater switches shall be clearly engraved with 'HEATER' and incorporate a neon indicator. They should be positioned adjacent to the door but distinctly separated from the light switches. The minimum

acceptable separation from the light switches is 150mm. Any variation on this shall be discussed with Facilities Management.

15.2 Water heating

In buildings where large quantities of hot water are required this shall be provided by a gas heater. In other buildings where hot water is only required for washing up in tea rooms and in some staff toilets, local storage-type hot water units may be installed. These units are usually supplied and installed by the plumber.

The electrical connection to the hot water unit is to terminate in an isolating switch from which a flexible connection is made to the appliance. Power should not be connected to the hot water unit until it is ready to be put into service. The specification should require the electrician to coordinate with the plumber the commissioning and putting into service of all electrical hot water units.

Where instantaneous or storage-type electrical hot water units are fitted with a "No Volt Release" this device should be disconnected and removed from the unit as it is not required.

A "No Volt Release" is fitted to storage hot water units as a requirement of the Supply Authority in the expectation that the units will be used in domestic installations.

The "No Volt Release" prevents undue power surges following a power failure. Such a situation does not exist at the University. Also as the units are often installed in concealed places the resetting of the "No Volt Release" may be difficult.

16.0 ELECTRIC MOTORS AND MOTOR CONTROL EQUIPMENT

All electrical motors shall be suitable for operation on 415/240 volts.

They should be selected for their duty. Ball or roller bearings shall be specified except in areas where noise from these motors may be a nuisance when sleeve bearings may be permitted. When situated close to teaching areas where noise from the motor may be a nuisance, super-silent type shall be specified.

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

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

Generally :

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

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

The appearance and marking of motor-control equipment shall conform to AS1431. Colours of indicating lights in particular shall conform to this standard as follows :

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

17.0 TOILET VENTILATION SYSTEMS

Toilet ventilation systems utilising dual-toilet extract fans are a requirement of the Public Health Department in some buildings.

The University requirement is for a control circuit which gives greater operating reliability than the basic requirements of the Public Health Department. The circuit diagram for the control of dual-toilet exhaust fans is attached (Appendix - standard drawing 206/E/29).

Consideration should be given to the positioning of this control panel. The essential factor is that the run/fault indicating light and lead/lag changeover switch should be readily accessible and visible to plant operating personnel.

Suggested positions are :

- a) with or adjacent to a main mechanical services control panel
- b) in the main switchroom
- c) control panel alongside the fans with indicating lights remotely positioned in an accessible public space

17.1 Lighting and ventilation are to be controlled by movement sensors strategically placed to cover the trafficable zones. The sensor is to be set so the lights and ventilation stay ON for a least a minimum of ten minutes after the last occupant vacated the toilets. Refer to the UWA Design Manual for Mechanical Services.

17.2 Toilet hand dryers

Toilet hand dryers are installed in high-use toilets. At the present time the University is installing the MacDonald "Applause" dryer. To conform to AS1428.1-1993 the dryer is to be installed at a height of 1,000mm to the base of the dryer.

18.0 CLOCK SYSTEMS

18.1 Master Clock

All clock systems within the main campus of the University are to be controlled from the master clock which is a "Simplex" Type 93 master time centre. This is a precision-made instrument which keeps time to an accuracy of 2 seconds per month. It is situated in the University telephone exchange.

On the hour it sends out a correcting impulse over separate cables to all the clocks on the system. This automatically corrects the minute hand of all indicating clocks to read the same time as the master. Every twelve hours an additional signal is sent out to correct the hour hands on the indicating clocks to read the same time as the master.

18.2 Connections

Buildings remote from the master clock are connected to the master via telephone cables. This connection is for the correction pulse only not for the power needed to drive the indicating clocks.

The master clock emits the correction pulse at 240 volts, this being stepped down by a relay to 30 volts DC for transmission over telephone lines to the remote building where a similar relay steps the impulse voltage up again to 240 volts.

240 volt AC power is supplied to the relay from a fuse within the building served. Although the current drain is very small the time service is so important that the clock system must be supplied from its own fuse or circuit breaker, preferably from the main switchboard.

18.3 Indicating clocks

Facilities Management will select indicating clocks for new buildings. For economy the type will be selected from the standard range of the supply firm Simplex International Time Equipment Pty Ltd.

Clock faces, chapters and hands must be clear, unambiguous and simple to read from a distance. The clock hands should move continuously and noiselessly. A sweep second hand should be fitted as standard.

Indicating clocks on the master system must be synchronous wired indicating clocks with individual automatic supervision.

Automatic self regulation should be :

- Once each hour on 58th minute for hourly correction
- Once each 12 hours for 12 hour correction

18.4 The position of indicating clocks will be decided by Facilities Management in consultation with the commissioned architect. Clocks will be required in all public areas where large groups of students congregate.

These will be :

- a) **In main entrance(s) to a building**
Clock to be placed in a prominent unobscured position preferably facing the door.
- b) **Lecture Theatres**
Clock to be so positioned that it is visible to both the lecturer and the audience without either having to turn around to see it. This implies that it should be placed not on the back or front wall but on a side wall forward of the front row of seats.
- c) **Teaching laboratories**
Clocks to be installed only if they are required for work carried out in the laboratory. In certain circumstances special clocks with pronounced sweep second hands or say 24 hour dials may be required.
- d) **Corridors**
To be provided in main corridors. This may require two-way clocks centrally positioned in the corridors.
- e) **Common rooms etc**
A small clock prominently displayed should be installed in common rooms, staff lunch rooms etc.
- f) **General offices, workshops etc.**
The administrative centre of a department where several staff work, should be provided with a clock in a prominent position. This also applies to workshops etc.
- g) **Libraries** should be provided with a clock clearly visible from the study area.

18.5 Maintenance

The University has a maintenance agreement for all clock systems with Simplex Pty Ltd. On a new building, clocks should be covered for defects liability for the period of the building maintenance only. After the building maintenance period expires, the clock system will be included in the University clock maintenance contract.

18.6 Installation

The electrical consultant should include in the electrical specification for the building the following work to be carried out by the electrician.

- a) A 20mm conduit with draw wire from the main or nearest telephone distribution frame to the clock relay. Connection to relay to be via 6/11 socket.
- b) From its own fuse or circuit breaker a circuit consisting of 7/0.5 PVC insulated red active, black neutral and 7/0.67 earth wires to the clock relay.
- c) The relay should be so positioned in a switchroom, duct or similar space that it is fully accessible to authorised personnel for maintenance and future additions.
- d) From the clock relay install a 20mm conduit containing 3 x 7/0.50 wires, one red, one black, one white and a 7/0.67 green/yellow insulated earth wire. The conduit and cables should loop from clock outlet to clock outlet. In multi-storey or similar block where it is

necessary to tap in on the main run of cables at a position other than a clock, a suitable terminal strip in a metal case should be installed.

- e) At each clock position the conduit run should terminate in a single gang wall box in such a position that it will be concealed by the clock. This is NOT central on the clock dial but has to be positioned off centre to avoid the clock movement. The clock suppliers can provide a cardboard template to position the outlet accurately.
- f) On the single gang box mount a 250 volt 5 amp Clipsal 4 pin base Cat No 408/4 wired as follows:

Reading from top and clockwise

Red	Active
Black	Neutral
Green	Earth
White	Correction wire

The clocks should be equipped with a Clipsal 4 pin plug top Cat.No.409/4. Outlets shall be concealed by the clock.

- g) It is usual to allow in the electrical contract for the electrician to install the hanging nail or screw and to plug in and mount the clocks.

18.7 Connection of telephone line to clock relay

This work is carried out by the telephone wiring technicians on the direction of Facilities Management. When the clock relay has been installed the electrical consultant should request Facilities Management in writing to arrange for the telephone technician to make the necessary connections. Sufficient finance must be allowed in the building contract for this to be done.

18.8 Battery-operated clocks will not normally be installed in the University as part of new projects.

18.9 Telechron Clocks should be submitted as an alternative to the Simplex system. Telechron clocks are corrected and synchronised via a paging system. The Telechron Clocks are manufactured by:Ingrams Bright
338 Separation St NORTHCOTE VIC 3070 Tel:(03) 9482 6477

19.0 MECHANICAL PLANT ROOMS (Refurbished and New)

19.1 Electrical Power Point. A double power point, RCD protected, shall be located in the plant room adjacent to or below the MSSB and BMCS panel.

19.2 Electric Wiring. All electric, light, communication, access control, DDC or any other cables snot in a conduit must be secured to a cable tray. The cable tray can be hung form the slab or inverted and secured directly to the slab. **Wiring just hanging from the slab will not be accepted. See Electrical Manual.**

19.3 Lights. Light fittings are to be located in areas above or adjacent to the MSSB, TAC boards and FCU access hatches or doors.

ATTACHMENTS

[CONNECTION FOR TEST LINK](#)

[DARKROOM LIGHTING](#)

[TOILET EXHAUST FAN SYSTEM](#)

[PILLAR - SECTION SHEET 1](#)

[PILLAR - SECTION SHEET 2](#)

[PILLAR - SECTION SHEET 3](#)

[PILLAR - SECTION SHEET 4](#)

[FM 'AS CONSTRUCTED' DRAWING - DATA PROCESS](#)