ELECTRICAL SERVICES STANDARDS

MACQUARIE University

DOCUMENT HISTORY & APPROVALS

Revision	Date	Description	Approved
V3	17/12/2021	Approved For Release	CK/AV

TABLE OF CONTENTS

1 DOCUMENT PURPOSE

This document sets out Macquarie University's minimum requirements for the design, construction and maintenance of electrical services and infrastructure. It aims to help ensures that new and refurbished electrical systems are fit-for-purpose, provide safe, efficient, and reliable electrical power, to facilities throughout our campuses. Macquarie University seek to ensure electrical systems are designed and constructed of durable high-quality materials, are cost effective to operate and maintain, and are flexible into the future.

Applicable requirements outlined within mandated Australian Standards (AS/NZS), the Australian National Construction Code (NCC), Workplace Health and Safety legislation any other relevant statutory codes and legislation are applicable when designing, constructing, and maintaining electrical systems at Macquarie University. This are to be considered the minimum for compliance only.

This document may include requirements that exceed those outlined within documentation mentioned above. Where this is the case, compliance with these additional requirements is an expectation when working with Macquarie University unless formal approval is received otherwise.

A detailed list of relevant codes and standards is included later in this document. This list of codes and standards is intended to include the minimum requirements only and should not be considered a comprehensive list of all applicable. Designer, installers, and maintenance persons shall undertake due diligence in ensuing the compliance of their works.

Where any ambiguity exists between this document and the aforementioned mandatory requirements then:

- The highest performance requirements must apply; and
- Applicable requirements must follow this order of precedence:
    - Workplace Health and Safety Legislation
    - National Construction Code (NCC)
    - Relevant Australian & New Zealand Standards (AS/NZS)
    - Any other relevant statutory requirements
    - Macquarie University Design Standards (This document).

2 SCOPE OF DOCUMENT

This standard describes the minimum requirements for the design, construction and maintenance of electrical services plant, equipment and infrastructure for buildings and spaces owned, operated, maintained and/or managed by the Macquarie University.

It applies to:

a. New buildings and spaces to be constructed and owned by MQU.
b. New buildings and spaces to be constructed and occupied/operated by MQU under a long-term lease agreement.
c. Existing MQU owned or leased buildings and spaces to be refurbished or modified.

The standard covers provision, installation and maintenance of electrical services including the following systems:-

- Low Voltage (LV) power quality, distribution, and protection.
- Onsite back-up power generation.
- Uninterruptable Power Supplies.
- Lighting system.
- Lightning protection systems.

It does not include:

- Electrical installations for specialised laboratories and research facilities – These are specifically defined within the project requirement and the applicable codes and standards.
- Electrical installations for patient care facilities – These are specifically defined within the project requirement and the applicable codes and standards
- Communications and data cabling systems – Refer separate MQ component specification.
- Energy Monitoring Systems – Refer separate MQ component specification.
- Access Control & Security Systems – Refer separate MQ component specification.
- Audio Visual Systems – Refer separate MQ component specification.

Where specific applications are not explicitly covered, or ambiguity exists, the intent of the standard must be met. In such cases a return design brief must be provided for review and approval by the issuer of this standard or their appointed delegate who must have relevant technical competence in the subject matter.

The standard applies to planners, project managers, consultants, contractors, sub-contractors, tenants, managing agents, University staff and others involved in the design, construction, installation, operation and maintenance of existing, new, and proposed University buildings and facilities.

Electrical products and services provided or specified by designers, consultants, staff, and contractors must conform to this standard

3 AUTHORITIES AND RESPONSIBILITIES

The document has been developed by Macquarie University Property department and is owned by Macquarie University. This standard has been reviewed and approved in accordance with the Document History & Approvals sections outlined at the beginning document.

This document may be modified and updated at any time, and it is the responsibility of the designer and installer to ensure the latest version has been utilised.

Where this standard is updated post engagement, any changes affecting the works shall be raised with the Macquarie University via the project representative, and direction sort prior to proceeding.

Should the designer or constructor have any issues complying with this standard, they shall be raised to MUP via the Macquarie University project representative with a completed Non-Conformance template.

Where non-conformance to these standards may be to the benefit of Macquarie University, it is the responsibility of the designer/constructor to raise this with the Macquarie University project representative for consideration.

Where any works interface with, or require the consultation of, external parties such as electrical utilities, communications authorities, local, state, or federal government bodies or the like, it is the responsibility of the designer to provide advice and seek direction for MQ.

4 GLOSSARY

Unless the context otherwise requires, the following definitions apply:

Term	Definition
ACA	Australian Communications Authority
ACB	Air circuit breaker
ASP (L1, 2 or 3)	Accredited Service Provider
AS/NZS	Australian / New Zealand Standard
BCA	Building Code of Australia
C/B or CB	Circuit Breaker
CT	Current Transformer
DLP	Defects & Liability Period
ECC	Earth Continuity Conductor
ELCB	Earth Leakage Circuit Breaker (also known as RCD)
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPO	Emergency Power Off
GPO	General Power Outlet
MUP	Macquarie University Property Department
DB	Distribution Switchboard
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MEN	Multiple Earthed Neutral (earthing system).
MIMS	Mineral Insulated Metal Sheathed cable
MSB	Main Switchboard
MQU	Macquarie University
MUP	Macquarie University Properties
NATA	National Association of Testing Authorities

Term	Definition
NCC	National Construction Code
O&M	Operation and Maintenance Manual
PFC	Power Factor Correction
RCD	Residual Current Device (also known as ELCB or RCBO)
SiD	Safety in Design
SPD	Service Protection Device
TPS	Thermoplastic-Sheathed Cable

5 CODES AND STANDARDS

Standard Number	Standard Title
AS/NZS 1158	Lighting for roads and public spaces
AS 1170.1	Structural design actions Permanent, imposed and other actions
AS 1170.4	Structural design actions – Earthquake actions in Australia
AS/NZS 1680	Interior Lighting
AS/NZS 1768	Lightning protection
AS/NZS 2053	Conduits and fittings for electrical installations
AS/NZS 2243	Safety in Laboratories
AS/NZS 2293	Emergency escape lighting and exit signs for buildings
AS 2676	Installation and maintenance of batteries in buildings
AS/NZS 3000	Electrical installations (also known as the Australian/New Zealand Wiring Rules)
AS/NZS 3009	Electric installations - Emergency power supplies in hospitals
AS/NZS 3008.1.1	Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1kV – Typical Australian installation conditions
AS/NZS 3010	Electrical Installations (General Sets)
AS 3011	Electrical installations - Secondary batteries installed in buildings
AS/NZS 3013	Electrical installations – Classification of the fire and mechanical performance of wiring systems
AS/NZS 3017	Electrical installations—Verification guidelines
AS/NZS 3019	Electrical installations—Periodic verification
AS/NZS 3080	Telecommunications installations - Generic cabling for commercial premises
AS/NZS 3084	Telecommunications installations - Telecommunications pathways and spaces for commercial buildings
AS/NZS 3100	Approval and test specification – General requirements for electrical equipment

Standard Number	Standard Title
AS/NZS 3760	In-Service Safety inspection and Testing of electrical equipment
AS/NZS 3947.3	Low-voltage switchgear and control gear - Switches, disconnectors, switch-disconnectors, and fuse-combination units
AS3996	Access Covers and Grates
AS/NZS 4251	Electromagnetic Compatibility (EMC) – Generic Emission Standards
AS/NZS 5000	Electric cables – Polymeric insulated
AS 60529	Degrees of protection provided by enclosures (IP Code)
AS 61439	Low Voltage Switchgear and Control Gear Assemblies
AS/ACIF S008	Requirements for customer cabling products
AS/ACIF S009	Installation requirements for customer cabling (wiring rules)
EIA/TIA 569	Commercial building standard for telecommunications pathways and spaces
EN 55015	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
EN 55022	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement
IEC 60038	Standard Voltages
IEC 60044.1	Instrument Transformers - Part 1: Curent Transformers
IEC 60051	Direct acting indicating analogue electrical measuring instruments and their accessories
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 61000	Electromagnetic compatibility (EMC)
IEC 61547	Equipment for general lighting purposes - EMC immunity requirements
IEC 62052	Electricity metering equipment (AC) - General requirements, tests, and test conditions
IEEE 1789	Recommended Practices for Modulating Current In High-Brightness LEDs For Mitigating Health Risks To Viewers
BCA	Building Code of Australia
SIR	Supply Authority Service Installation Rules (state applicable)

6 DESIGN & DOCUMENTATION REQUIREMENTS

6.1 DESIGN DRAWINGS AND SPECIFICATIONS

The following forms the minimum requirement for the design documentation for electrical services construction works:-

- The design of electrical services must be undertaken by qualified professional engineers covered by professional indemnity and public liability insurances. Where the value of cover is not stipulated within the contract of engagement, an appropriate level of coverage should be provided, and acceptance should be sought from the relevant MQ representative.
- Maintain reliability and availability of electrical systems of buildings during and after construction. Provide temporary power systems as required to meet the affected users requirements and liaise with the users and project manager to determine these requirements.
- State minimum warranty requirement for all new equipment and infrastructure.
- Specify maintenance requirements during the Defects Liability period.
- All designs must be compliant with BCA including Section J, Local Authorities regulations and all relevant Australian and New Zealand Standards (AS/NZS) whether specifically mentioned within this document or not.
- Allow for any University work embargo and restriction periods during the construction period.
- Provision of electrical maximum demand calculations in editable spreadsheet format, and to satisfy the Supply Authority and to AS/NZS3000 as a minimum.
- Application for connection of new loads to the Supply Authority.
- Supply of statutory design certifications and certifications of compliance to the University standards.
- National Construction Code Section J6 compliance calculations and certifications for energy consumption minimisation.
- Annual electrical energy consumption estimate based on building space types, occupancy and operation of planned plant and equipment.
- Power system calculations for the whole system in POWERCAD, or approved equal software, covering fault levels, voltage drop, cable sizing and circuit breaker discrimination.
- Supply of all calculations in electronic native software editable file and PDF output format.
- Design drawings in AutoCAD (and Revit 3D model where applicable) format including plans, schematics and single line diagrams.
- Testing and commissioning schedules and programme.
- Contractors must visit project sites to determine limitations to installing electrical services and include sufficient allowances in the tender price to cover these issues.
- Ensure that spatial and building general construction details are satisfactory and equipment can physically be installed within the building.
- Additional work items identified during tender inspections, but which may not be documented in the original scope of works.
- Early notification of adverse latent conditions and liaison with the University's Superintendent to resolve the issues and agree additional costs before proceeding with the works.
- Decommissioning and demolition of all redundant electrical services and infrastructure in the works area.
- Provide a detailed project description including the project drivers, the existing conditions, and the final project use.
- Provide a section listing any major deviations from this standard and summarising the reason.

- The floor plan scale must be a minimum 1:100.
- Use standard symbols and terminology from AS/NZS 3000 on the drawings and in the documents.

As a minimum, drawings must include, but not be limited to the following, as applicable:

- Site plans showing cabling layout and the location of the works.
- LV detailed single line diagrams including but not limited to:
  - Cable schedules
  - Circuit identification of LV primary systems showing the detailed configuration of the system
  - Cable sizes
  - Voltage drop
  - Protection ratings
  - Circuit breaker type
- Control topology / network drawings.
- Loop drawings if considered necessary to describe the system.
- Single line diagrams of all ancillary supplies, such as DC systems.
- Details of earthing systems, including layout drawings, schematic drawings, and cable sizes. All bonding to be shown on drawings.
- Layout drawings showing building and all major equipment locations. Dimensions are not required unless these are required for coordination purposes.

The Drawings and Specifications must clearly indicate the Scope of Works and must provide details of all the components to be installed. Specification by brand name is acceptable.

The Architectural Design Drawings (internal and external elevations) must include the locations of all the electrical accessories, e.g. switches, socket outlets, light fittings, air conditioning controls, access and security keypads and cards readers, door lock override pushbuttons, etc. including mounting heights and critical dimensions. Electrical drawings to accurately reflect the electrical equipment shown on the room layout sheets and locations.

6.2 WORKSHOP DRAWINGS

Prior to commencing construction, the relevant trade contractor is to determine the exact positions of all electrical equipment in conjunction with the head contractor, other trades, and to the approval of the design engineer. Exact positions must have regard to interior design, building features, other services, and the requirements of regulatory authorities and standards indicated above.

The trade contractor must supply construction workshop drawings detailing the following:

- Details of all trenching including routes, depths, backfill, reinstatement and distances from other services.
- Cable pit and trench locations
- Cable pit and trench construction details and sections
- Main Switchboards and all Distribution Boards including:
  - General plans, elevations and sections, construction, and weights.
  - Cable entry and gland plate details.
  - Circuit diagrams, busbar and cable sizes

- Current carrying capacity, current and fault ratings
- Equipment types and models, labelling and finishes
- Additionally, provide documentary evidence of fault withstand performance relevant to the applicable enclosure(s)
- IP ratings
- Arc fault venting or containment details, including arc fault category exposure details.
- Cupboard/riser layouts including door swings, fixing details

- Metering system network schematics
- Fire rating and fire barrier reinstatement proposals
- Busduct system including rating, route, supports and method of installation.
- Submain Conduit and cable tray routes
- Details of all associated works including wall, floor and ceiling penetrations, floor chases and wall chase locations including proposed depths and widths.
- Co-ordinate final lighting and power layouts with other services and to suit final furniture locations. Provide shop drawings showing fully co-ordinated floor and ceiling plans complete with dimensions.
- Details of equipment and cable support brackets and fixings including luminaire mountings and clearance to in-ceiling obstructions for all recessed equipment including mechanical services ductwork.
- Earthing and bonding:

  - General plans, elevations, sections, cable routes and construction details
  - Product selections
  - Schematic diagrams
  - Mounting and fixing details including fixing to racks

- Power factor correction equipment include general arrangement of cubicles, wiring and protection harrangement, control schematics.
- Cable tray proposed routes in full coordination with Mechanical Services workshop drawings detailing submain quantities, locations, penetrations, and support details.
- Lighting control panels showing labelling and disposition/type of equipment.
- Detailed design of lighting control system showing labelling and disposition/type of equipment.
- External lighting pole and support systems details
- Portable generator connection cubicle details
- Standby diesel generator including acoustic enclosure, exhaust system construction, fuel tank, plinth construction details, bunding, weight, installation clearance requirements, traffic bollards, control systems, mimic panels and indicator lamp details and interface to building electrical systems including auxiliary power supplies to canopy lighting, block heaters, battery chargers, etc.
- UPS system including weights, elevations, mounting and equipment details with manufacturers' data and schematic diagrams showing all components, wiring, protection, control, and capacities.
- Lightning protection arrangement including bonding to structure and earth.
- Termination points with all other trades.
- Details of all proposed labelling and engraving.

6.3 SAMPLES & TECHNICAL DATA

Designers must specify, and constructors must supply, samples and associated technical data for all products and equipment proposed for use in the works. Where samples cannot be provided due to excessive cost, delay or other practicalities, the provision of technical data only may be accepted if approved by the designer or MUP. Only those items that are approved may be installed on site.

For all products, regardless of the provision of physical samples, the following information must be made available to the designer and MUP prior to use onsite: -

a. Technical specifications and drawings.
b. Design Verification information and Test certificates (for switchboards)
c. Performance and rating tables.
d. Recommendations for installation and maintenance.
e. Schedule of proposed major products that are not specified as proprietary items.
f. Product certification.

6.4 AS-CONSTRUCTED DOCUMENTATION

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-Constructed’.

As-Constructed drawings must reflect the complete electrical installation and show dimensions, types and location of equipment, cables, tray / ladder, ductwork, pipework, and principal items of plant and equipment.

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

A Legend of Symbols shall be included with all "As-Constructed" drawings.

The drawings shall appear "as new". No previous approval stamps, handwritten 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 USB in both PDF format and DWG format compatible with the latest version of AutoCAD.

Show “as-installed” locations of building elements, plant and equipment in relation to permanent site features and other underground services. As-built drawings must show changes made during commissioning and the maintenance period.

6.5 OPERATION AND MAINTENANCE MANUALS

Operation and maintenance (O&M) manuals are to be provided for all projects prior to practical completion. Manuals shall be provided in digital form and logically structured for easy navigation. Documents and information that must be provided are described below.

Authors and compilers of the manual must be experienced in the maintenance and operation of the installed equipment and systems.

General Information

The following general information must be provided operation and maintenance manuals: -

a. Project Name and Location including campus and building address
b. Electrical Contractor's name, address, telephone number, email address and emergency telephone numbers.
c. General description of the installation, written as briefly as possible, consistent with providing a general understanding of its features and operation.

Operator's Manuals

For any major pieces of equipment operator's manuals must be provided and include:

a. Safe working procedures for operation and isolating the installation.
b. Operation and maintenance, information for the satisfactory long-term operation and maintenance of the electrical services.
c. Maintenance procedures, recommended maintenance periods and procedures.
d. Tools, particulars of maintenance equipment and tools provided, with instructions for their use.
e. Copies of single line diagrams / schematic diagrams for the installation / system.
f. A technical description of the equipment supplied, with diagrams and illustrations where appropriate.
g. Procedures for dismantling and re-assembling equipment.
h. Shop drawings
i. As-Built drawings.
j. List of the spare parts provided.

Equipment Descriptions

Equipment descriptions must include:

a. Schedules of equipment, equipment, duties, performance figures and dates of manufacture.
b. A unique code number cross-referenced to the record and diagrammatic drawings and schedules, including spare parts schedule for each item installed.
c. Name, address, telephone and email address of the manufacturer and supplier of equipment installed together with catalogue list numbers.

Maintenance Procedures

Procedures must include:

a. Manufacturers' technical literature as appropriate.
b. Preventative maintenance requirements.
c. Logical step-by-step sequence of instructions for safe troubleshooting, disassembly, repair and re- assembly, cleaning and alignment and adjustment procedures.
d. Schedule of recommended spares inventory to be held on site, items subject to wear or deterioration and which involve extended deliveries when replacements are required.

Certificates

Contractors must provide these certificates as a minimum for electrical services plant and equipment:

a. Copies of Manufactures guarantees and warranty.
b. Certificate of Compliance for Electrical Works (CCEW) forms
c. Certification from supply authority.
d. Product certification for compliance to relevant AS/NZS and other product standards and codes.

Testing Records

Include all reports for designated and statutory testing, including pre-delivery tests, for inclusion in O&M manuals such as:

a. RCD Test results
b. Exit and Emergency lighting discharge results
c. Communications cabling including calibration certificate for testing equipment
d. Compaction test results certificates
e. Engineering inspection report
f. Defect Notices and evidence of defect clearances

Further to the above all information must be provided in the format as outlined within the Macquarie University Operations and Maintenance Manual Template. A copy of this template can be provided by THE MACQUARIE UNIVERSITY PROPERTIES DEPARTMENT.

6.6 SAFETY IN DESIGN

Design consultants must consider safety risks during the design process. These risks must be address through the integration of control measures to eliminate, or minimise these risk as far as is reasonably practicable as part of the design. Risks must be identified throughout all stages of a project life cycle. These risks and the associated control measures must be documented by the design consultant and shared with the entire project team.

7 TECHNICAL REQUIREMENTS

7.1 ELECTRICAL SUPPLY

7.1.1 METHOD OF SUPPLY

The designer shall carry out all required investigations and undertake estimated maximum demand calculations to determine if the project works will result in a net positive increase in electrical peak load. If this is the case, the designer shall determine if the existing infrastructure has capacity to accommodate the load increase. In some cases, university metering data can be provided to assist in this process and hence should be requested from the university's property department.

Where the existing infrastructure is determined to have insufficient capacity to accommodate the project, the designer shall undertake the design of all required modifications, and these must be included in the project scope of works.

If the establish of a new LV electrical supply is determined to be required, the services of an ASP Level 3 Engineer must be engaged.

7.1.2 APPROVAL BY MUP

The proposed Method of Supply and all supporting calculations and data is to be submitted to Macquarie University Property for consideration during the concept design phase.

Prior to construction all completed design documentation involving a load increase must be submitted and signed off by the University.

7.1.3 APPROVAL BY AUTHORITY

Where the works involve the decommissioning, modification, or provision of new electrical utility infrastructure, all works must be fully designed and documented by an Accredited Services Provider (ASP) Level 3 Engineer. All works must receive in writing approval from the utility prior to proceeding to construction.

7.1.4 RETAILER METERING

All regional MSBs and Building MSBs directly connected to utility supplies shall be provided with electrical supply authority metering current transformers within dedicated and sealed compartments in accordance with the Service and Installation Rules. All meters and test links shall be provided in externally meter panels where possible.

For the modification of existing, or provision of new retailer electricity metering equipment all works must be designed and documented in accordance with the NSW 'Service and Installation Rules'. The designer must ensure fully compliance and nominate all construction works to be conduct by an Accredited Service Provider (ASP) Level 2 electrician.

For further guidance refer to Macquarie University –Design Standard for Energy and Utility Monitoring System (EMS).

7.1.5 PRIVATE METERING

All switchboard feeds to university tenants must be fitted with private energy smart meters and CTs of Tariff Accuracy NMI Compliant. These meters may be used to allocate energy usage charges as distinct from just monitoring energy use. Confirmation should be sort from the project design team, university project manager and university properties department to confirm if a building user is considered a university tenant, or other entity to be charged for energy consumption.

For further guidance refer to Macquarie University –Design Standard for Energy and Utility Monitoring System (EMS).

7.1.6 POWER QUALITY

7.1.6.1 POWER FACTOR CORRECTION

Power factor correction shall generally 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. It is at the discretion of the design engineer to determine if power factor correction is required on each project and to provide supporting evidence

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.

7.1.6.2 HARMONIC MANAGEMENT

Consulting engineers and designers shall work with the project design team and project stakeholders to consider the likelihood of harmonic distortion affecting the installation. Where the works involve the provision of large, or a significant quantities of small, non-linear loads

The following considerations must be made: -

- Position of Non-Linear Loads - Consider the position in the LV network of all large non-linear loads and locate as far upstream as possible. This will require early consultation with the project team.
- Group Non-Linear – Consider grouping non-linear loads and connecting and far upstream as possible. E.g. provided dedicated supplies directly from MSB and avoid connecting upstream to distribution boards also supplying sensitive equipment.
- Harmonic Filtration – Consult with specialists and consider the provision of Passive, Active and Hybrid filters.

Note: Harmonic Filtration can present significant cost to a project and should not be provided unless detailed calculations, modelling or measurement has occurred.

7.2 MAIN SWITCHBOARDS (MSBs) & MAIN DISTRIBUTION BOARDS (MDBs)

7.2.1 GENERAL

This section applies to all Regional Main Switchboards, Building Main Switchboards and large Main Distribution Boards. It describes the detailed requirements for these boards and may include other large switchboards typically of rating >250A.

All switchboards shall be designed and built-in accordance with AS61439, AS 3000 any other relevant Australian Standards and the authority's requirements.

7.2.2 CALCULATIONS

Estimated Maximum Demand

Estimated maximum Demand calculations must be completed for all new Main Switchboards and must consider all existing and proposed new outgoing circuits. Calculations must consider future spare capacity for growth.

Protection and Grading Studies

Provide the power supply system with equipment that fully grades during over current situations and discriminates during fault conditions.

Over currents on final sub-circuits must be cleared by that sub-circuit protective device only and must not affect any upstream protective device likely to cause disruption to non-related final sub-circuits.

Prove achievement of grading and discrimination for each protective device. When approved, supply all equipment necessary to align with evidence provided.

Co-ordinate the discrimination design with all other Trade Sub-Contractors. Cross reference requirements of the cable section.

Provide circuit breaker protection grading and co-ordination calculations using a proprietary software equal to POWERCAD. Provide PDF output documents showing:

a. System grading for each leg of the installation from main supply to final Distribution Board or major load.
b. Protective device type, trip unit and setting
c. Cable Current rating for the method of installation
d. Voltage drop at rated maximum demand load
e. Maximum cable length
f. Earth fault return impedance
g. Fault current at the load end

7.2.3 LOCATIONS

Where possible every effort shall be made to locate large switchboards indoors within a dedicated switchroom or cupboard which is provided with a university Bi-Lock. Where a suitable location cannot be negotiated inside a building, the designers shall seek in writing approval to locate the switchboard outside.

Where the installation of an external switchboard is approved the following minimum criteria must be met: -

a. IP54 rated
b. Stainless steel or aluminium and powder coated to match the building area
c. Have protective overhang or awning on external doors.
d. Have bottom cable entry.
e. Be installed on a concrete plinth on raised welded frame, galvanised, or wall mounted with SS anchor bolts.
f. Fitted with handles to take a university bi-lock key or able to accept a padlock with university bi-lock barrel.
g. 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.
h. The switchboard manufacturer is to have a temperature rise testing relevant to the IP rating nominated.

7.2.4 MANUFACTURERS

The following Manufacturers are considered approved by the University of Macquarie: -

- Fuji SMBE Harwal
- Fuji SMBE Macquarie
- Gosford Electrical Manufacturing
- KE Brown
- Relec Switchboards
- Southern Cross Switchboards

Alternative switchboards manufacturers shall be considered by the university provided the following considerations are made, and information provided: -

- Manufacturer shall by an experienced (min 5years), well-established company with local resources.
- Company profile can be provided.
- Compliance statements and verification certificates can be provided.
- Boards are manufactured in Australia
- Typical workshop drawings, for an equivalent switchboard can be provided for review.
- Onsite service can be provided for alterations or additional while maintaining compliance.
- Manufacturer has facilities to perform FAT prior to delivery.
- Warranty statements can be provided.
- Quality Assurance compliance can be provided.

The above information shall be provided prior to tendering, and in writing approved by Macquarie University Property department must be obtained.

7.2.5 CONSTRUCTION

Design of switchboards must satisfy these requirements:

a. LAYOUT: Position equipment to provide safe and easy access for operation and maintenance. Consider functional relationships between items of equipment in the laying out of equipment on the assembly.
b. SERVICE CONDITIONS: Normal service conditions Refer Annex C AS61439.
c. RATED CURRENTS:

- Rated Currents: Minimum continuous uninterrupted rated currents within the assembly environment, under in-service operating conditions.
- Assembly Short-Circuit Capacity Characteristic: Rate main circuit supply and functional units as follows:
- Back-up protective device not provided: Rated short-circuit current for 1s.
- Back-up protective device provided: Rated short-circuit current for the maximum opening time of the associated protective device.

d. FORM OF SEPARATION: As a minimum shall be in accordance with the requirements of AS3000

- Regional Switchboards - Form 4B – Unless approved otherwise by MQU
- Main Switchboards – From 3B as a minimum with Form 4 being considered for critical buildings. This should be confirmed with the university during design.

e. TYPE ih SEGREGATION: type ih (insulation & housing) segregation must not be used except for within fully metallic segregated compartments containing distribution chassis rated less than 400A, or otherwise to written approval by MU PROPERTY engineering.
f. DEGREE OF PROTECTION: Minimum IP42 indoors / IP54 outdoors
g. SPARE CIRCUIT SPACES:

- Provide minimum 25% spare submain circuit capacity unless specifically nominated otherwise on the drawings.
- Allow to fill all required switchboard tiers with spare spaces and where this spare capacity cannot be met due to physical restrictions, seek approval in writing from the University at workshop drawing stage.
- All spare spaces must be fully bus barred for the nominated rating or the compartment is prepared to allow installation of a functional unit with minimal downtime.

h. SPACE CONFIRMATION:

- Design and construct the main switchboard so it can be incorporated within the room space shown on the drawings. Examine the area for switchboard on site and take into account building column locations, beam clearance height, etc, prior to commencement of construction of the switchboard.
- Tenderers must confirm in their tender that the specified dimensions are achievable and will enable the main switchboard arrangement, ratings, connections, and equipment, etc, to comply with all requirements and conditions as specified in this specification.

- Ensure that the switchboard final dimensions, arc chutes, etc, will not prevent the transportation of the switchboard cubicles through standard height doorways and also under the cable ladder tray installation in the applicable areas of the building.

i. Ensure that the design and construction of the Electrical main switchboard must enable periodic maintenance and as much of the main switchboards equipment, busbars, connections, terminations, etc, as possible to have ability to be scanned by infra-red imaging equipment.

Use busbars or proprietary encapsulated flexible busbars for all power connections within a switchboard. They must meet these requirements:

a. MATERIAL: Bare bright Hard-drawn high-conductivity electrolytic tough pitched copper alloy bars specifically manufactured for electrical conductor use.
b. TEMPERATURE RISE LIMITS - ACTIVE AND NEUTRAL CONDUCTORS:

- Maximum Rated Current Temperature Rise Limits: 65 □ 1.5ºC by type test or calculation in accordance with Australian Standards.
- Maximum Short-Circuit Withstand Current Temperature Rise Limits: 160˚C by calculation in accordance with Australian Standards.

c. CROSS SECTION: Rectangular section with radiused edges.
d. TEE-OFF BUSBARS CURRENT RATING:

- For Individual Outgoing Functional Units: Equal to maximum frame size rating of the functional unit.
- For Multiple Functional Units: Equal to the diversity factors in accordance with Australian Standards, based on frame size rating.

e. CABLE CONNECTION FLAGS:

- General: Provide and support busbar flags for equipment with main terminals too small for cable lugs. Use flags sized to suit cable lug termination, with current rating of at least the maximum equipment frame size.
- Phase Isolation: Provide phase isolation between flags where the minimum clearance distances phase-to-phase and phase-to-earth are below the component terminal spacing.

f. FUTURE EXTENSIONS: Pre-drill the main circuit supply busbar for future extensions and extend busbar droppers into future functional unit locations.

External switchboard designs must include the following requirements:

a. GENERAL REQUIREMENT: Provide an enclosure comprising panels, doors and the like, giving the specified enclosure, segregation and degree of protection. Use construction methods verified by required tests to at least the nominated fault level and temperature-rise limits and internal arcing-fault containment. Fabricate from sheet metal of rigid folded and welded construction. Obtain approval for non-welded forms of construction.
b. SUPPORTING STRUCTURE: Fabricate supporting frames from rolled, cold formed or extruded metal sections, with joints fully welded and ground smooth. Provide concealed fixing or brackets located to allow the assembly to be mounted and fixed in the specified location without removal of equipment.

c. PANELS: Machine fold sheet metal angles, corners and edges with a minimum return of 25mm around the edges of front and rear panels, and 13mm minimum return edge around doors. Provide stiffening to panels and doors where necessary to prevent distortion or drumming.
d. LIFTING PROVISIONS: Provide fixings in the supporting structure, and removable attachments, for lifting switchboard assemblies whose shipping dimensions exceed 1.8m high x 0.6m wide.
e. FLOOR-MOUNTING: Provide a metal plinth channel, not less than 75mm high. Bolt fix the switchboard assembly to the plinth and the plinth to the floor.

Cable entries must satisfy the following requirements:

a. GENERAL: Provide sufficient clear space within each enclosure next to cable entries to allow incoming and outgoing cables and wiring to be neatly run and terminated without undue bunching and sharp bends.
b. BMCS AND EMS TERMINAL ZONE: Provide a fully segregated compartment for low voltage terminal for connection by others. Provide a segregated cable pathway to the exterior of the switchboard to permit cables to be installed and connected with the switchboard operating. Alternatively, locate separate enclosure externally (on top of switchboard).
c. GLAND PLATES: Provide removable gland plates fitted with gaskets to maintain the degree of protection.

Doors must meet these requirements:

a. MAXIMUM WIDTH: 900mm.
b. MINIMUM DOOR SWING: Through 90^{o}.
c. DOOR STAYS: Provide stays to outdoor assembly doors.
d. ADJACENT DOORS: Space adjacent doors to allow both to open to 90^{o} at the same time.
e. HANGING: Provide corrosion-resistant pintle hinges or integrally constructed hinges to support doors. For removable doors, provide staggered pin lengths to achieve progressive engagement as doors are fitted. Provide 3 hinges for doors higher than 1m. Provide restraining devices and opposed hinges for non lift-off doors.
f. DOOR INTERLOCKING OVERRIDE: Provide a tool override for any interlocked switch actuator to permit the door to be opened on load for thermographic testing.
g. DOOR HARDWARE:

Provide the following:

- Corrosion-resistant lever-type handles, operating a latching system with latching bar and guides strong enough to withstand explosive force resulting from fault conditions within the assembly.
- “T” handles with provision for key locking cylinder to university bi-lock standard
- Captive, corrosion-resistant knurled thump screws.
- Do not use door locks with removable plastic key tools
- Provide three point door securing system ridge centre door stiffener for all doors greater that 1.5m in height.

h. LOCKING:

- Internal switchboards do not require locks provided they are located within a room/cupboard accessible only by a University Bi-Locks cylinders.
- External switchboards must have pad locking facilities or University bi-lock fitted.

i. DUST SEALS: Provide a resilient strip seal, of foamed neoprene or the equal, around each door, housed in a channel and fixed with an approved industrial adhesive.
j. DOOR MOUNTED EQUIPMENT: Protect or shroud door mounted equipment and terminals to prevent inadvertent contact with live terminals, wiring, or both.
k. EARTHING: Maintain earth continuity to door mounted equipment using multi-stranded, flexible earth wire bonded to the door.
l. COVERS:

- Maximum Dimensions: 900mm wide and 1.2m2 surface area.
- Fixing: Fix to frames using at least 4 fixings. Provide corrosion-resistant acorn nuts if the cover exceeds 600mm in width. Rest cover edges on the cubicle body or on mullions. Do not use interlocked covers.

m. Handles: Provide corrosion-resistant “D” type handles.

Escutcheon plates must satisfy these requirements:

a. REQUIREMENT: Provide removable escutcheon plates with neat cut-outs for circuit breaker handles and corrosion-resistant lifting handles.
b. FIXING: Fix each plate to the frame with metal fixings held captive in the plate and spaced uniformly.
c. HANGING: Hang escutcheon plates on hinges which allow opening through a minimum of 90^{o} and permit the removal of the escutcheon when in the open position.

Finishes must satisfy these requirements:

a. EXTENT: Apply protective paint or powder coat finishes to internal and external metal surfaces of assembly cabinets including covers, except to stainless steel, galvanized, electroplated, or anodised surfaces and to ventilation mesh covers.
b. PAINT: To Australian Standards
c. Colours:

- Indoor Assemblies
  - Exterior: X15 Orange
  - Interior: White
- Exterior Assemblies
  - Exterior: to University approval
  - Interior: White

d. UNPAINTED METAL FINISHES: finishing, sanding, sand blasting, etching and the like must be within the range of approved samples.

7.2.6 LABELLING

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

- An elevation of the Switchboard showing the rating and function of all functional units.
- A single line diagram of the 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 Switchboard. For external switchboards the drawings shall be fixed to the inside of the switchboard doors.

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.

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.

Labels must be provided to meet these requirements:

a. MARKING: Marking must include labels for each switchboard control, circuit designations and ratings, fuses fitted to fuse holders, current-limiting fuses, warning notices for operational and maintenance personnel, and the like.
b. SET-OUT: Align horizontally and vertically with adjacent labels.
c. FIXING: Attach labels using plastic blind plugs through drilled holes or stainless-steel screws.
d. EXTERIOR LABELS:

- Manufacturers Name
- source of electrical supply
- Circuit designation for main switches, main controls, and sub-mains controls.
- Details of consumers" mains and sub-mains.
- controls and fault current limiters
- Fuse link size.
- Circuit breaker frame size & trip current settings
- Meter function identification immediately adjacent the meter.

e. INTERIOR LABELS: Provide labels for equipment within assemblies. Locate so it is clear which equipment is referred to, and lettering is not obscured by equipment or wiring.
f. SAMPLES: Provide samples of proposed label material, label sizes, lettering sizes and lettering text for approval.
g. MATERIAL: Engraved Two-colour laminated plastic, engraved filled metal or photo-anodised rigid aluminium.
h. COLOURS:

- Warning Notices: White letters on red background.
- Other Labels: Black letters on white background.

i. LETTERING HEIGHT: Generally, not less than the following:

- Main Switchboard Designation: 25mm.
- Main Switches: 20mm.
- Feeder Control Switches: 10mm.
- Identifying Labels: on outside of cubicle rear covers, etc.: 4mm.
- Equipment labels within cubicles: 3mm.
- Warning notices: 10mm for heading and 5mm for remainder.

j. SCHEDULE CARDS: For distribution boards provide schedule cards of A4 minimum size with text typewritten to show:

- Sub-main designation and rating
- Light and power circuit number, type and area supplied
- Submit the proposed schedule for approval
- Mount the schedule card in a holder fixed to the inside of the enclosure door, adjacent to the distribution circuit switches, and protect the schedule with a hard plastic cover.
- Digital copies of all scheduled shall also be provided.

A Rating Plate must be provided that satisfies these minimum requirements:

- Manufacturer's name
- Serial number / drawing number
- Relevant standard built to (e.g. AS 61439)
- Type of current (and frequency, in the case of ac)
- Rated operational voltages and maximum current
- Short-circuit withstand performance
- Degree of protection
- Type of system earthing
- Form of internal separation
- Date of manufacture

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

7.3 DISTRIBUTION BOARDS

7.3.1 GENERAL

This section applies to all general power and lighting Distribution Boards. It describes the detailed requirements for these boards and may include other smaller switchboards typically of rating <250A.

All switchboards shall be designed and built-in accordance with the Australian Standards and the relevant authority's requirements.

7.3.2 CALCULATIONS

Generally, all calculations as outlined within the requirements for MSBs and MDBs are also applicable to Distribution Boards. Refer section above for details.

7.3.3 LOCATIONS

Distribution boards must be located within dedicated cupboards accessible from circulation spaces, corridors and foyers, or within plantrooms. They must not be located in offices, classrooms or lecture theatres and where possible should be located outside of laboratories or clinical space.

Distribution boards should not be located outside in direct sunlight or exposed to the weather. Where this is not possible in writing approval should be obtained for the university.

7.3.4 MANUFACTURERS

The university does not maintain an approval list of manufacturers for distribution boards, however, wherever custom made boards are to be used they shall be manufactured locally by reputable well-established companies. Where off-the-shelf boards are to be utilised, the university will accept NHP or Schneider, or a verified design from a switchboard manufacturer only, unless in writing approval is obtained.

7.3.5 CONSTRUCTION

The distribution switchboards general design must:

a. be of the dead front, totally enclosed type.
b. be constructed of folded and welded sheet steel with a with an orange powder coat finish, unless otherwise specified.
c. utilise standard manufacturers encapsulated insulated copper busbar chassis mounted on a separate backing plate secured to the switchboard frame by threaded fasteners which are removable from the front.
d. allow for interchangeability of single and multiple pole breakers without alteration to busbar connection or breaker mounting fixtures.
e. Have all equipment accessible and removable from the front without dismounting the switchboard from its position.
f. Include a hinged removable white escutcheon panel.
g. Otherwise comply with the switchboards section of this standard.

The following minimum configuration requirements must be met:

a. MINIMUM SIZE & CONFIGURATION: The standard Distribution Board configuration must be:

- Form 2b – Type 1 segregation as a minimum. In critical applications such as data centres and laboratories high forms of separation should be considered.
- Minimum configuration of dual chassis - 12 poles for lighting and 18 poles for power in a 36 pole switchboard box.
- The switchboard enclosure must be sized up to next largest standard chassis to ensure there is adequate cabling and auxiliary space.
- Use 18mm pole pitch DinT or C60N 6kA miniature circuit breakers in proprietary encapsulated 250A 3 phase chassis.
- Provide Energy metering CTs for power & lighting sections complete with transducers having a Modbus interface. Mount on the Din rail.
- 20A lighting RCD circuit breakers. 20A Power RCD circuit breakers
- 160A or 250A Top centre main switch.
- Din rail beside main switch for ancillaries, potential fuse, lighting control, surge diverters.
- Installed in dedicated switchboard cupboards with University Bi-locks, or where not feasible have University Bi-locks locking facilities on the switchboard door.
- Slip in clear plastic Schedule card holder with University Standard MS Excel spreadsheet schedule. Provide soft copy of the schedule in the manuals.
- Have a hinged escutcheon panel.

b. CHASSIS SIZING & SPARE CAPACITY: The chassis pole capacity must be increased from the minimum to accommodate all initial sub circuits plus:

- 20% spare pole spaces for power
- 15% spare pole spaces for lighting.

c. All other relevant requirements as outlined within this standard for MSBs and MDBs.

7.3.6 LABELLING

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 frame installed on the inside of the switchboard doors or on the wall adjacent to the respective switchboard. Digital copies shall also be provided.

Switchboard and mechanical services control boards naming protocol. All new switchboard identification numbers must be obtained from the principal prior to construction.

Labels must be provided to meet these requirements:

a. MARKING: Marking must include labels for each switchboard control, circuit designations and ratings, fuses fitted to fuse holders, current-limiting fuses, warning notices for operational and maintenance personnel, and the like.
b. SET-OUT: Align horizontally and vertically with adjacent labels.
c. FIXING: Attach labels using plastic blind plugs through drilled holes or stainless steel screws.
d. EXTERIOR LABELS:

- Manufacturers Name
- source of electrical supply
- Circuit designation for main switches, main controls and sub-mains controls.
- Details of sub-main.
- Incoming busbar or cable rating to first tee-off.
- controls and fault current limiters
- Fuse link size.
- Circuit breaker frame size & trip current settings
- Meter function identification immediately adjacent the meter.

e. INTERIOR LABELS: Provide labels for equipment within assemblies. Locate so it is clear which equipment is referred to, and lettering is not obscured by equipment or wiring.
f. MATERIAL: Engraved Two-colour laminated plastic, engraved filled metal or photo-anodised rigid aluminium.
g. COLOURS:

- Warning Notices: White letters on red background.
- Other Labels: Black letters on white background.

h. LETTERING HEIGHT: Generally not less than the following:

- Main Switches: 20mm.
- Feeder Control Switches: 10mm.
- Warning notices: 10mm for heading and 5mm for remainder.

i. SCHEDULE CARDS: For distribution boards provide schedule cards of minimum size 200mm x 150mm with text typewritten to show:

- Sub-main designation and rating
- Light and power circuit number, type and area supplied
- Submit the proposed schedule for approval
- Mount the schedule card in a holder fixed to the inside of the enclosure door, adjacent to the distribution circuit switches, and protect the schedule with a hard plastic cover.
- Digital copies shall also be provided.

7.4 SWITCHGEAR & CONTROLGEAR

Switchgear and protection equipment must be of a single brand throughout any installation and must be fully coordinated and compatible.

7.4.1 CIRCUIT BREAKERS

The following types of circuit breakers for the appropriate current must be used:

a. 10-63A Din-T with integral RCD protection within a single pole space.
b. 63A-100A Din-T 27mm module
c. 100A – 1600A Moulded case circuit breakers
d. >1600A Withdrawable air 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 1600 amps per phase)

Air circuit breakers shall be used for circuit breakers above 16+00 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 1600 amps per phase. Moulded case circuit breakers shall only be used for circuit ratings above 1600 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.

7.4.2 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.

7.4.3 AUTOMATIC TRANSFER SWITCHES

Automatic transfer switches shall comprise two electrically and mechanically interlocked motorised circuit breakers. Alternatively, mechanically interlocked motor operated switch units may be used.

Transfer switches shall provide an easily selected 'Off' position for maintenance.

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.

Where the nature of the load does not permit an interruption to supply to enable the full building load 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. If approved all design documentation and calculations must be submitted that include prospective fault current consideration during parallel connection in accordance with the NSW Service and Installation Rules.

7.4.4 CONTROL RELAYS

Control relays must satisfy the following requirements:

a. APPLICATION/RELEASE: must be applied and released without the use of tools.
b. MINIMUM CONTACT RATING: 6A at 240V for ac applications.
c. TIME DELAY RELAYS: Time delay relays must be adjustable over the full timing range and have a timing repeatability within 12.5% of the nominal setting.
d. PHASE FAILURE RELAYS: Solid-state type phase failure relays which drop out at 80% of the normal voltage after an adjustable time delay. The sensing circuit must reject disturbances having frequencies other than 50 Hz, and induced voltage spikes.

7.4.5 TRANSIENT PROTECTION

Provide transient protection devices in all switchboards in accordance with the relevant Australian Standards. These protection levels must be provided:

a. Protection Level: consistent with the prospective surge current at the incoming supply point to the switchboard, graded appropriately between upstream and downstream switchboards or systems.
b. For Main Switchboard - Minimum 100kA aggregate rating at 8/20uS waveform rise times.
c. For Distribution Boards: - Minimum 20kA aggregate rating at 8/20uS waveform rise times.

d. Primary Protection: Provide shunt connected metal oxide varistors at assembly incoming supply terminals, on the line side of incoming functional units.
e. Failure Indication: Provide integrated indicating lamps to show arrestor status and fail alarm monitoring and terminals for connection to the University BMS system.
f. Remote Monitoring: For Main Switchboards and main distribution boards provide transient protection units complete with volt-free contacts, in order to allow provision for remote monitoring of the status of the unit components.
g. Short-circuit protective devices and isolators: Back-up each arrestor active supply with a live side totally enclosed fault current limiting fuse in accordance with the manufacturers nominated rating. Provide a multi-pole automatic miniature circuit breaker on load side of fuses as an arrestor isolator.
h. Surge Arrestor Enclosures: Totally ventilated sheet metal wall boxes with hinged covers, mounted within or on the wall next to designated assemblies, containing grouped surge arrestors.

7.4.6 METERING TRANSFORMERS

Metering transformers must meet these requirements:

a. TEST LINKS: Provide test links for the connection of calibration instruments
b. TYPE: Split core CTs may be used following written approval in locations where solid CTs cannot be fitted. In this case, split core CT"s may be specified at Class 1 accuracy.
c. ACCURACY: Accuracy classification and class:

- Energy measurements: 0.5M.
- Indicating and recording instruments: 1M.

7.4.7 MULTIFUNCTION METERS

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

7.4.8 INDICATOR LIGHTS

Indicator lights must be provided to meet these requirements:

a. STATUS: Lamps must indicate:

- Supply available
- Supply connected
- The state of ATS input and output supplies
- The state of bustie, by-pass or interconnect switches

b. LAMPS: Lamps must be LED type and must be changeable from the front of the panel without removing the holder.
c. LAMP TEST: Provide a lamp test button for indication lights not directly connected to a supply such as supply available lights..

7.4.9 GENERATOR CONNECTION FACILITIES

Switchboard generator connections must satisfy these requirements:

a. REQUIREMENT: Provide a generator connection terminal box and manual changeover switch for every regional and main switchboard.
b. Incorporate the changeover switch into all new switchboards, with a remote terminal box located adjacent to a nominated temporary generator location.
c. CONSTRUCTION: Comply with the requirements for switchboards and external switchboards.
d. CABLE ENTRY: Provide cable flags and removable gland plate in the bottom of the connection cubicle for temporary generator cables.
e. RATING: To match the main switch capacity of the associated switchboard.

7.4.10 INSPECTIONS

MUP and the design consultant must be notified in advance and provided with the opportunity to conduct the following inspections:-

- Fabrication and painting completed, assembly completed with busbars exposed and functional units assembled.
- Board completed, tested and ready for delivery.
- Board installed onsite in situ, ready for connection.

7.5 WIRING SYSTEMS

7.5.1 GENERAL

The Low Voltage power distribution system shall be designed in accordance with AS/NZS 3000 and AS/NZS 3008. Design must consider the effects of voltage drop, current carrying capacity and fault current requirements. Calculations are to be undertaken and made available upon request to Macquarie University Property.

7.5.2 CALCULATIONS

Current carrying capacity calculations shall be completed for all consumers mains, submains, and large sub-circuit cabling to ensure compliance with AS3008 including all requirement derating. Sufficient spare capacity shall be included in all calculations to cater for future growth, particularly where adjustable circuit breakers are installed.

Prospective fault current calculations shall be performed by the design engineer to ensure all cabling, including earth conductors, are suitably selected.

Provide all calculations for cabling using a proprietary software equivalent to POWERPAC or POWERCAD. Provide PDF output documents showing:

a. Protective device type and setting
b. Cable Current rating for the method of installation
c. Voltage drop at rated maximum demand load
d. Maximum cable length
e. Earth fault return impedance
f. Fault current at the load end

Maximum Demand

Maximum demand calculations are required to be undertaken for all projects regardless of size and be available upon request. All maximum demand calculations are to be undertaken in accordance with AS/NZS 3000 Appendix C. Calculation can be provided in a spreadsheet format provided the original file can be provided for review. PDF only format will not be accepted.

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 is compliant with the requirements of AS3000 and the Services and installation Rules. Generally voltage drop shall not exceed 5% of the nominal system voltage, and where the point of supply is a dedicate substation located on site this may be increased to 7%. It is the responsibility of the designer to ensure these calculations are completed in accordance with the relevant standards, that calculations can be provided for review and consider potential for future load increases.

Use the following as design limits for voltage drop, calculated at the rated maximum demand including any future spare capacity:

a. Total maximum 5%, or 7% for an installation with a dedicated substation
b. Consumer Mains – 0.5%, or 0.75% for an installation with a dedicated substation

c. Submains – 2%, or 3.75% for an installation with a dedicated substation
d. Final Subcircuits 2.5%

Note that lighting and general power sub-circuits shall be design to typically limited load to 10A maximum demand due to RCD limitations and anticipated combined earth leakage

7.5.3 CABLE SELECTIONS

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

7.5.4 SUBMAIN CABLING

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 10mm^2.

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.

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.

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.

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.

7.5.5 SUBCIRCUITS

For general sub-circuits use multi-stranded or flex copper conductors with the following minimum sizes:

a. 2.5mm^2 for 16A lighting sub-circuits
b. 2.5mm^2 for 20A power sub-circuits
c. 1.5mm^2 for 10A control circuits

The following requirements for subcircuit loading and non-RCD circuits must be satisfied:

a. SUBCIRCUIT LOADING:

- 16 Amp Lighting subcircuits must have a maximum initial connected load in consideration of RCD minimum trip tolerance and electronic driver leakage.

- 20A Power subcircuits must have a maximum of 6 double GPO connected.

b. NON RCD PROTECTED SUBCIRCUITS: Where non-RCD protected subcircuits are to be provided ensure all provision are in accordance with the requirements of AS3000. These circuits may be considered for the following load groups:-

- UPS powered critical equipment.
- Dedicated outlets for critical refrigerators and freezers
- Communications cabinet outlets
- Fire alarm and protection equipment

All outlets shall be dedicated to equipment being supplied, located out of reach or in an inaccessible location, and clearly labelled as Non-RCD protected.

7.5.6 SOFT WIRING SYSTEMS

Minimum rating: 240 V, 20 Amp rating minimum.

Plug: Provide a matching starter socket outlet on a faceplate with a locking mechanism, to prevent the socket from being pulled.

Installation: Unless specified otherwise, the outlet shall be installed at 300mm AFFL. If installed within the ceiling space, the outlets shall be securely fixed to the building structure.

Preferred Make and Type: CMS Electracom '20 Amp Side Entry Starter' Series or equal approved

Softwired Outlets: Provide with quad-block (4 off) auto-switched of outlets at each termination

Soft wiring systems must be compatible with the project workstation system, and comply with OHS safety regulations, and Australian codes and standards. The design and specification must specifically co-ordinate the supply of the soft wiring (by WS contractor or the electrician), the installation of the soft wiring, provision of cable containment in the desks and the starter socket / local isolator type and location.

7.5.7 INSTALLATION, SUPPORT & CONCEALMENT

Cables must be installed as follows:

a. STRAIGHT-THROUGH JOINTS: Run cables for their entire route length without intermediate straight- through joints unless unavoidable due to length or difficult installation conditions.
b. CABLE JOINTS: Cable joints must only be used with prior written approval of the University. Locate in accessible positions in junction boxes.
c. MARKING: Identify the origin of all wiring using legible indelible marking. Identify multi-core cables and trefoil groups at each end and at crowded intermediate points by means of stamped, non-ferrous tags clipped around each cable, or trefoil group.
d. INSTALLATION: Install and adequately support fixed wiring as specified throughout the installation. For cabling routes not specified in detail, submit a proposed route layout.
e. Where TPS cables are installed in accessible locations concealed from view, or within suspended ceiling spaces, secure them to the roof framing, slab or softwood battens with approved clips, straps, clamps, or saddles located as close to the slab soffit as practicable. Cables must not be secured to ceiling suspension system.

f. Support all cables at a maximum of 1200mm spacing with minimum sag.
g. All installations must be neat and tidy in appearance and installed parallel and/or perpendicular to building elements.
h. CABLE COLOUR: For fixed wiring colour the conductor insulation or, if this is not practicable, slide not less than 150mm of close fitting coloured sleeving to each conductor at the termination points as follows:

- Active conductors in single-phase circuits: RED.
- Active conductors in polyphase circuits:
- A PHASE - RED
- B PHASE - WHITE
- C PHASE - BLUE
- Switched Active Conductors To Fittings: WHITE.
- Earth - green with yellow stripe
- Technical Earth – purple

Conceal wiring runs within the building fabric or accessible spaces, except within plant rooms, which may be run in surface mounted steel conduits. Install concealed wiring so it can be rewired easily and without damage to finishes or materials.

Generally conduits must be fixed and supported as follows:

a. FIXINGS: Provide double sided saddles when surface mounting in areas where additional mechanical protection is required (walkways, plantrooms etc.).
b. SUPPORT: Unless otherwise specified, fix conduit saddles at a maximum of 800mm intervals in horizontal runs and 1200mm intervals in vertical runs. Ensure that installed conduits are fully supported during construction.
c. PROTECTION IN ACCESSIBLE OR TRAFFICABLE SPACE: Protect PVC conduits installed in all accessible spaces from damage.
d. DRAW CORDS: Provide draw cords in conduits not in use. Leave 1m of cord coiled at each end of the run. Draw wires must be insulated building wire (2.5mm minimum size) or nylon rope.
e. DRAW-IN BOXES: Provide draw-in boxes at suitable intervals not exceeding 20m in straight runs for smaller conduits up to 50mm (inclusive)
f. ROUTE OF RUN: Run conduits concealed in wall chases, embedded in floor slabs and installed in inaccessible locations, direct between points of termination with a minimum number of sets.
g. STEEL CONDUIT: Steel conduit must be galvanized or stainless.
h. FIXING: Fix conduits directly to the reinforcing where the conduits pass above a single layer of reinforcing or fix midway between double layers of reinforcing. Route the conduits in slabs to avoid crossovers and to keep the number of conduits in any one location to a minimum. Space conduits 75mm apart in slabs.

The following requirements must be met for non-metallic conduits and fittings:

a. CONDUIT IN SLAB: Use high compressions corrugated conduit and restraint at regular intervals to achieve a nominally straight run. Do not use glued elbows or tees.
b. CONDUIT UNDERGROUND: Use HD PVC conduits for all underground power cable runs. Use white communications grade conduit for all communications runs.

c. TYPE: Unless otherwise specified, use heavy duty conduits and associated fittings must be of the same material.
d. JOINTS: Use cemented joints. Adopt the manufacturer's recommended procedure for making joints.
e. FITTINGS: Use inspection-type fittings in accessible and exposed locations.
f. CONDUIT SETTING: Where practicable have conduits pre-formed by the manufacturer. At site, use correctly sized springs to form sets in UPVC conduit. Bends must be of large radii and, after setting, must maintain effective diameter and shape. Reject conduit sets distorted by kinks, wrinkles, flats or heating.
g. EXPANSION JOINTS: Install flexible couplings where structural expansion joints occur in buildings and in straight runs not embedded in wall chases or floor slabs. Space flexible couplings in straight
h. runs at maximum 10 intervals.
i. MECHANICAL DAMAGE: Where conduit are exposed to mechanical damage and external to buildings, provide mechanical protection to UPVC conduit for a height of not less than 3m above ground or platform level.
j. SPARE CAPACITY: Provide spare capacity within all conduit of a minimum 25% for the installations of additional cabling in future.

Flexible conduits must meet these requirements:

a. LENGTH: The maximum length of a flexible conduit connection must be 600mm.
b. USE: Use for expansion joints and fit flexible conduit to equipment and plant where subjected to vibration, or where necessary for adjustment or ease of maintenance. Do not use flexible corrugated conduit in place of set or glued bends in conduit installation or in areas exposed to high UV or direct sunlight.
c. High UV areas are to use zinc plated PVC coated conduit and fittings
d. EQUIPMENT CONNECTIONS: Use zinc plated steel flexible PVC coated conduit with associated fittings.

Mini PVC trunking /Duct must meet these requirements:

a. The use of surface mounted PVC mini ducting should be avoided wherever possible.
b. Use only in areas of high visibility.
c. Manufactured fittings shall be used on change of direction.
d. Mini ducting shall be screw fixed to surface in addition to the use of double sided adhesive tape. Adhesive tape alone shall not be used.

Skirting ducts must meet these requirements:

a. TYPE: Use only extruded multichannel aluminium duct with drop in screw fixed cover plates.
b. SIZE: Minimum 50mm deep x 150mm high with two channels.
c. 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.

Cable support systems must meet these requirements:

a. SUPPORT SYSTEM: 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.
b. STEEL TRAYS: Galvanize after manufacture. Exposed raw steel edges are not acceptable.

Minimum steel thickness of trays:

Width of Tray	Thickness of Material
<150 mm	1.0 mm
150-300 mm	1.2 mm
>300 mm	1.6 mm

- Folded edge: Minimum height 20mm, radiused.
- Slotting: Normal or reverse with no burrs or sharp edges on the side to which cables are attached.

a. CABLE LADDER:

- Small Cable: Do not run cables smaller than 13mm outside diameter on the cable ladder unless continuously supported.
- BEND RADIUS: Bends must have a minimum inside radius of not less than twelve times the outside diameter of the largest diameter cable carried.
- SPARE CAPACITY: Provide spare space for not less than 25% more cables or conduits than initially required to be installed, and all future design capacity.
- 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 STRAPPING: Fix cable to the support system 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.

b. Catenary suspension systems: Catenary cable support systems may be used to replace cable trays for retrofit or fitout installations where the installation of new cable trays is deemed impractical. Use high tensile multistranded galvanised steel cable with proprietary fixings and proprietary compression crimped rigging fittings. Provide cable tension adjustment.
c. 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.
d. Install a maximum of 1 submain or five TPS subcircuit cables on any one catenary. (Approval must be given by MU Property for catenaries with multiple circuits.

Metallic Support Systems and Fixings must meet these requirements:

a. FABRICATION: Provide brackets, racks, hangers and other supports sized to adequately support the installed system and equipment, fabricated from steel sections or from other materials in sections of equivalent strength.

Minimum thickness of structural steel sections:

- Angles and bars: 6.5mm.
- Rods: 10mm diameter.

b. FIXING TO BUILDING STRUCTURE: Fix the supports by surface fixing to ceilings and walls, or suspension hangers from ceilings, or angle brackets or racks from walls, using the following methods, as appropriate:

- Masonry or concrete walls: steel expanding or chemical anchor bolts
- Concrete slab ceilings: steel expanding or chemical anchor bolts
- Structural steel: Grade 8.8 machine bolts, hot dip galvanised.
- External fixings: Grade 8 (stamped marked) stainless steel bolts and chemical anchor bolt fixings

c. SPACING: Space the supports at intervals of not more than 1 m and provide a support at each joint in the tray or ladder system.
d. FINISHES:

- Galvanizing: Hot dip galvanize steel conduits and support systems exposed to the weather or installed in damp locations.

Paint System: Paint conduits and support systems as follows:

- Indoor locations: A system using FULL GLOSS, WATER-BORNE, OR Powder coating with zinc rich undercoat.
- Outdoor locations: A system not inferior to FULL GLOSS, SOLVENT-BORNE: EXTERIOR - PAINTING. OR Powder coating with zinc rich undercoat.
- Paint Colours: In locations exposed to view use a final coat of approved colour, generally to match the surroundings. In switchrooms and plant rooms, ceiling spaces, cable ways and underground use light orange.

e. All light fittings and load bearing devices mounted on concrete or masonry ceilings and walls, will be fixed using metal fastenings – Plastic or nylon tap-in fastenings are not suitable for these applications.

Underground cable installations must meet these minimum requirements:

a. SITE SERVICES PLAN: Obtain the University site services plan for the area concerned. Where insufficient detail is available the installation contractor shall undertake services tracing including ground penetrating radar analysis to identify all existing services.
b. UNIVERSITY STANDARD: Comply with the University standard specification for underground trench excavation and backfilling.
c. DETAILED HAND EXCAVATION: Allow for manual hand excavation and/or wet vacuum excavation where significant, dangerous or unknown services exist. Allow for detailed hand excavation through all tree zones to minimise damage to the tree roots in the drip zones.
d. CABLE PITS: are to be provided adjacent to the cable entry points to buildings, at changes in direction and at a maximum of 50m spacing for straight runs. All pits shall be selected and designed in accordance with AS 3996 based on the location of their installation. Pits shall generally comply with the following:-

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

e. Mould the word “ELECTRIC” into a lid for use on any pit containing electrical power cables or “COMMS” for communications systems. Comply with the University labelling and marking standards.
f. Where is high visibility areas pits should be provided with an infill to match the surrounding surfaces.
g. SURVEY: Accurately survey the routes of underground cables prior to backfilling and provide a survey plan, endorsed by a registered Surveyor, which identifies the cable locations in relation to permanent site features and other underground services.
h. LOCATION: Accurately locate underground cables using route markers placed at intervals of not more than 30m for straight distances, and at pits, route junctions, changes of direction, terminations and entry points to buildings.
i. DIRECTION INDICATORS: Mark the direction of the cable run by marker plate direction indicators. Provide four distinct versions of the marker plate engraved with a single arrow (->), through (<->), “L”, and “T” arrows. A group of two or more plates may be required at some route junctions.
j. MARKER PLATES: Engraved Stainless steel or brass, minimum size 75 x 75 x 1mm thick SS or 2mm thick brass.
k. PLATE FIXING: Waterproof adhesive and 4 brass or stainless steel countersunk screws. Set the marker plate flush in a 200mm minimum diameter concrete base, not less than 200mm deep.
l. MARKER TAPE: Where electric bricks or covers are not provided over underground wiring, provide a 150mm wide yellow or orange marker tape bearing the words *“WARNING - electric cable buried below”,* laid in the trench 150mm below ground level.

Cabling is Services Tunnels:-

The underground Services Tunnels within the main university campus are not to be considered as a fire separated environment. Hence, all cables to be installed within the tunnels shall be considered in the same way as any other part of a non-fire rated building. All cables to be installed within the Services Tunnels which provide supply to Fire and Life Safety Services (As defined by the BCA) or other critical loads shall be fire rated in accordance with the Australian Standards.

7.5.7.1 REDUNDANT CABLING

Remove redundant equipment and wiring, including in accessible ceiling spaces, and make good exposed surfaces before commencing the installation of new wiring. Remove redundant underground cables unless otherwise approved by the university.

Where it is will involve significant cost and/or disruption to remove redundant cabling, strip and bond together all redundant cable ends left in place. Insulate and label both ends with permanent tags. The labelling shall read “REDUNDANT UNUSED CABLE”.

7.5.8 FIRE RATING & SEALING

Provide fire, mechanical and water spray protection to wiring systems supplying safety services in accordance with AS3000:2018 clause 7.2 to ensure the supply of power is maintained when exposed to a fire.

Safety Services may include, but shall not be limited to:-

- fire pumps and automatic sprinkler systems
- fire and smoke detection equipment and fire alarm systems
- air-handling systems
- evacuation equipment
- emergency lifts.

Wiring systems associated with the supply of safety services may include, but shall not be limited to any of the following:

- consumer’s mains
- generator supplies
- normal and alternate supplies
- sub mains
- final sub circuit wiring.

Where a safety service has a Standard specific to the installation of that safety service equipment, and that Standard requires the wiring system to be a WS classified wiring system complying with AS/NZS 3013, then the wiring system (including all parts) must be WS classified to the level required by that Standard.

Fire penetrations are only to be installed where unavoidable. Where services penetrate fire walls, floors or other fire rated barrier, sealant for those penetrations shall be provided to the approval of the relevant Authorities.

The contractor must submit details of proposed fire resistant sealants for approval prior to use during installations. Fire proof each penetration through fire proof building members, irrespective of size, upon completion of installation of cables. Ensure fireproofing complies with all Building Code, Local Authority and Supply Authority requirements, utilising fire barrier pillows and mastic.

7.5.9 ACOUSTIC WALLS AND CEILINGS

Ensure acoustic walls and ceilings are not penetrated without approval of the acoustic engineer on the project. All acoustic rating of barriers, where penetrated by electrical services, shall be reinstated once cable installation is complete using an approved method. Provide approved proprietary acoustic-rated wall-boxes for accessories to be installed on acoustically rated walls. Seal to approval of the acoustic engineer and in accordance with the MUP Acoustic Service Design Standard.

7.5.10 FUNCTIONAL EARTHING SYSTEMS

Provide complete technical communications / technical earthing systems for all computer rooms and laboratory or sensitive areas. Where a technical earthing system is required for research / measurement facilities, it must be segregated from the communications and power earthing systems, except for the single bond at the building main earth bar.

The system must include:

a. a dedicated buried earth grid external to the building with a maximum impedance of 0.5 ohms.
b. A main technical earth bar with provision of slack cable and space to place a clamp current meter onto every outgoing radial cable.
c. Radial dedicated technical earth cable distribution to every equipment room or laboratory
d. A single link to the building main earth bar in the main switchroom
e. Earth leakage / circulation current alarm monitoring on the link to the main earth bar.

Provide independent earthing for raised floors, and all metallic building elements connected radially to the power protective earth bar.

7.6 EMERGENCY STANDBY POWER GENERATORS

7.6.1 GENERAL

The requirement for the provision of an emergency standby power generator shall generally be defined within the project brief. However, where a building includes critical facilities such as laboratories, data centres, research facilities or other facilities where the loss of power may cause significant financial loss, the provision of a generator shall be considered.

Where an emergency generator is to be provided, the following shall be considered:-

- Fuel storage capacity must be sized for generator operation at full load for a minimum of 8hrs. Generally, no more than 1,000L shall be stored within a building and must be fully compliant with the Building Code and AS1940.
- All bulk storage tanks must be self-bunded with integral leak detection. They must be located on or below the lowest level of the building and fully compliant with all EPA regulations, particularly when located underground.
- BMS and/or security alarm connection must be provided to ensure relevant contacts are aware of generator operation, failure, low fuel warnings etc.
- All engine exhaust discharge must be considered to ensure minimum required separation is achieved from any building openings, or air intakes.
- Noise levels produced by the chosen generator shall be assessed by an acoustic engineer
- Closed transition type Automatic Transfer switches shall be provided where possible with open transition being considered only if approved in writing.
- The provision of artificial load banks shall be considered and discussed with university stakeholders and dependant on the transfer switch arrangement and criticality of the building. Where a close transition ATS is to be provided, and regularly testing on building load is possible, an artificial load bank may not be required.
- The university will accept generators from the following manufacturers:

    - Cummins Australia
    - MTU
    - Caterpillar

The engine, alternator, controller, radiator, skid and associated components shall be of a complete type which is currently supported in Australia/NSW and for which spare parts and skilled maintenance are readily available.

The equipment provider is required to have a branch or facility within 50km of the site location which aligns with the ABN of the equipment manufacture & dedicated in house 24/7 support call centre

The warranty of the generator is to be direct from a single manufacturing source, multiple warranty statements for each component such as engine, alternator, controller, radiator, skid and associated components will not be accepted.

7.7 LIGHTNING PROTECTION

7.7.1 GENERAL

For all new buildings and building extension of significance the designer is to complete a lighting protection risk assessment in accordance with the requirements of AS/NZS 1768. The designer is to liaise with MQ project team representative to determine risk parameters and determine the requirement for lightning protection.

If determined to be required, a lighting protection system is to be designed in compliance with a conventional lightning protection system as outlined within AS/NZS 1768. Non-conventional lighting protection systems are not to be used on university buildings unless a cost benefit analysis is undertaken and submitted to MUP as part of a non-compliance request for approval.

Lightning protection system installations are to be certified by the manufacturer and warrantied for a minimum of 12 months.

The following requirement apply in addition to the Australian Standards:-

7.7.2 MATERIALS

Provide a coating of polyurethane compound to copper strip materials embedded in concrete.

7.7.3 FIXINGS

Fixing must meet these requirements:

a. FIXING TO MASONRY: Screws or bolts set in approved expansion-type masonry anchors contained in properly formed holes. Do not use explosive-driven fixings.
b. FIXING TO STEEL: Bolts of appropriate size (not less than 6mm diameter), with nuts and lock washers.
c. FIXING TO TIMBER: Adequate length self-drilling timber screws.

7.7.4 JOINTS AND BONDS

The following types of joints and bonds must be used:

Types Of Joints:

- Accessible Connections: TIG welded or bolted with high tensile SS bolts
- Inaccessible Connections: CAD or TIG welded
- Stranded Copper Connections: Bond corners, tee joints, and between the ends of non-overlapping bars by means of stranded copper connections, double-bolted at each end with appropriately sized stainless steel bolts, nuts, and lock washers. For this purpose, provide a 25mm gap between the members to be joined.

Bonding:

- Roof Projections: Bond to the air termination network the metallic projections shown on the Drawings on or above the main roof area, including TV aerials, flagpoles, handrails, metal roofing of secondary roofs, water tanks, ventilators, guttering, access ladders, and the like.

- Services: Bond metallic service pipes to the lightning protective system at the point of entry or exit outside the structure on the supply side of the service;
- Bond metallic sheathing or armouring of electric cables at the point of entry to the building.
- Down Conductors: Where a metal part of a building runs for more than 10 m in close proximity to a down conductor, bond the metal at top and bottom to the conductor;
- Where a down conductor occurs on the external face of a column, bond it at top and bottom to terminals on the column reinforcement;
- Where the column reinforcement is the down conductor, provide terminals and bond it at top and bottom to the conductor network.

7.7.5 INSTALLATION:

Before commencing the installation, coordinate and submit for approval drawings showing the proposed layout of the protective system, including details of the locations and types of joints, terminals and earthing terminals, and the arrangement of components in earthing pits.

Preference for the building structure to be utilised as down conductors where possible. Visible down conductors are to be avoided.

7.7.6 EARTH TERMINATIONS:

These requirements must be met for earth terminations:

- TERMINATING LUGS: Provide terminating lugs on each electrode or earth termination network for the connection of down conductors or base conductors.
- BASE CONDUCTORS: Provide base conductors between each driven electrode and buried electrodes to interconnect the buried earthing system. The connections between the base conductor and the individual electrodes must be capable of acting as removable test links.
- ELECTRODE PITS:
    - Electrode: Locate each driven electrode within a concrete pit of internal dimensions 300mm x 300mm x 500mm deep, so that the top of the electrode is not less than 150mm above the bottom of the pit and not less than 150mm below the underside of the pit cover.
    - Pit Walls: 150mm concrete or 200mm solid blockwork.
    - Pit Cover: Reinforced concrete 75mm thick, or equivalent. Set the top of the cover flush with the adjacent finished surface level. Label the pit cover in letters 10mm high: “LIGHTNING PROTECTION EARTH ELECTRODE”.
    - Labelling: engraved SS or brass plate

7.8 ELECTRICAL ACCESSORIES

7.8.1 GENERAL PURPOSE OUTLETS

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

Location	Preferred Make and Type
General Internal Areas	Clipsal ‘Pro 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 and distribution board.

Labelling shall be provided via ID windows. Adhesive printed labelling will not be accepted.

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

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

Colours of General-Purpose Outlets

General purpose outlets shall be coloured as follows:

Outlets	Colours
Outlets connected to General Supply Systems	Internal outlets with PVC cover plates to be white or to approval of architect/interior designer.
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	Colours
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 maximum of 10 socket outlets are to be installed on a 20A power subcircuit, or 8 socket outlets on a 16A power circuit. In areas such as computer laboratories, this number can be increased subject to approval by Macquarie University Property.

Quantities 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 – minimum 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 3lm of wall.

7.8.2 DEDICATED SWITCHED SOCKET OUTLETS

Single Phase Outlets Rated 15A and Above

- Internal Outlets: As per General Purpose Outlets
- External Outlets or outlets in Plant or similar areas: Clipsal ’56 Series’
- Communications Cabinet Outlets: Clipsal ’56 Series’ complete with captive locking ring facility and matched to the power rail in the respective cabinet. Provide a matching plug complete with locking ring with each outlet.

Multi-Phase Outlets

- To be Clipsal ’56 Series’

7.8.3 COMMUNICATIONS ROOM OUTLETS

Power provisions for communications cabinets and within communications rooms shall be discussed with the project team and university IT at the commencement, however as a minimum must meet the following requirements:

a. MINIMUM RATING: 20A dedicated outlets for cabinet, 10A for general portable testing equipment etc. and other equipment by assessment.
b. QUANTITY: Dual outlets for each communications cabinet and at least 1off dual outlet within each room/cupboard for the connection of portable equipment.
c. PIN ARRANGEMENT: To suit the equipment standard plug. Liaise with the rack power rail or equipment supplier to ensure co-ordination.
d. PLUG: Provide a matching plug top with a captive screw ring for each outlet provided for cabinets.
e. CONSTRUCTION: IP56 Surface mounting type of impact-resistant plastic, with spring loaded flap lid on the socket and captive socket thread. Mount the outlets in an accessible location either underfloor or overhead to suit the equipment room. Standard 10A outlets for general use.

7.8.4 ISOLATING SWITCHES

Minimum rating: 415V, 20A minimum, or to exceed the connected load. All isolators shall be of heavy duty type suitable for inductive loads. IP Rating shall 56 minimum, fully complying with AS 3000.

Weatherproof isolators shall be of “Clipsal 56” Series (or equal approved) high impact polycarbonate with locking provisions. Clipsal “Weathershield WHB IP66” Series (or equal approved) is acceptable in general external areas except in plant rooms, roofs or for specialist requirements.

Mechanisms: Isolating switches are to be provided with a rotating toggle with external locking facilities both in the ‘on’ and ‘off’ position.

The mechanism is to be rated in excess of the connected equipment.

Provide upstands and associated flashings as required for isolators. Do not mount isolators directly to equipment.

7.9 LIGHTING

7.9.1 INTERNAL LIGHTING

Internal luminaires shall be selected to provide an 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:

- Preferably manufactured by an Australian company.
- 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.
- 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 driver frequency and in accordance with IEEE 1789 flicker recommendations.

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.

7.9.2 EXTERNAL LIGHTING

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 only.

Area, Pathway and Roadway 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.

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 height.

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.

7.9.3 SWITCHING AND CONTROLS

All areas or external lighting (including some corridor, undercover and carpark areas) shall be controlled by the Campus BMS system via a PE cell located at building C1A.

Each new area shall be configured to allow the area to be separately bypassed by the BMS system

Lighting switches must meet the following requirements:

a. TYPE: Use C-bus compatible switches except for directly switched applications
b. MINIMUM RATING: 240 V, 15A fluorescent rated for mains current switches.
c. COLOUR: Standard manufacturers range. White, cream, black, stainless steel
d. LABELLING: Use Dymo or Brother type labels located on the flat portion of the faceplate. Use black lettering on white background. Use black lettering on silver background for stainless steel plates.
e. Use the University standard circuit labelling designations identified in the switchboard section of this document.
f. Provide a label clearly identifying the purpose, control zone of the switch and the on/off/dimming functions.

7.9.4 EMERGENCY AND ESCAPE LIGHTING

All emergency and escape lighting shall be designed and installed in accordance with the requirements of AS/NZS 2293.1 and the National Construction Code of Australia.

Emergency Lighting Monitoring System

All emergency and escape lighting system shall be 'Zoneworks XT HIVE' computerised automatic testing system by Clevertronics Pty Ltd. The system shall provide group luminaire testing and individual real time monitoring facilities in addition to compliance management software and electronic logbook in accordance with the requirements of the AS/NZS 2293 suite of standards.

System Server and Emergency Lighting Controllers

The System:

- Shall comprise a network of exit and emergency luminaires capable of being monitored and tested through a single RF Gateway (Hive Controller) per 1000 fittings.
- The network shall utilise Dynamic Self-Managed Meshing to enable the exit and emergency luminaires to autonomously build their own dynamic communications network and self-determine the optimal communications pathway to the gateway.
- Multiple gateways may be added as required and there shall be no limit to the number of exit and emergency luminaires able to be managed by the system.

- The system shall use a sub-gigahertz communications frequency with average luminaire status and request times of 1 second or less per fitting to allow real time analytics and response.
- Gateways / Hive Controllers shall be networked together via the university network. This will typically consist of an Ethernet Network Switch and CAT6 connections to emergency lighting controllers and the Server Hosting the management software application.
- Test and status information shall be reported to the WEB based management software, that will display all the system devices on screen and record and hold all information such as status, test results and maintenance logbook history.
- The management software application will be hosted by the university.

System Design Detail and Installation

Prior to installation contact Clevertronics for system documentation and to arrange a Zoneworks pre-installation meeting.

Luminaires

All emergency luminaires within the system must capable of the following:

- Monitoring the battery voltage
- Monitoring the state of the emergency lamp in test
- Monitoring the state of the normal lamp (mains lamp)
- Storing the result of its last discharge test in non-volatile memory that is retained even after loss of both AC power and DC battery supply
- Support dynamic allocation of the network address - no pre-programming of network ID

Test results of luminaires and components from a registered NATA laboratory shall be available on request. Classify luminaires in accordance with AS2293 and supply copies of test results to the university upon request.

- Be tested in accordance with AS2293.3 with respect to Thermal/Duration, and Photometry resulting in a classification.
- Be tested to comply with EMC Standard AS/NZS CISPR 15:2011.
- The AS2293 classification shall be clearly marked on the luminaire label.

Illuminated Exit Signs

Exit signs shall be both aesthetically and functionally suitable for the intended location and application. In general:

- Learning spaces, office areas, meeting rooms, and areas of high aesthetic value shall be provided with recessed or surface blade style exits with narrow edge illuminated diffuser.
- Functional areas, back of house, storage facilities and areas of low aesthetic value shall be provided with slide connect surface mounted fittings. The exit luminaire shall slide fit into the bracket and engage the power socket by a suitable fitted plug. A locking tab shall automatically secure the luminaire into position.
- Other exit types suitable for exterior use, impact resistant or large format may be used as required.
- Theatre Masks shall be considered for all areas that operate in low light situations such as lecture theatres, and performance spaces.

Provide mounting brackets, rods or wire suspension for ceiling mounting, surface wall mounting and cantilevered wall mounting as required.

Batteries

- Lithium cells with a minimum design life of ten years at an external ambient temperature of 40°C.
- Battery protection: over voltage in charge, low voltage protection and over current in discharge.
- Mount battery in location as far as practicable from heat producing components.
- Emergency Period: 2 hours initial duration, 90 minutes in-service duration.
- Labelling: date of manufacture, ampere hour (Ahr) rating and replacement part number.

System Software

The Management Software Application shall be updated to:

- Display graphical representations of the system server, controllers and emergency luminaires
- Display real time status information
- Provide the facility to create “groups” of emergency luminaires for testing and the ability to move devices between these different groups using “drag & drop”
- Provide reporting facilities capable of sorting by date, group and or device
- Provide the facility to replace of defective luminaires
- Provide the facility to program of multiple test groups to test at different times and dates
- Provide the facility to install emergency luminaires and dynamically allocate the network address
- Produce Emergency Lighting Test Reports that can be sorted by, fitting, group, test type (discharge or diagnostic) or date range plus the facility to generate a report with the last test result for each fitting
- Display a summary of the system status and produce a simple report containing only defective emergency luminaires including location details
- Provide an Emergency Lighting Electronic Logbook, that can be printed, detailing relevant location information (unit description, floor, DWG, grid ref, distribution board and circuit number), test results and maintenance history

Commissioning

- The Installing Contractor will engage the system manufacturer for commissioning the automatic emergency lighting system where required.
- Each emergency luminaire must be labelled with a user reference that can be entered into the electronic logbook and used as the primary reference for the device (device reference). The device reference shall be an alpha numeric reference such as the Building, Level and fitting number on that level, e.g. BLD-L1-XX and permanently and indelibly fixed to a visible part of the emergency luminaire.
- Location information is to be entered into the electronic logbook by the installing contractor at the time of installation and will be retained by the system’s management application on the server. This logbook information will be compiled during the construction of the project by the installing contractor in the form of Emergency Lighting Registers and Emergency Lighting Controller Registers. These registers will be provided to the emergency lighting system manufacturer for the purpose of commissioning the system and uploading into the management application’s logbook facility.

- A complete set of “as installed” drawings must be provided by the installing contractor detailing the following:

    - The location of the emergency luminaires
    - The Device Reference assigned to each emergency luminaire

Testing and Handover

- Test the emergency lighting system to the satisfaction of the regulatory Authority.
- Demonstrate the operation of the emergency lighting system by performing the 12 monthly test as specified in AS/NZS 2293.2 prior to the date of practical completion.
- All units which fail to operate for the required period will be rejected and shall be repaired or replaced and shall be similarly tested after repair.
- Results of the test at practical completion shall be recorded in the electronic log book.
- Rectify all defects, including replacement of failed lamps during the defects liability period.
- The electronic log book shall be accessible on site.

It should be noted that the university is transitioning from the Clevertronics ‘Zoneworks XT’ powerline monitoring system and where these fittings are already provided within a building, and the scope of works is minor, XT powerline fittings may still be used. Seek clarification from the university during design/tendering.

7.10 LIGHTING CONTROL

7.10.1 LIGHTING SWITCHES

Rating and Type: 230 V, 15 A. All mechanisms shall be of heavy duty type of manufacture 'Clipsal 30 USM' (or equal approved). Switches shall be UV stabilised where installed in external areas.

Lighting switches shall generally be of the following preferred types:

Location	Preferred Make and Type
General Internal Areas	Clipsal 'Pro 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

Time Delay Pushbutton Switches

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

Labelling Of Lighting Switches

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

Labelling shall be provided via ID windows. Adhesive printed labelling will not be accepted.

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

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

7.10.2 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

The use of microwave sensors shall not be permitted on university campus.

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.

7.10.3 LIGHTING DIMMING

General

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

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 Lighting Control Section.

7.10.4 LIGHTING CONTROL SYSTEMS

Intelligent lighting control systems can be installed within university buildings where appropriate. The preferred lighting control system at Macquarie University is Clipsal C-Bus and this system shall be used unless otherwise approved. The university recognises that some building may have existing alternative lighting control systems, and where this is found to be the case direction should be sought on the best path forward.

Power Supplies and Interfaces

Power supplies, interfaces and similar devices shall be installed in easily accessible locations, preferably distribution board cupboards. The devices shall be housed in suitable enclosures and shall be clearly labelled and control schematics provided. The system shall be BACnet addressable by means of a suitable gateway.

Switches and Sensors

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

Sensor devices such as occupancy sensors and light level sensors shall be of matching manufacture to the lighting control 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 enclosure.

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.

Hardware

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

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

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.

7.10.5 CONTROL OF EXTERNAL LIGHTING

Lighting within Building Footprint

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

Area Lighting

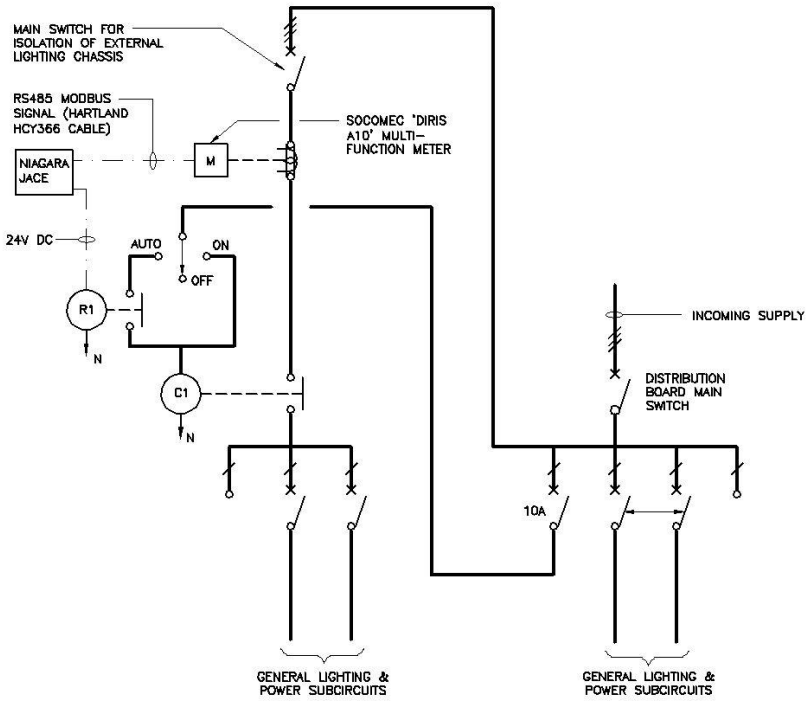
Area lighting, including pathways, roadways and external carpark lighting shall be controlled via the University Building Monitoring System (BMS).

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

7.11 ELECTRICAL INTERFERENCE AND COMPATIBILITY (EMI & EMC)

7.11.1 ELECTROMAGNETIC INTERFERENCE

Design and use electrical equipment which will not cause interference with electronic and electrical equipment in the vicinity. In the event that the inherent characteristics of equipment make interference possible, fit effective suppressors to eliminate the interference.

Maintain radio and television interference level within the limits set out in AS/NZS CISPR 14.1:2013.

Maintain electrical disturbances within the limits set out in AS/NZS 61000.3.7. Comply with AS/NZS 61000.6.1.

7.11.2 EQUIPMENT ELECTROMAGNETIC COMPATIBILITY

Equipment must comply with the following Standards and Regulations:

a. IEC 61000 - Electromagnetic Compatibility (EMC) – immunity requirements, latest issue of all relevant parts.
b. AS/NZS 4251.1 - Electrical and Electronic Apparatus

7.11.3 ELECTROMAGNETIC SHIELDING

Engage an appropriate Electromagnetic Interference (EMI) specialist to review the design and provide advice on the level of electromagnetic shielding required to comply with the World Health Organisation recommendations. Energy Networks Association Shielding shall consist of laminated high permeability magnetic steel around the relevant cable tray or group of conductors.

Review by EMI Engineer to include magnetic shielding material for the shielding of all transformer, main switchboard room, submain or consumers mains cabling throughout the design as required.

Make due allowance for derating of cables due to enclosure. Shielding enclosures shall be removable throughout their entire length.

7.12 EARTHQUAKE RESISTANCE

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.

All plant, equipment and conduits shall comply with the requirements of the following standards:

- AS/NZS 1170.4 – Structural design actions - Earthquake actions in Australia
- AS 2670 – Evaluation of human exposure to whole-body vibration - General requirements
- ISO 20816 – Mechanical Vibration
- ISO 21940 – Mechanical Vibration

For further information regarding earthquake restraining, refer to following:

- Gripple Seismic Installation Manual
- Tyco flow control, 2002, unistrut seismic bracing systems
- Fema e-74, January 2011, reducing the risks of non-structural earthquake damage - a practical guide.
- S.M.A.C.N.A seismic restraint manual, guidelines for mechanical systems, 1998, S.M.A.C.N.A, sheet metal and air conditioning contractors' national association.

Provide restraints and supports designed and certified by a structural engineer, to all plant, equipment, conduits and cable trays in accordance with AS/NZS 1170.4 Section 8.

The following do not require seismic bracing:

- All electrical conduit less than 64mm internal diameter

Transverse bracing for cable trays to be at 6.00m maximum centres and at section ends.

Longitudinal bracing for cable trays to be at 12.00m maximum centres and at section ends.

Transverse bracing on adjacent runs may be considered the longitudinal bracing for the adjacent section.

Spacing of the bracing may need to be reduced for example:

- Brace both sides of conduit or cable trays at flexible connections
- Brace to avoid collision between conduit or cable trays and other non-structural components
- Brace within 600mm of changes in direction, whether it be horizontal or vertical changes
- Brace where components penetrate floors or ceilings
- Brace in both directions at the top of all risers where risers exceed 900mm

The spacing of bracing along a run of conduit or cable tray should not vary greatly in order to ensure uniform deflection and loading.

Each unit of equipment connected to a run of conduit or cable tray shall be individually and independently braced. Thermal expansion and contraction forces, where present, must be considered in the layout of transverse and longitudinal braces. Flexibility should be provided where conduits pass through seismic or expansion joints or connect to equipment with vibration isolators.

Services braced in accordance with AS 1170.1 section 8 shall have a minimum of 50mm clearance from all ceiling hangers and the ceiling grid.

8 TESTING AND COMMISSIONING

8.1 DILAPIDATION REPORT

All contractors are to undertake a detailed site inspection and provide a dilapidation report before any demolition work is carried out on site.

The following works shall be undertaken prior to commencing works associated with the relocation, modification or installation of new conduits, pits, cables, switchboards, or any other electrical services.

Dilapidation report of all areas shall include photos and detailed description of the existing conditions,

verification of proposed cable pathways and equipment locations (within buildings and externally) to ensure there are no factors which would otherwise prevent the installation of the proposed equipment / cables.

8.2 TESTING

General: All testing and commissioning shall be undertaken in accordance with regulatory requirements, manufacturers requirements, and the requirements listed below.

Notice: Give sufficient notice so that all testing may be witnessed by the university, consulting engineer and/or designer.

Inspection / Testing Schedule: Provide a comprehensive Inspection and Testing Schedule a minimum of 10 working weeks prior to first inspection/test.

Minimum notice required: Provide 10 working days' notice for exact time and date of each test/inspection.

Testing certificates: Provide test certificates and Certificates of Compliance for approval. Include copies within Installation Manuals.

Approval for energising: Obtain approval before energising newly installed or reconnected wiring or equipment.

Faulty installation: During testing, replace fuses and all equipment damaged as a result of incorrect installation work.

Testing and Tagging: Undertake all testing in accordance with AS/NZS 3760 for all electrical equipment and accessories installed under this contract. Provide tags on the flex cable (if fixed) or on the chassis (if flex cable is removable).

Provide a schedule of equipment that has been tested and tagged under this contract in the Installation Manuals and confirm whether or not the appliance has passed or failed, date of test, and schedule for next test.

8.3 COMMISSIONING

Commissioning must be performed according to the MU PROPERTY-Commissioning standard.

An independent commissioning agent not involved with the design or construction of the project may be required to test, verify and certify that the electrical services meet or exceed the required performance criteria of this standard. This should be confirmed with

Detailed testing and commissioning requirements must be specified for each project by the consultant/designer. The AS/NZS 3017_Electrical installations - Verification guidelines are appropriate reference documents to be used.

Detailed testing and commissioning records must be provided for each system and each component as appropriate. All such records must be witnessed and verified by the project consultant/designer.

Minimum electrical services commissioning requirements are provided in following sections.

Notice: Give sufficient notice that commissioning of the electrical services is to commence.

Minimum notice required: 5 working days

Phase sequence: Test phase sequence prior to commencement of works and ensure the correct phase sequence is maintained throughout the installation.

Balancing of load: Balance the load as evenly as practicable at Practical Completion. Recheck and, where necessary, rebalance the load at completion of the Defects Liability Period. Arrange all circuits so that balance is obtained at maximum demand as well as normal operating conditions, in accordance with AS/NZS 3000.

Site commissioning to include the following:

Reticulation, Switchboards and Accessories

- Test and provide Certificates of Compliance for the installation in accordance with the requirements of the Electricity Act.
- Insulation resistance measurements.
- Provide full functional and operational checks on energised control equipment and circuits, including adjustments for the correct operation of safety devices.
- Provide full functional and operational checks for all SSOs and RCDs. Log all RCD test results.
- Provide full functional and operational checks for all RCD/LPD devices within Body Protected Areas. Log all RCD/LPD test results including number of times tested, trip time and equipment used, including calibration certificates.
- Labelling of all switches and outlets.
- Earth resistance measurement: To AS/NZS 3000.
- Earthing: Confirmation of effective earthing of the exposed metal of electrical equipment.
- Carry out a thermographic survey on each operational switchboard within one month after full operational load is established, or at latest one month before the end of defects liability period. Use an advanced thermal imaging camera driven by a software program and provide a report on the thermographic heat pattern of each switchboard. Any anomalous heat emissions which indicate presence of faults or hot joints must be rectified before the end of the defects liability period

Multi-Function and Check Meters

- Check and verify operation, calibration, and correct output of all meters. Provide calibration certificate and test results.

Circuit Protection

- Confirm that circuit protective devices are sized altered and adjusted, wherever necessary, to protect the installed circuits.

Luminaires

- Clean luminaire reflectors, mirrors and diffusers. Replace faulty components including accessories, and diffusers. Check for correct switching and demonstrate.

Emergency and Escape Lighting

- Test the operation and commission the emergency and escape lighting system as specified under the Generator Section of this document.

Standby Diesel Generator

- Test the operation of the generator systems as specified under the Generator Section of this document.

Uninterruptible Power Supply (UPS) System

- Test the operation of the UPS systems as specified under the UPS Section of this document.

Lighting Control System

- Test and commission the operation as specified under the Lighting Control System of this specification.

Refer Lighting Control System Section of this specification.

Movement Detection

- Test and commission each lighting movement sensor in accordance with the manufacturers requirements to ensure a fully operational system.
- Undertake a walkthrough of each control zone to ensure functionality is as specified.
- Engage the services of the manufacturer as required.

Defects

- Rectify all defects upon notification. Provide written notice to the Project Manager of completion of defects. Retention monies will not be released until completion and rectification to the Proprietors approval of all defects.

9 DEFECTS AND LIABILITY

Design consultants must specify the requirement for contractors to undertake the rectification of all defects and assume liability for all works completed as part of a project for a period of not less than 12months.

Further to the above, the following activities must be carried out during the Defects Liability Maintenance Period:

a. Periodic inspections and maintenance procedures for all equipment at frequencies according to the Manufacturer's requirements and relevant Australian Standards.
b. Fault rectification and replacement of faulty materials, equipment, and accessories with new.
c. Thermographic inspections of all switchboards in the last month of DLP.
d. RCD testing in accordance with AS3760 in the last month of DLP.
e. Ex/Em lighting shall be tested every 6months (twice) during DLP in accordance with AS2293.2
f. Prompt emergency response to failures and outages where required.

At the end of the Maintenance Period, contractors must make a final service visit to certify the installation is operating correctly.

ATTACHMENT 1 – REQUEST FOR DISPENSATION

Project:	
Project Manager:	
Project Location: (Building/Level/Rm No.)	
Requested By:	
Request Date:	
Project Phase:	
Applicable MUP Standard:	
Description of Non-Compliance:	
Reason for Non-Compliance:	
Cost of Implications:	
Programme Implications:	

APPROVED: Y / N	**APPROVED: Y / N**
SIGNATURE:	**SIGNATURE:**
MUP REPRESENTATIVE	**PROJECT MANAGER**
DATE:	**DATE:**