SECTION 7: ELECTRICAL SERVICES
CONTENTS

7.1 GENERAL

This section provides details of mandated minimum requirements for the design, installation and operation of Electrical Services. The Engineer/Consultant is expected to produce their own specification incorporating the elements of the following information and submit all designs to the Manager Engineering and Infrastructure for review prior to tendering or any works commencing on site. This Design Standards set out the University's minimum requirements and shall be considered an adjunct to all relevant statutory regulations and codes relevant to the works.

The Engineer/Consultant must use the Modification Request Form to obtain approval for any departure from any clause in the Design Standards.

All works, irrespective of the nature of the installation, shall incorporate value engineering in respect to energy saving, maintenance costs etc.

The Engineer/Consultant shall read this Electrical Services Design Standard in conjunction with the other sections of the University's Design Standards document.

Should any discrepancy occur between this section and other sections of the Design Standard or any of the mandatory requirements on the Australian Standards listed in Section 7.1.2 the more onerous requirement shall be adopted.

This section of the Design Standards includes:

- Electrical Switchboards (MSB, DB, MSSB)
- Low Voltage (LV) Distribution
- Power Factor Correction (PFC)
- Active Harmonic Filtering (AHF)
- Metering and Energy Monitoring
- Accessories and Equipment
- Lighting and Lighting Control Systems
- Exit and Emergency Lighting
- Stand-by Power Systems
- Photovoltaic Systems (PV)
- Testing, Commissioning and Operational Maintenance

It does not cover the following items;

- High Voltage (HV) distribution.
- Information Technology, Telecommunications and Communications. Refer to Section 21 - The University of Melbourne Computer and Network Accommodation Strategy (CANAS) standard, and Section 20 - The University of Melbourne Standards for the Installation of Telecommunications Networks document.
- Audio Visual systems and technologies. Refer to Section 18 – Audio Visual Services Design Guidelines.
- Theatrical lighting technologies and control systems.
- Freezer Farm Mechanical system design. Refer to Section 16 - Laboratory Refrigerator and Freezer Design Standards

7.1.1 Design Principle

Electrical systems are to be designed in accordance with the requirements of the Design Standards. The systems are to be designed and installed in a safe manner which simplifies future maintenance and replacement. Systems are to be designed and installed to meet current and expected future capacity requirements. In general, the

future capacity requirements for major infrastructure (i.e. consumer mains, MSB etc.) is 30%, however in some circumstances additional (or less) may be required. Any future capacity requirements must be confirmed with the Manager Engineering and Infrastructure. All new systems shall be designed and installed such that major modification is not required to extend the system.

In accordance with Green Star Design and As-Built Credit 3.1, it is encouraged that Electrical systems are designed such that they are resilient to the impacts of a changing climate and natural disasters. A Climate Adaptation Plan may be required (refer Section 3: Sustainable Design).

Refer to Section 3: Sustainable Design for details of the University's Green Star requirements.

Application of Green Star credits

The Green Star credits referred to in this section apply, at a minimum, to new buildings and major building refurbishments.

7.1.2 Heritage Requirements

Contractors shall note that various buildings on the campuses are heritage protected. Electrical system installation methods in these areas require approval by the Heritage Consultant and the University's Project Manager prior to any installation.

The contractor is to minimise interference with the original building fabric and is to note original architectural details and locations and record as necessary to ensure accurate and complete reinstatement.

All wiring shall be concealed within existing wall cavities. Where wall chases are unavoidable, proposed wall chases shall be marked and approval sought prior to proceeding.

A list of heritage listed buildings is available from the Heritage of Council Victoria and local Municipal Council's website.

7.1.3 Standards and Regulatory Requirements

This section provides details of the main Standards and regulatory requirements for the design, installation and operation of electrical systems. The list is not exhaustive and the Engineer/Consultant is required to ensure that the requirements of the latest edition of all the relevant Standards and regulating requirements are complied with.

Code	Description
AS/NZS 1158 Set	Code of Practice for Public Lighting
AS/NZS 1170.4	SAA Loading Code - Earthquakes
AS/NZS 1345	Identification of the Contents of Piping, Conduits and Ducts
AS/NZS 1627 Set	Metal Finishing - Preparation and Pre-treatment of Surfaces
AS/NZS 1680 Set	Interior Lighting
AS/NZS 1768	Lightning Protection
AS/NZS 1882	Earth and Bonding Clamps
AS/NZS 1939 Set	Degrees of Protection (IP Code)
AS/NZS 2053	Conduits and Fittings for Electrical Installations

AS/NZS 2067	Substations and High Voltage Installations Exceeding 1 kV A.C.
AS/NZS 2756	Low Voltage Switchgear and Control Gear
AS/NZS 2243	Safety in Laboratories
AS/NZS 2293 Set	Emergency Evacuation Lighting in Buildings
AS/NZS 2676	Installation and Maintenance of Batteries in Buildings
AS/NZS 2785	Suspended Ceilings, Design and installation
AS/NZS 2982	Laboratory Design and Construction
AS/NZS 3000	SAA Wiring Rules
AS/NZS 3008	Electrical Installations – Selection of Cables
AS/NZS 3010	Electrical Installations – Generating Sets
AS/NZS 3012	Electrical Installations – Construction and Demolition Sites
AS/NZS 3017	Electrical Installations — Verification Guidelines
AS/NZS 3019	Electrical Installations — Periodic Verification
AS/NZS 3100	Approval and Test Specification – General Requirements for Electrical Equipment
AS/NZS 3111	Approval and Test Specification for Miniature Overcurrent Circuit-Breakers
AS/NZS 3140	Approval and Test Specification - Edison Screw Type Lamp Holders
AS 3439.1	Low Voltage Switchgear and Control Gear Assemblies
AS/NZS 3820	Essential Safety Requirements for Electrical Equipment
AS/NZS 3947.3	Low-Voltage Switchgear and Control Gear - Switches, Disconnectors, Switch-Disconnectors and Fuse-Combination Units
AS 4282	Control of The Obtrusive Effects of Outdoor Lighting
AS/NZS 4680	Hot-Dip Galvanized (Zinc) Coatings on Fabricated Ferrous Articles
AS/NZS 4777 Set	Grid Connection of Energy Systems Via Inverters
AS/NZS 4792	Hot-Dip Galvanized (Zinc) Coatings on Ferrous Hollow Sections, Applied by a Continuous or a Specialized Process
AS/NZS 5000 Set	Electric Cables - Polymeric Insulated - For Working Voltages Up to and Including 0.6/1 kV
AS/NZS 5033 Set	Installation and Safety Requirements for Photovoltaic (PV) Arrays
AS/NZS 60598 Set	Luminaires
AS/NZS 60921 Set	Ballasts for Tubular Fluorescent Lamps - Performance Requirements
AS/NZS 60922 Set	Auxiliaries for Lamps - Ballasts for Discharge Lamps - General and Safety Requirements

AS/NZS 60923	Auxiliaries for Lamps - Ballasts for Discharge Lamps - Performance Requirements
AS/NZS 60925	D.C. Supplied Electronic Ballasts for Tubular Fluorescent Lamps - Performance Requirements
AS/NZS 61000 Set	Electromagnetic Compatibility
AS/NZS 61048	Auxiliaries for Lamps - Capacitors for Use in Tubular Fluorescent and Other Discharge Lamp Circuits - General Safety Requirements Capacitors for Use in Discharge Lamp Circuits
AS/NZS CISPR Set	Electromagnetic Compatibility

Comply fully with all relevant Standards and Regulatory Codes published and in force at the time of construction, including the following:-

- The Commonwealth and State Electricity Acts and Regulations
- Victorian Service and Installation Rules
- Victorian Electricity Distribution Code
- Occupational Health Safety & Welfare Act and Regulations
- National Construction Code (NCC)
- Electricity Supply Authority Service Rules and Conditions of Supply
- Energy Safe Victoria Regulations and Legislation
- Disability Discrimination Act (DDA)
- All Local Council regulations
- Worksafe Victoria
- Environment Protection Authority
- Australian Communications Authority (ACA)

7.2 ELECTRICITY SUPPLY

7.2.1 General Requirements

Distribution of services to new buildings should be via crawl culverts or tunnels connected to adjoining existing buildings, where possible.

The Consultant/Engineer shall prepare Single Line Diagrams for the entire distribution system. Calculations and a report shall be prepared to support the correct settings/rating, operation and discrimination of protective devices and be made available on request.

The Consultant/Engineer shall prepare fault level calculations estimating the fault level at all parts of the electrical distribution system. The fault withstand of the distribution equipment shall be specified in accordance with the results of the calculations.

The Consultant/Engineer shall observe appropriate segregation of circuits at different voltages for safety and avoidance of electromagnetic interference. It should be noted that certain University buildings and equipment are sensitive to electromagnetic interference.

7.2.2 Parkville Campus

The Parkville campus is provided with twenty-five (25) indoor CitiPower substations with various ratings and arrangements. LV electricity supply is distributed from the substations to buildings via precinct/building level Main Switchboards (MSB).

7.2.3 Southbank Campus

The Southbank campus is provided with five (5) indoor CitiPower substations with various ratings and arrangements. LV electricity supply is distributed from the substations to buildings via precinct/building level Main Switchboards (MSB). In addition to the substation supply, the Southbank campus is also provided with LV street supplies serving peripheral locations on the campus.

7.2.4 Werribee Campus

The Werribee campus is provided with two (2) CitiPower/Powercor substations. One (1) substation is in an open bush arrangement with the other in an indoor arrangement. LV electricity supply is distributed from the substations to buildings via precinct Main Switchboards (MSB).

7.2.5 Burnley Campus

The Burnley campus is provided with one (1) CitiPower substation. LV electricity supply is distributed from the substation to buildings via a precinct Main Switchboard (MSB).

7.2.6 Hawthorn Campus

The Hawthorn campus is provided with one (1) CitiPower substation. LV electricity supply is distributed from the substation to buildings via a precinct Main Switchboard (MSB).

7.2.7 Other Campuses

The remainder of the campuses (Dookie, Shepparton, Creswick) are generally provided a combination of substations (pole and pad mount) and/or Supply Authority LV street supplies.

7.2.8 Supply Capacity

The supply capacity adequacy must always be assessed prior to proceeding with detailed design of all minor and major projects. For new installations, approval must be provided by the Manager Engineering and Infrastructure for all new points of connection.

All projects require the existing and new maximum demand calculations to be provided to the Manager Engineering and Infrastructure for review. An increase in supply capacity must be requested by the Consultant/Engineer to the Electrical Supply Authority. The Consultant/Engineer shall liaise with the Supply Authority and assist the University with negotiations, including submission of applications, relating to reinforcement of existing and new electrical supplies.

All new connections (including new substations) shall be provided with 30% spare capacity for future growth. In some instances, spare capacity greater than 30% may be required. The spare capacity provision must be approved by the Manager Engineering and Infrastructure prior to design commencing.

7.3 SWITCHBOARDS

7.3.1 General Requirements

This section applies to all new MSB's, DB's and MSSB's. All new switchboard locations shall be approved by the Manager Engineering and Infrastructure prior to implementation.

New MSB's shall be installed within a 2-hour fire rated room. MSB rooms shall be provided with a thermostatically controlled fan for ventilation. Temperatures within the

MSB room shall be kept below 35 degrees to avoid derating of switchgear. MSB room doors shall be provided with the University Bi-Lock key system. MSB rooms to be provided with adequate space for Power Factor Correction (PFC) and Active Harmonic Filter (AHF) units.

MSB rooms installed in basement levels shall be above flood levels and shall be provided with bunding (minimum 200mm) at the entry doors to prevent water entering the MSB room. Basement level MSB rooms shall be provided with adequate drainage with drip detection. Any moisture detected within the drain shall raise an alarm to the BAS via a low-level interface connection. Signage shall be provided on MSB room doors, the signage shall read 'MAIN SWITCHROOM'. In general, MSB rooms shall not be established in areas subject to flooding and moisture ingress.

All new DB's shall be installed in cupboards and in accessible areas. DB's shall not be installed in enclosed rooms (other than plant rooms) or offices. DB's installed in a path of egress shall be provided with smoke seals. Cupboard doors to be provided with University Bi-Lock. Signage shall be provided on cupboard doors indicating the content of the cupboard.

All new switchboard installations shall be scanned with a thermographic camera immediately when the switchboard is energised and is at full load. Further scans are required six (6) months into the Defects and Liability Period (DLP) and four (4) weeks prior to the end of the DLP.

The thermographic scans shall be undertaken on the following;

- Exterior of switchboard
- Cable terminations
- Busbar links
- Switches
- Isolating links
- Circuit breakers

Any abnormalities shall be immediately reported to the Manager Engineering and Infrastructure and shall be rectified without delay.

Thermographic scan photos and report shall be submitted to the Manager Engineering and Infrastructure.

7.3.2 Main Switchboards (MSB)

The MSB shall be specified as a custom-built type-tested assembly and shall be designed to comply with the requirements of AS3000, AS61439, AS3947 and the additional requirements of the University as set out in this Design Standard. Modular construction MSB's are not permitted.

MSB enclosures shall meet the requirements of the relevant Australian Standard for the degree of protection. Generally, the Form of segregation for a MSB with ratings of 800 Amps and above shall be Form 3B (Form 3B IH will not be accepted), for lower rated MSB's it shall be Form 2A. Modular construction MSB's are not permitted.

Adequate support shall be provided for all busbars and the like to withstand the stresses caused by a prospective maximum fault current of not less than 50 kA for one second.

Tenderers are required to submit full details of the switchboard with their tender, together with the name of the testing authority and relevant information regarding the fault current rating of the switchboard. A type test certificate must be provided for all new MSB's.

Prior to manufacturing the MSB, comprehensive shop drawings, together with all relevant data relating to the proposed MSB, shall be submitted to and approved by the Manager Engineering and Infrastructure.

Switchboard design shall incorporate the following:

- The Engineer shall confirm the University's requirement for spare capacity during the design phase.
- Conductors of fire and smoke control equipment, evacuation equipment and lifts shall be segregated, and in a separate switchboard compartment. Provide adequate labelling in accordance with AS/NZS 3000.
- Cubicles to be manufactured from 2mm mild steel, folded and welded where required to form a rigid self-supporting structure.
- Doors to be manufactured from 2mm mild steel and fixed with chrome plated lift off block hinges and secured with chrome plated knurled captive head machine screws.
- The MSB shall be mounted onto a fixed galvanised dipped plinth manufactured from 75mm x 40mm channel iron.
- Louvred vents shall be provided fitted with fine filter material and perforated metal filter support which is to be vermin proof (whilst maintaining the IP protection rating).
- Gland plates shall be manufactured from 3mm aluminium, sealed with a gasket and bonded to earth.
- Busbars shall be manufactured from high conductivity (HCU) full radius edge or radius corner copper busbar. Joints to comply with test requirements using metric high tensile (grade 8.8) bolts and nuts.
- All busbars and busbar assemblies shall be designed to limit the rise in temperature to no more than 50°C above a 40°C ambient temperature when carrying the maximum current rating of each and all associated items of switchgear.
- All busbar supports shall be capable of supporting busbars for a temperature range of 15°C to 110°C in continuous service;
- Neutral busbars shall have the same current carrying capacity as the phase conductors;
- Readily removable busbar links shall be provided for specified current transformers;
- Busbars for the red, white and blue phases shall be colour coated. Colouring shall be by means of heat shrink (Thermoshrink or approval equivalent). Strips or bands of heat shrink shall be utilised to identify the neutral and earth conductors.
- Busbars shall extend to all spare poles/ways. The busbar rating shall be sized to the maximum pole capacity i.e. the busbar assembly serving a 400 Amp spare way/pole shall also be sized to 400 Amps.
- All joints, terminations and fixings shall be fully accessible.
- Provision shall be provided for 30% future expansion of the main busbar system; all junctions associated with the installation of copper busbar shall be established using full lap-joints or compression joints. Lap joints shall be secured using torqued bolt fasteners. Clamp joints will not be accepted.
- All 'live' sections of a main switchboard, within wiring chambers, etc. shall be fully insulated to prevent contact with live parts.
- Provide LED indicator lights to identify if all three (3) phases of mains power is available. The LED lights shall be Red, White and Blue.

- Control of outgoing supplies shall be as follows:
  - up to 800 Amps – moulded Case Circuit Breaker
  - 800 Amps and over – withdrawable Air Circuit Breaker
- The provision of a positive air ventilation system for the main switchboard room to minimise dust entry shall be considered. This requirement shall be confirmed with the Manager Engineering and Infrastructure.
- Internal switchboards shall be provided with protection to AS 1939 IP42.
- External switchboards shall be provided with protection to AS 1939 IP56.
- Free-standing MSB's with rear access shall be provided with rigid removable panels with lifting handles and captive knurl-headed fixing screws.
- Removable panels shall be supported by locating dowels or pins to provide support for the panel when the fixing bolts are removed.
- Provide surge protection.
- All new MSB's shall be Storm Grey in colour.
- Shall be installed and configured in accordance with all statutory requirements, and the Supply Authority requirements.
- An arc flash analysis will need to be undertaken for all new MSB's. All safety requirements and procedures of the analysis to be incorporated into the MSZB design and manufacture.
- All new MSB's shall be of one of the following approved manufacturers;
  - Aline
  - R.G Ladd
  - LAI Switchboards
  - Trinity Switchboards

  Alternatives will not be accepted.

Switchboard labelling

All switchgear, apparatus, terminal strips and controls shall be labelled in accordance with the Supply Authority's requirements and to the following:

Lift-off panels shall be labelled to identify their location on the main switchboard.

Labels shall be provided for Safety/Essential Services, which are deemed to include the following:

- Fire protection equipment;
- Fire indicating panel;
- Passenger elevators;
- Circuits supplying computer LAN, WAN or computer equipment;
- Circuits controlling emergency luminaires;
- Circuits controlling security or building access control equipment;
- Main switches controlling safety services shall be identified to indicate the equipment that they control and be marked 'IN THE EVENT OF FIRE, DO NOT SWITCH OFF'.

Traffolyte labels shall be installed on the front doors and shall be fixed with chrome-plated screws. The labels shall indicate the capacity of the unit, the rating of installed protective devices and the outgoing cable reference. Labels shall also be installed adjacent to the load terminals.

All essential safety services are to be colour coded separately. Labelling colours are defined as follows:

- GENERAL: Black lettering on white background;
- MAIN SWITCH AND CAUTION: Red lettering on white background;
- DANGER/WARNING LABELS: White lettering on red background.

Schematic Wiring Diagram

The Engineer/Consultant shall prepare a schematic wiring diagram of the complete switchboard. The wiring diagram shall include, but shall not be limited to, the following information:

- Main switch capacity, rating and trip settings
- Circuit breaker capacities, rating and trip settings
- Size and capacity of busbars
- Capacity, rating and arrangement of incoming supply
- Capacity, rating and arrangement of outgoing circuits
- Destination of submain supplies
- Size of main earth conductor and location of main earth electrode
- Type test rating of the Main Switchboard

An A1 laminated and framed copy of the Single Line Diagram shall be mounted within the MSB room adjacent the MSB.

7.3.3 Distribution Boards (DB)

Distribution boards shall generally be proprietary type panel boards constructed to Form 1 specifications and shall be manufactured by NHP or Schneider unless otherwise approved via a Modification Request Form.

100% spare pole capacity shall be provided for all distribution boards (i.e. 50% full). This may be reduced in some instances with the approval of the Manager Engineering and Infrastructure.

Distribution boards spare pole requirements shall be as follows:

- DB's with chassis sizes up to 48 poles to have 100% spare pole capacity (i.e., DB pole to be 50% populated).
- DB's with chassis sizes above 48 poles to have 50% spare pole capacity

Circuit breakers controlling final sub-circuits shall be manufactured by NHP or Schneider. Installation of lock dogs for all circuit breakers controlling special equipment shall be specified.

The installation of Duplex circuit breakers is not permitted.

All new DB's shall have the following:

- Isolating main switch to control each distribution board shall be provided.
- Busbars shall be type tested to a minimum of 20kA for 0.2 second.
- Split lighting and power chassis with 100% spare pole capacity

- Separate Power Monitoring Units (PMU) for lighting and power chassis. PMU's to be open protocol.
- Form 1
- IP42 for internal installations
- IP54 for external installations
- Front connected
- Cable entry and cable exit via gland plates
- Hinged doors (lift-off panels will not be accepted)

Freezer Farm rooms shall be provided with a dedicated distribution board. Each freezer and laboratory fridge shall be provided with a non-RCD protected dedicated final sub-circuit originating from the Freezer Farm distribution board, refer to the relevant section in AS3000 for non-RCD protected circuits. Where a Freezer Farm distribution board is not provided, a dedicated circuit shall be provided per fridge/freezer.

7.3.4 Mechanical Services Switchboards (MSSB)

In addition to the requirements of Section 7.3.3, all new MSSB's shall be Form 1, 2 or 3B to AS/NZS 61439 as required by the project. MSSB's with a supply of 800A or greater shall be Form 3B or a combination of Form 3B and Form 2. Final approval of the Form rating shall be provided by the Manager Engineering and Infrastructure.

Switchboards with Form 3B segregation shall be as per the University's requirements as described in Section 7.3.2 for main switchboards.

MSSB are to be generally located within plant rooms/electrical riser cupboards and must be in well ventilated areas. Externally located MSSB's must be marine grade, corrosion resistant or 3CR12 corrosion resistant steel construction and fitted with a sloped roof covering the entire MSSB with doors in open location.

All new MSSB's shall have the following:

- Isolating main switch shall be provided.
- Busbars shall be type tested to a minimum of 10kA for 0.2 second.
- 25% spare capacity in all compartments
- Form 2 or 3B (or a combination of 2 and 3B) for the mains distribution with input, output and functional units segregated using metallic compartments behind separate covers.
- IP54 for internal and external installations
- Front connected
- Cable entry and cable exit via gland plates
- Ventilation louvres on doors with internal mesh filters.
- Electrical orange X15 colour exterior with white internal escutcheon
- Green LED light for system RUN and Red LED light for system in FAULT. Lights to be mounted on the front of the MSSB.
- Internal condensation heaters for all externally located MSSB's.

7.3.5 Switchgear

All switchgear shall be manufactured and tested in accordance with the relevant Australian Standards. Switchgear and protection equipment must be of a uniform manufacture in any single installation. Switchgear ON/OFF positions must be visible when the switchboard escutcheon is closed. Circuit breakers and protection equipment must be of NHP or Schneider manufacture.

- For loads of 10 Amps up to 100 Amps, Miniature Circuit Breakers (MCB) shall be used. DIN mounted MCB's with integral RCD protection within a single pole shall be used
- For loads 100 Amps to 800 Amps, Moulded Case Circuit Breaker (MCCB) shall be used.
- For loads above 800 Amps, withdrawable Air Circuit Breakers (ACB) shall be used.

Discrimination and cascading

All protection devices shall be selected to enhance discrimination and avoid cascading between upstream and downstream devices. It shall be arranged so that only the protection device immediately upstream of the fault shall operate to clear the fault.

A discrimination study shall be provided as part of the switchboard shop drawing submission to confirm all circuit protection selections and settings.

7.3.6 Identification and Labelling

All new switchboards shall be provided with permanently fixed traffolyte labelling indicating the name of the switchboard. All new switchboards shall adopt the following naming convention; BNXXX.DB.Y-Z

Where XXX is the building number, Y is the floor number and Z is the switchboard number. Note MSSB shall be used instead of DB for mechanical switchboards.

In addition to the name label, the MSB and MSSB's shall be provided with a label showing the following minimum information;

- Rated current
- Rated voltage
- Short circuit fault current withstand
- Form rating
- IP rating
- Date of manufacture
- Supply mains size and arrangement
- Source of supply
- Miscellaneous equipment i.e. surge protection, time clocks, contactors etc.
- Main isolator rating
- Submain supply protection device
    - label to indicate name of switchboard being supplied
    - rating and protection setting
    - cable size

7.4 LOW VOLTAGE DISTRIBUTION

7.4.1 General Requirements

All new LV distribution systems shall be designed and installed to comply with the requirements of AS3000 and AS3008. Distribution systems shall be designed taking into consideration; current carrying capacity requirements, voltage drop and short circuit temperature rise.

A maximum of 5% voltage drop is allowed from substation to final sub-circuit, in some instances 7% may be used, however this needs to be approved by the electrical supply authority and the Manager Engineering and Infrastructure. The following voltage drop limits are applicable to all new and existing installations;

- Consumer mains – no greater than 1%
- Submains – no greater than 1.5%
- Final sub-circuits – no greater than 2.5%

All new cabling shall be copper, aluminium cabling is not permitted.

Any redundant cabling must be removed from site.

7.4.2 Consumer Mains and Submains

Current carrying capacity of consumer mains and submains shall suit the maximum demand in addition to 30% spare capacity, in some instances more than 30% may be required. Final approval shall be provided by the Manager Engineering & Infrastructure.

Cable joins are generally not permitted, however, if necessary, all cable joins must be;

- Approved by the Manager Engineering and Infrastructure
- Located in an accessible location
- In internal installations, only bolted joints with removable copper links will be accepted. The join must be enclosed within a sheet metal junction box with removable/openable door.
- In external installations, the join must be enclosed in a cable pit.

In-line joins and crimping of cables are not permitted.

All new consumer main cables shall be fire rated.

7.4.3 Final Sub-circuits

General power and lighting circuits shall be wired in not less than 2.5mm2 (Cu PVC/PVC or TPS minimum).

7.4.4 Busduct

Copper conductor busduct systems may be used in certain installations where appropriate. In general, busduct may be used to supply high current, non-fire rated loads. Final approval of the use of busduct to be provided by the Manager Engineering and Infrastructure.

7.4.5 Earthing

Protective earth cabling shall be in accordance with the requirements of AS3000.

All new substation installations require a new M.E.N to be installed within the substation, final sign-off shall be provided by Supply Authority.

Upgrade of existing MSB's connected to existing substations shall also include the establishment of a new M.E.N within the substation, final sign-off shall be provided by Supply Authority.

7.4.6 Cable Reticulation

Trench excavation, backfilling and compaction

Distribution of services to new buildings should be via crawl culverts or tunnels connected to adjoining existing buildings, where possible.

Drawings for existing underground services installed across the Parkville Campus are available from Campus Services and are to be used as a guide only, a detailed survey of the underground services is required to be undertaken prior to any excavation works.

New trenches shall be coordinated with existing underground services. Any trenching works shall be approved by the Manager Engineering and Infrastructure prior to commencement. Trenches shall be straight and parallel with the buildings, roadway, etc. Bitumen and concrete surfaces shall be cut prior to excavation by a concrete saw or similar. All surplus excavated spoil shall be removed from the site. All effected surfaces shall be reinstated to existing (or better) condition.

Underground cabling shall be installed in heavy duty non-metallic conduits in accordance with AS3000 and the following additional requirements:

- The minimum depth of laying and protection for underground wiring shall be 600mm (cover) below finished ground level.
- Conduits shall be embedded in a layer of clean washed sand to a minimum cover of 100mm followed by premium grade crushed rock in brick, concrete, bitumen areas or premium topsoil in garden areas.
- Marker tape shall be provided laid between 100mm and 200mm above the conduits. Trenches shall be allowed to remain open for the minimum length of time required for laying the conduits and cabling with due allowance for inspection. PVC marker tape complying with AS2648 part 1 shall be specified for cable trenches.
- Backfilling shall not commence until the laying of the conduit has been approved by the Manager Engineering and Infrastructure. The backfilling shall be compacted to 95% AASHO.
- All conduits shall be complete with suitable expansion couplers and suitable care shall be taken where conduits enter buildings to allow for earth/building movements. Conduits entering buildings shall be correctly sealed to ensure moisture does not enter the building from the outer perimeter of the conduit.
- Conduits located in hazardous areas shall be resistant against hydrocarbons and of type heavy duty fuel resistant ‘Nupi Smart Conduit’ or equivalent.
- Conduits shall be installed with suitable falls to allow for drainage
- Conduit segregation distances shall exceed the requirements of ACMA Regulations.
- After installation of cables all conduits shall be sealed to prevent ingress of dirt and moisture.
- Spare conduits shall be provided with draw wires and capped for future use.

50% spare conduits shall be provided in trenches, the final quantity of spare conduits shall be approved by the Manager Engineering and Infrastructure.

Cable markers shall be round stainless-steel flush type, complete with directional arrow. Markers to be provided every 20m in straight runs, where trenches change direction and where cables enter/exit buildings. Markers shall be selected from the Gatic range or as otherwise approved in writing by the Manager Engineering and Infrastructure.

The Contractor shall be responsible for the proper disposal (from the site) of all spoil and associated waste materials excavated during the project. The Contractor shall allow under the Contract to keep the Works Area clean and tidy and shall regularly remove from the site rubbish and surplus material arising from the execution of the work.

As-installed drawings must be provided for any underground conduit/cabling works.

Cable pits

Cable pits shall be installed at all changes in direction and at a maximum of 50m intervals.

Load Class C (minimum) pits shall be provided in trafficable areas in accordance with AS3996. New pits shall be constructed of steel reinforced pre-cast or in-situ cement concrete/fibre cement concrete. Pit lids to be heavy duty, cast iron with concrete/brick/pavement infill of Gatic manufacture.

Water ingress gaskets shall be provided to all new pit lids.

The pits shall be provided with drainage holes, located at the bottom of the pit to remove any ingress water. The Contractor shall ensure that sufficient drainage is provided to all pits, and to prevent water drainage through the conduits. This shall be undertaken in coordination with the pit manufacturer to ensure the integrity of the pit is maintained.

Provide embossed lids to all pits stating the contents of the pit i.e. 'ELECTRICAL PIT', ".

Pit lids are to be installed such that they do not cause a trip hazard and are flush with the existing surrounding area.

Underground cabling

Cables specified for underground wiring shall generally be elastomer or thermoplastic insulated with elastomer or thermoplastic sheathing (double insulated) complying with the relevant Australian Standard for underground cables, be enclosed in heavy duty rigid UPVC conduit and installed in Category A wiring system.

All underground wiring systems shall be fully coordinated with other services prior to any earth works to avoid clashes.

Cable trays and ladders

New cable trays and ladders shall be provided with 50% spare capacity.

All consumer mains and submains shall be installed on cable trays. Main runs of final sub-circuits are to be installed on cable trays.

Minimum cable tray thickness to be no less than 0.8mm.

The cable tray shall be galvanised steel with 20mm (minimum) high folder edges.

Slots or ladder rails shall be suitable for fixing cable ties, strapping or saddles.

Position cable tray supports to give adequate access for inspecting, replacing, or adding cable.

Provide a curved support surface under cables leaving the tray or cable ladder to protect the cable sheath from any sharp edges tray or ladder.

Segregation from communications, security etc. cabling shall be provided in accordance with the relevant standards.

Fire rated cables shall be installed in accordance with AS3000 and AS3013. Cables shall be fixed with certified steel cable ties with maximum 1000mm centres.

Earth all cable trays, ladder trays in accordance with the requirements of AS3000.

Conduits

Conduits shall not be installed in visible locations (i.e. on internal/external walls, ceilings and floors). Conduits shall be concealed in wall cavities, chased into floor slab.

Use metallic conduits in locations where mechanical damage is possible. All metallic conduits shall be galvanised steel in accordance with AS1074.

All conduits shall be mounted using dual fixing saddles spaces at a maximum of 1m intervals.

Flexible couplings shall be used at building expansion joints and in straight runs where mounted to a wall.

All spare conduits shall be provided with draw wires for future cable reticulation.

All conduits shall be sealed to avoid water ingress.

Floor boxes

Floor boxes shall be flush mounted, with hinged removable lids. Heavy duty floor boxes shall be specified in areas where heavy machinery may be used i.e. cherry picker etc. floor boxes shall be suitably selected to be fit for purpose in nominated areas.

Floor boxes locations shall avoid structural beams, sign off from a structural engineer is to be obtained prior to any on-site works.

All new floor boxes shall be of ECD manufacture.

Floor box design must ensure that cables cannot be 'pinched' when the floor box lid is closed.

Table boxes

Table boxes shall generally be provided by the joinery trade. In the instances where they are provided by the electrical trade, the table box shall be of ECD manufacture.

Table box power outlets to be soft wired using ECD manufactured equipment.

Under no circumstances shall power outlets be hard wired to tables.

Skirting duct

Skirting duct shall be made from extruded aluminium with drop in cover plates complete with powder coated finish to suit the wall colour

All new skirting duct to be provided with two (2) compartments for power and data cabling.

All new skirting duct shall be of ECD manufacture.

7.4.7 Labelling

All label printing shall be machine generated permanently engraved Traffolyte labels. Adhesive labels (Brother/Dynamo type) or free handwritten labels are not acceptable.

The labelling system shall include but no be limited to:

- Provide labels including control and circuit equipment ratings, functional units, notices for operational and maintenance personnel, incoming and outgoing circuit rating, sizes and origin of supply.
- Provide labels of each sub-main cable at each terminated end. The label shall designate cable destination or switchboard origin as well as the size and type of cable installed (see example picture).

7.5 POWER FACTOR CORRECTION

7.5.1 General Requirements

Provide Power Factor Correction (PFC) unit to maintain Power Factor at or above 0.95 to all building MSB's for the buildings which they serve.

All PFC units shall be provided with de-tuning reactors to avoid damage caused by harmonics.

The PFC Unit design criteria shall be as follows:

- Nominal Operator Voltage: 400V-415V, three phase
- Rated insulation Voltage: 690V
- Nominal Operating Frequency: 50Hz
- Network Pollution Level: < 15% at 400V-415V
- Capacitance Tolerance: -5% to 10%
- Power Frequency Withstand Voltage: 2.5kV, 50Hz, 1 minute
- Operating Temperature: -5^{O} to $+60^{O}$C

PFC units shall have the following:

- Be provided with a minimum of two (2) muffin type axial fans (operating on mains power) per PFC unit cubicle to maintain temperatures to manufacturers requirements. Fans to be provided with removable and washable filters.
- A reactive power controller to control the automatic switching of each capacitor step to achieve the desired power factor. The controller shall have the following features:
    - Minimum of 6 steps
    - Manual on/off control for capacitors.
    - Multi-function display indicating stages activated, actual power factor, reactive current, active current and apparent current.
    - Built in alarm indicator of faults including over current, equipment failure, incorrect power factor, harmonics.
    - Built in alarm indicator for over temperature, fan failure.
    - Balanced cyclic use of capacitor steps to ensure uniform usage.
    - Front panel mounted, and accessible without door removal.
- Inductors to be mounted in a separate cubicle to the capacitors, fuses and switchgear
- Capacitors to be spaced a minimum of 50mm to allow for airflow between capacitors.

PFC's shall be provided with a High-Level Interface (HLI) to the University BAS. The HLI shall provide information on the system PF, report system operating temperatures and faults.

7.6 ACTIVE HARMONIC FILTERS (AHF)

7.6.1 General Requirements

All MSB's shall be provided with provisions of connection of an Active Harmonic Filter.

AHF's must be provided to the limit the total harmonic distortion (voltage and current) in accordance with the Victorian Electricity Distribution Code and to Supply Authority's requirements.

AHF unit shall be installed and located in a manner that does not affect the ventilation requirements of the unit. As a minimum, AHF shall be installed with 300mm on either side of the enclosure, 300mm from the ceiling to the top of the enclosure and 1,000mm in front of the enclosure.

AHF's shall be provided with a High-Level Interface (HLI) to the University BAS. The HLI shall provide information on mains and load side harmonics on all odd harmonics up to the 15th harmonic on both the voltage and current. The HLI shall also report system operating temperatures and faults.

7.7 METERING

7.7.1 General Requirements

Meter selection shall be based on the following table;

Service	Meter Selection
Incoming supply (i.e. MSB)	EDMI Mk10A 400V AC and Type 1
Distribution Board supply*	Type 3
Light and power chassis	Type 3
Mechanical services over 200 Amps	EDMI Mk10A 400V AC and Type 2
Mechanical services under 200 Amps^	Eastron SMD630MCT- LoRa Type 4
Solar PV systems	Type 2
Tenancy supplies	EDMI Mk10A 400V AC and Type 3

**only require if the distribution board does not have separately metered lighting and power chassis.*

^ only where the mechanical service is not fitted with a high-level interface (HLI) capable of recording and transmitting energy telemetry directly to the BAS via LonWorks or BACnet.

Current Transformers (CT) shall be WF Energy Control Manufacture, Extended Range type with accordance in accordance with AS 60044.1 Class 0.5S. CT's shall be provided with removal test links.

7.7.2 Multi-Function Meters Parameters

All multifunction meters listing in the previous section shall be of either NHP or Schneider manufacture.

Meter Type-1:

- Class 0.2S accuracy.
- Suitable for Large Scale Generator certificates.
- Approved by Clean Energy Regulator.
- Total Harmonic Distortion up to 32 harmonics.
- Harmonics analyser up to 128th harmonic.
- 10ms samples.
- Communication over IP. (Note University has multiple BAS systems and Microgrid innovative technology in place that require TCP, Modbus, RS232 and RS-485 communication protocol, metering platform shall be capable of open protocol type).
- Communications Ports: Ethernet and 2 x RJ45.
- Data logging capable of storing for at least 120 days.
- Measurement variables shall be as follows:
    - Disturbance Direction Detection for transient flickers, sag/swell, harmonics etc.
    - Voltage - L-N Avg, L-L A-B, L-L B-C, L-L C-A
    - Current - A, B, C, N, Current Avg
    - Power – kW Total, kVA Total and kVAr Total
    - Demand - Real Power Total, Apparent Power Total, Reactive Power Total (if available)
    - Energy - Reactive Energy into the Load, Reactive Energy out of the Load, Apparent Energy out of the Load (If available)
    - Power Factor - PF A, PF B, PF C
    - Frequency
    - Harmonic Distortion – THD Current A, B, C, N and THD Voltage A-N, B-N, C-N (if available), THD Voltage LL, Total
    - Demand Distortion

Meter Type-2:

- Class 0.2S accuracy.
- Panel mount.
- Suitable for Large Scale Generator certificates.
- Approved by Clean Energy Regulator.
- Total Harmonic Distortion up to 11th harmonics.
- Harmonics analyser up to 32nd harmonic.
- 32 samples/cycle.
- Communication over IP. (Note University has multiple BAS systems and Microgrid innovative technology in place that require TCP Modbus, RS232 and RS-485 communication protocol, metering platform shall be capable of open protocol type).
- Communications Ports Ethernet and dual RJ45.
- Data logging capable of storing for at least 90 days.
- Measurement variables shall be as follows:
    - Voltage - L-N Avg, L-L A-B, L-L B-C, L-L C-A
    - Current - A, B, C, N, Current Avg
    - Power – kW Total, kVA Total and kVAr Total
    - Demand - Real Power Total, Apparent Power Total, Reactive Power Total (if available)
    - Energy - Reactive Energy into the Load, Reactive Energy out of the Load, Apparent Energy out of the Load (If available)
    - Power Factor - PF A, PF B, PF C
    - Frequency

- Harmonic Distortion – THD Current A, B, C, N and THD Voltage A-N, B-N, C-N (if available), THD Voltage LL, Total
- Demand Distortion

Meter Type-3:

- Class 0.5S accuracy.
- Panel or DIN mount.
- Total Harmonic Distortion up to 11th harmonics.
- Communications Ports Ethernet or RS-485.
- Communication over IP. (Note University has multiple BAS systems and Microgrid innovative technology in place that require TCP Modbus, RS232 and RS-485 communication protocol, metering platform shall be capable of open protocol type).
- Data logging capable of storing for at least 30 days.
- Measurement variables shall be as follows:
  - Voltage - L-N Avg, L-L A-B, L-L B-C, L-L C-A
  - Current - A, B, C, N, Current Avg
  - Power – kW Total, kVA Total and kVAr Total
  - Demand - Real Power Total, Apparent Power Total, Reactive Power Total (if available)
  - Energy - Reactive Energy into the Load, Reactive Energy out of the Load, Apparent Energy out of the Load (If available)
  - Power Factor - PF A, PF B, PF C
  - Frequency
  - Harmonic Distortion – THD Current A, B, C, N and THD Voltage A-N, B-N, C-N (if available), THD Voltage LL, Total
  - Demand Distortion

Meter Type-4

- Class 0.5S accuracy.
- Panel or DIN mount.
- Communications: LoRaWAN v1.0.2 (minimum) Class C - AS923 – OTAAMeasurement variables shall be as follows:
  - Voltage - L-N Avg, L-L A-B, L-L B-C, L-L C-A
  - Current - A, B, C, N, Current Avg
  - Power – kW Total, kVA Total and kVAr Total
  - Power Factor - PF A, PF B, PF C

7.7.3 Supply Metering

Metering shall be provided at each building to allow the monitoring of the total energy use of a building. Building meters shall be of EDMI manufacture (model number: Mk10A 400V AC) and shall be connected to the University Clariti system.

A Single Line Diagram (SLD) shall be provided to the Manager Engineering and Infrastructure for approval of the proposed metering arrangement.

In addition to the above, multi-function metering shall be provided at the switchboard level to monitor separately the lighting and power chassis, lifts etc. in accordance with the requirements of the NCC. These meters shall not be connected to the Clariti system, however connection provisions shall be provided for connection to the BAS.

All Current Transformers (CT) must be provided with removal test links.

7.7.4 Network Monitoring

All EDMI meters shall be connected to the University Clariti energy monitoring system, using standard cellular connectivity as defined by EDMI/Clariti.

In addition, Type 1 and 2 meters shall be integrated with the University's Smart Campus platform using RS-485/Modbus connectivity. These meter types shall be supplied and connected to a RS-485/Modbus to Low Power Wide Area Network (LoRaWAN) controller. This controller must support the Australian LoRaWAN AS923 band-plan and over-the-air-activation (OTAA).The Consulting Engineer shall consult with the University's Smart Campus team in relation to the LoRaWAN design requirements supporting Type 1 and 2 metering.

All new multi-function meters shall be connected to the University BAS system via an appropriate LON based gateway router using ethernet cabling. Any devices communicating over the University network shall only communicate via LON. All new metering must connect to the University BAS via a dedicated gateway router.

Gateway routers shall be capable of storing at least 5 years of data at 15 minute intervals.

All Type 4 meters shall be connected the University's private Long Range Wide Area Network (LoRaWAN) with connectivity facilitated using the AS923 band-plan and over-the-air-activation (OTAA). These meters shall be integrated directly to the University Smart Campus platform.

The Consulting Engineer shall consult with the University's Smart Campus team in relation to the design requirements supporting Type 4 metering.

Data shall be exported to the University's Smart Campus platform in a format the conforms to platform's data standards

Devices (meters) shall be named by the Manager Engineering and Infrastructure during the commissioning process. Allow to provide a list of all devices which shall be connected to the University's telemetry platforms. This list must be inclusive of device MAC address (Ethernet) or DevEUI (LoRaWAN).

A metering topology schematic shall be provided to the Manager Engineering and Infrastructure for approval during the design phase

7.8 ACCESSORIES AND EQUIPMENT

7.8.1 General Requirements

All light switches, general power outlets, isolators etc. shall be of Clipsal or HPM/Legrand manufacture.

All mechanisms shall be of heavy duty type suitable for inductive loads and of Clipsal 30 USM manufacture (or HPM/Legrand equivalent). Mechanisms shall be mounted to accessory plates of Clipsal Classic C2000 series, HPM Standard series or Legrand Excel Life series manufacture and to be high impact polycarbonate.

Weatherproof switches shall be of Clipsal 56 Series (or HMP/Legrand equivalent) manufacture with locking provisions. Switches shall be UV stabilised where installed in external areas.

Chemical resistant switches shall be of Clipsal 56 Series (or HMP/Legrand equivalent) manufacture.

The following colour scheme shall be used for power outlets and lighting switches;

- Mains power White
- Generator power Red
- UPS power Green
- Cleaners outlet Blue

7.8.2 Lighting Switches

Light switches to be 15A rated and of Clipsal Classic C2000 series, HPM Standard series or Legrand Excel Life series manufacture.

Cable reticulation to light switches shall be via the existing wall cavity, surface mounted conduit is not permitted.

Light switches installed on fire rated walls shall be installed within a fire rated wall box to maintain the fire rating integrity of the surface

Label each light switch with the switchboard same and circuit breaker serving the switch with Traffolyte labelling. Dymo/Brother labelling will not be accepted.

7.8.3 Isolating Switches

All isolating switches shall have a minimum rating of 400V 20A, or to exceed the connected load (whichever is larger). Isolators shall be IP56 minimum in accordance with AS3000.

Where isolators are nominated as weatherproof they shall be of Clipsal 56 Series manufacture (or HMP/Legrand equivalent) with high impact polycarbonate casing and locking provisions (in ON and OFF positions).

Label each isolating switch with the switchboard name and circuit breaker serving the isolator and the item of plant served with Traffolyte labelling. Dymo/Brother labelling will not be accepted.

7.8.4 Switched Socket Outlets (SSO)

All SSO's shall have a minimum rating of 230V 10A. Mount to accessory plates of Clipsal C2000 series (or NHP equivalent) and to be high impact polycarbonate.

GPO's at workstations and hot desks shall be provided with Clipsal 30 Series USB Charger Mech (or NHP equivalent) USB outlets for mobile phone charging and the like.

Where SSO's are located on fire rated walls, they shall be installed within a with fire rated box to maintain the integrity of the wall. SSO's shall be typically mounted at a minimum of 300mm AFFL unless otherwise specified by the architect. SSOs shall be installed no closer than 500mm to any internal corner in accordance with DDA requirements.

Captive screw type outlets shall be Clipsal 56 Series (or HMP/Legrand equivalent) and to be provided for ultra-cold freezers. For regular fridges and freezers, Clipsal 10PL (or similar) shall be provided.

Label each outlet with the switchboard name and circuit breaker serving the outlet using Traffolyte labelling. Dymo or Brother type labelling will not be accepted.

Outlet quantities

Power outlet quantities shall be as follows;

- Office workstation Two (2) double GPO's
- Hot desk Two (2) double GPO's
- Printer One (1) double GPO
- Toilet hand dryer One (1) GPO
- Corridors (cleaners) One (1) GPO every 15m

- Open plan areas (cleaners) One (1) GPO ever 100m^2

7.8.5 Emergency stop (e-stop) buttons

Zonal (fixed space) e-stops shall be of Clipsal manufacture or approved equivalent. E-stops to be mushroom push button with key to reset functionality. All e-stops to be provided with accidental activation shroud. All e-stop controlled power outlets are to be provided with a traffolyte type label saying 'E-STOP PROTECTED'. The label shall be white background with black text.

Zonal e-stops shall utilise contactors for circuit control – shunt trip devices shall not be used. Contactors may be used to control chassis in DB's, individual circuits or a group of circuits depending on the installation. Upon reset of the e-stop, the contactor shall reactivate the controlled circuit(s).

Allow to install e-stops a minimum of 400mm clear of any other switches, outlets and other controls mechanisms.

E-stop button must be interlocked with local Emergency Gas shutoff solenoids to isolate and gases when the EPO has been activated.

Provide clear labelling at the e-stop location stating that the e-stop must only be reset by suitably qualified person.

Fridges and freezers (including ultra-cold freezers) are not to be on e-stop controlled circuits.

7.9 LIGHTING

7.9.1 General Requirements

Internal lighting shall be in accordance with the requirements of AS/NZ 1680, the requirements of the NCC and the relevant Green Star Design and As-Built Credit 11.1 requirements.

In general, lighting shall have an installed light power density at least 30% below the maximum requirements of the Section J of the NCC whilst accommodating the requirements of AS/NZ 1680. External lighting shall have a light source efficacy at least 30% better than the minimum required by Section J of the NCC.

The consultant shall submit the Section J calculations / report for review to validate the power density achieves the 30% improved performance.

All new lighting shall be LED technology. Light fittings installed in enclosed offices, open plan offices, teaching spaces, auditoriums, lecture theatres, meeting rooms, boardrooms etc. shall be provided with DALI dimmable control gear as standard. Fluorescent and discharge lamp technologies are not permitted unless approved by the Manager Engineering and Infrastructure via the Modification Request Form process.

LED diodes within a fitting and throughout the installation must be from the same grouping bin such that colour variations between diodes and fittings is not noticeable. LED batch bin numbers shall be provided as part of the project O & M manual submission. LED diodes shall be of Philips, Osram, Xicato, Luxeon or Cree manufacture.

3500K lamp colour temperature shall be provided in lecture theatres, 4000K to be used in all other areas.

The minimum permissible Colour Rendering Index (CRI) shall be 80.

Lighting shall be designed and installed to achieve maximum efficiency, maintainability and controlled by suitable control systems.

In general, all lighting system products shall;

- Comply with the relevant Australian Standards and have relevant current compliance certifications to quality management systems, standards and codes.
- Be readily available in large volumes with no greater than 8-week lead times.
- Long-standing Australian luminaires suppliers shall be given preference.
- Be provided with minimum 5 years warranty.

Luminaires shall be installed in readily accessible areas. Locations of luminaires shall avoid the use of scissor lifts, scaffolding and access via crawl spaces for maintenance and replacement purposes. Some examples may be the use of wall lights in high ceiling stair wells etc.

Areas where luminaires are suspended with wire suspension, the contractor shall provide provisions to the wire suspension system such that if a single wire fails, the luminaire remains in its original suspended arrangement.

Application of Green Star credits

The Green Star credits referred to in this section apply, at a minimum, to new buildings and major building refurbishments.

7.9.2 Lighting Calculations

When undertaking lighting calculations on computer-based software, a maintenance factor of no greater than 0.7 shall be used unless otherwise required by Green Star. Having dimmable control gear will allow for the lights to be dimmed down (during commissioning) to the required lux levels (as per AS/NZS 1680) and to be dimmed up once the luminaire light levels depreciate.

7.9.3 Switching

Light switches shall generally be located at the entry to each space. Switches shall not be installed external to the space it is serving with the exception of chemical and hazardous materials storage spaces. Only light switches shall be provided to substations, switch rooms, plant rooms, Comms rooms, and services risers i.e. occupancy detection is not permitted in these areas.

Light switches shall be installed in series with occupancy sensors where both switching methods exist i.e. the light switch shall control the luminaires and occupancy sensors on the circuit. The default setting for the occupancy sensors shall be 30 minutes.

The table below provides direction on the types of areas and their required switching arrangements;

Open office areas	Manual switching installed in series with occupancy sensor with switching zones no greater than 100m^2
Enclosed office areas	Manual switching installed in series with occupancy detection
Lecture theatres	Dynalite LCS
Teaching spaces	Manual switching installed in series with occupancy detection
Boardrooms/Conference rooms	Manual switching installed in series with occupancy detection with separate switching zones for presentation mode i.e. projector screen lighting circuits to be switched separate to the remaining fittings.

Corridors	Time clock with occupancy detection for afterhours operation
Publicly accessible areas	Time clock with occupancy detection for afterhours operation
Computer labs	Time clock with occupancy detection for afterhours operation
Entry lobbies	Time clock with occupancy detection for afterhours operation
Plant rooms	Manual wall switching
Service Risers	Manual wall switching
Laboratories	Manual wall switching
Toilets	Manual switching installed in series with occupancy detection
External lighting	Time clock control with manual override located at the switchboard

Perimeter lighting zones shall be provided with photoelectric sensors control to automatically dim fittings down when the natural light exceeds 340 lux at desk height.

Corridors and lobbies shall be provided with 24-hour lighting. Allow to provide one (1) 24-hour light every 15m in corridors and every 100m^2 in lobbies.

7.9.4 Occupancy Detection and Photoelectric Sensors

Where occupancy sensors and photoelectric sensors are being used, they shall be of BEG manufacture. Integral occupancy photelectric sensors may be used.

The occupancy sensors shall have timer adjustment setting from 1 minute up to 30 minutes.

7.9.5 Lighting Control System

All new and refurbished lecture theatres and auditoriums shall be provided with a Dynalite Lighting Control Systems (LCS) to control lighting. In new buildings, the Base building lighting shall also be controlled by a Dynalite LCS.

The new Dynalite equipment shall be DIN rail mounted in the supplying switchboard. The system shall be provided with following minimum features:

- Dynalite Universal Controller
- Dynalite Antumbra Dynet Communications module
- Dynalite PDEB AV ethernet interface with socket plate
- Dynalite Antumbra lighting control panel
- Dynalite PDEG headend ethernet interface (for headend integration)

The new Dynalite LCS shall be interfaced to the AMX AV control system where installed.

All new Dynalite LCS's shall connect to the University Dynalite System Manager software. New instances of the System Manager software shall not be provided. The project shall allow to provide the University with a copy of the Dynalite Program File(s) at the end of the defects liability period for incorporation into the System Manager head-end.

All external lighting shall be controlled via PE cell and time clock control, with manual override located at the switchboard supplying the external lighting circuit

7.9.6 Control Gear

Electronic control gear shall be provided for all luminaires and shall be of Tridonic Atco, Philips or Osram manufacture and include the following features as a minimum:

- Flicker free - constant current LED driver (minimum 12-bit)
- Constant light output, output to be independent of fluctuating supply voltage
- Voltage protection (i.e. protection against under and over voltage)
- Other Features
    - Operating frequency ≥ 40 kHz
    - Earth leakage current ≤ 0.5mA.
    - Operating temperature range from -25°C to +50°C
    - For luminaries with or an in accordance with EN 60598
    - Thermal protection according to AS/NZS 61347.1
    - EMC compliance according AS/NZS CISPR Set

Drivers must meet harmonic requirements outlined in AS/NZS 61000.3.2.

LED Drivers – DALI

Digital Addressable Lighting Interface (DALI) drivers shall be provided as required by the project. The driver shall be of Tridonic Atco, Philips or Osram manufacture.

The selected driver shall match the performance characteristics of the conventional electronic driver, and shall incorporate the following additional characteristics:-

- All DALI control gear shall be capable of lamp monitoring.
- All DALI control gear shall be of the same manufacture, generation and have compatible firmware installed.

7.9.7 External Lighting General Requirements

External lighting shall be designed in a manner to avoid upward light pollution and to be in accordance with the requirements of AS1158 and AS4282. In some instances, up lighting may be considered to enhance the aesthetics of a building, final approval shall be provided by the Manager Engineering and Infrastructure. Under no circumstances shall lighting be directed into the night sky.

The AS/NZ 1158 lighting category shall be selected by the Manager Engineering and Infrastructure.

External lighting shall be provided to all internal roads, walk ways and pathways to provide a safe environment for pedestrians.

In general, external lighting shall be via pole top or wall mounted luminaires and shall have the following minimum specifications;

- Marine grade, die cast aluminium body.
- IK07 impact protection.
- IP66 ingress protection.
- Corrosion protection.
- Provided with integral circuit breakers with removable panels (for pole tops).

All pole top luminaires shall be installed in strict accordance with the pole manufacturers installation details, in particular footing details. Where this information is not available, the footing specification shall be determined by a Structural Engineer.

An external lighting masterplan design has been undertaken for the Parkville campus and is available on the Design Standards web page. This masterplan must be used for all external grounds lighting installations. Any changes to the masterplan design must be approved by the Manager Engineering and Infrastructure via the Modification Request Form process.

Bollard luminaires will not be accepted.

Switching and control

All external lighting shall be controlled via time clock control, with manual override located at the switchboard supplying the external lighting circuit. PE sensors shall only be installed with approval from the Manager Engineering and Infrastructure via the Modification Request Form process.

7.10 EXIT AND EMERGENCY LIGHTING

7.10.1 General Requirements

An exit and emergency lighting system shall be installed in accordance with the requirements of the NCC and AS/NZS 2293.

The University utilises wired and wireless technology computer-based monitoring system of Legrand Axiom manufacture in all new buildings across all campuses.

7.10.2 System Description

The system comprises of the following equipment;

- Exit and emergency luminaires
- Wireless Area Controllers (WAC)

Exit and emergency luminaires shall be located in accordance with the spacing requirements of AS/NZS 2293, WAC's shall be located after a site survey has been undertaken to determine the best position for maximum coverage. In general, WAC's shall be located in electrical cupboards away from public view. Connection from the WAC to the luminaires shall be via cable connection. In the instance where this is not possible, wireless connectivity between the WAC and luminaire is acceptable.

The system shall be complete with all necessary equipment and components for a fully operational network and with data connectivity. The electrical contractor installing the system shall coordinate the works with Legrand for commissioning and sign-off prior practical completion.

7.10.3 Exit and Emergency Luminaires

Exit and emergency luminaire shall be supplied complete with RF antenna. All new exit and emergency luminaires shall meet the following minimum specification:

- Comply with AS/NZS 2293.
- Be marked and labeled in accordance with AS/NZS 2293.
- Be supplied with Lithium Iron Phosphate batteries. Each battery pack to be marked with the date of manufacture.
- Have incorporated iSmart temperature control for Lithium Iron Phosphate batteries.
- Be supplied with an LED to indicate network communications.
- To be independent and fail safe in the event of a network system failure.
- Be tested in accordance with AS/NZS 2293.

- Each exit and emergency luminaire shall be installed per AS/NZS 2293 and the Building Code of Australia and have a directional arrow as appropriate.
- Satellite emergency luminaires shall be either standard circular or corridor lighting distributions.

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7.11 STANDBY POWER SYSTEMS

7.11.1 General Requirements

Standby power supply systems are generally not considered unless specifically required by statutory regulations for life safety or as required due to special requirements of a project. Approval for the requirement of a standby power supply system shall be sought from the Manager Engineering and Infrastructure early in the design process.

7.11.2 Standby Generator

When required, direct injection standby diesel generators shall be installed within a sound attenuated enclosure to achieve no louder than 75 dBA (minimum) measured at 1m from the enclosure. The generator set rating shall be Standby rated and to be sized to 30% above the calculated maximum demand.

Automatic transfer switches shall be provided for the connection from the generator to the MSB. MSB's supplied by standby generators shall be provided with motorised breakers (for outgoing circuits) with PLC control for load shedding and connection to the University BAS.

The generator set output switchboard and control panel shall also be connected to the BAS for system monitoring.

The generator set shall be provided with a brushless, self-regulating alternator rated to provide an overload capacity of 10% for 1 hour and up to 50% for 2 minutes without causing damage to the generator.

Fuel sources and storage

Standby generators shall be diesel type and provided with internal double skinned tanks achieving no less than 24 hours of runtime at full load. If external tanks are required for additional run time, they shall be self-bunded, double skinned type. Flow and return pumps shall be provided to pump fuel from the tank to the generator set. Fault alarms shall be sent to the BAS to indicate pump failure.

Remote refuelling points shall be provided with an indicator panel showing overflow alarm and a fuel tank level indicator. A connection to the BAS is required to provide information of the fuel level in the tank.

Battery and charger

Provide a generator set starting battery of heavy duty sealed lead-acid type, suitable to start the generator set continuously for 30 seconds initially, and for a further similar period after 2 minutes.

The battery charger shall be connected to mains power supply and shall be constant potential type with integrated current protection.

Alarms

Provide for alarms from the generator to be connected to the University's BAS system. Confirm the communications protocol to allow for a high level interface with the BAS system.

7.11.3 Uninterruptable Power Supply (UPS)

UPS's shall not be provided to supply base building loads. Please refer to the University's CANAS standard for (see Associated Documents section of the Design Standards web page) UPS required for I.T. and Communications systems.

7.12 PHOTOVOLTAIC (PV) SYSTEMS

7.12.1 General Requirements

In general, the PV system shall be in accordance with the relevant Australian Standards, the requirements of the Victorian Service and Installation Rules (SIR's) and the requirements of the local electrical Supply Authority.

The purpose of this section is to cover the requirements and recommendations of grid connected PV systems, including systems with battery storage capabilities. Selection and provision of system equipment, pre-installation requirements, post installation requirements shall be in accordance with this section, and deviations to the requirements of this section must be approved by the Manager Engineering and Infrastructure.

7.12.2 System Delivery

A complete turnkey PV system shall be provided by the system Provider (system designer, installer and commissioner). The Provider shall design, supply, install and commission the PV system and all necessary ancillary works to provide a fully operational system.

When delivering a grid-connected PV system, the system Provider is required to undertake all works in accordance with the manufacturers requirements, the University if Melbourne Design Standards, and make all necessary applications to the local electricity Supply Authority. In addition to the above, the Provider shall be fully accredited by the Clean Energy Council (CEC) of Australia. Any LV electrical work must be undertaken by a licensed electrical contractor.

7.12.3 Site Assessment

A complete site assessment needs undertaken prior to the installation of a PV system. The site assessment shall allow for the following as a minimum;

- Solar access and resource (roof orientation and pitch, shading etc.)
- Available roof space for the PV panels.
- Establishment of inverters and batteries.
- Structural integrity of the roof to accommodate the weight and wind loading
- Effect of the proposed system on other Services
- Access requirement for initial installation and ongoing maintenance.
- Review and upgrade (as required) of existing electrical systems which are directly connected to the PV system.
- Voltage rise assessment.

7.12.4 Roof Access

A permanent safe roof access system shall be provided for future access to all parts of the PV system. Refer also to Section 11 of the Design Standards.

Where strings of panels are installed adjacent each other, the array must be installed in a manner which only requires the removal of one (1) panel in order to gain access to a panel in the array.

7.12.5 System Design

The system design shall be in accordance with the requirements of the CEC Grid Connected Solar PV System – Design Guidelines for Accredited Installers.

To avoid systems losses, DC quasi-currents and circulating currents, system strings connected in parallel to a common inverter must have less than 5% voltage mismatch and have similar rated electrical ratings.

A system single line diagram must be provided to the Manager Engineering and Infrastructure for approval.

7.12.6 Mounting and Location

In general, the mounting system shall be in accordance with AS/NZS 1170 and must include engineering certification.

The location of the PV system shall be such that the system yields maximum annual soar generation.

Flat mounted systems shall only be installed on roofs with a minimum gradient of 10 degrees to the horizontal and shall be installed on north facing roofs.

Rake mounted system shall be installed on an incline with the same angle as the angle of latitude of the site ±10º.

Systems may be installation on east/west facing roofs if a north facing roof is not available provided the system yield meets the requirements of Section 7.12.7. Final approval must be provided by the Manager Engineering and Infrastructure.

Inverters shall be located in plant room or restricted access areas. In general, they must be located away from excessive heat, moisture, dust and direct sunlight. They should also be located such that DC and AC losses are reduced.

7.12.7 System Rating and Capacity

For systems offsetting the building electrical usage, the system capacity rating shall be sized in accordance with the building energy usage (obtained from Clariti) and existing power bills (available from Engineering and Infrastructure). For new buildings, the PV system shall be sized based on the anticipated building load profile. System capacity rating and payback calculation shall be provided to the Manager Engineering and Infrastructure for approval.

7.12.8 Supply Authority Approval

The system Provider shall be responsible for applying for and obtaining approval from the electrical Supply Authority for the connection of the new PV system. This also includes for coordination and liaison with the electrical Supply Authority until a grid connection agreement has been received from the electrical Supply Authority. Allowance shall be made to pay all associated fees and charges as required for the approval process.

7.12.9 Equipment Requirements

Photovoltaic Modules

PV modules used in a single installation shall be of the same manufacture.

In general, all PV modules used in an installation must comply with AS/NZS 5033, be certified to IEC-61215, IEC-61646 IEC-61730 and be listed in the Clean Energy Council approved PV module list.

PV modules must be Class A also be certified as meeting Fire Safety Class C or better per UL 790.

PV modules installed in agricultural areas shall be certified to IEC-62716 (ammonia corrosion testing of PV modules).

The minimum PV module efficiency shall be no less than 14% for poly-crystalline modules, no less than 15% for monocrystalline modules and no less than 9% for thin film PV modules. Roof mounted modules shall have an effective operating temperature range of between -20ºC to +80 ºC with a maximum allowance temperature coefficient of 0.5%/ ºC.

Inverters

In general, 3 phase inverters shall be used, however micro-inverters may also be used as required. In the case that micro-inverters are used, AC isolators must be provided for each array grouping. AC isolation requirements to be in accordance with the requirements of the local electrical Supply Authority.

Inverters must comply with the requirements of AS/NZS 4777 and AS/NZS 5033.

Inverter specifications must comply with the over/under voltage requirements of the local electrical Supply Authority and the Victorian SIR's and have the following minimum requirements;

- Total harmonic distortion of the output current (THDC) to be no greater than 5% (applicable to all harmonics)
- Auto-synchronization capability with the LV network
- +10%/-6% voltage regulation
- Passive and active anti-islanding protection
- Voltage protection, frequency protection and transient voltage limitation
- Earth fault detection and alarm
- Include the capability to be coupled with a battery storage system

Multiphase systems shall be balanced in accordance with the requirements of the local electrical Supply Authority. Network protection shall be provided to isolate the system when voltage imbalances exceed 2%.

DC Cables and Equipment

In general, all DC cabling and system equipment shall be in accordance with the requirements of AS/NZS 5033. DC cabling shall be installed in a separate conduit/cable tray to AC cabling.

7.12.10 System Voltage Drop/Rise

The DC voltage drop from the inverter to the final PV module shall not exceed 3%.

The AC voltage rise between the inverter and the MSB and the MSB to the point of supply shall be no greater than 1%

7.12.11 Earthing and Lightning Protection

The entire system (DC and AC) shall be earthed in accordance with requirements of AS/NZS 3000 and AS/NZS 5033.

DC surge protection shall be installed at the DC side of the system and shall be provided for each inverter.

The PV system wiring shall be installed in accordance with the recommendation of AS/NZS 5033 to reduce the magnitude of over voltages caused by lightning strikes.

7.12.12 Warranty Periods

The following warranty requirements shall apply;

- Inverter and PV module manufacturer's warranty shall be no less than 10 years.
- Manufacturer's power warranty shall be no less than 10 years at 90% output and 25 years at 80% output
- Mounting systems shall be provided with 5-year workmanship warranty and 10-year equipment warranty

In general, the system equipment shall be of the same manufacturer as to not void system warranty.

7.13 ELECTRIC VEHICLE CHARGING STATIONS

7.13.1 General Requirements

In general, the Electric Vehicle (EV) charging stations shall be in accordance with the relevant Australian Standards (in particular AS3000:2018 - Appendix P), the requirements of the Victorian Service and Installation Rules (SIR's) and the requirements of the local electrical Supply Authority.

The purpose of this section is to cover the requirements and recommendations of switchboard connected EV chargers. Selection and provision of system equipment, pre-installation requirements, post installation requirements shall be in accordance with this section, and deviations to the requirements of this section must be approved by the Manager Engineering and Infrastructure.

All EV charging stations shall be installed by a registered electrician. The source distribution board (DB) shall be inspected to ensure sufficient spare physical and electrical capacity is available to accommodate the electrical load of the EV charging station. Single phase chargers shall be installed in a manner to ensure balance between all three phases.

Dedicated, RCD protected circuits are to be provided to each EV charging station. In accordance with AS3000, type A RCBO's are to be used if the EV charger can ensure disconnection of the supply in case of a DC fault current above 6mA. EV chargers without this capability are to use type B RCBO's.

An appropriately sized isolator shall be provided adjacent to the location of the EV charger. EV charging locations are to be out of direct sun light and rain.

The wiring system serving the EV charger (from DB to isolator and from isolator to EV charging point) and the wiring enclosure/support system shall be in accordance with AS3000. Typically cabling supplying EV charging stations shall be designed to WSX3 medium duty protection.

7.14 TESTING, COMMISSIONING AND OPERATIONAL MAINTENANCE

7.14.1 General Requirements

Testing, commissioning and the submission of detailed Operational & Maintenance Manuals (O&M) shall be provided for all projects. Draft soft copies shall be submitted by the contractor to the Engineer/Consultant for review no less than four weeks prior to Practical Completion. Final copy documents are to be provided no later than 4 weeks after Practical Completion.

A list of all systems which are being tested and commissioned shall be provided to the Manager Engineering and Infrastructure for review and approval.

Qualified technicians shall undertake testing and commissioning as may be necessary to satisfy the Independent Commissioning Agent (ICA) and the University and that the installation meets the requirements of this Design Standard. All test instruments/equipment are to be calibrated at an approved N.A.T.A. certified laboratory prior to carrying out the tests. ICA's shall be used for all new build projects subject to final approval by the Manager Engineering and Infrastructure, this is also in-line with Green Star Design and As-Built Credit 2.4. Refer to Section 3: Sustainable Design for details of the minimum requirements for Green Star points.

In accordance with Green Star Design and As-Built Credit 2.1, a services and maintainability review shall be undertaken during the design phase of the project. The review shall facilitate input from the University and shall address the following;

- Commissionability
- Controllability
- Maintainability
- Operability, including fitness for purpose
- Safety

Refer to Section 3: Sustainable Design for details of the minimum requirements for Green Star points

Application of Green Star credits

The Green Star credits referred to in this section apply, at a minimum, to new buildings and major building refurbishments.

7.14.2 Testing and Commissioning

Testing and commissioning of all installed electrical systems shall be in accordance with the relevant regulatory requirements and the specific manufacturers requirements.

Sufficient notice shall be provided for all testing and commissioning such that the University's Engineering and Infrastructure team can be present as required.

In addition to the Consultant's/Engineer's requirements for systems testing and commissioning, the following systems shall also be tested and commissioned;

- Phase rotation
- Cable insulation resistance.
- Correct tightness of screwed and bolted connections.
- Circuit protection including operation and discrimination of RCD's, MCCB's, MCB's and ACB's etc.
- Balancing of loads, ensure no greater than 20% imbalance across the active phases.
- Check and verify operation, calibration and correct output of all meters. Provide calibration certificate and test results.
- Connection and operation of new meters to Clariti and University network data monitoring system.
- Correct operation of lighting control systems, and lighting control mechanisms.
- Generator startup, and correct operation under full load.
- Power Factor Correction unit
- Active Harmonic Filter unit

The electrical contractor shall submit all completed ITCs / ITPs for all the systems to be commissioned prior to any witness testing being undertaken. This provides the

Consultant / Engineer the ability to review results and provide any commentary prior to the final witnessing / signoff of the system/s.

Provide all testing and commissioning data to the University in a report format which shall also be included in the O&M manuals.

In accordance with Green Star Design and As-Built Credit 2.2, pre-commissioning and commissioning shall be undertaken in accordance with the Green Star Credit requirements. A Commissioning Specification and Commissioning Plan shall be provided.

Refer to Section 3: Sustainable Design for details of the minimum requirements for Green Star points.

7.14.3 Building System Tuning

In accordance with Green Star Design and As-Built Credit 2.3, tuning and adjustments of all building systems is to be provided on a quarterly basis for a period of 12 months from date of Practical Completion.

The objectives of the building tuning process are as follows:-

- Verify that systems are performing to their design potential during all full and part load conditions;
- Reviews of environmental performance against the environment targets;
- Collection of user feedback to match the system performance with the occupant's needs;
- Adjustment of all the systems to account for all deficiencies discovered;

A building tuning report shall be provided which reports the outcomes of the quarterly turning process.

Refer to Section 3: Sustainable Design for details of the minimum requirements for Green Star points.

7.14.4 Samples, Technical Data Sheets and Shop Drawings

Under certain circumstances, the University may request samples, technical data sheets and shop drawings to be submitted for review and approval. As a minimum, the following are required to be reviewed;

Samples;

- Luminaires
- Lighting control panel (for Dynalite systems)

Data sheets;

- Floor boxes
- Generator sets
- Diesel fuel tanks
- Pumps (diesel)
- Cable pits
- PV system

Shop drawings;

- Main Switchboards
- Distribution boards above 250 Amps
- Generator set, acoustic enclosure, fuel storage tanks and generator switchboards

- Single line diagrams
- Busduct systems
- Trenching routes
- PV system and AC/DC switchboards
- Power Factor Correction units
- Active Harmonic Filter units

7.14.5 Operational Maintenance and Operation & Maintenance Manuals (O&M)

The design consultant must ensure that the project documentation includes a requirement that all installations are provided with a 12-month defect liability period from the date of practical completion. PV systems shall be provided with a 5-year maintenance period.

During the defect liability period, electrical contractors must allow for all scheduled maintenance requirements, including but not limited, to the following services;

- Undertake monthly inspections and provide maintenance repair works.
- Undertake periodic testing of Lighting Control Systems to ensure correct operation
- Check installed switchboards
- Provide bi-annual testing of the generator system
- Switchboard thermographic scans

Monthly maintenance reports shall be provided for the University's records and information.

Provide O&M manuals at practical completion consisting of:

- Operational & Maintenance manuals and instructions
- Maintenance reports
- Testing and commissioning reports
- Measuring and testing equipment calibration certificates
- Product manufacture data sheets (specifics only, entire product catalogs will not be accepted)
- Schematic diagrams and single line diagrams
- Switchboard as-built shop drawings
- Switchboard schedules
- Discrimination studies and circuit breaker settings
- As-installed drawings
- System operation descriptions
- Product warranty certificates
- Copies of all test and approval certificates
- Details of the grid connection agreement (for PV systems)
- Renewable Energy Certificates agreement (either STC or LGC registration details)
- Thermographic scan results
- Registrations (as applicable) in the name of the University of Melbourne

For PV systems, one set of manuals shall be stored in a weatherproof clear document holder that is fixed to the wall beside the inverters.

7.14.6 Design Change Authorisation

All requests for changes to the requirements of the Design Standards must be made on the Modifications Request Form. No design work is to proceed on the basis of the proposed modification until the modification request has been approved in writing.

A schedule of all requested modifications and a signed copy of all approved modification request forms is to be provided as part of the project handover documentation.

7.15 MATERIAL SELECTION

The Designer/Engineer shall select products from this table; proposed alternatives require approval via the Modification Request Form.

Item	Supplier	Model no.	Description	Notes
Wiring accessories	Clipsal	IP56 range	Weatherproof wiring accessories	Wet areas
Wiring accessories	Clipsal, HPM or Legrand	2000 series Standard Series Excel Life	General purpose power outlet (GPO)	Single and dual outlet
Wiring accessories	Clipsal, HPM or Legrand	2000 series Standard Series Excel Life	Light switch	Min 15A mechanism
Floor box	ECD CMS Electracom	FB4MU series V181220N1 V181220N2 98FBMUFB1 98FBMUFB2 98FBMUFB3	With rubber cable exits	
Emergency Lighting System	Legrand	Axiom		
Exit Luminaire (general)	Legrand	G2 Slide Connect	Slide Connect fitting, white body rim	
Exit Luminaire (theatres)	Legrand	G2 Slide Connect	Slide Connect fitting, green on black diffuser	
Emergency Luminaire (general)	Legrand	Satellite Axiom series		Provide surface mounted box where required
Emergency Luminaire (car parks & fire stairs)	Legrand	WP2 from Axiom series	2100 lumen option	
Emergency Luminaire (car parks)	Legrand	WP2 from Axiom series	4100 lumen option	

Item	Supplier	Model no.	Description	Notes
LED diodes	Philips, Osram, Xicato, Luxeon or Cree	To suit application		
LED drivers	Tridonic Atco, Philips or Osram	To suit application		
Lighting control system (general & theatres)	Philips Dynalite	To suit application		
Motion sensors	Dynalite BEG	To suit application		Use Dynalite sensors where Dynalite is available
Pole-Top Luminaires	WE-EF	Refer to the External Lighting Masterplan		
Pole-top luminaire pole	WE-EF Vicpole	Refer to the External Lighting Masterplan		
Miniature circuit breaker (MCB)	NHP, Schneider, Eaton Quicklag			
Control gear	Sprecher + Schuh		Contactors, relays, panel-mounted control switches	
Electronic time-switch clock	Sauter, NHP or Schneider	ZDR102-F02	Dual Channel electronic time-switch clock	