Electrical Services Design Standards

DOCUMENT HISTORY

<table>
<thead>
<tr>
<th>Revision No.</th>
<th>Date</th>
<th>No. of Pages</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1.0</td>
<td>April 2015</td>
<td>48</td>
<td>For Review</td>
</tr>
<tr>
<td>V1.1</td>
<td>Dec 2015</td>
<td>48</td>
<td>For Circulation</td>
</tr>
</tbody>
</table>
## CIRCULATION APPROVAL

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dennis Spicer</td>
<td>Engineering Project Manager</td>
<td></td>
</tr>
<tr>
<td>David Matley</td>
<td>Technical Services Manager</td>
<td></td>
</tr>
</tbody>
</table>
### Table of Contents

1. **Purpose** 1 
2. **Scope** 2 
3. **Glossary of Terms** 3 
4. **Authorities & Responsibilities** 4 
5. **Technical Requirements** 5 
   5.1. **SPECIFIC SCOPE OF WORKS FOR DESIGN AND CONSTRUCTION** 5 
   5.2. **ELECTRICAL INSTALLATION SCOPE OF WORKS** 6 
   5.3. **WORKSHOP AND AS-BUILT DRAWINGS** 6 
   5.4. **DEFECTS LIABILITY PERIOD MAINTENANCE** 7 
   5.5. **OPERATION AND MAINTENANCE MANUALS** 7 
      5.5.1. **OPERATOR’S MANUAL** 7 
      5.5.2. **EQUIPMENT DESCRIPTIONS** 7 
      5.5.3. **OPERATION AND MAINTENANCE PROCEDURES** 8 
      5.5.4. **CERTIFICATES** 8 
      5.5.5. **TEST RECORDS** 8 
   5.6. **APPROVAL OF MATERIALS AND COMPONENT SAMPLES** 8 
   5.7. **LABELS AND MARKING** 9 
   5.8. **FIRE RATED SEALING OF PENETRATIONS AND CUTTINGS** 9 
   5.9. **EQUIPMENT RADIO FREQUENCY INTERFERENCE** 9 
   5.10. **EQUIPMENT ELECTROMAGNETIC COMPATIBILITY** 9 
   5.11. **ACCESSORIES** 9 
      5.11.1. **ACCESSORIES TYPE** 10 
      5.11.2. **LIGHTING SWITCHES** 10 
      5.11.3. **ISOLATING SWITCHES** 10 
      5.11.4. **GENERAL POWER SOCKET OUTLETS** 10 
      5.11.5. **SOFT WIRING SYSTEMS** 11 
      5.11.6. **RACK COMPUTER EQUIPMENT OUTLETS** 12 
      5.11.7. **ACCESSORY MOUNTING HEIGHTS** 12 
   5.12. **WIRING SYSTEMS** 12 
      5.12.1. **SELECTION** 12 
      5.12.2. **CABLE CALCULATIONS** 13 
      5.12.3. **VOLTAGE DROP** 13 
      5.12.4. **CABLE MATERIAL AND MINIMUM SIZES** 13 
      5.12.5. **REDUNDANT CABLES** 13 
      5.12.6. **CABLE INSTALLATION** 13 
      5.12.7. **FIRE RATED CABLE SYSTEMS INSTALLATION** 14 
      5.12.8. **COPPER CONDUCTOR TERMINATIONS** 14 
      5.12.9. **ULTRA FLEXIBLE COPPER CONDUCTOR TERMINATIONS** 14 
   5.13. **UNDERGROUND SERVICES** 14 
      5.13.1. **CONDUITS** 14 
      5.13.2. **TRENCHING & BACKFILLING** 14 
      5.13.3. **CABLE PITS** 15
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.13.4.</td>
<td>UNDERGROUND CABLE ROUTE MARKING</td>
<td>15</td>
</tr>
<tr>
<td>5.14.</td>
<td>CONDUITS AND CABLE SUPPORTS</td>
<td>16</td>
</tr>
<tr>
<td>5.14.1.</td>
<td>CONDUITS GENERALLY</td>
<td>16</td>
</tr>
<tr>
<td>5.14.2.</td>
<td>CONCEALED CONDUITS</td>
<td>16</td>
</tr>
<tr>
<td>5.14.3.</td>
<td>NON-METALLIC CONDUITS AND FITTINGS</td>
<td>16</td>
</tr>
<tr>
<td>5.14.4.</td>
<td>FLEXIBLE CONDUITS</td>
<td>16</td>
</tr>
<tr>
<td>5.14.5.</td>
<td>GALVANISED STEEL WATER PIPE</td>
<td>17</td>
</tr>
<tr>
<td>5.14.6.</td>
<td>SKIRTING WIRING DUCT</td>
<td>17</td>
</tr>
<tr>
<td>5.14.7.</td>
<td>CABLE SUPPORT SYSTEM</td>
<td>17</td>
</tr>
<tr>
<td>5.14.8.</td>
<td>METALLIC SUPPORT SYSTEMS AND FIXINGS</td>
<td>18</td>
</tr>
<tr>
<td>5.15.</td>
<td>DIESEL EMERGENCY GENERATORS</td>
<td>18</td>
</tr>
<tr>
<td>5.16.</td>
<td>LARGE SWITCHBOARDS</td>
<td>19</td>
</tr>
<tr>
<td>5.16.1.</td>
<td>SWITCHBOARD LOCATION</td>
<td>19</td>
</tr>
<tr>
<td>5.16.2.</td>
<td>MANUFACTURERS</td>
<td>19</td>
</tr>
<tr>
<td>5.16.3.</td>
<td>PROTECTION GRADING STUDY</td>
<td>19</td>
</tr>
<tr>
<td>5.16.4.</td>
<td>GENERATOR CONNECTION PROVISIONS</td>
<td>20</td>
</tr>
<tr>
<td>5.16.5.</td>
<td>SWITCHBOARD DESIGN</td>
<td>20</td>
</tr>
<tr>
<td>5.16.6.</td>
<td>SWITCHBOARD SHOP DRAWINGS</td>
<td>21</td>
</tr>
<tr>
<td>5.16.7.</td>
<td>INSPECTION</td>
<td>21</td>
</tr>
<tr>
<td>5.16.8.</td>
<td>PRE-COMPLETION TESTS</td>
<td>21</td>
</tr>
<tr>
<td>5.16.9.</td>
<td>SUBMISSIONS</td>
<td>22</td>
</tr>
<tr>
<td>5.16.10.</td>
<td>TRANSIENT PROTECTION</td>
<td>22</td>
</tr>
<tr>
<td>5.16.11.</td>
<td>SWITCHBOARD METALWORK</td>
<td>23</td>
</tr>
<tr>
<td>5.16.12.</td>
<td>CABLE ENTRIES</td>
<td>23</td>
</tr>
<tr>
<td>5.16.13.</td>
<td>SWITCHBOARD DOORS</td>
<td>23</td>
</tr>
<tr>
<td>5.16.14.</td>
<td>ESCUTCHEON PLATES</td>
<td>24</td>
</tr>
<tr>
<td>5.16.15.</td>
<td>FINISHES</td>
<td>24</td>
</tr>
<tr>
<td>5.17.</td>
<td>CONDUCTORS</td>
<td>24</td>
</tr>
<tr>
<td>5.17.1.</td>
<td>BUSBARS</td>
<td>24</td>
</tr>
<tr>
<td>5.17.2.</td>
<td>WIRING</td>
<td>26</td>
</tr>
<tr>
<td>5.18.</td>
<td>EXTERNAL SWITCHBOARDS DESIGN AND CONSTRUCTION</td>
<td>26</td>
</tr>
<tr>
<td>5.19.</td>
<td>SWITCHGEAR AND CONTROL GEAR</td>
<td>26</td>
</tr>
<tr>
<td>5.19.1.</td>
<td>SWITCHGEAR</td>
<td>26</td>
</tr>
<tr>
<td>5.19.2.</td>
<td>CIRCUIT BREAKER TYPES</td>
<td>26</td>
</tr>
<tr>
<td>5.19.3.</td>
<td>ATS TYPES</td>
<td>27</td>
</tr>
<tr>
<td>5.19.4.</td>
<td>MOULDED CASE AND MINIATURE CIRCUIT BREAKERS</td>
<td>27</td>
</tr>
<tr>
<td>5.19.5.</td>
<td>CONTROL RELAYS</td>
<td>27</td>
</tr>
<tr>
<td>5.19.6.</td>
<td>EXTRA-LOW VOLTAGE TRANSFORMERS</td>
<td>27</td>
</tr>
<tr>
<td>5.20.</td>
<td>ACCESSORIES, INSTRUMENTS, METERS</td>
<td>27</td>
</tr>
<tr>
<td>5.20.1.</td>
<td>METERING TRANSFORMERS</td>
<td>27</td>
</tr>
<tr>
<td>5.20.2.</td>
<td>MULTIFUNCTION METERS</td>
<td>27</td>
</tr>
<tr>
<td>5.20.3.</td>
<td>INDICATOR LIGHTS</td>
<td>27</td>
</tr>
<tr>
<td>5.20.4.</td>
<td>LABELS</td>
<td>28</td>
</tr>
<tr>
<td>5.21.</td>
<td>THERMOGRAPHIC SURVEY</td>
<td>29</td>
</tr>
<tr>
<td>5.22.</td>
<td>ENERGY &amp; TARIFF METERING SYSTEMS</td>
<td>29</td>
</tr>
<tr>
<td>5.22.1.</td>
<td>AUTHORITY TARIFF METERING</td>
<td>29</td>
</tr>
<tr>
<td>5.22.2.</td>
<td>PRIVATE TARIFF METERING</td>
<td>29</td>
</tr>
<tr>
<td>5.22.3.</td>
<td>ENERGY CONSUMPTION METERING</td>
<td>29</td>
</tr>
<tr>
<td>5.22.4.</td>
<td>METERING NETWORKING SYSTEM</td>
<td>29</td>
</tr>
<tr>
<td>5.22.5.</td>
<td>NETWORKING</td>
<td>29</td>
</tr>
</tbody>
</table>
5.22.6. METER DOCUMENTATION 29

5.23. DISTRIBUTION SWITCHBOARDS 30
  5.23.1. DISTRIBUTION BOARD MINIMUM CONFIGURATION 30
  5.23.2. SUBCIRCUIT LOADING & NON-RCD CIRCUITS 30
  5.23.3. DISTRIBUTION SWITCHBOARD DESIGN AND CONSTRUCTION 30
  5.23.4. TRANSIENT PROTECTION 31
  5.23.5. DISTRIBUTION BOARD NAME/ DESIGNATION LABELS 31

5.24. TECHNICAL EARTHING SYSTEMS 31

5.25. LIGHTNING PROTECTION SYSTEM 32
  5.25.1. MATERIALS 32
  5.25.2. FIXINGS 32
  5.25.3. JOINTS AND BONDS 32
  5.25.4. INSTALLATION 32
  5.25.5. EARTH TERMINATIONS 33

5.26. POWER FACTOR CORRECTION 33
  5.26.1. AUTHORITY APPROVALS 33
  5.26.2. SHOP DRAWINGS 33
  5.26.3. CUBICLE 34
  5.26.4. CAPACITORS TYPE 34
  5.26.5. CAPACITOR INSTALLATION 34
  5.26.6. COOLING FANS 34
  5.26.7. WIRING 34
  5.26.8. CONTACTORS 35
  5.26.9. STEP CONTROLLER 35
  5.26.10. INRUSH CURRENT SURGE LIMITING 35
  5.26.11. HARMONIC AND SUPPLY AUTHORITY RIPPLE SIGNAL REJECTION 35

6. Commissioning 37
  6.1. TESTING AND COMMISSIONING 37
    6.1.1. INSPECTION & WITNESS TESTING 37
    6.1.2. TESTING EQUIPMENT SCHEDULE 38
    6.1.3. INITIAL CERTIFICATION 38

7. Documentation & Records 39

8. Operations 40

9. Authorisation of Variations 41

10. Quality Control 42

11. References 43

12. Attachments 44

Attachment 1 Design Standard Compliance Checklist 45

Attachment 2 Deemed-to-Comply Switchboard Manufacturers 47

Attachment 3 Deemed-to-comply Switchboard Meters and Gateways 48
1. PURPOSE

The Macquarie University Property - Electrical Services Design Standards set out Macquarie University's minimum requirements for the design, construction and maintenance of electrical services and infrastructure. It ensures new and refurbished electrical systems are fit-for-purpose, provide secure, efficient, safe and reliable electrical power, are made from durable good-quality materials, are cost efficient to operate and maintain.

Applicable requirements documented in Australian and New Zealand Standards (AS/NZS), Australian National Construction Code (NCC), Workplace Health and Safety legislation and other relevant statutory requirements are minimum for compliance and are considered mandatory. The minimum relevant AS/NZS documents are provided in Section 11 of this standard. Where any ambiguity exists between this standard and the aforementioned mandatory requirements then:

a. the highest performance requirements must apply
b. applicable requirements must follow this order of precedence:
   i. Workplace Health and Safety legislation and other relevant statutory requirements
   ii. National Construction Code (NCC)
   iii. Australian & New Zealand Standards (AS/NZS)
   iv. This standard
2. **SCOPE**

This standard describes minimum requirements for design, purchase, construction, and operation 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 building construction
b. refurbishment projects for University-owned spaces
c. refurbishments of spaces that form part of a broader medium-term (less than five years) programme/plan of progressive upgrades to a University-owned building
d. refurbishment projects for long-term University-leased
e. facilities maintenance services

The standard covers provision of electrical services for most University-projects. It covers:

- Design Calculations including grading studies and cable sizing
- Main and Distribution Switchboards
- External switchboards
- Generators
- Submains
- Socket Outlets
- Lighting system installation
- Power factor correction
- Earthing
- Lightning protection
- Labelling
- Testing & commissioning

It does not cover:

- Special electrical installations for specialised laboratory and research spaces which will be specifically defined in the project.
- Communications and data cabling systems – refer to Macquarie University ICT Standard.
- Metering and energy monitoring – refer to Macquarie University BMS & metering Standard

Where specific applications are not explicitly covered or ambiguity exists, the intent of the design standard must be satisfied. 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.
### GLOSSARY OF TERMS

Unless the context otherwise requires, the following definitions apply:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACA</td>
<td>Australian Communications Authority</td>
</tr>
<tr>
<td>ACB</td>
<td>Air circuit breaker</td>
</tr>
<tr>
<td>AS/NZS</td>
<td>Australian / New Zealand Standard</td>
</tr>
<tr>
<td>BCA</td>
<td>Building Code of Australia</td>
</tr>
<tr>
<td>Ausgrid</td>
<td>The Sydney city area Supply Authority</td>
</tr>
<tr>
<td>C/B or CB</td>
<td>Circuit breaker</td>
</tr>
<tr>
<td>MU PROPERTY</td>
<td>Macquarie University Property Department</td>
</tr>
<tr>
<td>DB</td>
<td>Distribution Switchboard</td>
</tr>
<tr>
<td>MCCB</td>
<td>Moulded case circuit breaker</td>
</tr>
<tr>
<td>MEN</td>
<td>Multiple Earth Neutral earthing system.</td>
</tr>
<tr>
<td>MSB</td>
<td>Main Switchboard</td>
</tr>
<tr>
<td>NATA</td>
<td>National Association</td>
</tr>
<tr>
<td>NCC</td>
<td>National Construction Code</td>
</tr>
<tr>
<td>RCD or ELCB</td>
<td>Residual Current Device (Earth leakage protection)</td>
</tr>
</tbody>
</table>
4. **AUTHORITIES & RESPONSIBILITIES**

The design standard is owned by MU PROPERTY. It is approved and signed-off by the Director MU PROPERTY.

The MUP Asset Management Unit is responsible for reviewing and maintaining the standard and keeping it up-to-date. *(check with MU)*

The standard must be reviewed and kept up-to-date at least biennially.
5. TECHNICAL REQUIREMENTS

5.1. SPECIFIC SCOPE OF WORKS FOR DESIGN AND CONSTRUCTION

These specific requirements must be included in the scope of works specification for design and construction of electrical services:

a) Electrical services must be detailed and designed by qualified professional engineers covered by professional indemnity and public liability insurances. Insured Values must be in accordance with the contract.

b) 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.

c) Provide warranty for all new equipment and services.

d) Maintenance requirements during the Defects Liability period.

e) Compliance with BCA including Section J, Local Authorities’ regulations and all relevant Australian and New Zealand Standards (AS/NZS).

f) Allow for any University work embargo and restriction periods during the construction period.

g) Provision of electrical maximum demand calculations in editable spreadsheet format, and to satisfy the Supply Authority and to AS/NZS3000 as a minimum.

h) Application for connection of new loads to the Supply Authority.

i) Supply of statutory design certifications and certification of compliance to the University standards.

j) National Construction Code Section J6 compliance calculations and certifications for energy consumption minimisation.

k) Annual electrical energy consumption estimate based on building space types, occupancy and operation of planned plant and equipment.

l) Power system calculations for the whole system in POWERCAD, or approved equal software, covering fault levels, voltage drop, cable sizing and circuit breaker discrimination.

m) Supply of all calculations in electronic native software editable file and PDF output format.

n) Design drawings in Autocad (and Revit 3D model where applicable) format including plans, schematics and single line diagrams.

o) Testing and commissioning schedules and programme.

p) Contractors must visit project sites to determine limitations to installing electrical services and include sufficient allowances in the tender price to cover these issues.

q) Ensure that spatial and building general construction details are satisfactory and equipment can physically be installed within the building.

r) Additional work items identified during tender inspections, but which may not be documented in the original scope of works.

s) 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.

t) Decommissioning and demolition of all redundant electrical services and infrastructure in the works area.

u) Provide a detailed project description including the project drivers, the existing conditions and the final project use.

v) Provide a section listing any major deviations from this standard and summarising the reason.
5.2. **ELECTRICAL INSTALLATION SCOPE OF WORKS**

A project specific scope of works must be prepared by the designer. It must cover all major electrical systems specifically, and all minor systems generally.

It must detail the design requirements for Design and construct projects, including references to the project definition documents.

It must consider and specify any staging and temporary power provisions.

The codes listed below were suggested as reference documents, but not limited to:

- Australian standards AS 3000
- AS/NZS3008
- OH&S Regulation 2001
- Risk management AS/NZS 4360.1999
- Electrical trades Union OH&S Safety Policies.
- OH&S Electrical equipment Regulation 2006
- WorkCover Electrical equipment 2001
- Safety in labs AS 2982.1

RCD installation

AS 2243.1 Clause 2.9.3 “Safety in Laboratories”

AS 2982.1 Clause 4.2 Laboratory Design and Construction

Lighting levels (lux) AS 1680.2.1 and 1680.2.2

5.3. **WORKSHOP AND AS-BUILT DRAWINGS**

The following drawings must be submitted for approval before commencing installation work for relevant electrical services:

a) Site excavation plan, including survey of obstructions and existing services

b) Cable pit and trench locations

c) Cable pit and trench construction details and sections

d) Submain Conduit and cable tray routes

e) Busduct systems including routes, dimensions and connection details

f) Switchboard Workshop drawings and schematics

g) Switchboard cupboard layouts including risers

h) External lighting pole and support systems details

i) Metering system network schematics

j) General power, communications and lighting plans

k) C-Bus lighting schematics and control zone plans

l) Lighting system suspension details

m) Generator connection cubicle details

n) Update existing site services drawings
As-built 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. 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.

As-Built drawings must be provided in full size and CD ROM with latest AutoCAD drawing files including “ctb” file.

5.4. DEFECTS LIABILITY PERIOD MAINTENANCE

The following activities must be carried out during the Defects Liability Maintenance Period:

a) Periodic inspections and maintenance procedures at frequencies according to the Manufacturer’s requirements and Australian Standards AS 2239.1.

b) Thermographic inspections of switchboards.

c) Fault rectification and replacement of faulty materials, equipment and accessories with new.

d) Prompt emergency response when required.

e) RCD Maintenance AS 3760 & AS 3012

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

5.5. OPERATION AND MAINTENANCE MANUALS

Provide electronic online operation and maintenance (O&M) manuals and two hardcover loose leaf copies. Documents and information that must be provided are described below.

5.5.1. OPERATOR’S MANUAL

All O&M manuals must be received and approved for final re-issue prior to Practical Completion. Authors and compilers of the manual must be experienced in the maintenance and operation of the installed equipment and systems.

The operator’s manual must 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.

5.5.2. 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 facsimile numbers of the manufacturer and supplier of equipment installed together with catalogue list numbers.

5.5.3. OPERATION AND 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 trouble-shooting, 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.

5.5.4. CERTIFICATES

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

- Copies of Manufactures warranty.
- Certification from supply authority.
- Product certification for compliance to relevant AS/NZS and other product standards and codes.

5.5.5. TEST RECORDS

Submit reports or certificates for designated tests, including pre-delivery tests, for inclusion in O&M manuals. Provide copies of Supply Authority Contractor’s Completion of Electrical Works (CCEW) forms, including inspection reports, defect notices and defect clearances.

5.6. APPROVAL OF MATERIALS AND COMPONENT SAMPLES

Designers must request samples of all accessories, fittings and apparatus proposed for use in the works must be submitted for approval. Only those items that are accepted may be installed on site. Submit the manufacturer’s product data for proprietary equipment, including:

a) Technical specifications and drawings.

b) Type test reports.

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.
5.7. LABELS AND MARKING

Mark operable control devices, indicators, isolating switches and outlets to provide a ready means of identification. Equipment labelling must be used to mark equipment, controls, switchboards, panels, services routes, conduit / duct / pipe runs, etc, for easy identification:

<table>
<thead>
<tr>
<th>Description</th>
<th>Type for Indoor Location</th>
<th>Type For Outdoor / Exposed Location</th>
<th>Lettering Size / Height &amp; Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment name plate</td>
<td>Engraved Traffolyte – similar approved</td>
<td>Engraved stainless steel</td>
<td>40mm</td>
</tr>
<tr>
<td>Cable marker plate</td>
<td>Engraved Traffolyte – similar approved</td>
<td>Engraved stainless steel</td>
<td>8mm</td>
</tr>
<tr>
<td>Warning notices</td>
<td>Engraved two-colour laminated plastic</td>
<td>Engraved stainless steel</td>
<td>7mm</td>
</tr>
<tr>
<td>Automatic control &amp; electrical equipment</td>
<td>Engraved two-colour laminated plastic</td>
<td>Engraved stainless steel</td>
<td>5mm</td>
</tr>
<tr>
<td>Isolating switch / valve</td>
<td>Engraved two-colour laminated plastic</td>
<td>Engraved stainless steel</td>
<td>5mm</td>
</tr>
<tr>
<td>Inside panels</td>
<td>Adhesive type printed</td>
<td>Engraved stainless steel</td>
<td>3.5mm</td>
</tr>
</tbody>
</table>

Labelling must match terminology of “As-Built” drawings. Locate labels so that they are easily seen and are either attached to, below or beside the items being identified. Use mechanical brass or stainless steel screw fixing and do not penetrate vapour barriers.

*Embosed printed type labels are not acceptable except on GPO’s and light switches.*

5.8. FIRE RATED SEALING OF PENETRATIONS AND CUTTINGS

Must comply with NCC requirements. Also refer to MU PROPERTY Essential Fire Safety Measures Standard.

5.9. EQUIPMENT RADIO FREQUENCY INTERFERENCE

Use equipment which generates interference within limits set by AS/NZS CISPR.14.1. If necessary, provide suppression devices. If required, shield equipment to achieve compliance.

5.10. 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

5.11. ACCESSORIES

Requirements for general outlet switches and sockets are provided below.
5.11.1. ACCESSORIES TYPE

Accessory outlet plates shall be HPM 777 series or approved equal. They must have adequate flat, faceplate area to accommodate identification labels.

Flat stainless steel type plates may be used for special areas.

5.11.2. LIGHTING SWITCHES

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.

5.11.3. ISOLATING SWITCHES

Provide easily accessible local isolating switches for all electrically operated equipment within the immediate vicinity.

Use IP56 isolating switches in plant rooms, car parks, damp / wet areas or external locations.

5.11.4. GENERAL POWER SOCKET OUTLETS

Provide power outlets in accordance with the project room data sheets. A maximum of 5 double 10A GPO’s are to be connected to any 20A circuit, or 4 double GPO’s on a 16A circuit. This can be revised (increased), if approved by MUP for areas such as computer laboratories

a) Office desk position - 2 double GPOs person, allow density of 1 person per 8m²

b) Kitchen areas are to have a minimum of 2 circuits, with heating appliances connected to different circuits.

c) Appliances with a load greater than 1 kVA, are to have a dedicated circuit.

d) Lecture theatre seats – 1 double GPO every third seat divider.

e) Plantrooms – 1 x 15A GPO IP56

f) Toilet – 1 Double GPO (not including power for hand dryer/s)

g) Corridors – 1 Double GPO per 10 meters length

h) Lobbies / Foyers – 1 Double ‘GPO per 100m²

i) Electrical & Comms risers or cupboards – 1 GPO per cupboard

j) Computer laboratories – 1 double GPO per seat

k) Seminar rooms – 1 double GPO per 3 lm of wall

l) Laboratories – requirement must be provided in user brief which must consider greater demand from anticipated plant and equipment use.

GPOs must have the following features:

a) COLOUR:

i. General Power – white, cream, black, stainless steel to architects selection.
ii. Generator Power – Blue
iii. UPS Power - Red

b) LABELLING: Use Dymo or Brother type labels located on the flat non-removable portion of the faceplate. Use black lettering on white background. Use black lettering on silver background for stainless steel plates.

Use the University standard circuit labelling designations provided in the switchboard section of this specification.

Also Label all soft wiring socket outlets.

**LIGHT FITTINGS**

External light fittings

- Road way lights: WE-EF PLF 240 Cat No 108-0951
- Pathway lights: WE-EF VFL 530 Cat No 108-1178
- External wall mounted lights: Phillips 20 w LED Metro (replaces the metroson)
- Internal lighting fitting: Harcroft SLA5D LED

**EXTERNAL LIGHT POLES**

- Poles shall be positioned adjacent level ground to provide maintenance from a step ladder.
- Exit conduits shall be installed at each pole to allow for future expansion.
- Each pole shall have an identification number engraved on the label (approx 50mm characters and be approved by Property) and installed at a height so it is ledgeable at ground level. The site services drawing shall be updated to reflect the pole numbers and the circuit origin.

**EMERGENCY AND EXIT LIGHTS**

All emergency and exit lights will be installed in accordance with AS/NZS 2293.1 - 1995.

All exit and emergency lights will be provided with a separate, active neutral and earth conductor emanating from the lighting circuit breakers at the local distribution board, by-passing any local switching and/or contractor control.

Provision must be made to allow all the emergency and exit lights to be tested without interrupting supply to the general lighting.

Supply and install a 2 hour minimum adjustable timer (NHP), relays, push button or key switch and reset button. This equipment should be mounted in the switchboard. If there is insufficient room in the switchboard a lockable Eldon enclosure is to be mounted adjacent to the switchboard. The enclosure is to be fitted with a Coin lock keyed CL003 Cat No 2536. Allow at least 100% spare space capacity within the enclosure.

**UNIVERSITY AREA LIGHTING CONTROL**

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

5.11.5. **SOFT WIRING SYSTEMS**

Use only 20A rated soft wiring systems.
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.

5.11.6. RACK COMPUTER EQUIPMENT OUTLETS

Equipment outlets must meet the following requirements:

a) MINIMUM RATING: 15A.

b) PIN ARRANGEMENT: To suit the equipment standard plug. Liaise with the rack power rail or equipment supplier to ensure co-ordination.

c) PLUG: Provide a matching plug top with a captive screw ring for each outlet.

d) 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.

5.11.7. ACCESSORY MOUNTING HEIGHTS

Except where mounting heights are self evident e.g. skirting ducts, workstation situations, drawings, etc, the following mounting heights above finished floor level must be assumed:

a. Lighting switches The centre line of the box to align with the door furniture. Must not be installed across the junction of different wall finishes.

b. Socket-outlets in plant rooms and car parks 1300mm to the centre line of the box.

c. Socket-outlets over benches 150mm to the centre line of the box.

d. Socket-outlets in other areas 200mm to the centre line of the box.

e. Distribution Boards 2200mm to the topmost part of the board.

f. Telephone, MATV, Voice/Data outlets etc. 200mm to the centre line of the box

g. Socket-outlets and light switches in disabled toilet In accordance with the Accessibility Codes

5.12. WIRING SYSTEMS

5.12.1. SELECTION

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.

Use the following systems:

a) Cast Concrete Slabs: Unsheathed cable in heavy duty UPVC conduit.

b) Accessible Spaces: Thermoplastic insulated and sheathed cables.

c) Concealed Spaces: Unsheathed cable in UPVC conduit.

d) Plantrooms: Unsheathed cable in heavy duty galvanised steel conduit.

e) Plastered Or Rendered Surfaces: Cable in UPVC conduit.
f) Stud Walls Without Bulk Insulation: Thermoplastic insulated and sheathed cables.

5.12.2. CABLE CALCULATIONS

Provide cable calculations using a proprietary software equivalent to 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

5.12.3. VOLTAGE DROP

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 subcircuits are to be typically limited to 10A maximum demand due to RCD limitations.

5.12.4. CABLE MATERIAL AND MINIMUM SIZES

Use multi-stranded copper conductors with the following minimum sizes:

a) 2.5mm² for lighting sub-circuits
b) 2.5mm² for 16A power sub-circuits
c) 63A / 10mm² for submains
d) 1.5mm for 10A control circuits

5.12.5. REDUNDANT CABLES

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 project superintendent.

Where it is not possible 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”.

5.12.6. CABLE INSTALLATION

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. Note EMR is a product of current, this is not a practical or industry standard method of wiring.

g. Support all cables at a maximum of 1200mm spacing with minimum sag.

h. All installations must be neat and tidy in appearance and installed parallel and/or perpendicular to
building elements.

i. CABLE COLOUR: For fixed wiring colour the conductor insulation or, if this is not practicable, slide not
less than 150mm of close fitting sleeving to each conductor at the termination points as
follows:

   i. Active conductors in single-phase circuits: RED.
   ii. Active conductors in polyphase circuits:
      iii. A PHASE - RED
      iv. B PHASE - WHITE
      v. C PHASE - BLUE
   vi. Switched Active Conductors To Fittings: WHITE.
   vii. Earth - green with yellow stripe
   viii. Technical Earth – purple

5.12.7. FIRE RATED CABLE SYSTEMS INSTALLATION

Provide fire, mechanical and water spray protection to WS52W classification in accordance with
AS/NZS3013.

Cable manufacturers recommended by CSIRO or NATA tested complete cable support system must be
used.

As a minimum, heavy duty cable ladder with unistrut supports and metallic fixings and hangers must be
used. All fixings to the building fabric must be metallic. Provide stainless steel wide band cable ties at not
less than 0.9m intervals horizontal and 0.6m vertical, or as per the manufacturer’s recommendations and
tested system.

5.12.8. COPPER CONDUCTOR TERMINATIONS

Use compression-type lugs of the correct size for the conductor, compressed only by the correct tool.

5.12.9. ULTRA FLEXIBLE COPPER CONDUCTOR TERMINATIONS

Use proprietary special purpose made crimp lugs and dies designed to ensure adequate clamping of fine
multi-stranded cables.

5.13. UNDERGROUND SERVICES

5.13.1. CONDUITS

Use HD PVC conduits for all underground power cable runs. Use white communications grade conduit for
all communications runs.

Provide minimum 25% spare capacity, and one whole spare conduit minimum for all runs.

5.13.2. TRENCHING & BACKFILLING

Trenching and backfilling operations must consider:

a) SITE SERVICES PLAN: Obtain the University site services plan for the area concerned.
b) UNIVERSITY STANDARD: Comply with the University standard specification for underground trench excavation and backfilling.

c) DETAILED HAND EXCAVATION: Allow for detailed hand excavation where the University Site services plan indicates significant or dangerous existing in ground conditions, or carry out a specialist site survey where the survey plan is not available or clear. Allow for detailed hand excavation through all tree zones to minimise damage to the tree roots in the drip zones.

5.13.3. CABLE PITS

Cable pits are to be provided adjacent to the cable entry points to buildings, at changes in direction and at a maximum of 40m spacing for straight runs.

Construction of cable pits must satisfy these requirements:

a) CONSTRUCTION: Walls and bottom must be steel reinforced cast concrete, 75mm thick, or moulded fibre cement cast in place with minimum 75mm concrete surround. Incorporate an additive to render or concrete to prevent the ingress of water.

b) In pedestrian areas use an approved metal lid on a cast metal, cast or precast concrete pit.

c) RATING: Load rate pits to the maximum vehicle wheel load of the roadway.

d) REQUIREMENT: Provide draw-in and turning pits at maximum 50m intervals or as required to avoid damage to cables during installation.

e) MARKING: 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) PIT COVERS:
   i. Cover type: In trafficable areas provide GATIC brand heavy duty cast iron lid with an infill to match the surrounding surfaces, fitted to heavy duty trafficable pits or approved equal.
   ii. General: Provide pit covers to suit expected loads. Fit flush with the top of the pit.
   iii. Maximum Weight: 40kg for any section of the cover.
   iv. Lifting Handles: Provide any proprietary lifting handles for pit covers as spare parts.

g) PIT DRAINAGE: Provide each pit with a drain hole in the base, positioned to drain into a draina
from each cable pit for 2000mm.

h) Conduit depths must be as AS/NZ 3000, except for conduits buried in grass, where the minimum depth should be 750mm

5.13.4. UNDERGROUND CABLE ROUTE MARKING

Cables route marking must meet these requirements:

a) 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.

b) 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.

c) 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.

d) MARKER PLATES: Engraved Stainless steel or brass, minimum size 75 x 75 x 1mm thick SS or 2mm thick brass.

e) 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.

f) 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.
5.14. **CONDUITS AND CABLE SUPPORTS**

5.14.1. **CONDUITS GENERALLY**

Generally conduits must be fixed and supported as follows:

a) **FIXINGS**: Provide two fixings per conduit saddle 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).

5.14.2. **CONCEALED CONDUITS**

Concealed conduits must be routed, supported and fixed as follows:

a) **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.

b) **STEEL CONDUIT**: Steel conduit must be galvanized if run in concrete slabs.

c) **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 so as to avoid crossovers and to keep the number of conduits in any one location to a minimum. Space conduits 75mm apart in slabs.

5.14.3. **NON-METALLIC CONDUITS AND FITTINGS**

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) **TYPE**: Unless otherwise specified, use heavy duty conduits and associated fittings must be of the same material.

c) **JOINTS**: Use cemented joints. Adopt the manufacturer’s recommended procedure for making joints.

d) **FITTINGS**: Use inspection-type fittings in accessible and exposed locations.

e) **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.

f) **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 runs at maximum 10m intervals.

g) **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.

5.14.4. **FLEXIBLE CONDUITS**
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

Manufactured fittings shall be used on change of direction.

5.14.5. GALVANISED STEEL WATER PIPE

Galvanized steel pipe cable conduits must be used as follows:

a) USE: Galvanized steel water pipe may be used for cable enclosures buried in the ground or run in concrete trenches or similar situations.

b) JOINTS & FITTINGS: Seal joints against the entry of water or moisture. Associated fittings must be either galvanized steel, cast iron or approved non-ferrous metal.

5.14.6. SKIRTING WIRING DUCT

Skirting wiring ducts must satisfy 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.

5.14.7. CABLE SUPPORT SYSTEM

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.

i. Minimum steel thickness of trays:
   ▪ Trays Up To 150mm Wide: 1.0mm
   ▪ Trays From 150mm To 300mm Wide: 1.2mm
   ▪ Trays Over 300mm Wide: 1.6mm

ii. Folded edge: Minimum height 20mm, radiused.

iii. Slotting: Normal or reverse with no burrs or sharp edges on the side to which cables are attached.

c. CABLE LADDER:

i. Small Cable: Do not run cables smaller than 13mm outside diameter on the cable ladder unless continuously supported.

ii. BEND RADIUS: Bends must have a minimum inside radius of not less than twelve times the outside diameter of the largest diameter cable carried.

iii. 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.
iv. 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.

v. 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.

d. 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 galvanized steel cable with proprietary fixings and propriety compression crimped rigging fittings. Provide cable tension adjustment. Use only where structurally sound fixing into solid concrete masonry is achieved with chemical anchors. Provide load calculations and do not load beyond 70% of rating. Install a maximum of 1 submain or or five TPS subcircuit cables on any one catenary. (Approval must be given by MU Property for catenaries with multiple circuits.

5.14.8. METALLIC SUPPORT SYSTEMS AND FIXINGS

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.

i. 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:

   i. Masonry or concrete walls: steel expanding or chemical anchor bolts
   ii. Concrete slab ceilings: steel expanding or chemical anchor bolts
   iii. Structural steel: Grade 8.8 machine bolts, hot dip galvanised.
   iv. 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:
   i. Galvanizing: Hot dip galvanize steel conduits and support systems exposed to the weather or installed in damp locations.
   ii. 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.

5.15. DIESEL EMERGENCY GENERATORS

It is University normal practice to provide manual transfer switches within regional and main switchboards, and temporary mobile generator connection terminal boxes external to the building.
External generator connection boxes shall be of stainless steel construction, provided: with safety interlocks, power availability indications, and phase rotation indicators. All connection boxes shall be located in vehicle accessible areas and be suitably protected from mechanical impact.

It is not University practice to install diesel emergency generators or ATS systems, unless it is specifically required by the statutory regulations for life safety or specified for the project. Where diesel life safety generators are required they must comply with relevant AS/NZ Standards and a specialist specification must be prepared covering:

a. Location  
b. Fuel storage  
c. Fuel transfer systems  
d. Noise control  
e. Exhaust flue placement  
f. Ventilation grills and acoustic attenuation  
g. Vibration control  
h. Controls and BMS monitoring  
i. Alarms

5.16. LARGE SWITCHBOARDS

This section applies to all Regional Switchboards and all building Main Switchboards. It describes the detailed requirements for main switchboards and main distribution boards, and typically any switchboards of rating >250A.

5.16.1. SWITCHBOARD LOCATION

All new switchboards must be enclosed in a cupboard or plant room fitted with a university Bi-lock. The cupboard must be in a serviceable location.

5.16.2. MANUFACTURERS

Approved switchboard manufacturers are provided in Attachment 2. Alternative manufacturers may only be submitted with prior approval of the issuer of this standard.

The following switchboard assemblies are used:

a. TTA: Type tested assemblies.  
b. NTTA: Non-type tested assemblies.  
c. PTTA: Partially type tested assemblies.

5.16.3. PROTECTION GRADING STUDY

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.

Demonstrate achievement of grading and discrimination for each protective device. When approved, supply all equipment necessary for this demonstration.

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

5.16.4. GENERATOR CONNECTION PROVISIONS

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.

5.16.5. SWITCHBOARD DESIGN

Design of switchboards must satisfy these requirements:

a. REMOVE - The university has approved modular switchboards on a case by case basis, and is very happy with the result.
b. 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.
c. SERVICE CONDITIONS: Normal service conditions.
d. RATED CURRENTS:
   i. Rated Currents: Minimum continuous uninterrupted rated currents within the assembly environment, under in-service operating conditions.
   ii. Assembly Short-Circuit Capacity Characteristic: Rate main circuit supply and functional units as follows:
   iii. Back-up protective device not provided: Rated short-circuit current for 1s.
   iv. Back-up protective device provided: Rated short-circuit current for the maximum opening time of the associated protective device.
e. FORM OF SEPARATION:
   i. Regional Switchboards - Form 4B
   ii. Main Switchboards – From 3B
f. 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.
g. DEGREE OF PROTECTION: Minimum IP42 indoors / IP65 outdoors
h. SPARE CIRCUIT SPACES:
   i. Provide minimum 25% spare submain circuit capacity unless specifically nominated otherwise on the drawings.
   ii. 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.
   iii. All spare spaces must be fully bus barred for the nominated rating.
i. SPACE CONFIRMATION:
   i. 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.
   ii. 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.

iii. 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.

j. 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.

5.16.6. SWITCHBOARD SHOP DRAWINGS

Prior to ordering equipment or commencing manufacture, supply shop drawings showing:

a. Types, model numbers and ratings of assemblies.

b. Component details, functional units and transient protection.

c. Detailed dimensions.

d. Shipping sections, general arrangement, plan view, front elevations and cross-section of each compartment.

e. Projections from the assembly that may affect clearances or inadvertent operation, such as handles, knobs, arcing-fault venting flaps and withdrawable components.

f. Fault level and rated short circuit capacity characteristics.

g. IP rating.

h. Fixing details for floor or wall mounting.

i. Front and back equipment connections and top and bottom cable entries.

j. Door swings.

k. External and internal paint colours and paint systems.

l. Quantity, brand name, type and rating of control and protection equipment.

m. Construction and plinth details, ventilation openings, internal arcing-fault venting and gland plate details.

n. Terminal block layouts and control circuit identification.

o. Single line power and circuit diagrams.

p. Details of mains and sub-main routes within assemblies.

q. Busbar arrangements, links and supports, spacing between busbar phases, and spacing between assemblies, the enclosure and other equipment and clearances to earthed metals.

r. Dimensions of busbars and interconnecting cables in sufficient detail for calculations to be performed in accordance with Australian Standards.

s. Internal separation and form of separation and details of shrouding of terminals.

t. Labels and engraving schedules.

5.16.7. INSPECTION

Inspections must be conducted at the following stages:

a. Fabrication and painting completed.

b. Works assembly completed, with busbars exposed and functional units assembled.

5.16.8. PRE-COMPLETION TESTS

Pre-completion tests must be performed and meet these requirements:

a. TYPE TESTS: In accordance with the current relevant AS/NZS

b. Testing Facility: Accredited by NATA or registered with the Association of Short-Circuit Testing Authorities (ASTA).

c. PRODUCTION TESTS: Carry out the following tests:

i. Residual current devices: Test using apparatus which displays the trip current and trip time of each device.

ii. Dielectric testing:

iii. NTTAs and PTTAs: 2.5 kV rms for 15s.
iv. Functional testing: Operate mechanical devices, relays, programmable logic controllers and logic controls, protection, interlocking and alarm equipment.

v. Protection relays: Primary current injection tests or, if approved, secondary current injection tests, to verify time/current characteristics and settings.

vi. Carry out secondary current injection tests on adjustable trip circuit breakers after installation and before energisation, to verify time/current characteristics and settings.

Give minimum 3 days notice of testing so that the Superintendent may witness the tests.

5.16.9. SUBMISSIONS

Submit type test certificates for components, functional units and assemblies including internal arcing-fault tests and factory test data. Submissions must include:

a. CALCULATIONS: Submit detailed certified calculations verifying design characteristics.

b. TYPE TEST DATA:

i. General: Verify that type tests and internal arcing-fault tests, if any, were carried out at not less than the designated fault currents at rated operational voltage.

ii. Alterations To TTAs: Submit records of alterations made to assemblies since the tests.

c. PRODUCT DATA FOR PROPRIETARY ASSEMBLIES:

i. Types and model numbers of items of equipment.

ii. Overall dimensions.

iii. Fault level.

iv. IP rating.

v. Rated current of components.

vi. Number of poles and spare capacity.

vii. Mounting details.

viii. Door swings.

ix. Paint colours and finishes. All switchboards are to be externally orange in colour, unless otherwise approved.

x. Access details.

xi. Schedule of labels.

5.16.10. 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 200kA aggregate rating at 8/20uS waveform rise times.

c) Primary Protection: Provide shunt connected metal oxide varistors at assembly incoming supply terminals, on the line side of incoming functional units.

d) Secondary Protection: Provide metal oxide varistors or zener diode surge protection to in-built equipment and semi-conductor components which are not able to withstand transient over-voltages exceeding primary protection let-through residual levels.

e) Failure Indication: Provide integrated indicating lamps to show arrester 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 arrester 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 arrester 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.

5.16.11. SWITCHBOARD METALWORK

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.

5.16.12. CABLE ENTRIES

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.

c. GLAND PLATES: Provide removable gland plates fitted with gaskets to maintain the degree of protection.

5.16.13. SWITCHBOARD DOORS

Doors must meet these requirements:

a. MAXIMUM WIDTH: 900mm.

b. MINIMUM DOOR SWING: Through 90°.

c. DOOR STAYS: Provide stays to outdoor assembly doors.

d. ADJACENT DOORS: Space adjacent doors to allow both to open to 90° 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:

i. Provide the following:

ii. 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.

iii. "T" handles with provision for key locking cylinder to L&F Key No 92268.

iv. Captive, corrosion-resistant knurled thumb screws.

v. Do not use door locks with removable plastic key tools

h. LOCKING:
i. Incorporate a cylinder lock in the latching system. All the locks of one installation must be keyed alike. Fit University Bi-Locks cylinders to all internal switchboards or access into the room.

ii. External switchboards must be fitted with a hasp and staple lock to accept the University standard padlock.

iii. Number Of Keys Required: TWO per switchboard / room

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:
   i. Maximum Dimensions: 900mm wide and 1.2m² surface area.
   ii. 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.

5.16.14. ESCUTCHEON PLATES

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. FRAME: Provide a continuous 12mm wide support frame for the fixing of each escutcheon plate, including additional support where necessary to prevent panel distortion.

c. FIXING: Fix each plate to the frame with metal fixings held captive in the plate and spaced uniformly.

d. MAXIMUM HEIGHT: 1200mm.

e. HANGING: Hang escutcheon plates on hinges which allow opening through a minimum of 90° and permit the removal of the escutcheon when in the open position.

5.16.15. FINISHES

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:
   i. Indoor assemblies: Approved colour to University’s requirements.
   ii. Removable equipment panels: Off white Y35.
   iii. Assembly interior: White.

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

5.17. CONDUCTORS

5.17.1. BUSBARS

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. PLATING: Do not use plated busbars.

c. TEMPERATURE RISE LIMITS - ACTIVE AND NEUTRAL CONDUCTORS:
i. Maximum Rated Current Temperature Rise Limits: 65 ± 1.5°C by type test or calculation in accordance with Australian Standards.

ii. Maximum Short-Circuit Withstand Current Temperature Rise Limits: 160°C by calculation in accordance with Australian Standards.

d. CROSS SECTION: Rectangular section with radiused edges.

e. BUSBAR JOINTS:
   
i. Bolts: Use 304 stainless steel, minimum grade 8 bolts with industry standard head markings. Do not use tapped holes and studs or similar situations for jointing current carrying sections.
   
ii. Washers: must be fitted with split spring or Belleville washers.
   
iii. Bolt Holes: Punch busbar bolt holes using purpose made double sided die sets.
   
iv. Bolt Torque Witness: Mark all bolts and nuts with indelible pen across the fastener and adjacent metal when tightened to conform proper torque has been applied and they have not been tampered with.

f. BUSBAR COVERING:
   
i. General: Provide colour coded heat shrink covering applied to busbars.
   
ii. Active Busbars: Red, white and blue respectively for the A, B and C phase.
   
iii. Neutral Busbar: Black.
   
iv. MEN Link: Green-yellow and black.
   
v. Protective Earth Busbar: Green-yellow.

Restrictions:

i. Do not use adhesive or tape colour bands.

ii. Do NOT cover bolted busbar joints.

h. BUSBAR INSULATION

i. Active And Neutral Busbars And Joints: Select from the following:
   
ii. Polyethylene: At least 0.4mm thick with dielectric strength of 2.5 kV rms for 1 min, applied by a fluidised bed process in which the material is phase coloured and directly cured onto the bars.
   
iii. Close fitting busbar insulation mouldings at least 1mm thick.

j. PROPRIETARY BUSBAR SYSTEMS: Use multi-pole proprietary busbar assemblies or busbar systems, which have been verified for short circuit capacity and temperature rise-limits by type tests. Where used in type ih segregation, they must be tested to comply with the increased insulation required limits.

k. CURRENT CARRYING CAPACITY:

i. Active Conductors: Maximum 90°C final temperature.

ii. Neutral Conductors: Use full size neutral conductors unless approved in writing.

iii. Protective Earth Conductors: Size for at least 50% of the rated short circuit withstand current for 100% of the time duration.

l. TEE-OFF BUSBARS CURRENT RATING:

i. For Individual Outgoing Functional Units: Equal to maximum frame size rating of the functional unit.

ii. For Multiple Functional Units: Equal to the diversity factors in accordance with Australian Standards, based on frame size rating.

m. CABLE CONNECTION FLAGS:

i. 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.
ii. 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.

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

5.17.2. WIRING

Wiring must satisfy these requirements:

a. CABLE TYPE: Unless otherwise specified, provide 0.6 kV V-75 multi stranded copper conductors PVC insulated cables for general internal wiring, and heat resisting insulated cables for connection to equipment capable of raising the insulation temperatures above 75°C.

b. CONTROL AND INDICATION CIRCUITS: Provide stranded copper conductors of not less than 1.0mm².

c. CABLE COLOURS: Colour code the wiring in accordance with Australian Standards:

d. WIRING SUPPORT: Use mechanically fixed ducting or clips. Do not use self adhesive cable clips of any type.

e. TERMINATIONS:

i. Terminals: For connections up to 15 kW load provide rail-mounted tunnel type terminal blocks.

ii. Lugs: Terminate wiring into terminal blocks using compression type lugs compatible with the terminals, and cramped by the use of the correct tool. Lugs for connection to tunnel type blocks must be of pre-insulated lipped blade type.

iii. Grouping: Segregate terminal groups and install together terminals for each outgoing circuit, in the same order throughout, as follows:

iv. Terminals for power wiring: 3 phases or phase and neutral;

v. Control terminals: In numerical or alphabetical order of wire identification, with the lowest number or letter next to the power terminals.

vi. Spare Terminal Space: Provide sufficient space on mounting rails for 25% future outgoing circuits possible in any cabling compartment.

vii. Wiring Identification: Identify power and control cables at both ends using neat fitting ring type ferrules agreeing with record circuit diagrams.

5.18. EXTERNAL SWITCHBOARDS DESIGN AND CONSTRUCTION

All external switchboards must be:

a. IP65 rated

b. Stainless steel and powder coated to match the building area

c. Stainless steel or chromed brass furniture.

d. Double skinned for solar load reduction and condensation minimisation.

e. Have protective overhang or awning on external doors.

f. Have bottom cable entry.

g. Be installed on a concrete plinth on raised welded frame, galvanised, or wall mounted with SS anchor bolts.

h. Fitted with hasp and staple to take a University bi-lock padlock.

5.19. SWITCHGEAR AND CONTROL GEAR

5.19.1. SWITCHGEAR

Switchgear and protection equipment must be of one brand throughout any single installation, and must be fully co-ordinated and compatible.

5.19.2. CIRCUIT BREAKER TYPES
Use air circuit breakers supplied from companies with 24 hour service facilities located within the Sydney metropolitan area. 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 – 1200A Moulded case circuit breakers
d. >1200A Withdrawable air circuit breakers

5.19.3. ATS TYPES

Use motorised moulded case circuit breakers fitted with walking beam interlocks. Alternatively, Mechanical interlocked motorised switch units may be used with prior approval.

Contactor type AT Ts are not permitted.

5.19.4. MOULDED CASE AND MINIATURE CIRCUIT BREAKERS

Provide circuit breakers which are all of the same manufacture and match the brand installed in any existing installation. Ensure te new circuit breakers grade and cascade with any existing installation.

5.19.5. 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.

5.19.6. EXTRA-LOW VOLTAGE TRANSFORMERS

The transformer output loading must be ≤ 80% of transformer continuous rating, taking account of degree of ventilation and ambient temperature within assembly and supplied load.

5.20. ACCESSORIES, INSTRUMENTS, METERS

5.20.1. 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:
   i. Energy measurements: 0.5M.
   ii. Indicating and recording instruments: 1M.

5.20.2. MULTIFUNCTION METERS

Refer to Macquarie University Property metering and BMS.

5.20.3. INDICATOR LIGHTS

Indicator lights must be provided to meet these requirements:

a. STATUS: Lamps must indicate:
   i. Supply available
   ii. the “run” state of motors.
   iii. The state of ATS input and output supplies.
iv. The state of bypass, by-pass or interconnecting switches

b. LAMPS: Lamps must be multi-element LED type and must be changeable from the front of the panel without removing the holder.

c. LAMP TEST: Provide a lamp test button.

5.20.4. LABELS

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:

i. Manufacturers Name

ii. Source of electrical supply

iii. Circuit designation for main switches, main controls and sub-mains controls.

iv. Details of consumers’ mains and sub-mains.

v. Incoming busbar or cable rating to first tee-off.

vi. Controls and fault current limiters

vii. Fuse link size.

viii. Circuit breaker frame size & trip current settings

ix. 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:

i. Warning Notices: White letters on red background.

ii. Other Labels: Black letters on white background.

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

i. Main Switchboard Designation: 25mm.

ii. Main Switches: 20mm.

iii. Feeder Control Switches: 10mm.

iv. Identifying Labels: on outside of cubicle rear covers, etc.: 4mm.

v. Equipment labels within cubicles: 3mm.

vi. Warning notices: 10mm for heading and 5mm for remainder.

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

i. Sub-main designation and rating

ii. Light and power circuit number, type and area supplied

iii. Submit the proposed schedule for approval

iv. 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.
5.21. **THERMOGRAPHIC SURVEY**

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.

5.22. **ENERGY & TARIFF METERING SYSTEMS**

5.22.1. **AUTHORITY TARIFF METERING**

All regional distribution boards (RDB) and main switchboards (MSB) directly connected to a substation must contain Electricity Supply Authority Metering current transformers within the switchboard enclosure.

All main switchboards (MSB) supplied from a regional distribution board (RDB) must include cubicle space and links for the future installation of Electricity Supply Authority Metering current transformers, allowing future re-configuration of electrical supplies.

5.22.2. **PRIVATE TARIFF METERING**

All main switchboard feeds (MSB) and sub-tenant submains must be fitted with private energy smart meters and CTs of Tariff Accuracy classification and class:0.5M. These meters may be used to allocate energy usage charges as distinct from just monitoring energy use.

5.22.3. **ENERGY CONSUMPTION METERING**

Sub-metering must be installed to monitor the following loads, or as required to meet any energy rating scheme for the project, during any switchboard upgrade/new installation.

- a. Mechanical services
- b. Essential services
- c. Lifts
- d. Individual building floors supplies
- e. House services general supply
- f. Any tenanted or potentially tenanted space
- g. Separate Lighting and general power for each DB via split chassis metering.
- h. Any laboratory/specialist equipment or high energy use area with total load >50 amps/ph.

Refer to Macquarie University Property metering and BMS.

5.22.4. **METERING NETWORKING SYSTEM**

Please refer to Mac Uni Property campus metering and BMS for connection of all Multifunction metering and electronic circuit breakers

Assett Management Team.

5.22.5. **NETWORKING**

Metering Spec to cover

5.22.6. **METER DOCUMENTATION**

The contractor is to supply MU PROPERTY with:

- a. switchboard single line diagrams
b. network communications network schematics, including for devices within the switchboard.

c. network address identification schedules in editable spreadsheet format

d. plans showing meter locations and coverage.

5.23. DISTRIBUTION SWITCHBOARDS

5.23.1. DISTRIBUTION BOARD MINIMUM CONFIGURATION

Distribution boards must be located circulation spaces, corridors and foyers, in a location dry and free of dust. They must not be located in classrooms and lecture theatres.

The following minimum configuration requirements must be met:

a. MINIMUM SIZE & CONFIGURATION: The standard Distribution Board configuration must be:
   i. Minimum configuration of dual chassis - 12 poles for lighting and 18 poles for power in a 36 pole switchboard box.
   ii. The switchboard box must be sized up to next largest standard chassis to ensure there is adequate cabling and auxiliary space.
   iii. Use 18mm pole pitch DinT C60N 6kA miniature circuit breakers in proprietary insulated 250A 3 phase chassis.
   iv. Provide Energy metering CTs for power & lighting sections complete with transducers having a Modbus interface. Mount on the Din rail.
   v. 20A lighting RCD circuit breakers. 20A Power RCD circuit breakers
   vi. 100A Top centre main switch.
   vii. Din rail beside main switch for ancillaries, potential fuse and transducers.
   viii. Installed in dedicated switchboard cupboards with University Bi-locks, or where not feasible have University Bi-locks on the switchboard door.
   ix. Slip in clear plastic Schedule card holder with University Standard MS Excel spreadsheet schedule.
      Provide soft copy of the schedule in the manuals.
   x. 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:
   i. 20% spare pole spaces for power
   ii. 15% spare pole spaces for lighting.

5.23.2. SUBCIRCUIT LOADING & NON-RCD CIRCUITS

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

a. SUBCIRCUIT LOADING:
   i. 20 Amp Lighting subcircuits must have a maximum initial connected load of 12 lights to allow for RCD minimum trip tolerance and electronic ballast leakage of 1mA per luminaire. The ultimate maximum connected load for a refurbishment shall generally be 15 lights, depending on manufacturer’s figures for ballast leakage.
   ii. 20A Power subcircuits must have a maximum of 8 workstations or 8 GPO (single or double) locations connected.

b. NON RCD SUBCIRCUITS: Provide correctly labelled dedicated non-RCD protected subcircuits to the following load groups:
   i. UPS powered equipment and workstations. Use red coloured outlets labelled “UPS Power – No Earth Leakage Protection)"
   ii. Refrigerators and freezers
   iii. Fire alarm and protection equipment

5.23.3. DISTRIBUTION SWITCHBOARD DESIGN AND CONSTRUCTION
The distribution switchboards general design must:

- be of the dead front, totally enclosed type.
- be constructed of folded and welded sheet steel with a with an orange powder coat finish, unless otherwise specified.
- 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.
- allow for interchangeability of single and multiple pole breakers without alteration to busbar connection or breaker mounting fixtures.
- Have all equipment accessible and removable from the front without dismounting the switchboard from its position.
- Include a hinged removable white escutcheon panel.
- Otherwise comply with the switchboards section of this standard.

5.23.4. TRANSIENT PROTECTION

Provide Metal Oxide Varister (MOV) transient protection devices in all switchboards in accordance with the relevant AS/NZS.

Protection Level must be consistent with the prospective surge current at the incoming supply, graded between upstream and downstream switchboards or systems.

Provide visual illuminated indication of correct operation, and fail alarm monitoring and terminals for connection to a BMS system.

Locate Main or Zone Switchboard surge diverters in segregated metal compartments within the switchboard with a clear polycarbonate inspection window.

5.23.5. DISTRIBUTION BOARD NAME/ DESIGNATION LABELS

Provide labels of material, colours and set out in accordance with the University Standard requirements.

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

Generally name and designation labels must be as follows:

- Identification Number must be based on the room number where the board is located e.g. DB304 – will be in room number 304, being room 4 on L3.
- Additional location identifiers such as a letter from the alphabet (sequentially) must be used if there is more than one switchboard in a room e.g. DB304A and DB304B.
- Mechanical boards must be labelled as per above followed by the words "Mechanical Services Board".
- All switchboards must have a separate label identifying the building number and name where it is located e.g. Building E7B.
- All switchboards must be labelled with the origin of supply eg. Supplied from E7B MSB.
- All outgoing subcircuits must be labelled “DBxx-yy” where xx is the DB number, and yy is the circuit breaker number.

5.24. TECHNICAL 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 dedicated buried earth grid external to the building with a maximum impedance of 0.5 ohms.
- A main technical earth bar with provision of slack cable and space to place a clamp current meter onto every outgoing radial cable.
- 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.

5.25. LIGHTNING PROTECTION SYSTEM

Provide a complete lightning protection system in accordance with AS/NZS 1768.

5.25.1. MATERIALS

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

5.25.2. 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.

5.25.3. JOINTS AND BONDS

The following types of joints and bonds must be used:

a. TYPES OF JOINTS:

i. Accessible Connections: TIG welded or bolted with high tensile SS bolts

ii. Inaccessible Connections: CAD or TIG welded

iii. 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.

b. BONDING:

i. 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.

ii. Services:

iii. 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;

iv. Bond metallic sheathing or armouring of electric cables at the point of entry to the building.

v. Down Conductors:

vi. 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;

vii. Where a down conductor occurs on the external face of a column, bond it at top and bottom to terminals on the column reinforcement;

viii. Where the column reinforcement is the down conductor, provide terminals and bond it at top and bottom to the conductor network.

ix. TERMINALS:

x. For the above cases, provide 50mm x 6mm terminals of stainless steel, grade 304 to AS1449, clamped and bolted to not less than four reinforcing rods.

5.25.4. INSTALLATION
Before commencing the installation, 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.

5.25.5. EARTH TERMINATIONS

These requirements must be met for earth terminations:

a. TERMINATING LUGS: Provide terminating lugs on each electrode or earth termination network for the connection of down conductors or base conductors.

b. 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.

c. ELECTRODE PITS:
   
i. 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.
   
ii. Pit Walls: 150mm concrete or 200mm solid blockwork.
   
iii. 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”.
   
iv. Method Of Labelling: engraved SS or brass plate

5.26. POWER FACTOR CORRECTION

Provide Power Factor (PF) Correction equipment to maintain the PF at between 0.95 and unity. It must be reliable with a minimum life expectancy of 10 years for all components.

The following PF equipment along with all necessary ancillary requirements must be provided for satisfactory operation:

a. PF Correction Equipment with:
   
i. High voltage MPP capacitors
   
ii. Special duty rated step contactors
   
iii. High quality iron cored harmonic rejection inductors
   
iv. Microprocessor step controller

b. Items within the Main Switch Boards for:
   
i. Sub-main protection for the PFC feeder cables
   
ii. Incorporation of the PFC Current Sensing Transformer

c. Sub-mains and cable tray supports between the MSB and PFC equipment.

d. Terminals for connection of a remote group alarm.

e. Shop drawings

f. As installed drawings and maintenance manuals

g. 24 month warranty with six monthly service

h. The PF Correction equipment must be located as close as possible to the main switch boards.

5.26.1. AUTHORITY APPROVALS

Obtain Supply Authority approval of the installation, including submission of equipment details prior to construction or installation.

5.26.2. SHOP DRAWINGS

Shop drawings must include the following:

a. General arrangement of each cubicle

b. All equipment listing

c. Equipment site plan including cable routes.
d. General arrangements including method of construction, materials used, finishes, clearance distances and method of support for busbars and cables.

e. Makers or manufacturers’ name and catalogue number of all proprietary equipment.

f. Schedules of all labels for all equipment.

g. Control schematics. Provide a description of operation with all controlled schematics.

5.26.3. CUBICLE

The cubicle must:

a. be manufactured in accordance with the specification section for switchboards. (Obtain a copy of this section prior to completing the tender)

b. be painted a colour to match the Main Switchboard.

5.26.4. CAPACITORS TYPE

The capacitors must:

a. Comply with AS1013 and IEC 831-1.

b. Be vacuum oil impregnated metallised polypropylene (MPP)

c. Incorporate discharge resistance

d. Have a minimum dielectric rating of 480VAC as required to accommodate the series reactor voltage addition

e. Be rated of 60°C maximum surface temperature

f. Incorporate automatic overpressure disconnection

g. Be of cylindrical construction with single capacitor units per can

h. Have a tolerance of -5%, +10% of value

i. Have their KVAR rating at 415V.

5.26.5. CAPACITOR INSTALLATION

The capacitor installation must have:

a. Inductors mounted in a separate cubicle, segregated from capacitors, fuses and switchgear.

b. Capacitors cans separated by a minimum air space of 25mm for ventilation

c. Layout arranged for easy removal and replacement of capacitors

d. All live parts insulated to protect Personnel from accidental contact

e. Be ventilated to ensure internal cabinet temperature rise is less than 15°C above ambient

f. A maximum step size of 50 KVAR with fuses for each step. Provide a 25 KVAR step in each installation to allow for finer control.

5.26.6. COOLING FANS

The cubicle cooling fans must:

a. Be muffin type axial fans for 240VAC.

b. Be twin units per cubicle.

c. Be sized to limit the internal cabinet temperature rise to less than 5°C above ambient room temperature.

5.26.7. WIRING

The following details must be incorporated:

a. Generous space must be provided for use of a clamp on ammeter to measure individual capacitor phase currents

b. Where welding type multi-stranded flexible cables are used, they must be terminated in a manner which ensures adequate clamping of the fine conductors. Compression ferules must be used for tunnel type terminations.

c. Where there is no fault protection device incorporated in the Main switchboard, the cable to the PFC cubicle must be Radox or XLPE, installed to withstand the prospective fault current.
5.26.8. CONTACTORS

The capacitor switching contactors must:

a. Be rated for capacitor switching duty at 1.5 times the capacitor step full load current. For example, 100AMPS AC3 for a 50KVAR capacitor at 415V.
b. Comply with IEC 947 contactors for capacitor switching AC-6b.

5.26.9. STEP CONTROLLER

The capacitor switching step controller must:

a. Be of fully electronic microprocessor type.
b. Be easily site programmable.
c. Have spare capacity increase in the number of steps of 25%.
d. Incorporate non-volatile program and data memory.
e. Have a digital display for the following parameters:
   i. Power Factor
   ii. Incoming supply load
   iii. Number of capacitor steps in use in the incoming supply
   iv. % Harmonic current
f. Incorporate harmonic monitoring and automatic disconnection in the case of overload of the capacitors.
g. Provide for automatic alarm and isolation of the capacitors in case of over temperature or overcurrent.
h. Provide for automatic disabling of all capacitor steps when the installation is being powered from any existing diesel generator. A signal for this control must be derived from the phase failure relay in the MSB.
i. Automatically cycle the capacitor steps to ensure equal ageing of components.
j. Have a local and remote group alarm facility for any abnormal condition.
k. An integral MODBUS data interface, for connection of a monitoring system and be complete with associated software.

5.26.10. INRUSH CURRENT SURGE LIMITING

Limitation of the capacitor inrush current must be achieved by means of inductance in series with the capacitors.

5.26.11. HARMONIC AND SUPPLY AUTHORITY RIPPLE SIGNAL REJECTION

This must be achieved using series-connected iron cored reactors tuned to a frequency suitable to limit the harmonic current within the capacitors to less than 5% of their nominal rating, and to limit the increase in the incoming supply voltage total harmonic distortion to less than 2.5% and in no instance to be more than 4% total THD. (Typically this frequency will be slightly above or below the 4th harmonic).

The reactors must be purpose designed and manufactured to Australian standards, and carry a compliance and rating plate.

Provide calculations for the sizing of the reactors, and workshop drawings showing form of construction and all materials.

The reactors must:

a. Be provided for each capacitor step
b. Be of very low loss design
c. Be wound from high purity copper conductors using Class F temperature rated insulation
d. Have insulated, laminated, high permeability silicon iron (or equivalent) cores
e. Have non-ferrous mounting hardware
f. Be designed to carry 1.5 times the rated capacitor current at 50Hz without saturating. (ie: 100A for 50KVAR capacitor at 415V) at 40°C Ambient
g. Have a Q factor >10
h. Be firmly constructed to avoid the possibility of noise due to vibration
i. Have a tolerance on inductance value of ±5% at rated current
j. Be permanently labelled with manufacturers’ details and rating information
k. Have a nominal current rating of at least 1.25 times the nominal capacitor current.
6. 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 must test, verify and certify that the electrical services meet or exceed the required performance criteria of this standard.

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.

6.1. TESTING AND COMMISSIONING

<table>
<thead>
<tr>
<th>Item</th>
<th>Description of Item</th>
<th>Description of Works</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Phase Sequence</td>
<td>Ensure the correct phase sequence at the equipment after connection of the supply.</td>
</tr>
</tbody>
</table>
| 2.   | Balancing of Load.  | Balance the load as evenly as practicable at the Main Switchboard and the sub switchboards DB-__ & __ at Practical Completion.  
At 6 months after practical completion Recheck and, where the maximum demand indicates more than 20% phase imbalance at the incoming supply, rebalance the load in consultation with the University.  
Re-Check at completion of the Defects Liability Period and advise the status to the University. |
| 3.   | Circuit Protection  | Confirm that circuit protective devices are sized and adjusted, where necessary, to protect the installed circuits. Provide a commissioning data schedule for all circuit breaker grading settings. |
| 4.   | Starting Up         | Co-ordinate schedules for starting up of various systems and equipment.  
Have authorised manufacturers” representatives present on site to inspect, check and approve equipment or system installation prior to starting up, and to supervise placing equipment and operation.  
Execute starting up under supervision of manufacturers” representative and appropriate Main Contractor personnel, in accordance with manufacturers” instructions. |
| 5.   | Tests               | Verify that tests, meter readings, and specified electrical characteristics agree with those required by the manufacturer. |

6.1.1. INSPECTION & WITNESS TESTING

Do not conceal works/parts of works that require inspection prior to inspection, without approval.
6.1.2. TESTING EQUIPMENT SCHEDULE

<table>
<thead>
<tr>
<th>Test To be Performed</th>
<th>Equipment To Be Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation resistance measurements on cables and wiring to AS/NZS 3000.</td>
<td>Megger Tester with 500V</td>
</tr>
<tr>
<td>Earth resistance measurement to AS/NZS 3000.</td>
<td>Earth Resistance Meter</td>
</tr>
<tr>
<td>Confirmation of effective earthing of the exposed metal of electrical equipment</td>
<td>Continuity Meter</td>
</tr>
<tr>
<td>Earth fault loop impedance to AS/NZS 3017</td>
<td>Impedance Tester</td>
</tr>
<tr>
<td>Full functional checks and operational checks on energised control equipment and circuits, including adjustments for the correct operation of safety devices</td>
<td>As appropriate</td>
</tr>
<tr>
<td>Smart Metering systems &amp; network</td>
<td>Refer metering Spec</td>
</tr>
</tbody>
</table>

Use instruments calibrated by Authorities accredited by NATA for tests.

6.1.3. INITIAL CERTIFICATION

On satisfactory completion of the installation arrange an installation inspection by The Supply Authority. Submit both Contractor certificates and signed Supply Authority inspection notes stating that each section of the installation is operating correctly.

The final installation must comply with the requirements of the BCA with respect to emergency services. Installers’ Certificates of Compliance must be provided.
7. DOCUMENTATION & RECORDS

The following design documents must be provided:

a. University Design Guide compliance check-sheet from the attachment to this document must be completed by both the designers and countersigned by the project manager or MU PROPERTY representative.
b. Return Brief defining the systems proposed and any deviations from this specification.
c. Electrical maximum demand calculation spreadsheet.
d. Computer design calculation files for circuit breaker grading study, fault levels, voltage drops and cable calculations.
e. Budget calculations
f. Applications to Supply authorities, and their responses,
g. Designers statutory compliance certificates

The following documents must be provided at practical completion:

a. Maintenance manuals
b. Commissioning records
c. Product Manufacturer specific information
d. System schematics
e. Complete As-built drawings, including switchboard workshop drawings
f. Electrical and wiring diagrams
g. System functionality and operation description
h. System set point values
i. Installers Statutory certificates
j. Supply authority completion forms and inspection records, including the CCEW (completion certificate)
8. OPERATIONS

Consultants/designers must include in the project specification detailed requirements for operation and maintenance manuals, including system description, operation procedures, testing and commissioning records, maintenance instructions, product support information and recovery protocols for any computer related systems. Contractors must provide these to the satisfaction of the consultant/designer and providing a collection of manufacturers’ brochures and catalogues is not acceptable to the University.

Contractors must submit loose leaf log book designed for recording operational and maintenance activities including materials used, test results, comments for future maintenance actions and notes covering asset condition. Completed log book pages recording the operational and maintenance activities undertaken for Practical completion and during the defects liability period must also be provided.

Facilities Maintenance must establish, document and implement procedures for electrical services, plant and equipment operation and maintenance to ensure electrical services are fit-for-purpose, provide secure, efficient, safe and reliable electrical power and comply with requirements of this standard.
9. AUTHORISATION OF VARIATIONS

The issuer of this standard must review and decide whether to approve variations to this standard. The review must consider requirements of stakeholders from clients, projects and facilities management before deciding whether to approve variations.

Where alternative electrical services solutions are proposed by contractors, all information and detailed calculations must be provided in accordance with this specification. The contractor must pay any costs associated with design verification for the alternative proposal.
10. QUALITY CONTROL

Minimum compliance requirements of this design standard are specified in Attachment 1. Project managers, consultants, contractors, commissioning agents and facilities maintenance personnel must ensure compliance with these requirements is achieved.

Consultants and designers must include check sheets for each system component detailing each item that needs to be checked, tested and verified during the installation process in project specifications. Such check sheets must be completed and verified by the project consultant/designer, including the identification of any defects and the closing out of such defects.

Formal sign-off from the issuer of the standard or their delegated authority is required for acceptance of any non-compliances and departures from this standard's requirements.
11. REFERENCES

<table>
<thead>
<tr>
<th>Standard</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS/NZS 1158</td>
<td>Lighting for roads and public spaces</td>
</tr>
<tr>
<td>AS/NZS 1680</td>
<td>Interior Lighting</td>
</tr>
<tr>
<td>AS/NZS 1768</td>
<td>Lightning protection</td>
</tr>
<tr>
<td>AS/NZS 2053</td>
<td>Conduits and fittings for electrical installations</td>
</tr>
<tr>
<td>AS/NZS 2293</td>
<td>Emergency escape lighting and exit signs for buildings</td>
</tr>
<tr>
<td>AS 2676</td>
<td>Installation and maintenance of batteries in buildings</td>
</tr>
<tr>
<td>AS/NZS 3009</td>
<td>Electric installations - Emergency power supplies in hospitals</td>
</tr>
<tr>
<td>AS 3011</td>
<td>Electrical installations - Secondary batteries installed in buildings</td>
</tr>
<tr>
<td>AS/NZS 3000</td>
<td>Electrical installations (also known as the Australian/New Zealand Wiring Rules)</td>
</tr>
<tr>
<td>AS/NZS 3008.1.1</td>
<td>Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1kV – Typical Australian installation conditions</td>
</tr>
<tr>
<td>AS/NZS 3013</td>
<td>Electrical installations – Classification of the fire and mechanical performance of wiring systems</td>
</tr>
<tr>
<td>AS/NZS 3017:2007</td>
<td>Electrical installations—Verification guidelines</td>
</tr>
<tr>
<td>AS/NZS 3019:2007</td>
<td>Electrical installations—Periodic verification</td>
</tr>
<tr>
<td>AS/NZS 3080</td>
<td>Telecommunications installations - Generic cabling for commercial premises</td>
</tr>
<tr>
<td>AS/NZS 3084</td>
<td>Telecommunications installations - Telecommunications pathways and spaces for commercial buildings</td>
</tr>
<tr>
<td>AS/NZS 3100</td>
<td>Approval and test specification – General requirements for electrical equipment</td>
</tr>
<tr>
<td>AS 3439.1</td>
<td>Low Voltage Switchgear and Control Gear Assemblies</td>
</tr>
<tr>
<td>AS/NZS 3947.3</td>
<td>Low-voltage switchgear and control gear - Switches, disconnectors, switch-disconnectors and fuse-combination units</td>
</tr>
<tr>
<td>AS/NZS 5000</td>
<td>Electric cables – Polymeric insulated</td>
</tr>
<tr>
<td>AS 60529-2004</td>
<td>Degrees of protection provided by enclosures (IP Code)</td>
</tr>
<tr>
<td>AS/ACIF S008</td>
<td>Requirements for customer cabling products</td>
</tr>
<tr>
<td>AS/ACIF S009</td>
<td>Installation requirements for customer cabling (wiring rules)</td>
</tr>
<tr>
<td>ASC 168</td>
<td>Fluorescent lamp ballasts</td>
</tr>
<tr>
<td>BS 5042</td>
<td>Specification for lampholders and starter holders.</td>
</tr>
<tr>
<td>EIA/TIA 569</td>
<td>Commercial building standard for telecommunications pathways and spaces</td>
</tr>
<tr>
<td>EN 55015:2006</td>
<td>Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment</td>
</tr>
<tr>
<td>EN 55022</td>
<td>Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement</td>
</tr>
<tr>
<td>EN 61347</td>
<td>Lamp control gear</td>
</tr>
<tr>
<td>EN 60929</td>
<td>AC-supplied Electronic Ballasts For Tubular Fluorescent Lamps - Performance Requirements</td>
</tr>
<tr>
<td>IEC 60038</td>
<td>Standard Voltages</td>
</tr>
<tr>
<td>IEC 60044.1</td>
<td>Instrument transformers - Part 1: Current transformers</td>
</tr>
<tr>
<td>IEC 60051</td>
<td>Direct acting indicating analogue electrical measuring instruments and their accessories</td>
</tr>
<tr>
<td>IEC 60529</td>
<td>Degrees of protection provided by enclosures (IP Code)</td>
</tr>
<tr>
<td>IEC 61000</td>
<td>Electromagnetic compatibility (EMC)</td>
</tr>
<tr>
<td>IEC 61547</td>
<td>Equipment for general lighting purposes - EMC immunity requirements</td>
</tr>
<tr>
<td>IEC 62052</td>
<td>Electricity metering equipment (AC) - General requirements, tests and test conditions</td>
</tr>
<tr>
<td>BCA</td>
<td>Building Code of Australia Building Code of Australia, specifically Section J energy efficiency</td>
</tr>
<tr>
<td>SIR</td>
<td>Supply Authority Service Installation Rules</td>
</tr>
<tr>
<td></td>
<td>Workcover requirements</td>
</tr>
<tr>
<td></td>
<td>All Health Authority Requirements</td>
</tr>
<tr>
<td></td>
<td>State Fire Brigade requirements</td>
</tr>
<tr>
<td></td>
<td>All Local Council regulations</td>
</tr>
<tr>
<td></td>
<td>Electricity Safety (Installations) Regulation</td>
</tr>
</tbody>
</table>
12. ATTACHMENTS

Attachment 1  Design Standard Compliance Checklist
Attachment 2 Approved switchboard manufacturers
Attachment 3 Approved Switchboard Meters and Gateways
## ATTACHMENT 1  DESIGN STANDARD COMPLIANCE CHECKLIST

<table>
<thead>
<tr>
<th>Key Standard Requirements</th>
<th>Project Phase</th>
<th>Compliant</th>
<th>Non-Compliance / Departure Description</th>
<th>Non-Compliance Approved</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>设计 &amp; 文档</td>
<td>立项</td>
<td>确认</td>
<td>无</td>
<td>无</td>
<td>无</td>
</tr>
<tr>
<td>设计 &amp; 文档</td>
<td>招标</td>
<td>确认</td>
<td>无</td>
<td>无</td>
<td>无</td>
</tr>
<tr>
<td>设计 &amp; 文档</td>
<td>施工</td>
<td>确认</td>
<td>无</td>
<td>无</td>
<td>无</td>
</tr>
<tr>
<td>设计 &amp; 文档</td>
<td>DLP</td>
<td>确认</td>
<td>无</td>
<td>无</td>
<td>无</td>
</tr>
<tr>
<td>Key Standard Requirements</td>
<td>Project Phase</td>
<td>Compliant</td>
<td>Non-Compliance / Departure Description</td>
<td>Non-Compliance Approved</td>
<td>Comments</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------</td>
<td>-----------</td>
<td>----------------------------------------</td>
<td>-------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>☒ Design &amp; Documentation</td>
<td>Tender</td>
<td>☑ Yes</td>
<td>☐ No</td>
<td>☐ Yes</td>
<td></td>
</tr>
<tr>
<td>☒ Construction</td>
<td>Tender</td>
<td>☑ Yes</td>
<td>☐ No</td>
<td>☐ Yes</td>
<td></td>
</tr>
<tr>
<td>☒ DLP</td>
<td>Tender</td>
<td>☑ Yes</td>
<td>☐ No</td>
<td>☐ Yes</td>
<td></td>
</tr>
<tr>
<td>☒ Design &amp; Documentation</td>
<td>Construction</td>
<td>☑ Yes</td>
<td>☐ No</td>
<td>☐ Yes</td>
<td></td>
</tr>
<tr>
<td>☒ Tender</td>
<td>Construction</td>
<td>☑ Yes</td>
<td>☐ No</td>
<td>☐ Yes</td>
<td></td>
</tr>
<tr>
<td>☒ DLP</td>
<td>Construction</td>
<td>☑ Yes</td>
<td>☐ No</td>
<td>☐ Yes</td>
<td></td>
</tr>
<tr>
<td>☒ Design &amp; Documentation</td>
<td>DLP</td>
<td>☑ Yes</td>
<td>☐ No</td>
<td>☐ Yes</td>
<td></td>
</tr>
<tr>
<td>☒ Tender</td>
<td>DLP</td>
<td>☑ Yes</td>
<td>☐ No</td>
<td>☐ Yes</td>
<td></td>
</tr>
<tr>
<td>☒ DLP</td>
<td>DLP</td>
<td>☑ Yes</td>
<td>☐ No</td>
<td>☐ Yes</td>
<td></td>
</tr>
</tbody>
</table>
ATTACHMENT 2 DEEMED-TO-COMPLY SWITCHBOARD MANUFACTURERS

Approved switchboard manufacturers:
1. Gosford Electrical Manufacturing
2. SMB Harwal
3. KE Brown
4. Relec Switchboards
5. Southern Cross Switchboards
ATTACHMENT 3 DEEMED-TO-COMPLY SWITCHBOARD METERS AND GATEWAYS

Refer Metering Standard