



MACQUARIE
University

ELECTRICAL SERVICES DESIGN STANDARDS

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Revision Table		
Revision	Date	Description
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Revised	October 2017	Comments & Recommendations by Phil Hunt & Alan Vidler
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For Issue	April 2019	Comments & Recommendations by Alan Vidler

1 SCOPE

1.1 GENERAL

This specification sets out the equipment and materials to be used and installation methods employed in electrical services installations carried out for the University.

The designer is required to use the Standards as the foundation for the system design. However, the site specific operational, logistical and performance requirements of the respective project shall be observed.

Where alternatives are proposed to the requirements of this Standard, the Designer shall obtain specific approval from Macquarie University Property. Any application for an alternative shall be supported by an analysis of the benefits of that alternative.

1.2 ENERGY CONSERVATION

Low energy, high efficiency equipment shall be incorporated in all University projects. The design shall be in accordance with the requirements of the National Construction Code for Energy Efficient Installations.

1.3 LIFE CYCLE COSTS

Equipment selection and system design shall ensure the most effective life cycle costs by minimising maintenance costs and taking into consideration the expected life of the equipment.

1.4 FLEXIBILITY

The installation shall be designed to maximise future re-use and adaptability in the event of change of use of the respective space.

1.5 DESIGN SUBMISSION

On completion of the tender documentation, submit to Macquarie University Property the tender drawings and specification together with the following:

- Maximum demand calculations
- Voltage drop and submain sizing calculations
- Calculated fault levels at each new switchboard
- Lighting level calculations
- NCC Section J6 calculations

1.6 STANDARDS

The installation shall be in complete accordance with the current editions of all applicable standards, including the following:

AS 1170.4: Earthquake Loads

AS/NZS 1680: Interior Lighting

AS/NZS 1768 Lightning Protection

AS/NZS 2243: Safety in Laboratories

AS/NZS 2293: Emergency Evacuation Lighting for Buildings

AS 3000: Electrical Installations (Wiring Rules)

AS 3008: Electrical Installations – Selection of Cables

AS/NZ S3010: Electrical Installations – General Sets

AS 3439: Low Voltage Switchgear and Control Gear Assemblies

AS/NZS 61439: Low Voltage Switchgear and Control Gear Assemblies

AS/NZS 4251: Electromagnetic Compatibility (EMC) – Generic Emission Standard

National Construction Code

1.7 AUTHORITIES

The installation shall comply with the requirements of all authorities having jurisdiction over the works, including:

- The Supply Authority
- The Local Council
- NSW Fire Brigade
- Safework NSW

1.8 'AS INSTALLED' DRAWINGS

On completion of the works and two weeks prior to the issue of the Notice of Practical Completion, the Contractor shall supply a set of drawings showing the complete services installation 'as-installed'.

The drawings shall be to the same scale as the design drawings and shall record details of the work actually installed and titled "as installed".

A symbols legend shall be included with all "as installed" drawings.

The drawings shall appear "as new". No previous approval stamps, hand written notes or erase markings shall be evident.

The location information shown on the drawings shall be accurately measured from permanent building boundaries or other permanent features.

The drawings shall be provided on disc in both PDF format and DWG format compatible with the latest version of AutoCAD.

1.9 OPERATING AND MAINTENANCE MANUALS

One (1) hard copy of Operating and Maintenance Manuals shall be provided by the Contractor in the following format together with one copy provided in PDF format on electronic storage media:

- A4 size loose leaf sheets in commercial quality 4–ring binders with hard covers;
- Each binder is to be indexed, divided and titled.
- Binders are to include a typed or printed title on both the cover and the spine to clearly identify the project name, project location by block and section numbers and suburb, client name, and volume number.

Template

The format and contents of the manuals shall follow the following format:

- General Description of Project
 - System operation
 - Design parameters
- Operating Procedures
 - General
 - Automatic/Manual operation
 - Routine inspection and reporting templates
 - Emergency procedures
 - Fault finding information
- Maintenance procedures
 - Maintenance procedures for plant & equipment
 - Manufacturers recommendation
 - Templates and matrix tasks for all items applicable to AS 1851
- Maintenance schedules
 - Plant and equipment schedules
 - Spare parts list
 - Manufacturers contact details
- Manufacturers literature & warranties

- Health and Safety (refer to appendix 1 for guidance)
- Commissioning data
 - Commissioning documentation to include but not limited to
 - * Residual current device (RCD) test records
 - * Emergency lighting test records
- Certification data
 - Certificate of Compliance
- Asset register (excel format) with hyperlinks to the sections listed above
- Drawings
 - PDF
 - DWG

1.10 EQUIPMENT RADIO FREQUENCY INTERFERENCE

Equipment shall comply with the requirements of AS/NZS CISPA.14.1 with regard to the generation of radio frequency interference.

If required, suppression devices or shielding devices shall be installed.

1.11 EQUIPMENT ELECTROMAGNETIC COMPATABILITY

Equipment shall comply with the requirements of AS/NZS 4251 with regard to the generation of electromagnetic emissions.

1.12 SEISMIC RESTRAINT

All components, other than service items exempted in AS 1170.4, shall be arranged to resist seismic loads determined in accordance with AS 1170.4.

2 SUPPLY

2.1 METHOD OF SUPPLY

The Designer shall carry out all required investigations and prepare the maximum demand calculations to determine the optimum method of supply to the new installation.

2.2 NOTICE TO MACQUARIE UNIVERSITY PROPERTY

The proposed Method of Supply and the supporting data is to be submitted to Macquarie University Property for confirmation prior to implementation.

2.3 NOTICE TO SUPPLY AUTHORITY

The Designer shall make all necessary applications and provide all notices to the Supply Authority with regard to the connection of the load of the new installation.

2.4 ENERGY SUPPLIER METERING

Energy Supplier metering shall be provided in accordance with the NSW 'Service and Installation Rules'.

3 SWITCHBOARDS

3.1 MANUFACTURERS

All switchboards shall be manufactured by an experienced, well established switchboard manufacturer approved by Macquarie University Property.

3.2 MAIN SWITCHBOARDS AND LARGE DISTRIBUTION SWITCHBOARDS (RATED >250 AMPS PER PHASE)

Location

All Switchboards and Large Distribution Switchboards shall be installed in a dedicated room or cupboard and in a manner designed to enable safe access for operation and maintenance.

Standards

Switchboards shall be constructed in accordance with the relevant sections of AS/NZS 3439 and AS/NZS 61439.

Form of Segregation

Unless otherwise approved by Macquarie University Property, switchboards shall be designed to provide the following forms of segregation to AS/NZS 3439:

Main Switchboards (Rated > 1200 amps per phase) – Form 4b

Main Switchboards (Rated > 250 amps per phase) – Form 3b

Main Distribution Switchboards (Rated > 250 amps per phase) – Form 3b

Type ih (insulation and housing) segregation shall only be provided with the prior approval of Macquarie University Property.

3.3 SUPPLY AUTHORITY REQUIREMENT

Switchboards shall meet the requirements of the respective Supply Authority and Energy Provider.

3.4 SWITCHBOARD ASSEMBLIES

Mounting

Switchboard assemblies less than 2m² in elevation may be wall mounted. Assemblies of 2m² or greater shall be floor mounted.

Modular Switchboards

The use of modular switchboard design for floor mounted switchboards is acceptable, particularly in installations where alterations and additions to the original switchboard are probable.

Modular switchboards shall only be accepted from well established manufacturers with extensive experience in the use of the respective system.

The design of all modular systems shall be supported by Type Test Certificates to AS/NZS 3439 or AS/NZS 61439.

Metalwork

Internal switchboard enclosures shall be manufactured from first quality plated steel sheet. The assembly shall be of sound and rigid construction, free from any sag, deformation or twisting and shall be designed to withstand normal operating stresses and the prospective fault conditions.

External switchboard enclosure cubicles shall be manufactured from marine grade stainless steel.

Floor mounted switchboards shall be complete with a 75mm high (minimum) galvanised channel iron plinth.

Hardware

Removable panels shall be secured by means of captive, corrosion resistant, knurled thumb screws. Fixings requiring the use of removable plastic key tools are not acceptable.

Panels of the same physical size shall be fitted with locating pins to prevent interchangeability.

Hinged panels shall be mounted on removable pintle hinges and secured by locking systems with lever action handles and locking cylinders matched to the University keying system.

The external doors of external switchboards shall be fitted with a hasp and staple to enable the installation of a padlock keyed to the University keying system.

Hardware for internal switchboards shall be chrome plated cast metal. Hardware for external switchboards shall be marine grade stainless steel.

Switchgear

All switchgear for the control and protection of outgoing circuits shall be in the form of circuit breakers. The cascading properties of circuit breakers shall be used to minimise the use of fuses for fault current protection.

Spare Spaces

Switchboard design shall include spare spaces for a future increase of 25% (minimum) in the number of circuit breakers installed in each section of the switchboard. Where different circuit breakers frame sizes are installed in the one section, allow for an increase of 25% (minimum) of each frame size.

IP Rating

Internal Switchboards : IP52 minimum

External Switchboards : IP56 minimum

Gaskets on doors and panels shall be of neoprene rubber and shall be of the pinch weld type or similar mechanically fixed type. Self-adhesive gaskets are not acceptable.

Painting

Switchboard enclosures shall be polyester powdercoat paint finished to a dry film thickness of 50-60 microns.

For external switchboards 40 microns of primer shall be applied and cured prior to application of final colour.

Paint colours shall be as follows:

Gear Trays, Escutcheon Panels and similar internal surfaces of Switchboards : Gloss White Enamel

Interior and exterior of the main cubicle of Internal Switchboards : X-15 Orange to AS 2700

Interior and exterior of the main cubicle of External Switchboards : G-13 Emerald Green to AS 2700 (unless otherwise approved by Macquarie University Property)

Busbars

Busbars shall be hard drawn, high conductivity copper colour code for phase identification at regular centres. Neutral and earth conductors shall be identified by labelling and colour coding.

Neutral and earth cable termination points are to be brought forward for safe and easy access and be located adjacent to the associated phase conductor terminals.

Busbar systems shall be designed with a current carrying capacity adequate to suit the specified load and voltage.

Busbar systems shall be designed to withstand the prospective fault level without permanent distortion and to carry the maximum load current whilst maintaining temperature rises within the limits specified in AS/NZS 61439.

Type Test Certificates

The design of switchboard assemblies shall be supported by type test certificates to verify:

- Temperature rise limits
- Dielectric properties
- Short circuit withstand strength
- Clearance and creepage distances
- Degree of protection and internal separation
- Mechanical operation

Where type test certificates are not directly applicable to the respective assembly, additional calculations or other means shall be provided to demonstrate the derivation of the non-type tested assembly.

Separation of Supplies

Where different supplies, eg essential and non-essential, are controlled by the one switchboard, the switchgear controlling the different supplies shall be separated from each other by means of sheetmetal segregations.

Provision for Cable Entries

Switchboards shall be complete with removable gland plates to enable cable entries. Where necessary to maintain IP ratings, gland plates shall be complete with gaskets.

Anti-Condensation Heaters

All external Main Switchboards and large external Distribution Switchboards shall be complete with anti-condensation heaters. Heaters shall be housed in die cast aluminium housings design for DIN rail mounting. Heaters shall be thermostatically controlled and protected by dedicated fuses or circuit breakers.

Rating Plate

Each Main Switchboard or Distribution Switchboard shall be complete with an engraved metal rating plate providing the following information:

- Manufacturer's name or trade mark
- Serial number / drawing number
- Relevant standard (eg. AS/NZS 3439.1)
- Type of current (and frequency, in the case of ac)
- Rated operational voltages
- Short-circuit withstand strength
- Degree of protection
- Type of system earthing
- Weight
- Form of internal separation
- Date of manufacture

The plate shall be securely fixed in a prominent position on the front of the respective switchboard.

3.5 DISTRIBUTION SWITCHBOARDS (RATED UP TO 250 AMPS PER PHASE)**Location**

Distribution switchboards rated up to 250 amps per phase shall be installed in plant areas or circulation spaces. Distribution boards shall not be located in classrooms or lecture theatres.

Where not installed in a dedicated cupboard, distribution switchboards shall be complete with a hinged lockable door.

Form of Segregation

Distribution switchboards shall be manufactured to Form 2 in accordance with AS/NZS 3439.

Metalwork

Internal distribution switchboards shall be manufactured from first quality plated steel sheet. External distribution switchboards shall be manufactured from marine grade stainless steel.

Escutcheon panels shall be fitted to circuit breaker sections. Access to cabling and auxiliary equipment shall be by means of removable panels.

Removable gland plates shall be provided to facilitate cable entries. Where necessary to maintain IP ratings, gland plates shall be fitted with gaskets.

Hardware

Removable panels shall be secured by means of captive, knurled head thumb screws. Fixings requiring the use of removable plastic key tools are not acceptable.

Hinged panels shall be mounted on pintle hinges and secured by means of captive screws.

Enclosure doors shall be mounted on pintle hinges and secured by locking system with lever action handles and locking cylinders matched to the University keying system.

Hardware for internal switchboards shall be chrome plated cast metal. Hardware for external switchboards shall be stainless steel.

IP Rating

Internal Switchboards : IP52 minimum

External Switchboards : IP56 minimum

Gaskets on doors and panels shall be of neoprene rubber and shall be of the pinch weld type or similar mechanically fixed type. Self-adhesive gaskets are not acceptable.

Painting

Switchboard enclosures shall be polyester powdercoat paint finished to a dry film thickness of 50-60 microns.

For external switchboards 40 microns of primer shall be applied and cured prior to application of final colour.

Paint colours shall be as follows:

Gear Trays, Escutcheon Panels and similar internal surfaces of Switchboards : Gloss White Enamel

Interior and exterior of the main cubicle of Internal Switchboards : X-15 Orange to AS 2700

Interior and exterior of the main cubicle of External Switchboards : Brushed finished stainless steel or colour to be selected to suit respective location.

Busbars

Busbars shall be hard drawn, high conductivity copper colour code for phase identification at regular centres. Neutral and earth conductors shall be identified by labelling and colour coding.

Neutral and earth cable termination points are to be brought forward for safe and easy access and be located adjacent to the associated phase conductor terminals.

Busbar systems shall be designed with a current carrying capacity adequate to suit the specified load and voltage.

Busbar systems shall be designed to withstand the prospective fault level without permanent distortion and to carry the maximum load current whilst maintaining temperature rises within the limits specified in AS/NZS 61439.

Main Switch

All distribution switchboards shall be complete with a minimum number of main switches to facilitate the isolation of the respective switchboard.

Switches shall be in the form of circuit breakers or load break isolating switches.

Separation

Where installed on the one distribution board, equipment controlling different voltages or different 240 / 415 volt supplies shall be separated by sheetmetal divisions.

Spare Capacity

Distribution boards shall be designed to provide spare space for an increase of 25% (minimum) in the number of installed circuit breakers.

3.6 DISTRIBUTION SWITCHBOARDS IN DATA CENTRES, LABORATORIES AND SIMILAR LOCATIONS

Where serving Data Centres, Laboratories or similar areas where security of electricity supply is essential, consideration is to be given to the use of propriety distribution boards designed specifically to enable individual circuits to be installed / removed safely and without affecting

other circuits. The distribution boards shall incorporate fully insulated busbar systems and disconnectable neutral terminals.

Distribution boards of this type shall only be installed with the specific prior approval of Macquarie University Property.

3.7 CIRCUIT BREAKERS

Manufacture

Circuit breakers shall be of Schneider Electric or Terasaki manufacture. Circuit breakers of other manufacturers shall only be used with the prior approval of Macquarie University Property.

Air Circuit Breakers (Ratings above 1200 amps per phase)

Air circuit breakers shall be used for circuit breakers above 1200 amps per phase. Air circuit breakers shall be of the fully withdrawable type and be complete with electronic trip units.

The trip units shall incorporate, as a minimum, adjustable long term, short term and instantaneous trip settings together with a digital meter providing current, voltage, power factor and energy measurement. The trip units shall incorporate a communications (Modbus) port to enable monitoring of the circuit breaker status by an external monitoring system. The communications port is to be cabled to accessible terminals within the respective switchboard.

Moulded Case Circuit Breakers (Ratings above 630 amps per phase)

Moulded case circuit breakers shall be used for the control of circuits in the range of 630 amps per phase to 1200 amps per phase. Moulded case circuit breakers shall only be used for circuit ratings above 1200 amps per phase with the prior approval of Macquarie University Property.

Moulded case circuit breakers rated above 630 amps per phase shall be complete with electronic units incorporating, as a minimum, adjustable long term, short term and instantaneous trip settings.

Where deemed necessary for load or energy monitoring the circuit breakers shall be complete with a digital meter providing current, voltage, power factor and energy displays.

Trip units incorporating digital meters shall incorporate a communications (Modbus) port to enable monitoring of the circuit breaker status by an external monitoring system. The communications port shall be cabled to accessible terminals within the respective switchboard.

Moulded Case Circuit Breakers (Ratings 40 – 630 amps per phase)

Moulded case circuit breakers of ratings 40-630 amps per phase and protecting distribution systems shall be complete with electronic trip units incorporating adjustable long term and short term trip settings. Circuit breakers protecting motor loads shall incorporate electronic trip units incorporating adjustable motor current trip settings.

Where deemed necessary for load or energy monitoring, the circuit breakers shall be complete with a digital meter providing current, voltage, power factor and energy displays. Trip units incorporating digital meters shall incorporate a communications (Modbus) port to enable monitoring by an external monitoring system. The communications port shall be cabled to accessible terminals within the respective switchboard.

Miniature Circuit Breakers (Ratings 10-125 amps per phase)

Miniature circuit breakers rated 10-125 shall be of the DIN rail mounted type.

Miniature Circuit Breakers With Integral Residual Current Protection

Miniature circuit breakers with integral residual current protection shall be of the RCBO type providing short circuit, over current and earth leakage protection in the one unit.

3.8 AUTOMATIC TRANSFER SWITCHES

Configuration

Automatic transfer switches shall comprise two electrically and mechanically interlocked motorised circuit breakers. Alternatively, mechanically interlocked motor operated switch units may be used subject to approval by Macquarie University Property. Transfer switches shall provide an easily selected 'Off' position for maintenance.

Control Systems

The control systems for transfer switches shall be of the solid state type of matching manufacture to the switch or from an approved specialist controls manufacturer.

The control system shall provide the following functions:

- Transfer the load from the 'Normal' services to the standby generator depending on the presence of the 'Normal' source.
- Provide the required time delays in relation to failure of the respective sources and the presence of the 'Normal' and generator supplies.
- Provide a start signal to the standby generator
- Transfer the load to the standby generator if one of the phases on the 'Normal' source fails.

The control system shall incorporate a communications port to enable status indications and control functions to be carried out via a building monitoring system.

Closed Transition Switches

Where the nature of the load does not permit an interruption to supply to enable the testing of a standby generator, consideration shall be given to the provision of a closed transition transfer switch. The installation of such switches shall be subject to the approval of Macquarie University Property.

Connection

Automatic transfer switches shall be installed in accordance with AS3010 : 2017.

3.9 CONTACTORS**Manufacture**

Contactors shall be of Sprecher & Shuh or Schneider Electric manufacture.

Rating

Contactors shall be rated for the full load current of the controlled load or 16 amps whichever is the greater. Contactors shall be rated for 1 million operations at AC-3 or DC-3 to AS60947.4.1.

Auxiliary Contacts

Provide auxiliary contacts with at least one normally open and one normally closed separate contacts of 6 amp, 240 V ac rating.

Interconnection

Contactors are not to be connected in series or parallel to achieve ratings.

3.10 LOAD BREAK SWITCHES

Load break switches shall be of the fault make, load break type complying with AS60947.1 and AS/NZS 3947.3.

Switches shall incorporate a rotary handle and a positive ON / OFF indication. Switches shall incorporate facilities to enable the switch to be locked in the OFF position.

3.11 SELECTOR SWITCHES

Selector switches shall be of the rotary type and of Sprecher & Shuh or Kraus & Naimer manufacture. Switches shall be accessible on the front of switchboard cubicles.

3.12 MULTI-FUNCTION METERS

Multi-function meters shall be installed as specified in the Macquarie University 'Energy Metering System (EMS) Design Standard'.

3.13 SURGE AND TRANSIENT POWER PROTECTION**General**

Surge and transient power protection shall be installed in all installations. As a minimum, the protection shall comply with AS/NZS 1768 : 2007 and comprises:

- Point of entry protection at main switchboards (Category C1 Protection to AS/NZS 1768 : 2007).
- Surge diverters at distribution boards (Category B Protection to AS/NZS 1768 : 2007).

Point of Entry Protection

Point of entry protection shall incorporate the following features:

- Replaceable fuse cartridges
- Changeover contacts to enable remote monitoring, if required
- Visual status indication per phase.

Distribution Board Protection

Distribution board protection shall incorporate the following features:

- Replaceable surge modules
- Changeover contacts to enable remote monitoring, if required
- Mechanical status flag per phase.

Surge Reduction Filters

Where supply systems serve sensitive electronic equipment, surge protection filters shall be installed. Filters shall be designed to reduce the rate-of-rise of the leading edge of the impulse to less than 20V/microsecond.

3.14 LABELLING OF SWITCHBOARDS**Display Drawings at Main Switchboards**

The following display drawings shall be provided at each Main Switchboard:

- An elevation of the Main Switchboard showing the rating and function of all functional units.
- A single line diagram of the Main Switchboard.
- A single line diagram of the submain system through the whole installation including each distribution board and the size and type of each submain.

The drawings shall be laminated and securely fixed on a wall adjacent to the Main Switchboard. For external switchboards the drawings shall be fixed to the inside of the switchboard doors.

Labelling of Incoming Supply System

The size and type of the incoming supply cabling to each switchboard shall be indicated by means of an engraved laminated plastic label, fixed to the front of the respective switchboard.

Labelling of Submain Control Circuit Breakers

All circuit breakers controlling submains or similar major circuits shall be labelled by means of engraved laminated plastic labels to indicate:

- The frame size rating of the circuit breaker
- The trip unit setting of the circuit breaker
- The size and type of the protected submain cabling.

Circuit Schedules

Circuit schedules shall be provided at each distribution switchboard to indicate the following:

- Designation or number of each subcircuit
- Rating of controlling circuit breaker
- Description of circuit/connected equipment
- Contactor number and contacts (where applicable)

Schedules shall be typed or machine printed and shall be mounted behind a clear plastic sheet in a metal or timber frame installed on the inside of the switchboard doors or on the wall adjacent to the respective switchboard.

3.15 POWER FACTOR CORRECTION

General

Power factor correction shall be installed at each Main Switchboard and / or for each separate electrical installation to achieve a power factor under all load conditions of 0.98 lagging or better.

Cubicles

The power factor correction equipment shall be of modular construction housed in free standing sheetmetal cubicles constructed as specified for switchboard cubicles. Cubicles shall be complete with thermostatically controlled ventilation fans.

Cubicles shall be designed to accommodate an increase of 25% in the number of installed capacitors and control switchgear.

Capacitors

Capacitors shall be of the mineral oil or gel impregnated type housed in cylindrical aluminium cans and complete with overpressure disconnection devices and discharge resistors.

Capacitors shall comply with IEC 831 Parts 1 and 2 and shall have a rated current 1.5 times maximum in the presence of 10% overvoltage and harmonics. Power loss shall be less than 0.25 watts per kVAr.

Capacitors shall be mounted in a separately ventilated cubicle, away from reactors, contactors and any heat generating equipment.

Contactors

Contactors used for switching individual capacitor steps shall be of a type specifically designed for switching low inductive capacitive loads.

Contactors shall be provided to enable the capacitors to be switched in banks of 25kVAr or 50kVAr.

Fused Switches

The individual steps of the power factor correction system shall be protected by fully shrouded fused isolators.

Reactive Power Controller

The reactive power controller for monitoring the power factor and controlling the capacitor steps shall be mounted on the front of the cubicle. The controller shall incorporate the following features:

- Microprocessor based
- Digital display of Power Factor, Step Number Operating and all setup information
- Zero Voltage Tripping
- Filter on input circuits to protect against harmonics
- Alarm output and indications of:
 - Failure to achieve target power factor
 - Mains failure
 - Temperature
 - Harmonic levels (voltage and current)
 - Voltage and current levels
 - Display of volts, amps, kW, kVA, harmonics, temperature, contactor switching.

The controller shall incorporate an RS485 (Modbus) port to enable monitoring by an external monitoring system.

Harmonic Detuning Reactors

Where necessary, reactors shall be connected prior to capacitors to 'detune' the capacitors below the harmonic frequencies generated by power electronic switching devices. The reactors shall comply with AS1028 and shall be connected via flexible lugged cables rated for the respective step protection.

Isolation Switch

A suitably rated circuit breaker shall be installed on the respective switchboard to enable isolation of each power factor correction system and associated cabling.

4 CABLING SYSTEMS

4.1 VOLTAGE DROP

Cabling systems shall be designed to ensure that the total voltage drop from the point of supply for a low voltage installation to any point on that installation does not exceed 5% of the nominal system voltage irrespective of whether the point of supply is a substation located on the respective premises.

Voltage drop calculations shall include provision for any spare load capacity.

4.2 SUBMAINS CABLING Size & Type

Submains cabling shall be sized with a minimum of 30% spare capacity in relation to current carrying capacity and voltage drop. Where serving distribution boards, submains shall be of minimum size 10mm².

Submain cables shall incorporate copper conductors. Aluminium conductors shall only be used with the specific approval of Macquarie University Property.

Cabling with flexible conductors are acceptable, particularly where space for cable installation is limited.

Installation

Internal submains cabling shall be supported on cable tray wherever practical. Where the installation of cable tray is not practical, cables shall be supported on catenaries or other proprietary support systems but subject to the approval of Macquarie University Property.

External submains shall be installed underground and enclosed in HDPVC conduit.

Cables shall be installed as one complete run without joints and with adequate circulation around the cables to avoid overheating. Where bends are necessary, the bending radius shall not exceed the manufacturers recommendations.

Termination

Unless connecting to equipment with suitably sized tunnel terminals, submains cabling shall be terminated using propriety crimp type lugs sized for the respective cable.

Identification

All submain cables shall be identified at each end by approved permanent engraved / printed label tags fixed to the cable sheath or conduits (as appropriate) and identifying the cable size, type, purpose, origin and destination.

Fire Rated Cables

Fire rated cables shall be of the polymeric insulated type complete with standard copper conductors and complying with AS/NZS 5000.1, 110°C and rated WS52W to AS/NZS 3013 : 2005.

Cables shall be installed using an installation system tested and approved under AS/NZS 3013 : 2005.

4.3 SUBCIRCUIT CABLING Size and Type

Subcircuit cabling shall comprise PVC insulated multi-stranded copper conductors of the following minimum size:

- Lighting subcircuits : 1.5mm²
- General power subcircuits : 2.5mm²

Installation

Except where installed in plant and service areas, subcircuit cabling shall generally be concealed as far as practical by enclosure within the building fabric. Cabling shall be installed as described below:

In-situ Concrete Slabs and Columns	PVC insulated cables enclosed rigid PVC conduit cast into the concrete structure.
False Ceiling / Roof Spaces	TPS cables securely fixed to the building structure. Major runs of cables shall be supported on cable tray or catenary.
Stud Partitions	TPS cabling installed in a manner designed to enable later replacement. Where cables pass through steel studs suitable sleeving shall be installed to protect the cable.
Masonry Walls	PVC insulated / TPS cables enclosed in rigid PVC conduit chased into the respective wall.
Single Face Brick Walls	PVC insulated / TPS cables enclosed in rigid PVC conduit 'biscuit cut' into the brickwork.
Hollow Concrete Block Walls	PVC insulated / TPS cables enclosed in rigid PVC conduit installed via the wall cavity.
Accessible Underfloor Spaces	TPS cables securely fixed to the building structure. Major runs of cables shall be supported on cable tray or catenary.
Plant and Service Areas	PVC insulated / TPS cables installed in surface run rigid PVC conduits.
External Subcircuit Cabling	PVC insulated / TPS cables installed underground and enclosed in HDPVC conduit (refer 'Underground Cabling').

Where numbers of subcircuit cables are bunched together, the cables shall be installed in a manner designed to allow adequate cooling and to reduce the de-rating of the cables.

Termination

Subcircuit cables shall be terminated in tunnel type terminals or by suitably sized crimp type lugs. Where stud or pillar type connections are made, stranded conductors shall be prevented from spreading by approved cable terminators.

Jointing of Cables

Unless unavoidable, subcircuit cables shall be installed for their full length without intermediate joints. Joints shall only be installed with the specific prior approval of Macquarie University Property.

Joints shall be installed in easily accessible locations and using equipment and materials matched to the specific cable size.

4.4 CABLE MANUFACTURE

All power control cables shall be purchased from well-established Australian manufacturers and shall comply fully with the relevant Australian Standards. Acceptable suppliers are:- Nexans Olex Australia Pty Ltd, Electra Cables Pty Ltd, Prysmian Australia Pty Ltd

4.5 CONDUIT

General

Unless otherwise indicated, conduit shall be of the rigid PVC type.

Unless installed in plant and service areas or where surface run conduit is unavoidable, all conduit shall be concealed wherever possible by enclosure in concrete slabs, masonry walls etc. and by installation in false ceiling spaces. Surface run conduit shall be installed true and straight and aligned to perpendicular and lateral building elements.

The entire works shall be carried out on the draw-in principal.

All conduit joints shall be free from burrs and rough edges and adequate precautions shall be taken at all times to prevent entry of moisture or foreign matter into the conduit systems.

All conduits for future use shall be complete with polypropylene draw-cords.

PVC Conduit

PVC conduit shall comprise light duty UPVC conduit in compliance with AS 2053. The conduit shall be of minimum size 20mm diameter and shall be complete with moulded PVC conduit fittings fixed with approved adhesive cement. All fittings and wall boxes used in conjunction with the conduit shall be of the same manufacture and material as the conduit.

Corrugated PVC conduit shall only be installed with the prior approval of the Macquarie University Property.

Heavy Duty UPVC Conduit

HD UPVC conduit shall comply with AS 2053 and with 'Category A' enclosures as defined in the SAA Wiring Rules. All fittings shall be of the material specified for the piping and all joints shall be made with an approved adhesive cement.

4.6 CABLE SUPPORT SYSTEM**General**

Bends, connectors, trays, ladders, brackets and other supports necessary to make a complete cable or conduit support system must be of the same manufacture, sized to adequately support the installed cabling.

Cable Trays

Cable trays shall have a cold rolled galvanised finish and shall be machine press formed with both edges returned a minimum of 50mm for stiffening. Tray shall be formed in 3 metre lengths and shall be of the following minimum gauges:

Width of Tray	Thickness of Material
75, 100, 150 mm	1.0 mm
225 mm	1.2 mm
300 mm	1.6 mm

Cable Ladder

Cable ladder shall be manufactured as specified for cable tray. Bends shall have a minimum inside radius of not less than 12 times the outside diameter of the largest cable carried.

Cables smaller than 13mm diameter are not to be installed on ladders unless continuously supported.

Spare Capacity

Provide spare space on all support systems for not less than 30% more cables or conduits than initially required to be installed.

Access

Position the support system to give adequate access for inspecting, replacing or adding cable. Provide a minimum of 150mm free space above the top edge and 600mm free space on one side of trays and ladders.

Cable Tying

Secure cables to the support systems by proprietary nylon ties, straps or saddles, at 800mm centres for vertical runs and 1200mm centres for horizontal runs. Use wide band stainless steel straps on fire rated cables.

Fire Rated Systems

Cable support systems for fire rated cables shall be of a type tested and approved to AS/NZS 3013 : 2005.

4.7 CATENARY SUSPENSION SYSTEMS

Catenary cable support systems may be used to replace cable trays for retrofit installations where the installation of new cable trays is deemed impractical.

Use high tensile multi-stranded galvanised steel cable with proprietary fixings and proprietary compression crimped rigging fittings. Provide cable tension adjustment.

Use only where structurally sound fixing into solid concrete masonry is achieved with chemical anchors. Provide load calculations and do not load beyond 70% of rating.

4.8 CABLE TROUGHING

General

Cable troughing and fittings shall be of approved manufacture and shall be complete with clip-on type covers, formed true and straight and returned not less than 10 mm over the sides of the troughing.

Cable troughing shall be fixed to walls or supported in an approved manner at minimum 1200 mm centres. Each length of troughing shall have at least two (2) fixings or supports.

Cable troughing shall be installed in such a manner that the demountable covers are accessible.

Retaining clips shall be installed to retain the wiring at intervals not exceeding 1000 in all locations except where cable troughing is run horizontally with covers uppermost.

Plastic Troughing

Plastic troughing shall be U.P.V.C. The troughing and covers shall be robustly constructed from heavy gauge material to avoid sagging between supports and to avoid warping. All associated fittings shall be of similar material to the troughing.

Metal Troughing

Metal troughing shall be of approved design and construction. The troughing and covers shall be of galvanised sheet steel or aluminium of minimum 0.8 mm thickness and shall be free from burrs and sharp edges.

4.9 SKIRTING DUCTING

Skirting wiring ducts must satisfy these requirements:

Type	Use only extruded aluminium duct with drop in cover plates.
Size	Minimum 50mm deep x 150mm high with two channels.
Accessories	Provide purpose made accessories and covers to match the duct system. Use screw fixed covers or clip-on covers removable only with the use of tools. Provide machine punched holes for outlets.

4.10 UNDERGROUND CABLING

General

All underground power cabling shall be enclosed in orange coloured heavy duty PVC conduit installed with a minimum of 750mm cover.

Existing Site Services

Prior to excavation, obtain the University site services plan for the respective area. Where the site services plan is not available or is unclear, carry out a specialist site survey.

Where the services plan or site survey indicates significant or hazardous inground conditions, the excavation shall be carried out by hand.

Excavation around major tree root systems or similar sensitive areas shall be carried out using non-destructive vacuum excavation systems.

University Standard

Comply with University standard specification for underground excavation and trenching.

Trenching

All trenching shall be excavated to an even surface free from sharp projections. Lift all unit pavers and saw cut in-situ paving to facilitate restoration.

Conduits shall be bedded on a minimum of clean sand and covered by a further minimum of 50mm of clean sand prior to backfilling.

After the laying of the cables / conduits the trench shall be backfilled with spoil removed from the trench and all excess spoil shall be removed from the site.

Marker Tape

A 150mm wide yellow or orange marker tape bearing the words "WARNING – ELECTRIC CABLE BURIED BELOW" or similar shall be laid in each trench 150mm below ground for the entire length.

Reinstatement of Paved Surfaces

On completion, any existing paved surfaces affected by the works shall be reinstated to their original condition and level using specialist tradesmen as required.

Where necessary the new paving shall be keyed into the existing.

Marking Plates for Underground Cabling

Provide engraved brass marker plates to indicate the routes of underground cabling / conduits. Each plate shall be 75mm x 75mm and of minimum thickness 1mm and shall be screw fixed to a concrete block approximately 150 x 150 x 300 deep located immediately above the cable / conduits. The plates shall be installed in the following locations:

- Where underground cables / conduits enter the building
- At each change in direction of underground cabling / conduits
- At the point of termination of underground conduits

At the point at which an underground cable / conduits enters or leaves a building the marker plate shall be engraved with an arrow pointing in the direction in which the cable is laid and the words "ELECTRIC CABLE".

At each change of direction, two (2) marker plates shall be installed. Each plate shall be engraved with an arrow pointing in the direction in which the cable / conduits is laid and the words "ELECTRICAL CABLE".

At the point at which an underground conduit is terminated the marker plate shall be engraved with the words "CONDUIT TERMINATED BELOW".

4.11 CABLE PITS**Locations**

Provide draw-in or turning pits at maximum 50 metre spacing along cable routes. Pits are to be sized to enable adequate space for the installation of initial and future cabling without damage to the cables.

Cable pits are not to be installed in roadways or similar trafficable locations unless unavoidable and subject to approval by Macquarie University Property.

Pit Types

Pits shall generally comply with the following:

Location	Pit Type
Landscaped Areas	Polyethylene or polycrrete pits complete with a precast concrete or galvanised steel cover.
Footways or Cycleways	Polyethylene or polycrrete pits complete with a precast concrete plinth and galvanised steel cover.
Footways which may be mounted by a vehicle	Polycrrete or precast concrete pit complete with Class B cast metal cover.
Pedestrian areas open to slow moving traffic	Polycrrete or precast concrete pit complete with Class B cast metal cover.
Roadways	Precast concrete pit complete with Class C cast metal ribbed cover.

All pits and pit covers shall be installed in accordance with the pit / pit cover manufacturers recommendations for the respective duty class to AS3996 : 2006.

Labelling

An engraved brass label shall be securely fixed to the cover of all cable pits to clearly indicate their function and the direction of the incoming and outgoing cabling.

Drainage

Pits shall be bedded on a minimum of 100mm of gravel aggregate which shall extend under the entire pit bottom. Pits shall be installed with covers flush with the finished ground level. For each pit a rubble drain of minimum 300 x 100 deep shall be provided and graded away from the pit a minimum distance of 2 metres.

4.12 CABLING IN SERVICES TUNNELS

Non Fire Rated Environment

The underground Services Tunnels are not to be considered as a fire rated environment. All cables installed in Services Tunnels and which serve safety services or other critical loads shall be fire rated.

5 ACCESSORIES

5.1 LIGHTING SWITCHES

Lighting switches shall be rated at 10 amps minimum. Where controlling fluorescent lighting loads, switches shall be specifically rated to withstand the transient currents with the associated switching currents.

Lighting switches shall generally be of the following preferred types:

Location	Preferred Make and Type
General Internal Areas	Clipsal '2000 Series' with PVC cover plates
Prestige Internal Areas	Clipsal '30 Series' switch mechanism complete with flat brushed finished stainless steel flushplate
Exterior Areas	Clipsal 'WSC Series' weatherproof switches, IP56 rated.
Plant and Industrial Areas	Clipsal '56 Series' switches

Labelling of Lighting Switches

Switches shall be clearly labelled to indicate designation of the respective lighting subcircuit.

Switches with clip-on cover plates shall be labelled by means of a printed label fixed to the grid plate behind the cover plate.

Switches with stainless steel flushplates shall be labelled by means of a printed label (black letters on silver background) fixed to the flushplate.

External and industrial switches shall be labelled by means of an engraved laminated plastic label securely fixed to the switch.

5.2 GENERAL PURPOSE OUTLETS

General purpose outlets shall generally be of the following preferred types:

Location	Preferred Make and Type
General Internal Areas	Clipsal '2000 Series' with PVC cover plates
Prestige Internal Areas	Clipsal socket outlet complete with flat brushed finished stainless steel flushplate
Exterior Areas	Clipsal 'WSC Series' weatherproof switches, IP53 rated and with rocker type switch
Plant and Industrial Areas	Clipsal '56 Series' switches

Labelling of General Purpose Outlets

All general purpose outlets shall be clearly labelled to indicate designation of the respective power subcircuit.

Internal outlets with clip-on cover plates shall be labelled by means of a printed label fixed to the cover plate and an indelible label written on the outlet behind the cover plate.

Internal outlets with stainless steel flushplates shall be labelled by means of a printed label (black letters on silver background) fixed to the flushplate.

External and industrial type outlets shall be labelled by means of an engraved laminated plastic label securely fixed to the outlet.

Colours of General Purpose Outlets

General purpose outlets shall be coloured as follows:

Outlets connected to General Supply Systems	Colour as per Architects selection..
Outlets connected to Generator Back Up Supply Systems	Internal outlets with PVC cover plates to be red. Internal outlets with stainless steel flushplates to have red coloured mechanisms. External and industrial type outlets to have circuit labels with red background.
Outlets connected to UPS Systems	Internal outlets with PVC cover plates to be blue. Internal outlets with stainless steel flushplates to have blue coloured mechanisms. External and industrial type outlets to have circuit labels with blue background.

Circuiting of General Purpose Outlets

A minimum of 10 socket outlets are to be installed on a 20 amp power subcircuit. In areas such as computer laboratories, this number can be increased subject to approval by Macquarie University Property.

Requirements for General Purpose Outlets

General Purpose outlets shall be installed in accordance with the specific briefing requirements of the respective project and the following guidelines:

- Office desk position – 2 double GPOs person, allow density of 1 person per 8m²
- Kitchen areas are to have a minimum of 2 circuits, with heating appliances connected to different circuits.
- Appliances with a load greater than 1kVA are to have a dedicated circuit.
- Lecture theatre seats – 1 double GPO every third seat divider.
- Plantrooms – 1 x 15A GPO IP56.
- Toilet – 1 double GPO (not including power for hand dryer/s)
- Corridors – 1 double GPO per 10m length.
- Lobbies / Foyers – 1 double GPO per 100m².
- Electrical and Comms riser or cupboards – 1 GPO per cupboard.
- Computer laboratories – 1 double GPO per seat.
- Seminar rooms – 1 double GPO per 3m of wall.

5.3 SWITCHED PLUG SOCKET OUTLETS

Single Phase Rated 15 Amps and 20 Amps

Internal Outlets: As per General Purpose Outlets

External Outlets or outlets in Plant or similar areas: Clipsal '56 Series'

Multi-Phase Outlets

Clipsal '56 Series'

5.4 SOCKET OUTLETS SERVING DATA EQUIPMENT CABINETS

Outlets shall be Clipsal '56 Series' complete with locking ring facility and matched to the power rail in the respective cabinet. Provide a matching plug complete with locking ring with each outlet.

5.5 ISOLATING SWITCHES

Isolating switches installed in plant areas, carparks, damp / wet areas or external areas shall be Clipsal '56 Series' outlets.

All isolating switches shall be installed in easily visible and accessible locations.

5.6 TIME DELAY PUSHBUTTON SWITCHES

Time delay pushbutton switches shall be of the electronic type and of the same make and type as lighting switches.

5.7 OCCUPANCY SENSORS

General

Occupancy sensors shall be provided in teaching, research and office areas to ensure that the lighting is not energised when the respective room is unoccupied.

The detectors shall be a standalone, mains voltage unit designed specifically for the switching of lighting. The contacts in the detector shall either be rated to switch the inductive load connected or the detector shall control a contactor rated for its duty.

The detector shall cover all locations where people may normally be expected to occupy. Additional detectors are to be provided where the room shape or obstructions will restrict the coverage of the detector.

The selection of detector types shall be made to ensure the maximum coverage in the respective space.

The detectors shall have a switch off delay between 15 and 25 minutes.

Detectors shall be of Energy Conservation Systems type or other as approved by Macquarie University Property.

Passive Infra-Red Detectors (PIR)

PIR detectors shall be used in small rooms and rooms that are subdivided with obstructions.

The detectors shall be selected based on the design range of the detector. Where a space requires more than three detectors to cover an open area a unit with a larger range should be specified.

PIR detectors should not be used in areas with areas of rapidly changing temperature.

Ultrasonic Detectors

Ultrasonic detectors shall be used in rooms that are of sufficient size to require more than three PIR detectors. They shall also be used in rooms with extensive divisions and obstructions.

Ultrasonic detectors shall not be installed adjacent to air conditioning registers or in areas subject to air movement or moving objects such as machines or ceiling fans.

Microwave Detectors

Microwave detectors interfere with campus Wi-Fi and so are unacceptable for use.

Switching

Irrespective of the presence of motion detection all rooms shall be fitted with switches at the door.

In lecture theatres and spaces that are likely to be blacked out, the switches are to be fitted with integral LEDs that illuminate when the switch is in the off position.

LIGHTING DIMMING

General

All lighting dimmers shall be of a solid state type matched to the respective luminaires.

5.8 Controllers shall preferably be of a pushbutton type and of the same style as lighting switches.

DALI Dimming

The use of DALI dimming is acceptable. Refer Clause 5.9.

5.9 DALI LIGHTING CONTROL
Preferred Type

DALI lighting control systems shall be of Clipsal manufacture unless otherwise approved by Macquarie University Property.

Power Supplies and Serial Interfaces

Power supplies, serial interfaces and similar devices shall be installed in easily accessible locations, preferably distribution board cupboards. The devices shall be housed in suitable sheetmetal enclosures and shall be clearly labelled.

Drivers and Ballasts

LED drivers and fluorescent ballasts shall be of matching type to the DALI system.

Switches and Sensors

Wall switches and sensors shall be installed on Clipsal 'Series 2000' wall plates unless otherwise approved by Macquarie University Property.

Sensor Devices

Sensor devices such as occupancy sensors, lux level sensors shall be of matching manufacture to the DALI system.

Dimmers

DALI dimmers shall be matched to the respective light source. Dimmers shall be installed in readily accessible locations preferably at the respective distribution board and shall be housed in an approved sheetmetal enclosure.

5.10 CONTROL OF EXTERNAL LIGHTING**Lighting within Building Footprint**

Lighting within the footprint of a building such as covered walkways, under building carpark, courtyards, perimeter lighting etc. shall be controlled by localised photoelectric / time controls as appropriate for the respective building.

Area Lighting

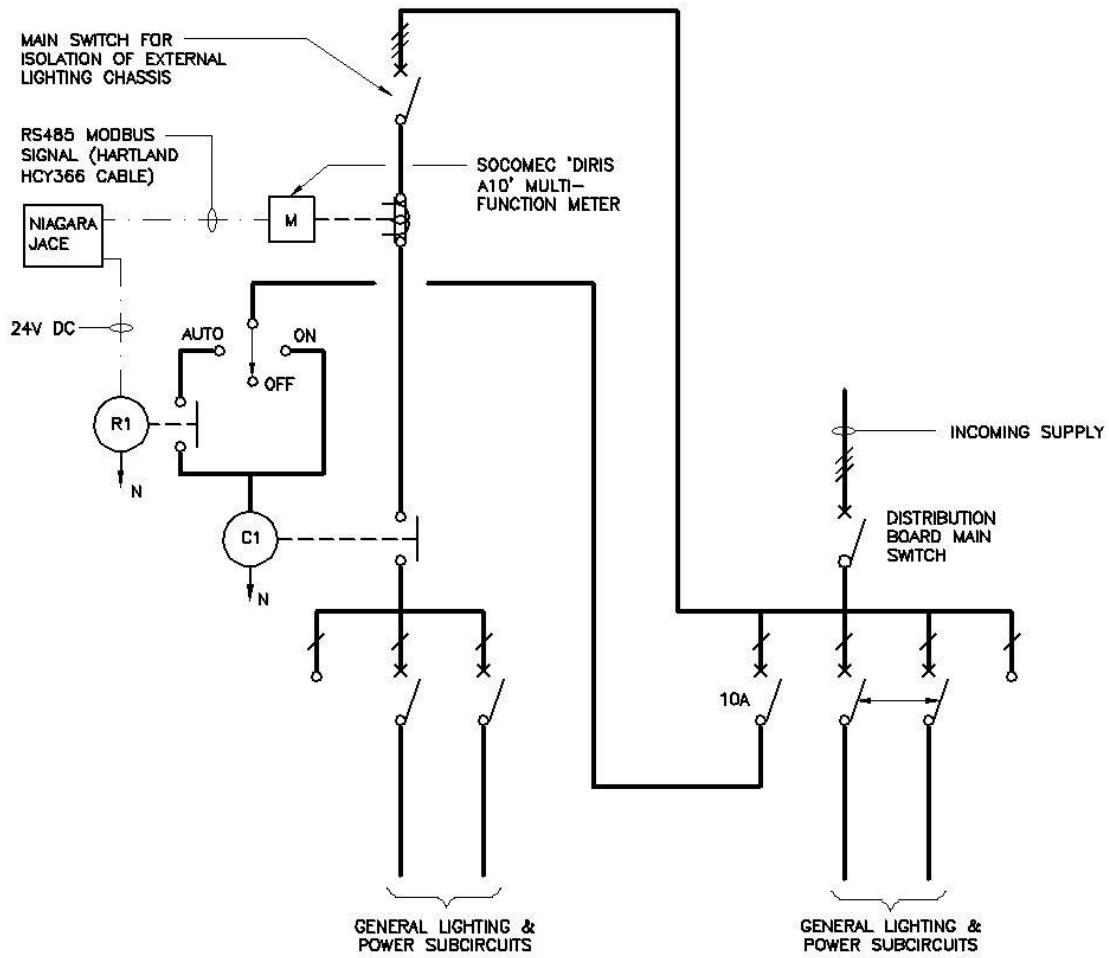
Area lighting, including pathways, roadways and external carpark lighting shall be controlled via the University Building Monitoring System (BMS).

Area lighting subcircuits shall be installed on a dedicated busbar chassis within the respective distribution board and controlled by a JACE controller and contactor together with a Socomec 'Diris A10' multi-function meter and an auto / off / manual bypass switch as indicated on the diagram following.

Where space prevents the installation of current transformers to suit all the Diris A10 meter, the direct reading Socomec 'Countis E33' meter may be installed subject to the approval of Macquarie University Property.

Data Outlets

At the position of each JACE controller provide a dual data outlet connected to the University data network and installed in accordance with the University Structured Cabling Standards.



TYPICAL AREA LIGHTING CONTROL CIRCUIT

6 LUMINAIRES

6.1 INTERNAL LUMINAIRES

Internal luminaires shall be selected to provide a energy and cost efficient method of illuminating the respective space.

Lighting shall comply with the requirements of AS1680 for both illuminance and glare.

Luminaires shall meet the following criteria:

- Manufactured by a substantial and well established manufacturer
- Incorporating an LED lighting source
- Use LED drivers of Tridonic, Osram or other well established manufacture acceptable to Macquarie University Property
- Replaceable LED modules to be used in linear LED luminaires
- Recessed luminaires to be connected via plug and socket connections to facilitate maintenance and replacement
- Luminaires to be designed for the respective environment.

6.2 EXTERNAL LUMINAIRES

External luminaires shall be weatherproof and selected to provide an energy and cost efficient lighting system for the respective area. Luminaires shall have a certified IP rating (to AS60529) to suit the respective location and shall be UV resistant.

External luminaires shall incorporate LED light sources where practical.

6.3 LIGHTING FLICKER

All LED lighting systems, including drivers and dimmers shall be designed to ensure that the associated lighting flicker is below the level which may affect the comfort and health of people in the respective area.

The maximum allowable Percentage Flicker shall be 0.08 times the flicker frequency (Refer IEEE PAR 1789 dated 2015).

In this regard, pulse width modulation drivers and dimmers shall be avoided.

6.4 AREA LIGHTING

Area lighting shall generally meet the requirements of AS1158 for the function of the respective area.

Area luminaires shall be of We-ef Pty Ltd manufacture unless otherwise approved by Macquarie University Property and shall be selected to suit the particular application. Luminaires shall incorporate LED light sources wherever practical.

6.5 AREA LIGHTING POLES

Area lighting poles shall be of International Poles manufacture.

Poles shall be baseplate mounted and secured to substantial concrete footings.

Poles for streetlighting shall generally be 7 metres in height. Poles for pathway lighting shall be 4 metres in heights.

Poles shall incorporate a 300 x 100 gear compartment (minimum 450mm above ground) to house luminaire control gear (if required) and terminals for connection of incoming cabling.

An engraved metal plate is to be fixed to the bottom of all lighting poles giving the pole identification number (Refer MUP) and full details of the respective area luminaire.

6.6 LED LIGHT SOURCES

LED light sources shall be 4000°K unless otherwise approved by Macquarie University Property.

6.7 ACCESSIBILITY

Where luminaires are mounted greater than 3.5 metres above the ground or above an uneven floor or above fixed furniture or equipment, the design shall consider the method of maintenance access. The method must be safe and efficient, not require the use of scaffolding or more than two people and be in accordance with OH&S requirements.

7 EMERGENCY AND EXIT LIGHTING

7.1 LUMINAIRES

Emergency and Exit luminaires shall be Clevertronics manufacture complete with 'L10 Optimum' lithium batteries.

The luminaires shall be complete with facilities to interface with a Clevertronics 'Zoneworks XT' powerline monitoring system.

7.2 MONITORING SYSTEMS

Clevertronics 'Emergency Lighting Controllers' shall be installed at distribution boards throughout the respective installation to enable the emergency lighting installation to be monitored via the University data network. A dual data outlet shall be installed at each lighting controller for this purpose.

8 LIGHTING AND SERVICES CONTROL SYSTEMS

8.1 APPROVAL

Lighting and services control systems such as C-Bus, Dynalite and KNX may be installed in appropriate installations but only with the prior approval of Macquarie University Property.

8.2 PREFERRED SYSTEM

The preferred system in the University is Clipsal C-Bus. Other systems may be considered but only specified with the approval of Macquarie University Property. The selected system shall be BACnet addressable by means of a suitable gateway.

8.3 CONTROL CABLING

Control cabling for such systems shall be selected to suit the respective system and shall be complete with a distinctive colour sheath to differentiate it from other cabling systems. Control cabling shall not share cable pathways with communications cabling.

8.4 HARDWARE

Where installed at distribution boards, control system relays, power supplies etc. shall be installed in separate segregated sheetmetal cubicles.

Switches shall be Clipsal '2000 Series' C-Bus switches unless otherwise approved by Macquarie University Property.

8.5 PROGRAMMING

On completion of the installation the Contractor is to provide to Macquarie University Property full details of the completed programming on compact disc or other non-corruptible media.

9 ELECTRICAL INSTALLATIONS IN PATIENT AREAS

9.1 REQUIREMENT

Electrical installations in patient treatment areas shall comply fully with AS/NZ 3003, including colours of power outlets and signage.

9.2 TESTING AND CERTIFICATION

As part of the contract works, the Contractor shall engage an experienced specialist testing company to test and inspect the completed installation for compliance with AS 3003. Written certification shall be provided as part of the 'As Installed' documentation.