THE UNIVERSITY OF SYDNEY

CIS Electrical Services Standard

The University of Sydney

Engineering & Sustainability Team

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1 PURPOSE

The CIS Electrical Services Standard sets out the University of Sydney'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 and are cost effective to operate and maintain.

Applicable requirements documented in Workplace Health and Safety legislation, Disability Discrimination legislation, State Environmental Planning legislation, Commonwealth and State legislation, National Construction Codes (NCC) and Australian and New Zealand Standards (AS/NZS) are the minimum and mandatory compliance requirements.

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;
    ii. Disability Discrimination legislation;
    iii. State Environmental Planning and Assessment legislation;
    iv. All other Commonwealth and State legislation;
    v. NCC;
    vi. AS/NZS;
    vii. This standard and other University standards.

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 University of Sydney. 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); program/plan of progressive upgrades to a University-owned building;
d. Refurbishment projects for long-term University-leased spaces;
e. Facilities maintenance services.

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

a. Design calculations including grading studies and cable sizing;
b. Main and distribution switchboards;
c. External switchboards;
d. Generators;
e. Metering and energy monitoring;
f. Consumer mains, sub-mains and sub-circuit wiring;
g. Socket outlets, isolators and small power installations;
h. Cable trays and conduits;
i. Power factor correction and active harmonic filtering;
j. Earthing and bonding;

k. Lightning protection;
l. Labelling;
m. Testing and commissioning;
n. Electromagnetic Compatibility, Hazards and performance.

It does not cover:

a. Lighting system design and specification – refer to the **CIS Lighting Services Standard**;
b. Special electrical installations for specialised laboratory and research spaces which will be specifically defined in the project;
c. Communications and data cabling systems – refer to the University of Sydney **ICT Communications Cabling 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.

3 GLOSSARY OF TERMS

Unless the context otherwise requires, the following definitions apply:

ACA	Australian Communications Authority
ACB	Air circuit breaker
AGL	Australian Gas Light Company
ASTA	Association of Short-Circuit Testing Authorities
AS/NZS	Australian / New Zealand Standard
AUMS	University Private Advanced Utilities Monitoring System
Ausgrid	The Sydney City Area Supply Authority
NCC	National Construction Code of Australia
BMCS	Building Management Control System
CB	Circuit breaker
CCEW	Contractor's Completion of Electrical Works
CIS	Campus Infrastructure Services – University of Sydney
CT	Current Transformer
DB	Distribution Board
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
Endeavour Energy	NSW Regional Supply Authority
GPO	General Power Outlets
MCB	Miniature Circuit Breaker
MCCB	Molded Case Circuit Breaker
MDB	Main Distribution Board

MEN	Multiple Earth Neutral (earthing system)
MOV	Metal Oxide Varistors
MSB	Main Switchboard
NATA	National Association of Testing Authorities
O&M	Operation and Maintenance Manual
PCA	Principal Certifying Authority
Pf / PFC	Power Factor / Power Factor Correction
RCBO	Residual Current Circuit Breaker with Integral Overcurrent Protection
RCD	Residual Current Device
RMSB	Regional Main Switchboard
SPD	Service Protective Device
TPS	Thermoplastic sheathed cable

4 AUTHORITIES & RESPONSIBILITIES

The design standard is issued by CIS. It is approved and signed-off by the Director CIS. The Engineering & Sustainability Unit is responsible for reviewing and maintaining the standard and keeping it up-to-date. The standard must be reviewed at least biennially.

5 TECHNICAL REQUIREMENTS

5.1 SPECIFIC SCOPE FOR DESIGN AND CONSTRUCTION PROJECTS

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 an experienced and suitably qualified electrical engineer covered by professional indemnity and public liability insurances. Insured Values must be in accordance with the contract;
b. Provision of formal Engineering Certification for the design in accordance with the PCA requirements, and an Engineering certificate of inspection and completion of the works in accordance with the University standards and statutory requirements;
c. Include “Safety in Design” requirements for installation, operation, maintenance and eventual decommissioning of the works;
d. Maintain reliability and availability of electrical systems of buildings during and after construction. Provide temporary power systems as required to meet the affected user’s requirements, and liaise with the users and project manager to determine these requirements;
e. Warranty requirements for all new equipment and services;
f. Maintenance requirements during the Defects Liability period;
g. Compliance with NCC including Section J, Local Authorities’ regulations and all relevant Australian and New Zealand Standards (AS/NZS);
h. Allow for any University work embargo and restriction periods during the construction period;
i. Provision of electrical maximum demand calculations in editable spreadsheet format, and to satisfy the Supply Authority and to AS/NZS 3000 as a minimum including 20% spare capacity;
j. Application for connection for new and increased loads to the Supply Authority;
k. Supply of statutory design certifications and certification of compliance to the University standards;

l. Building Code of Australia Section J6 compliance calculations and certifications for energy consumption minimisation;
m. Annual electrical energy consumption estimate based on building space types, occupancy and operation of planned plant and equipment;
n. Power system calculations for the whole system in POWERCAD, or approved equal software, covering fault levels, voltage drop, cable sizing and circuit breaker discrimination;
o. Supply of all calculations in electronic native software editable file and PDF output format;
p. Design drawings in AutoCad (and Revit 3D model where defined in the project brief) format including plans, schematics and single line diagrams;
q. Testing and commissioning schedules and program;
r. Contractors must visit project sites to determine constraints and risks when installing electrical services at the University's buildings and include sufficient allowances in the tender price to cover these issues;
s. Ensure that spatial and building general construction details are satisfactory and equipment can physically be installed within the building;
t. Additional work items identified during tender inspections, but which may not be documented in the original scope of works;
u. 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;
v. Decommissioning and demolition of all redundant electrical services and infrastructure in the works area. Remove any hazardous materials in accordance with the CIS Resource Recovery and Waste Management Standard.
w. Provide a detailed project description including the project drivers, the existing conditions and the final project use;
x. 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.

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. Sub-main 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. Lighting control schematics/methodology and control zone plans;

l. Lighting system suspension details;
m. Generator connection cubicle details;
n. Lightning protection plans;
o. Earthing and bonding plans/details;
p. EMI surveys and mitigation measures.

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.
If the project is a large new building, the As-Built drawings must be completed in 3D Revit. Each As-Built 3D Revit model must be modified to suit the on-site installation by the contractor.

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 or minimum 6 monthly;
b. Thermo-graphic inspections of switchboards;
c. Fault rectification and replacement of faulty materials, equipment and accessories with new;
d. Prompt emergency response when required.

At the end of the Maintenance Period, contractors must make a final service visit to certify the installation is operating correctly. CIS staff to sign off on all site maintenance documents for all site visits.

5.5 OPERATION AND MAINTENANCE MANUALS

Provide electronic online O&M manuals using the University OMTRACK system plus a CD softcopy after the OMTRACK version has been approved and provide one hardcover loose leaf copy. 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. Project Description;
b. Engineering Design Certification and Installation Certificates;
c. Contacts list including all major system suppliers and sub-contractors;
d. Safe working procedures for operating and isolating the installation;
e. Operation and maintenance information for the satisfactory long-term operation and maintenance of the electrical services including frequency of maintenance;

f. Maintenance procedures, recommended maintenance periods and procedures;
g. Tools, particulars of maintenance equipment and tools provided, with instructions for their use;
h. Copies of single line diagrams / schematic diagrams for the installation / system;
i. A technical description of the equipment supplied, with diagrams and illustrations where appropriate;
j. Procedures for dismantling and re-assembling equipment;
k. As-Built drawings including A1 laminated single line diagrams to be installed in Regional or Main Switchrooms;
l. List of the spare parts provided.

5.5.2 EQUIPMENT DESCRIPTIONS

Equipment descriptions must include:

a. Schedules of 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, and items subject to wear or deterioration and which involve extended deliveries when replacements are required;
e. Special precautions or residual risks that must be managed during operation or maintenance.

5.5.4 EQUIPMENT CERTIFICATES

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

a. Copies of Manufacturer's warranty;
b. Certification from supply authority;
c. 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 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 to 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:

Description	Lettering Size / Height & Colour	Type for Indoor Location	Type For Outdoor / Exposed Location
Equipment name plate	40mm -	Engraved two-colour laminated plastic fixed with adhesive and plastic pins or metal screws. Black lettering on white plate	Engraved stainless steel or brass fixed with adhesive and four metal screws or pins
Cable marker plate	8mm		
Warning notices	8 – 12mmmm		
Automatic control & electrical equipment	5mm – 10mm		
Isolating switch / valve	5mm – 10mm		
Inside panels	3.5mm – 5mm	Self-Adhesive machine type written. Black lettering on white plate	
Cable pits	40mm	NA	Engraved brass fixed with adhesive and four metal screws or pins

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. Embossed or printed 'Dymo' type labels are not acceptable.

5.7.1 ASSET LABELLING AND BAR CODING

Equipment must be provided with asset labels and bar codes as per CIS Asset Identification and Labelling Standard.

5.8 FIRE RATED SEALING OF PENETRATIONS AND CUTTINGS

Sealing of all penetrations must comply with NCC requirements for fire resistance. Also refer to **CIS Essential Fire Safety Measures Standard.**

Biomedical Hazard – PC3 Laboratory - sealing of penetrations in PC3 labs must be completed including cables through walls.

5.9 ACCESSORIES

Requirements for general outlet switches and sockets are provided below.

5.9.1 ACCESSORIES TYPE

Accessory outlet plates must be Clipsal 2000 series or approved equal. They must have adequate flat, non-removable faceplate area to accommodate identification labels.
Flat stainless steel type plates may be used for special areas.

5.9.2 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, 15 A, for mains current switches;
c. COLOUR: Standard manufacturers range. White, cream, black, stainless steel;
d. LABELING: Use engraved traffolyte labels fixed with double sided adhesive tape 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;
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.

5.9.3 ISOLATING SWITCHES

Provide easily accessible local isolating switches for all electrically operated equipment within the immediate vicinity. Isolators must be located within 3m of the equipment. Note: All power sources must be isolated prior to working on the equipment via the Isolator switch.

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

5.9.4 GENERAL POWER SOCKET OUTLETS

Provide power outlets in accordance with the project room data sheets. These are the minimum number of General power outlets (GPO) for specific spaces:

a. Office desk position – 2 double GPOs person, allow density of 1 person per 8m2;
b. Lecture theatre seats – 1 double GPO every third seat divider;
c. Plantrooms – 1 GPO, 10A IP56;

d. Toilet – 1 GPO;
e. Corridors – 1 GPO per 10 metres length;
f. Lobbies / Foyers – 1 GPO per 100m2;
g. Electrical cupboards – 1 GPO per cupboard;
h. Comms rooms – double GPO on wall and 15 A circuits (Refer to the ICT Communications Cabling Standard for quantities);
i. Computer laboratories – 1 double GPO per seat;
j. Seminar rooms – 1 double GPO per 3 lm of wall;
k. Laboratories – requirement must be provided in user brief which must consider greater demand from anticipated plant and equipment use;
l. Cooling Towers – 1 GPO, IP65.

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 engraved traffolyte labels fixed with double sided adhesive tape 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.

Cleaners GPOs must incorporate specific labelling either cast during manufacture or as part of the circuit identification label.

Use the University standard circuit labelling designations provided in the switchboard section of this specification and also label all soft wiring socket outlets.

5.9.5 SOFT WIRING SYSTEMS

Use only 20A rated soft wiring systems. Soft wiring systems must be compatible with the project workstation system, and comply with WHS 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.

5.9.6 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 under floor or overhead in accordance with ICT Communications Cabling Standard.

5.9.7 EMERGENCY POWER OFF

Emergency Power Off must use shunt trip circuit breakers and the location of the Emergency Power Off button must be 400mm clear of any other switches, controls or obstructions with a clear label stating how to get it reset by an electrician at the associated DB. The Emergency Power Off button must be co-ordinate with any Emergency Gas shutoff button. The button colours and labelling must be co-ordinated with the Architect.

5.9.8 ACCESSORY MOUNTING HEIGHTS

Except where mounting heights are self-evident e.g. skirting ducts, workstation situations, 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
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.	Socket-outlets n laboratories	>300mm above floor level
f.	Distribution Boards	2200mm to the topmost part of the board
g.	Telephone, MATV, Voice/Data outlets etc.	200mm to the centre line of the box
h.	Socket-outlets and light switches in disabled toilet	In accordance with the Disabled Persons Code
i.	Hazardous Areas – Labs	The zone 300mm above the floor where water or gas are used in any lab is a prohibited area for mounting socket outlets

5.10 WIRING SYSTEMS

5.10.1 SELECTION

Conceal wiring runs within the building fabric or accessible spaces, except within plant rooms, where the wiring may be run in surface conduits in accordance with the conduit section of this standard.

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. GENERAL SERVICES PLANTROOMS: Unsheathed cable in heavy duty UPVC conduit fixed with double saddles;
e. LOADING DOCK, GARBAGE ROOM, CARPARK, GAS STORAGE AND THE LIKE: Galvanized steel conduit fixed with double saddles;
f. PLASTERED OR RENDERED SURFACES: Cable in UPVC conduit;
g. STUD WALLS WITHOUT BULK INSULATION: Thermoplastic insulated and sheathed cables.

5.10.2 CABLE CALCULATIONS

Provide cable calculations using 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 loop impedance;
f. Fault current at the load end.

5.10.3 VOLTAGE DROP

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

g. Total maximum - 5%, or 7% with an in-building substation;
a. Consumer Mains - 0.5%, or 0.75% with an in-building substation;
b. General Sub-mains - 2.5%;
c. Sub-mains to Mechanical Services MCCs – 2%
d. Final Sub-circuits - 2.5%.

Note that lighting and general power sub-circuits are typically limited to 10A maximum demand by RCD limitations.

5.10.4 CABLE MATERIAL AND MINIMUM SIZES

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

a. 1.5mm2 for lighting sub-circuits;
b. 2.5mm2 for power sub-circuits;
c. 63A / 10mm2 for sub-mains.

5.10.5 REDUNDANT EQUIPMENT

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. Strip and bond together all redundant cable ends left in place. Insulate and label both ends with permanent tags.

5.10.6 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. Use proprietary IP rated cable joint kits and 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 throughout the installation. For cabling routes not specified in detail, submit a proposed route layout on a workshop drawing;
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 the ceiling suspension system or laid on ceiling tiles or on gyprock ceilings;
f. Use special dedicated fixings for cables attached under thermal insulation under concrete slabs. Do not attach to the insulation fixings.
g. Run all conductors associated with two-way lighting switching wires together (i.e. run switch wire from the light fitting to the first switch and then run three conductors from this switch to the second switch). Throughout the installation, keep the live, switch and neutral conductors together to avoid EMI;
h. Support all cables at a maximum of 1200mm spacing with minimum sag;
i. All installations must be neat and tidy in appearance and installed parallel and/or perpendicular to building elements;
j. CABLE COLOUR: Use Australian Standard colours for active conductors, white for switch wires, and Purple for Technical Earth.

5.10.7 FIRE RATED CABLE SYSTEMS INSTALLATION

Provide fire, mechanical and water spray protection to WS52W classification in accordance with AS/NZS 3013.

CSIRO or NATA tested complete cable support system must be used. A cable or support system manufacturer's published complying support system may be used.

As a minimum, heavy duty cable ladder with double uni-strut supports and metallic fixings and 12mm diameter 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.

5.10.8 COPPER CONDUCTOR TERMINATIONS

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

5.10.9 ULTRA FLEXIBLE COPPER CONDUCTOR TERMINATIONS

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

5.11 UNDERGROUND SERVICES

5.11.1 CONDUITS

Use HD PVC conduits for all underground cable runs.

Provide minimum 25% spare capacity, and one whole spare conduit minimum for sub-mains runs.

5.11.2 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 CIS Excavation Standard;
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.

5.11.3 CABLE PITS

NOTE – Communications pits must be constructed of reinforced cast in situ concrete to ICT Communications Cabling Standard by an ICT approved Telstra certified pit builder.
Construction of electrical 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. Comply with the University labelling and marking standards;
f. PIT COVERS:
    iv. Cover type: In trafficable areas provide GATIC brand heavy duty cast iron lid with concrete infill fitted to heavy duty trafficable pits or approved equal;
    v. General: Provide pit covers to suit expected loads. Fit flush with the top of the pit;
    vi. Maximum Weight: In accordance with WH&S regulations for any section of the cover;
    vii. 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 drainage pit. Provide a connection to stormwater system or a dedicated drainage pit filled with rubble, graded away from each cable pit for 2000mm.

5.11.4 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;
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.

5.12 CONDUITS AND CABLE SUPPORTS

5.12.1 CONDUITS GENERALLY

Generally, conduits must be fixed and supported as follows:

a. TYPES – refer to the Cabling Section of this document;
b. FIXINGS: Provide two fixings per conduit saddle;
c. SUPPORT: Unless otherwise specified, fix conduit saddles at a maximum of 800mm intervals in horizontal runs and 1200mm intervals in vertical runs.
d. PROTECTION IN ACCESSIBLE OR TRAFFICABLE SPACE: Protect PVC conduits installed in all accessible spaces from damage or use galvanized steel conduit;
e. DRAW CORDS: Provide draw cords in conduits not in use. Leave 1m of cord coiled at each end of the run;
f. DRAW-IN BOXES: Provide draw-in boxes at suitable intervals not exceeding 20m in straight runs.

5.12.2 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.

5.12.3 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 restrained 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. 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: Use galvanized steel conduit in areas subject to mechanical damage where HD PVC conduit is permitted, provide mechanical protection to UPVC conduit for a height of not less than 3m above ground or platform level.

5.12.4 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 for final connection to equipment and plant subjected to vibration, or where necessary for adjustment or ease of maintenance. Do not use flexible conduits in place of set or glued bends in exposed conduit installation;
c. TYPE: Use zinc plated steel flexible conduit with associated fittings for areas requiring steel conduit.

5.12.5 GALVANISED STEEL WATER PIPE

Galvanised 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;
c. STEEL CONDUIT: must be electrically continuous.

5.12.6 SKIRTING WIRING DUCT

Skirting wiring ducts must satisfy these requirements:

a. TYPE: Use only extruded multichannel aluminium duct with drop-in 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.

5.12.7 CABLE SUPPORT SYSTEM

Cable support systems must meet these requirements:

a. TYPE: Provide ladder tray equal to Uni-strut type ST5 or Ezy-strut type ET5;
b. 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;
c. CABLE LADDER:
    viii. TYPE: Provide minimum NEMA 2 rated ladder;
    i. FINISH: Zinc plated for internal dry spaces, and hot dip galvanized for damp or external locations;
    ii. SMALL CABLE: Provide additional continuous support for single cables less cables less than 13mm outside diameter;
    iii. BEND RADIUS: Bends must have a minimum inside radius of not less than twelve times the outside diameter of the largest diameter cable carried;
    iv. SPARE CAPACITY: Provide spare space for not less than 20% more cables or conduits than initially required to be installed, and all future design capacity;
    v. ACCESS: Position the 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;
    vi. 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 fit out installations where the installation of new cable trays is deemed impractical. Use high tensile multi-stranded galvanised steel cable with proprietary fixings and proprietary compression crimped rigging fittings. Provide cable tension adjustment.
Use only where structurally sound fixing into solid concrete masonry is achieved with chemical anchors. Provide load calculations and do not load beyond 70% of rating.
Install a maximum of 1 sub-main or ten TPS sub-circuit cables on any one centenary.

5.12.8 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.
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;
    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;

v. Threaded Rods: Minimum 12mm diameter.

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, trays, ladders and support systems exposed to the weather or installed in damp locations;

ii. Paint System: Paint conduits and support systems as follows:

i. Indoor locations: A system using FULL GLOSS, WATER-BORNE, OR Powder coating with zinc rich undercoat;

ii. Outdoor locations: A system not inferior to FULL GLOSS, SOLVENT-BORNE: EXTERIOR - PAINTING OR Powder coating with over hot dip galvanising;

iii. 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.

5.13 SWITCHBOARDS

This section applies to all Regional Main Switchboards (RMSB), building Main Switchboards (MSB), Main Distribution Boards (MDB) and all Distribution Boards (DB). It also applies to Mechanical Services Switchboards (MCC) rated equal or more than 400A sub-main input, as referenced in the Mechanical Services standard.

Regional Main Switchboard is defined as a large Main Switchboard supplying two or more buildings, rating equal or above 800A and fed from a substation. Note: All RMSB designs are to be signed off by the CIS Electrical Engineer prior to construction.

Building Main Switchboard is defined as a large indoor MSB which distributes electricity supply to multiple DBs within the building.

Main Distribution Board is defined as a large indoor switchboard connecting between MSB and DBs.

Distribution Board is defined as a switchboard that distributes electricity to final sub-circuits or loads.

5.13.1 SWITCHBOARD ROOMS AND LOCATIONS

All new RMSB and MSB must be enclosed in a 2-hour fire-rated electrical switch room fitted with a University Bi-lock and WHS compliant warning signs. All RMSB & MSB switchrooms must have two egress doors spaced apart and minimum 1m wide egress pathway between the doorways, irrespective of AS/NZS 3000 service clearance requirements, and including all miscellaneous panels, meter cabinets or other obstructions. Provide fan assisted ventilation from outside of the building fitted with fire dampers. Mechanical AC cooling systems may only be used with approval of the University Mechanical Engineer.

The electrical switch room or cupboards must not be located in a restricted location to comply with AS/NZS 3000 including in wet areas, near water containers/ showers, automatic fire sprinklers, fire hose reels, hosing down areas, under roof storm water box gutter/ water pipes, in kitchen, hazardous areas, in/ under fire isolated stairs, in public corridors, above-ground platforms or in communications rooms.

Distribution Switchboards must be located within a locked smoke sealed cupboard fitted with University Bi-lock and WHS compliant warning signs. Dedicated clear space not obstructing any cable or service

access must be allocated for C-Bus control panels within the cupboard workshop drawing, or alternatively integrated into a dedicated switchboard compartment.

Distribution boards may be located in open plantrooms without a cupboard but must be fitted with University Bi-lock, and C-Bus or other controls must be integrated into the Distribution Board chassis in a separated compartment.

Distribution Boards must not serve more than one floor. Only in certain circumstances may this be permitted, and this must be approved by the issuer of this standard.

5.13.2 MANUFACTURERS

Switchboard manufacturers are provided in the **CIS Deemed-to-comply Switchboard Manufacturers Form (CIS-ENG-F004)** for Type 1 - 5 switchboards. Alternative manufacturers may only be submitted at tender time and with prior approval of the CIS Electrical Services Engineer.
Alternative manufacturers not shown on the **CIS Deemed-to-comply Switchboard Manufacturers Form (CIS-ENG-F004)** must submit a typical switchboard workshop drawings (clause 5.17), switchboard Type test report/ certificates, switchgear test certificates / technical information, quality assurance documents, warranty certificates, company profiles (includes financial report, past completed projects, personal and industry experience) and other requested technical documents to CIS Electrical Services Engineer for approval prior to tendering for the works. Non-compliant switchboard installations will be rejected by CIS and the Contractor must replace the non-compliant switchboard with a new Deemed-to-Comply switchboard.

5.13.3 ELECTRICAL PROTECTION GRADING STUDY CALCULATIONS

The Electrical Consulting Engineers and Contractors must supply and install an electrical infrastructure and power supply system with automatic circuit breakers and protective devices that fully grades during overcurrent, short circuit situations and discriminates during fault conditions.

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

The short-circuit protective devices must be provided to protect the entire electrical installation, personal and live stocks from damage under all fault conditions. The Electrical Consulting Engineers and Contractors must demonstrate and provide evident that the electrical installation achieved the grading fault protection (cascade protection) and discrimination for each protective device.

Co-ordinate the discrimination design with all other trade sub-contractors. Cross reference requirements of the cable section and the circuit breaker fault rating. Provide automatic Moulded Case Circuit Breakers (MCCB) and Miniature Circuit Breakers (MCB) for grading short-circuit protection. The Electrical Consulting Engineers must provide short-circuit and overcurrent calculations using electrical design software, e.g. POWERCAD or equal proprietary software. Submit to CIS Electrical Services Engineer the calculation printouts in PDF documents showing:

a. System grading for each level of the electrical installation from Substation, Point of Attachment, Main Switchboard, Main Distribution Boards, to final Distribution Boards or major loads;
b. MCCB/ MCB time/ current co-ordination curves;
c. Fault level calculations for each level;
d. Protective device selection includes type, trip unit and setting;
e. Cable selection includes sizing, current carrying capacity and the method of cable installation;
f. Cable voltage drop at rated maximum demand load;

g. Maximum cable length;
h. Earth fault loop impedance or Earth Fault Return;
i. Low Voltage Distribution Network modelling and single line diagram.

5.13.4 MAIN SWITCHBOARD DESIGN

Design of switchboards must satisfy these requirements:

a. CONSTRUCTION: Provide Type Tested Assemblies which are identifiable with respective current Type Test Certificates. Provide fully welded custom fabricated construction. Modular construction switchboards are not preferred and non-compliant switchboards will cause costly project delays.
b. LAYOUT: Position the switchboard and equipment to provide safe and easy access for operation and maintenance as per AS/NZ 3000. 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 – MSB feed under 800A – Form 3B, MSB feed over 800A – Form 4B.
f. TYPE ih SEGREGATION LIMITATION: type ih (insulation & housing) segregation must not be used except a small distribution chassis rated less than 400A may be permitted as a fully metallic segregated compartment contained within a Form 3 or 4 switchboard fed with a Form 3 segregated protection device, to written approval by CIS Electrical Engineer;
g. DEGREE OF PROTECTION: Minimum IP42 for indoor (see separate Outdoor Switchboard section);
h. SPARE CIRCUIT SPACES:
    i. Provide minimum 25% spare sub-main circuit capacity (or minimum two spaces) 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 submission 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 makes periodic maintenance easy and as much of the main switchboard equipment, busbars, connections, terminations etc. can be scanned by infra-red imaging equipment.

5.13.5 SWITCHBOARD SHOP DRAWINGS

Prior to ordering equipment or commencing manufacture, switchboard shop drawings must be submitted and approved showing:

a. Types, model numbers, dimensions and ratings of assemblies;
b. Component details, utility metering compartment, Service Protective Device (SPD), busbar assembly, metering, electrical switchgears, 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 with-drawable 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. Hinged doors, hinged escutcheons, and 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, cable glands, gaskets 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 assembles, 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, form of separation and details of shrouding of terminals;
t. Labels and engraving schedules.

5.13.6 SWITCHBOARD INSPECTION

Switchboard inspections must be conducted at the following stages:

a. Factory Inspection and Tests - Fabrication and painting completed, busbars and functional units assembled;
b. On-site commissioning Tests – switchboard installation completed, sub-mains connected and ready to be energised;
c. ATS and MTS generator and supply operation;
d. AUMS metering function and connection to the University data network.

5.13.7 PRE-COMPLETION TESTS

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

a. 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; In accordance with the current Australian switchboard standard;
   iii. Functional testing: Operate mechanical devices, relays, programmable logic controllers and logic controls, protection, interlocking and alarm equipment;
   iv. Protection relays: Primary current injection tests or, if approved, secondary current injection tests, to verify time/current characteristics and settings;
   v. Carry out secondary current injunction tests on adjustable trip circuit breakers after installation and before energisation, to verify time/current characteristics and settings;
   vi. Record verification of the CB trip settings on the Single line diagram.

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

5.13.8 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;
   x. Access details;
   xi. Schedule of labels.

5.13.9 SWITCHBOARD METALWORK

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.

5.13.10 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. GLAND PLATES: Provide removable aluminium gland plates fitted with cable glands and gaskets to maintain the degree of protection;
c. CABLE GLANDS: Provide a suitable nylon cable gland for every cable has an outer diameter of over 20mm;
d. BUILDING MANAGEMENT CONTROL SYSTEM (BMCS) and LIGHTING CONTROL SYSTEM TERMINAL ZONE (AUMS): 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.

5.13.11 SWITCHBOARD DOORS

Switchboard doors must meet these requirements:

a. MAXIMUM WIDTH: 800mm;
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 90o at the same time;
e. HANGING: Provide corrosion-resistant pintle hinges or integrally constructed hinges to support doors. For removable doors, provide staggered pin lengths to achieve progressive engagement as doors are fitted. Provide 3 hinges for doors higher than 1m. Provide restraining devices and opposed hinges for non-lift-off doors;
f. DOOR INTERLOCKING OVERRIDE: Provide a tool override for any interlocked switch actuator to permit the door to be opened on load for thermographic testing;
g. DOOR HARDWARE: Provide the following;
    i. 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;
    ii. 'T' handles with provision for key locking cylinder;
    iii. Captive, corrosion-resistant knurled thump screws;
    iv. 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 if installed outside the electrical switchroom or cupboard;
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. SMOKE and 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.

5.13.12 ESCUTCHEON PLATES

All compartments containing mains voltage protection devices must be fitted with escutcheon plates that prevent contact with live parts when the cover or door is open. 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 support frame for the fixing of each escutcheon plate, including additional support where necessary to prevent panel distortion;
c. HANGING: Provide corrosion-resistant hinges to support escutcheon plates. Provide 3 hinges for escutcheon plates higher than 1m;
d. FIXING: Fix each plate to the frame with minimum two metal fixings held captive in the plate and spaced uniformly;
e. MAXIMUM HEIGHT: 1200mm;
f. HANGING: Hang escutcheon plates on hinges which allow opening through a minimum of 90o and permit the removal of the escutcheon when in the open position.

5.13.13 FINISHES

Finishes must satisfy these requirements:

g. 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;
h. PAINT: Two pack solvent paint or Powder coat;
i. Colours:
    i. Indoor assemblies: generally powder coat Orange X15, Light Grey N42 or other approved colour to University's requirements;
    ii. Removable equipment panels: White;
    iii. Assembly interior: White.

5.14 CONDUCTORS

5.14.1 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 and 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. Cleaning: ensure busbar joint surfaces are flat, bright and chemically clean;
    v. Bolt Torque Witness: Mark all bolts and nuts with indelible pen across the fastener and adjacent metal when tightened to confirm 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. Do not use adhesive or tape colour bands;
    iii. Do NOT cover bolted busbar joints.
g. 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;
    iv. Heat shrink material: Use only on rounded edge busbars;
    v. DO NOT apply tape or heat shrink to busbar joints to permit inspection.
h. 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;
i. 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 withstands current for 100% of the time duration.
j. 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.

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

5.14.2 WIRING

Wiring must satisfy these requirements:

a. CABLE TYPE: Provide PVC insulated 0.6 kV V-75 multi stranded copper conductor cables for general internal wiring, and V-90 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 Standard AS/NZS3000 and other relevant 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 crimped 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,
   iv. Spare Terminal Space: Provide sufficient space on mounting rails for 25% future outgoing circuits possible in any cabling compartment;
   v. Wiring Identification: Identify power and control cables at both ends using neat fitting ring type ferrules agreeing with record circuit diagrams.

5.15 DISTRIBUTION SWITCHBOARDS (UNIVERSITY STANDARD DB)

5.15.1 UNIVERSITY STANDARD DISTRIBUTION BOARD DESIGN INTENT

Standard switchboards must be used for University "RCD and Switchboard Replacement program" and ongoing University Capital Works projects for consistency of quality and ease of maintenance. The switchboards must be manufactured by Deemed-to-comply suppliers, type tested, fully compliant with CIS Electrical Standards and available through using of the shelf standard materials in order to reduce manufacture time.

Switchboard features must include:

a. High quality, future-proof uniform modular design;
b. Uniform compartment sizes, configuration and equipment locations;
c. Spacious uncramped cable zones and equipment space;

d. Reliable design with capacity for future electrical demand;
e. Includes all the CIS electrical safety, AUMS, lighting control, sustainability initiatives and requirements.

5.15.2 MINIMUM CONFIGURATION & CONSTRUCTION

For the reasons of safety, easy maintenance, and quality controls for projects with short project delivery time during University term breaks, The University of Sydney has adopted a range of standardised Distribution Boards. The following University Standard DB minimum configuration requirements must be met:

a. MINIMUM SIZE and CONFIGURATION:
    i. Minimum configuration of dual chassis;
    ii. 18 poles for lighting and 48 poles for power sections in a Type 1 DB;
    iii. 24 poles for lighting and 84 poles for power sections in a Type 2 DB;
    iv. 60 poles for lighting and 180 poles for power sections in a Types 3 and 3A DB;
    v. Two-off 60 poles for power sections in a Type 4 DB;
b. DISTRIBUTION BOARD CONSTRUCTION DETAILS:
    i. Comply with switchboard section of this standard clauses 5.15 and 5.16 requirements, e.g. switchboard metalwork, doors, escutcheon plates, cable entries, finishes, conductors, busbars and wiring;
    ii. Wall mounted front connected, totally enclosed type;
    iii. Be constructed of folded and welded sheet steel with a powder coat finish;
    iv. Utilise standard manufacturer's encapsulated insulated copper busbar chassis mounted vertically on a separate backing plate. Do not provide soft wired power distribution systems;
    v. Allow for interchangeability of single and multiple pole breakers without alteration to busbar connection or breaker mounting fixtures;
    vi. Have all equipment including the chassis backing plate accessible and removable from the front without dismounting the switchboard from its position;
    vii. Use din rail beside main switch for ancillaries, potential fuse and transducers in the metering section;
    viii. Fit University Bi-locks either in an electrical cupboard door, or in the switchboard doors if the DB is not located in a dedicated electrical cupboard;
    ix. Provide 18mm wide single-pole din-rail mounted 6kA miniature circuit breakers in proprietary insulated 250A 3 phase busbar chassis;
    x. Din-type single pole space RCBO circuit breakers - Minimum 16A for lighting and 20A for power circuits;
    xi. 250A Main switch;
    xii. Provide Multi-function energy metering in accordance with the metering section of this standard and the AUMS standard for sub-main and lighting sections complete with transducers having a Modbus interface. Mount on the din-rail in the metering section;
c. 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;
    iii. 5% spare circuit breakers installed for DBs;
    iv. Schedule card holder fixed inside the door with screws and a clear cover with a University Standard MS Excel spreadsheet schedule. Provide a separate schedule for lighting and power sections. Provide soft copy of the schedule in the manuals;
    v. Provide a hinged removable escutcheon panel that conceals all live parts.

5.15.3 STANDARD DISTRIBUTION BOARD DESIGN

a. **Type 1 DB** –
Application: small general areas (<200 sqm) lighting and power systems.
Features: 48 pole power and 18 pole lighting chassis.
Separate main switches and separate AUMS meters located on din-rails at the top of the DB. 250 A circuit breaker feed. Separate C-BUS controls compartment accessible without turning off the whole DB.

b. **Type 2 DB** –
Application: general purpose lighting and power switchboard (most commonly use), **Features**: 84 pole power and 24 pole lighting chassis.
Separate main switches and separate AUMS meters located on din-rails at the top of the DB. 250A circuit breaker feed. 3-off spare 125A frame unmetered CB spaces for separate supply to major loads or sub DBs exceeding 63A.

c. **Type 3 DB** –
Application: general purpose lighting and power switchboard (large DBs), 180 power and 60 lighting circuits)
Features: 180 pole power and 60 pole lighting chassis.
250A circuit breaker for electrical protection downstream up to 25kA fault level, separate lighting and power busbar chassis (both lighting and power sections can be switch-off for urgent maintenance), 2-off spare for separate supply to major mechanical, DB, ICT and hydraulic switchboards, separate meter/ lighting control / contactor section (to be assessed by other tradesmen), meter for lighting, power sections and other switchboards (total DB power consumption measured at the MSB/MDB).

d. **Type 3A DB** –
Application: for general purpose lighting and power switchboard (Laboratory DB, 180 power and 60 lighting circuits)
Features: 180 pole power and 60 pole lighting chassis.
250A circuit breaker for electrical protection downstream up to 25kA fault level, separate laboratory power and lighting busbar chassis (both lighting and each laboratory power sections can be switch-off for safety in laboratory and for urgent maintenance without affect other laboratories), 1-off spare for separate supply to major mechanical, DB, ICT or hydraulic switchboard, separate meter/ lighting control / contactor section (to be assessed by other tradesmen), meter for lighting, power sections and other switchboards (total DB power consumption measured at the MSB/MDB).

e. **Type 4 DB** –
Application: modular DB design for future bolt-on extension, add to existing University standard lighting and power switchboard (additional 2x60 circuits)
Features: two separate 60-pole power or lighting busbar chassis, easy for future bolt-on to existing University standard DB.

f. **Type 5 MDB** –
Application: Main Distribution Board (MDB) for connecting between Main switchboard and lighting and power DB (supply 10 lighting & power DB, mechanical or hydraulic switchboards)
Features: 400A circuit breaker (maximum to 630A) for electrical power distribution and protection downstream DB, 10-off MCCB circuit breakers for separate supply to lighting & power DB, major Mechanical, ICT and hydraulic switchboards, separate meter for each of the outgoing sub-main. The use of MDB is to decentralise and zone the electricity power distribution in buildings. The size of Main Switchboard will be reduced and best suit many existing buildings in the University with physical limitations. The MDB switchboard construction requirement is a Form 2 construction instead

of Form 3 or 4 for MSB. The MDB switchboard is smaller in physical size and reduces construction requirements compared with the MSB.

Refer to **Attachment 1** - University Standard Switchboard drawings for details.

5.15.4 SUB-CIRCUIT LOADING

The following requirements for maximum sub-circuit loading must be complied with:

a. 16A Lighting sub-circuits must have a maximum initial lighting connected load of 15 luminaires of any type up to maximum 10A load, allowing a spare capacity of 5 additional luminaires within the RCD trip tolerance with spurious device leakage current;
b. 20A Power sub-circuits must have a maximum 5-off double socket outlets or 10-off single socket outlets initial connected load or maximum connected load of 16A for air-conditioned spaces. Typically a maximum cluster of 6-off workstation positions or 4-off hard wired offices with wall outlets may be connected to one circuit.
c. 20A Power sub-circuits must have a maximum 4-off double socket outlets or 8-off single socket outlets initial connected load or maximum connected load of 16A for non-air-conditioned spaces.

5.15.5 NON-RCD SUB-CIRCUITS

The following non-RCD sub-circuit requirements must be complied with:

a. NON RCD SUB-CIRCUITS: Provide correctly labelled dedicated non-RCD protected sub-circuits to the following load groups:
    i. UPS powered equipment using red coloured socket outlets labelled 'UPS Power – No RCD Protection)';
    ii. Socket outlets rated equal of more than 20A;
    iii. Permanent connected equipment and control panels with supply rating over 20A per phase;
    iv. Permanent connected Fire alarm and protection equipment.

5.15.6 DISTRIBUTION BOARD NAME AND DESIGNATION LABELS

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

All new switchboard identification numbers must be obtained from the University through a formal Request for Information.

Generally, name and designation labels must be as follows:

a. 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;
b. 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;
c. Mechanical boards must be labelled as above, followed by the words 'Mechanical Services Board';
d. All switchboards must have a separate label identifying the building number and name where it is located e.g. G12 Services Building;

e. All switchboards must be labelled with the origin of supply e.g. Supplied from G12 MSBA;
f. All outgoing sub-circuits must be labelled 'DBxx-yy' where xx is the DB number, and yy is the circuit breaker number.

5.16 EXTERNAL SWITCHBOARDS

All RMSB, MSB, MDB, DBs and switchboards must be installed within a fire rated electrical switch room or cupboard in building with roof covering.

The safety risk of operating on an outdoor external switchboard under wet weather and dark environment is not acceptable.

5.17 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.

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/NZS and a specialist specification must be prepared covering:

a. Location (external canopy or generator plantroom);
b. Fuel storage;
c. Noise control;
d. Exhaust flue placement;
e. Ventilation grilles and acoustic attenuation;
f. Vibration control;
g. Controls and BMCS monitoring;
h. Alarms connected to BMCS or Security Cardax System;
i. Cabling.

If a building RMSB or MSB does contain an ATS, then the ATS logic procedure must be laminated and hung on the wall for reference to the maintenance contractor.

5.17.1 GENERATOR CONNECTION PROVISIONS

Switchboard generator connections must satisfy these requirements:

a. REQUIREMENT: Provide a generator connection terminal box and manual changeover switch for every Main Switchboard and as required in Regional Main Switchboards;
b. Incorporate a manual changeover switch into all new Main Switchboards. Provide a remote generator connection terminal box and fire rated sub-main between the MSB and generator connection box which must be 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 as shown on the University Standard Generator Connection Box;
e. RATING: To match the main switch capacity of the associated Main Switchboard;

f. LABELLING: The external generator cubicle will have a schematic within the cubicle to describe the function for connecting a temporary generator. The cubicle will also be labelled to describe what switchboard it supplies;

5.17.2 UPS OR GENERATOR BACKED DISTRIBUTION BOARDS

All distribution boards that are either UPS or generator backed must be labelled to identify mains and UPS / Generator supplies for isolation purposes.

5.18 SWITCHGEAR AND CONTROL GEAR

5.18.1 SWITCHGEAR

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

5.18.2 MOULDED CASE AND MINIATURE CIRCUIT BREAKERS

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

a. 10A-100A Din-mounted 27mm module Miniature Circuit Breakers (MCB);
b. 10-63A Din-mounted MCB with integral RCD protection within a single pole space (RCBO);
c. 100A –1600A Moulded Case Circuit Breakers (MCCB);
d. >1600A Withdrawable Air Circuit Breakers (ACB).

The Deemed-to-Comply circuit breakers are:

a. Schneider - Multi 9, Compact NS and Masterpact NT systems;
b. NHP – Din-T, Terasaki TemBreak systems.

Provide circuit breakers which are all of the same manufacture as above and match the brand installed in any existing installation.

5.18.3 TRANSIENT PROTECTION

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

Main Switchboards:

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 arrestor status;
f. Remote Monitoring: For Regional Main Switchboards, building Main Switchboards and main distribution boards provide transient protection units complete with volt-free contacts, in order to allow provision for remote monitoring of the status of the unit components;
g. Short-circuit protective devices and isolators: Back-up each arrestor active supply with a live side totally enclosed fault current limiting fuse in accordance with the manufacturer's nominated rating. Provide a multi-pole automatic miniature circuit breaker on load side of fuses as an arrestor isolator;
h. Locate Regional Main Switchboard, Main Switchboards and Main Distribution Boards surge diverters in segregated metal compartments within the switchboard with a clear polycarbonate inspection window;
i. Surge Arrestor Enclosures: Totally ventilated sheet metal wall boxes with hinged covers, mounted within the switchboards.

Distribution Boards:

a. Provide Metal Oxide Varister (MOV) transient protection devices in all switchboards in accordance with the relevant AS/NZS;
b. Protection Level must be consistent with the prospective surge current at the incoming supply, graded between upstream and downstream switchboards or systems;
c. Provide visual illuminated indication of correct operation, and fail alarm monitoring; and
d. Provide terminals for connection to the AUMS system.

5.18.4 CONTROL RELAYS

Control relays must satisfy the following requirements:

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

5.18.5 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.

5.19 ACCESSORIES AND INSTRUMENTS

5.19.1 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 CTs may be specified at Class 1 accuracy;
c. ACCURACY: Accuracy classification and class:

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

5.19.2 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 bustie, by-pass or interconnect 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.

5.19.3 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;
d. EXTERIOR LABELS:
   i. Manufacturer's 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 to the meter.
   x. 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;
   xi. SAMPLES: Provide samples of proposed label material, label sizes, lettering sizes and lettering text for approval;
e. MATERIAL: Engraved two-colour laminated plastic, engraved filled metal or photo-anodised rigid aluminium;
f. COLOURS:
   i. Warning Notices: White letters on red background;
   ii. Other Labels: Black letters on white background;
g. 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.

h. SCHEDULE CARDS: For distribution boards provide schedule cards of minimum size 200mm x 150mm with text 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.

5.20 THERMOGRAPHIC SURVEY

Carry out a thermographic survey on the operational switchboard one month after full operational load is established, or at latest one month before the end of the defects liability period. Use an advanced thermal imaging camera driven by a software program and provide a report on the thermographic heat pattern of the relevant switchboards. Any anomalous heat emissions which indicate presence of faults or hot joints must be rectified before the end of the defects liability period

5.21 METERING SYSTEMS

5.21.1 AUTHORITY TARIFF METERING

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

All MSB supplied from a RMSB must include cubicle space and removable links for the future installation of Electricity Supply Authority Metering current transformers, allowing future re-configuration of electrical supplies.

Current signals from the CTs must be clearly colour coded to the phase and labelled at each end of the cable to indicate the phase and secondary orientation of current signal (e.g. Red S1 and S2).

5.21.2 PRIVATE METERING (MULTI-FUNCTION METER)

All MSB supplies and sub-tenant sub-main supplies 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.
Meters must record and report kVA, kWh, Pf, V, A, maximum demand and power harmonics quality.
Meters must be connected to, and configured in, the University's AUMS in conformance to CIS AUMS Standard.

5.21.3 ENERGY CONSUMPTION METERING (SECONDARY CLASS METER)

Sub-metering must be installed to monitor the following loads, or as required to meet any energy rating scheme for the project including NCC compliance, 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. Note: the standard type DB only includes one single meter installed on the lighting section of the DB; the power meter is typically installed on the upstream MSB. If the upstream MSB does not have provision for metering the DB, a second meter is required on the DB on the power section.
h. Any laboratory/specialist equipment or high energy use area with total load > 50 amps/ph.

Sub-meters and all communication hardware software must be connected to, and configured in, the University's AUMS in conformance to CIS AUMS Standard.

5.21.4 SUMMARY OF METER REQUIREMENTS

Items to be Individually Metered	Meter Quality
Supplies to RMSB or MSB	Authority Tariff Meter
Supplies from RMSBs to MSBs/MSSB's etc.	Multi-Function Meter
Supplies from MSB to all DBs/MSSBs etc.	Multi-Function Meter
Tenants Supply from an Unmetered Supply from the MSB or RMSB	Authority Tariff Meter
Lighting at DB Level	Secondary Class Meter
Power at DB Level	Secondary Class Meter
Kitchens	Secondary Class Meter
Photo Voltaic Metering (Contractor to Confirm Supply Authority Requirements)	Bi-directional Multi-Function Power Meter with 'Time of Use' Capabilities
Lifts	Secondary Class Meter
External Lighting	Secondary Class Meter
Individual Chillers	Secondary Class Meter
General Sub-Mechanical Boards (e.g. where an MSSB is a sub-feed from a MSB/ DB /MSSB)	Secondary Class Meter
HVAC Water Pumping Power	Secondary Class Meter
Electrical Heating Water Plant	Secondary Class Meter
Electrical Hot Water Plant	Secondary Class Meter
Laboratory or Research Equipment Larger than > 50 amps/ph	Multi-Function Meter
Cooling Tower Fans	Secondary Class Meter
HVAC AHUs including associated supply, return, relief and outside air fans	Secondary Class Meter

Note: All meters must use native Modbus protocol.

5.21.5 METER LABELLING

All new meters installed must be physically labelled with new Traffolyte labels as per the AUMS system. Meters are to be identified as per their asset (i.e. Power Meter no. 1 located on DB-05 shall be labelled DB-05 – Power Meter).

5.21.6 METER DOCUMENTATION

The contractor must supply the CIS, Sustainability & Engineering Team with:

a. Switchboard single line diagrams;
b. Network communications schematics, including for devices within the switchboard;
c. Network address identification schedules in editable spreadsheet format;
d. Plans showing meter locations, meter identification and coverage.

5.21.7 UTILITIES METERING AND ACCOUNT CONNECTIONS, DISCONNECTIONS AND TRANSFERS

The University uses the services of an external utilities advisor to manage changes to utilities metering and account connections, disconnections and transfers. All utilities connections, disconnections and transfers for the University must be requested by Project Managers, Facilities Managers or their delegates via the external utilities advisor for a fee. The procedure for connections, disconnection and transfers of utility metering and accounts is documented in **CIS-Procedure-Utilities Connections, Disconnections and Transfers.** Project Managers, Facilities Managers or their delegates must make the external utilities advisor aware of any changes to utility metering or accounts including requests for new meters, transfer of accounts or disconnection of existing meters within the timeframes stipulated in the procedure and by completing **CIS Utilities Connections, Disconnections and Transfers Form (CIS-ENG-F010).**

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

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

5.23 LIGHTNING PROTECTION SYSTEM

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

5.23.1 MATERIALS

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

5.23.2 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: Wood screws.

5.23.3 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:
        - Bond metallic service pipes to the lightning protective system at the point of entry or exit outside the structure on the supply side of the service;
        - Bond metallic sheathing or armouring of electric cables at the point of entry to the building.
    iii. Down Conductors:
        - Where a metal part of a building runs for more than 10 m in close proximity to a down conductor, bond the metal at top and bottom to the conductor;
        - Where a down conductor occurs on the external face of a column, bond it at top and bottom to terminals on the column reinforcement;
        - Where the column reinforcement is the down conductor, provide terminals and bond it at top and bottom to the conductor network.
c. TERMINALS:
    i. For the above cases, provide 50mm x 6mm terminals of stainless steel, grade 304 to AS 1449, clamped and bolted to not less than four reinforcing rods.

5.23.4 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.

5.23.5 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 stainless steel or brass plate.

5.24 POWER FACTOR CORRECTION

Provide Power Factor Correction (PFC) 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. PFC 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 Switchboards or Regional MSB 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/ RMSB and PFC equipment;
d. Terminals for connection of a remote group alarm;
e. PFC calculation;
f. Shop drawings;
g. As installed drawings and maintenance manuals;
h. 24-month warranty with six monthly service;
i. The PFC equipment must be located as close as possible to the main switchboards or RMSB.

5.24.1 AUTHORITY APPROVALS

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

5.24.2 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. Maker's or manufacturer's 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.

5.24.3 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

5.24.4 CAPACITOR TYPE

The capacitors must:
a. Comply with AS 1013 and IEC 831-1;
b. Be vacuum oil impregnated metallised polypropylene;
c. Incorporate discharge resistance;
d. Have a minimum dielectric rating of 500VAC as required to accommodate the series reactor voltage addition;
e. Be rated for 60oC 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.

5.24.5 STEP SIZE

The capacitor installation must have minimum 2 off 25kVAR steps for fine tuning at low loads, and the remainder in 50kVAR steps.

5.24.6 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 15oC above ambient;
f. A maximum step size of 50 KVAR with fuses for each step.

5.24.7 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.

5.24.8 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 a 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.

5.24.9 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.

5.24.10 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;
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, complete with associated software.

5.24.11 INRUSH CURRENT SURGE LIMITING

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

5.24.12 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. (i.e.:. 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.

5.25 ELECTROMAGNETIC INTERFERENCE & COMPATIBILITY (EMI & EMC)

5.25.1 PROJECT DEFINITION PHASE

There are various levels of sensitivity to EMI across the wide range of University space uses, ranging from low sensitivity transient human occupancy to extreme sensitivity world class ultra-sensitive research laboratory spaces. There are also many instances where the equipment within laboratories poses an external interference or EMI hazard to external occupants or processes, which must be managed or mitigated.

Generally, projects need only consider basic EMI considerations of separating power supply infrastructure from user spaces by distances in the range of 5-10 meters.
The unit of measurement for magnetic fields is the milligauss (mG), and for electric fields it is Volts/meter. Electric fields are easily stopped by thin metal sheet or mesh, whereas magnetic fields are more penetrative (e.g. connecting the individual cables in the trefoil formation minimizes the magnetic field around the conductor and reduces the heating).

Each project definition phase shall include a basic EMI sensitivity analysis identifying the classes of space, defined occupancy, the maximum permissible EMI levels within those spaces, and any potential user equipment posing an external risk.

Where special needs are identified outside of the normal permissible range (5-50mG), a detailed investigation and specification of the performance levels shall be undertaken.

Special use spaces (typically electronic or physics laboratories) being created within existing buildings requiring EMI levels below 2mG will require a site EMI survey to be carried out as part of the project definition phase to determine if the space is fundamentally suitable for the use, and / or expensive shielding or other mitigation is required, or even feasible.

Residential and office spaces must carefully consider the location of substations, switchboards and sub-main routes to avoid long term exposure to residents or staff.

The location of lift cores and loading docks to highly sensitive spaces must be considered in the spatial design. Lifts and large vehicle traffic on adjacent roadways pose an EMI risk to sensitive laboratory spaces as they generate fluctuations in the surrounding earth magnetic field that can affect measurements or equipment calibration.

5.25.2 EMI TYPES

There are broad classes of EMI or field as follows;

a. **Static Magnetic** (0 Hz) – Earth magnetic field, powerful DC or permanent magnets in lab equipment.
b. **Fluctuating Magnetic** (0.01 – 1 Hz) – generated by Lift counterweight, large vehicle etc. moving.
c. **Oscillating Magnetic** (50-1000Hz) – typically mains power electrical equipment including substations, switchboards, sub-mains, and single phase sub-circuit cables loaded to more than 10 amps.
d. **Radio Frequency Interference** (10kHz – 10GHz) – Electronic light fitting ballasts, Mobile phones, Microwaves, some lab equipment, RF heating dryers, high power Laser drivers, mobile telephone base stations etc.

Generally, the higher the frequency, the less penetration that radiated interference will have.

5.25.3 EMI MITIGATION

Electric fields (radio frequency) are easily stopped by thin metal or mesh. Magnetic fields are much more penetrative and troublesome. The methods for mitigating or reducing EMI impact are;

a. **Spacing**

This is the best and cheapest option. EMI fields fall off at the square of the distance between source and receptor (2 x distance = ¼ field strength). Move the source and receptor apart as far as possible. Typically, 10m for a substation and 5m for major sub-main routes is satisfactory.

b. **Shielding of the Receptor**

Room Shielding is very expensive and a last resort. It requires complex design, verification, large amounts of expensive specialist metals and labour intensive installation. Usually the whole room must be fully enclosed, including special doors and frames.

c. **Shielding of the source**

Shielding at the source is less expensive as it usually requires a smaller area to be covered, such as a single cable tray or Distribution switchboard. It may only be used where the situation is already nearly satisfactory and does not require a major improvement, and the source is small, such as a cable tray or Distribution switchboard.

It is extremely difficult if not impossible to shield a substation, and the Supply Authorities are unco-operative in permitting it.

d. **Active Cancellation**

This is applicable for slowly changing EMI or static fields, working by generating a counter field with a large coil of wire surrounding the space. It requires complex design verification, and large expensive equipment.

5.25.4 EMI ACCEPTANCE LEVELS

The following maximum EMI levels shall apply, unless written permission to deviate is received from CIS. These levels are the maximum 1-minute average broadband EMI level at any occupiable location in the room at 1m above floor level. They shall be measured using a tri-axial Gauss meter on 15Hz -10kHz range, and DC range for laboratories.

SPACE TYPE	TYPICAL OCCUPANCY	MAXIMUM AVERAGE EMI
Residential	24 hour	5mG
Office	10 hour	10mG
Teaching Space	4 hour	15mG
Transient space	1 hour	50mG
General Laboratories	Note -Pre-occupancy / fit-out	15mG
Special Laboratories	E.g. – Medical, electrical, physics	0.1 – 2mG

Within existing buildings, an on-site measurement would be required to determine the existing EMF readings in order to assess the mitigation measures required.

5.25.5 DESIGN GUIDELINES

Provide equipment designed and manufactured to minimise the impact of EMI where particular risks exist to or from other systems. Generally:

a. Substations are to be located to ensure that the Electromagnetic Interference (EMI) on surrounding facilities is below the specified levels. Substations or Main Switchboards shall not be located directly underneath or adjacent at ground level to a residential dormitory, office, laboratory or teaching space. The minimum separation from occupied areas shall be 10m in any direction;
b. Main sub-main routes or risers shall not be located backing directly onto, or passing on the ceiling under, any office space or residential dormitory. The minimum separation from occupied areas shall be 5m for major sub-main routes;
c. Shielding of the sources or receptor areas is to be used only as a last resort, and dispensation must be sought from the CIS Electrical Engineer. Dispensation will not be automatic, and the designer will need to prove that there is no alternative. The Design Submission is to include detailed calculation of the EMI in occupied areas by a specialist using CAD modelling software;
d. Special (laboratory) spaces requiring EMI fields less than 2mG must have an EMI specialist involved in the concept design phase.

5.25.6 POWER LINE FILTRATION

Where there is significant high frequency EMI (10kHz – 10GHz) generated from laboratory equipment, or sensitivity within the laboratory, provide whole current pass-through passive power line filters on the sub-mains to the dedicated Distribution Switchboard. These shall be equal to Schaffner FN351, rated for the line current.

5.25.7 SIGNAGE REQUIREMENTS

It is further advised that warning signage shall be provided:

a. Where areas have oscillating magnetic fields above 20 mG and below 1,000 mG and staff or students may occupy such areas regularly. Regularly means more than once per week for periods over an hour.
b. Areas that have oscillating magnetic fields of 1,000 mG or above should have an appropriate warning sign posted. Entry to such areas must be controlled by a Permit system.
c. Appropriate Safe Work Method Statements should be applied to all incidences of elevated electromagnetic or electric fields.

5.25.8 CONSTRUCTION & VERIFICATION REQUIREMENTS

Provide equipment designed and manufactured to minimise the impact of EMI where particular risks exist to or from other systems. Generally:

a. Shielding of the EMI source or of the receptor areas is to be used only as a last resort, and dispensation must be sought from the CIS Electrical Engineer. Dispensation will not be automatic, and the designer will need to prove that there is no alternative. The Design Submission is to include detailed calculation of the EMI in occupied areas.
b. The electrical contractor shall engage the services of a specialised EMI consultant to identify sources of EMI interference and propose remedial actions to limit the field levels to comply. Provide all shielding and screening of EMI sources as directed by the EMI after review and approval by the CIS Electrical Engineer.
c. At the discretion of the CIS representative based upon likelihood of any EMI issues in the finished project, carry out 1-minute average broadband EMI measurements in areas of concern in the room at 1m above floor level. They shall be measured using a tri-axial Gauss meter on 15Hz -10kHz range, plus the DC / ELF range for laboratories. Record the measurements on a floor plan drawing and submit for approval.
   The site shall be complete and electrically operational with at least all of the lighting and air conditioning systems running.

5.25.9 EMC COORDINATION WITH OTHER SERVICES

Provide details to the Mechanical and Hydraulic contractor of the power supply system fault level and cable impedance at the local switchboard termination for co-ordination of Variable Speed Drive load EMC compliance and power system Harmonic Distortion limitation.
Assist these contractors to read the AUMS meters provided by the electrical contractor to determine the voltage and current THD at the metering point.

5.25.10 EMC STANDARDS

The following standards apply for design and equipment:

a. The whole series of AS/NZS 61000, and specifically
   i. AS/NZS 61000.1.1:2000
      Electromagnetic compatibility (EMC) - General - Application and interpretation of fundamental definitions and terms;
   ii. **AS/NZS 61000.2.7:2009**
      Electromagnetic compatibility (EMC) - Environment - Low frequency magnetic fields in various environments;
   iii. AS/NZS 61000.3.2:2013
      Electromagnetic compatibility (EMC) - Limits - Limits for harmonic current emissions (equipment input current =16A per phase);
   iv. AS/NZS 61000.3.4:2007

Electromagnetic compatibility (EMC) - Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 75A;

v. AS/NZS 61000.3.11:2002 (R2013)
Electromagnetic compatibility (EMC) - Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current less than or equal to 75 A and subject to conditional connection;

vi. AS/NZS 61000.3.12:2013
Electromagnetic compatibility (EMC) - Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and =75 A per phase;

vii. AS/NZS 61000.6.3:2012
Electromagnetic compatibility (EMC) - Generic standards - Emission standard for residential, commercial and light-industrial environments;

viii. **AS/NZS CISPR 14.1:2013**
Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus – Emission;

ix. AS/NZS CISPR 32:2013
Electromagnetic compatibility of multimedia equipment - Emission requirements.

6 SHOP DRAWINGS

The Contractor must submit the following shop drawings, document and samples for the approval of CIS Electrical Services Engineer prior to commencement of installation:

a. Maximum demand and cable sizing calculations with digital printouts;
b. Short-circuit and Overcurrent protection calculations by POWERCAD with digital printouts and selection of switchgears;
c. Power layouts (1:100 scale) and electrical schematic diagrams;
d. Switchboard and single line schematic diagrams;
e. Technical catalogue and documents for electrical installation, power and equipment;
f. Compliance certifications from accredited qualified Electrical Consulting Engineer;
g. Sample of all proposed electrical installation, power and equipment.

7 SAFETY IN DESIGN

The contractor must consider risk during the design. A design safety report must be submitted to the relevant CIS Project Manager for every design project. Contractors must confirm, so far as it is reasonable practicable (SFAIRP), that the structure is without risks to health and safety.

Design risks must be considered for the asset lifecycle covering construction, operational and maintenance, refurbishments and decommissioning.

The design safety report must include the following:

a. Description of design element;
b. Description of potential risks and hazards associated with the design element;
c. A low/medium/high risk assessment considering likelihood and consequence;
d. Proposed measures to eliminate risks where practicable;
e. Control measures to mitigate and manage design risks;
f. Nominating responsibilities for managing the design risks.

This may be provided as a design risk register where appropriate and must include results of any calculations, testing and analysis etc.

8 COMMISSIONING

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. This will apply to transformational projects.

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 the following sections.

8.1 TESTING AND COMMISSIONING

Item	Description of Item	Description of Works
1.	Phase Sequence	Ensure the correct phase sequence at the equipment after connection of the supply.
2.	Balancing of Load.	Balance the load as evenly as practicable at the Main Switchboard and the sub switchboards 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 manufacturer's representatives present on site to inspect, check and approve equipment or system

Item	Description of Item	Description of Works
		installation prior to starting up, and to supervise placing equipment and operation. Execute starting up under supervision of manufacturer's representative and appropriate Main Contractor personnel, in accordance with manufacturer's instructions.
5.	Tests	Verify that tests, meter readings, and specified electrical characteristics agree with those required by the manufacturer.

8.1.1 INSPECTION AND WITNESS TESTING

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

8.1.2 TESTING EQUIPMENT SCHEDULE

Test To be Performed	Equipment To Be Used
Insulation resistance measurements on cables and wiring to AS/NZS 3000.	Megger Tester with 500V
Earth resistance measurement to AS/NZS 3000.	Earth Resistance Meter
Confirmation of effective earthing of the exposed metal of electrical equipment	Continuity Meter
Earth fault loop impedance to AS/NZS 3017	Impedance Tester
Full functional checks and operational checks on energised control equipment and circuits, including adjustments for the correct operation of safety devices	As appropriate
Smart Metering systems & network	Laptop computer with software to display the network and operating parameters

Use instruments calibrated by NATA-accredited laboratories.

8.1.3 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 NCC with respect to life safety services. Installers' Certificates of Compliance must be provided.

9 DOCUMENTATION & RECORDS

The following design documents must be provided:

a. Return Brief defining the systems proposed and any deviations from this specification;
b. Electrical maximum demand calculation spreadsheet;
c. Computer design calculation files for circuit breaker grading study, fault levels, voltage drops and cable calculations;
d. Budget calculations;
e. Applications to Supply Authorities, and their responses;
f. Designers statutory compliance certificates;
g. Requests for all variations to this Standard submitted using the **CIS Request for Dispensation Form (CIS-ENG-F001);**
h. Complete the Design & Construct checklist using the **CIS Design & Construct Electrical Services Checklist Form (CIS-ENG-F009).**

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);
k. Certification of compliance to the design standard by completing and submitting the **CIS Project Design Certification Form (CIS-PROJ-F001).**

10 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. 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 operation and maintenance of electrical services, plant and equipment to ensure electrical services are fit-for-purpose, provide secure, efficient, safe and reliable electrical power, and comply with requirements of this standard.

11 AUTHORISATION OF VARIATIONS

Project managers, consultants, contractors, commissioning agents and facilities maintenance personnel must ensure compliance with these requirements is achieved.

Variations to this standard must only be considered where:

a. The University Standard's requirement cannot physically or technically be achieved;
b. The alternative solution delivers demonstrated and proven superior performance for the same capital and life cycle cost or better.

Consultants and contractors must identify and justify requirements of the standard that do not apply to the project or which need to be varied and these which must be approved by the issuer of this standard. Formal requests for all variations to this Standard must be submitted using the **CIS Request for Dispensation Form (CIS-ENG-F001)**. The issuer of this standard or their delegated authority must review and consider requirements of stakeholders from clients, projects and facilities management before deciding whether to approve variations. Their formal sign-off is required for acceptance of any non-compliances and departures from this standard's requirements.

12 QUALITY CONTROL

12.1 DESIGN STANDARD COMPLIANCE

Compliance with requirements of this standard must be checked throughout the design, construction and commissioning phases of projects by CIS' services consultant. Any issues or deviations from this standard must be reviewed and approved in writing by the author of this standard.

Competent CIS consultants and representatives must check compliance with this standard during design reviews and formal site inspections. Any non-conformances with requirements of this standard must be documented and provided to the CIS Project Manager for issue to contractors and their consultants.

Project Managers must maintain a formal register of non-conformances and manage close out of outstanding non-conformances. Contractors and their consultants issued with non-conformances must take appropriate corrective actions. The CIS Project Manager must ensure:

a. proposed corrective actions are implemented
b. close out of non-conformances in relation to this standard is formally approved and signed off by the author of the standard or their delegate.

12.2 DESIGN STANDARD CERTIFICATION

Contractors and Consultants must certify compliance to the design standard by completing and submitting the **CIS Project Design Certification Form (CIS-PROJ-F001)** to the CIS Project Manager at each of the following project phases:

a. Design and Documentation;
b. Tender;
c. Construction.

Notwithstanding CIS' internal quality control processes, contractors and their consultants must implement their own robust quality assurance and control procedures to ensure compliance with requirements of this standard.

13 REFERENCES

Standard	Title
AS/NZS 1158	Lighting for roads and public spaces
AS/NZS 1680	Interior Lighting
AS/NZS 1768	Lightning protection
AS/NZS 2053	Conduits and fittings for electrical installations
AS/NZS 2293	Emergency escape lighting and exit signs for buildings
AS 2676	Installation and maintenance of batteries in buildings
AS/NZS 3009	Electric installations - Emergency power supplies in hospitals
AS 3011	Electrical installations - Secondary batteries installed in buildings
AS/NZS 3000	Electrical installations (also known as the Australian/New Zealand Wiring Rules)
AS/NZS 3008.1.1	Electrical installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1kV – Typical Australian installation conditions
AS/NZS 3013	Electrical installations – Classification of the fire and mechanical performance of wiring systems
AS/NZS 3017:2007	Electrical installations—Verification guidelines
AS/NZS 3019:2007	Electrical installations—Periodic verification
AS/NZS 3080	Telecommunications installations - Generic cabling for commercial premises
AS/NZS 3084	Telecommunications installations - Telecommunications pathways and spaces for commercial buildings
AS/NZS 3100	Approval and test specification – General requirements for electrical equipment
AS 3439.1	Low Voltage Switchgear and Control Gear Assemblies
AS/NZS 3947.3	Low-voltage switchgear and control gear - Switches, disconnectors, switch-disconnectors and fuse-combination units
AS/NZS 5000	Electric cables – Polymeric insulated
AS 60529-2004	Degrees of protection provided by enclosures (IP Code)
AS/CA S008	Requirements for customer cabling products
AS/CA S009	Installation requirements for customer cabling (Wiring Rules)
ASC 168	Fluorescent lamp ballasts
BS 5042	Specification for lamp holders and starter holders.
EIA/TIA 569	Commercial building standard for telecommunications pathways and spaces
EN 55015:2006	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
EN 55022	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement

Standard	Title
EN 61347	Lamp control gear
EN 60929	AC-supplied Electronic Ballasts For Tubular Fluorescent Lamps - Performance Requirements
IEC 60038	Standard Voltages
IEC 60044.1	Instrument transformers - Part 1: Current transformers
IEC 60051	Direct acting indicating analogue electrical measuring instruments and their accessories
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 61000	Electromagnetic compatibility (EMC)
IEC 61547	Equipment for general lighting purposes - EMC immunity requirements
IEC 62052	Electricity metering equipment (AC) - General requirements, tests and test conditions
NCC	National Construction Code of Australia, specifically Section J energy efficiency
SIR	Supply Authority Service Installation Rules
--	Workcover requirements
--	All Health Authority Requirements
--	State Fire Brigade requirements
--	All Local Council regulations
--	Electricity Safety (Installations) Regulation

14 NOTES

N/A

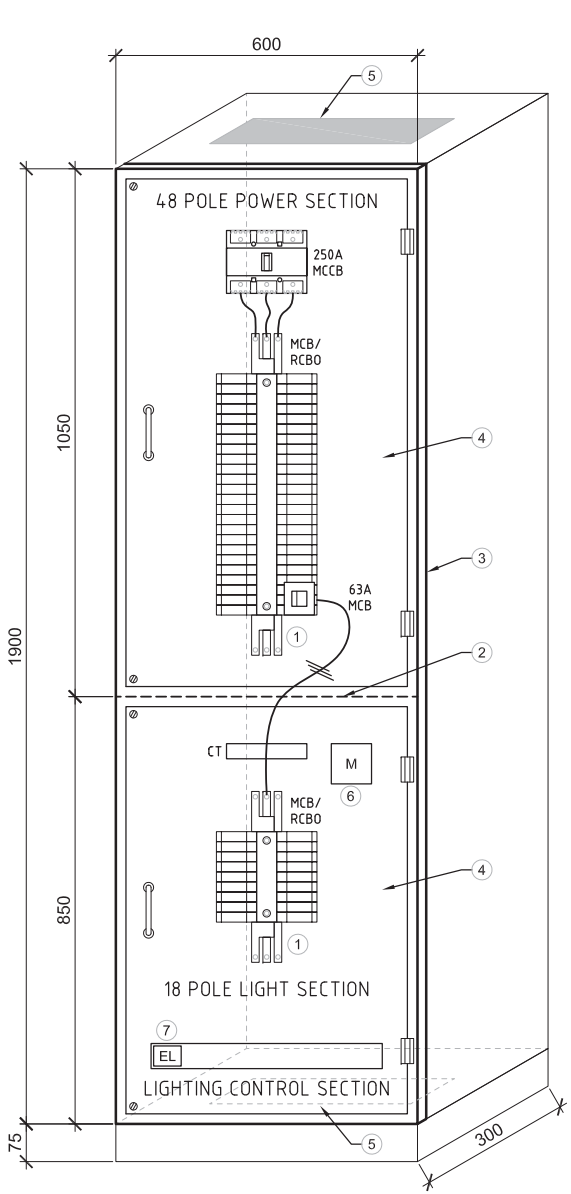
15 DOCUMENT AMENDMENT HISTORY

Revision	Amendment	Commencing
001	First Issue	16 August 2013
002	Second Issue - Amendments • As-Built drawings clause 5.3 now includes Lightning Protection and Earthing & Bonding drawings; • Asset labelling clause 5.7.1 added; • Summary of Meter Requirements clause 5.23.4 added; • Meter Labelling clause 5.23.5 added; • Electromagnetic Interference clause 5.27 added; • Shop Drawing clause 6 added; • Safety in Design clause 7 added; • Deemed to Comply University Standard Switchboard Types 1-5; New Forms added to the website; • CIS Design & Construct Checklist Form (**CIS-ENG-F009**).	18 September 2015

16 ATTACHMENTS

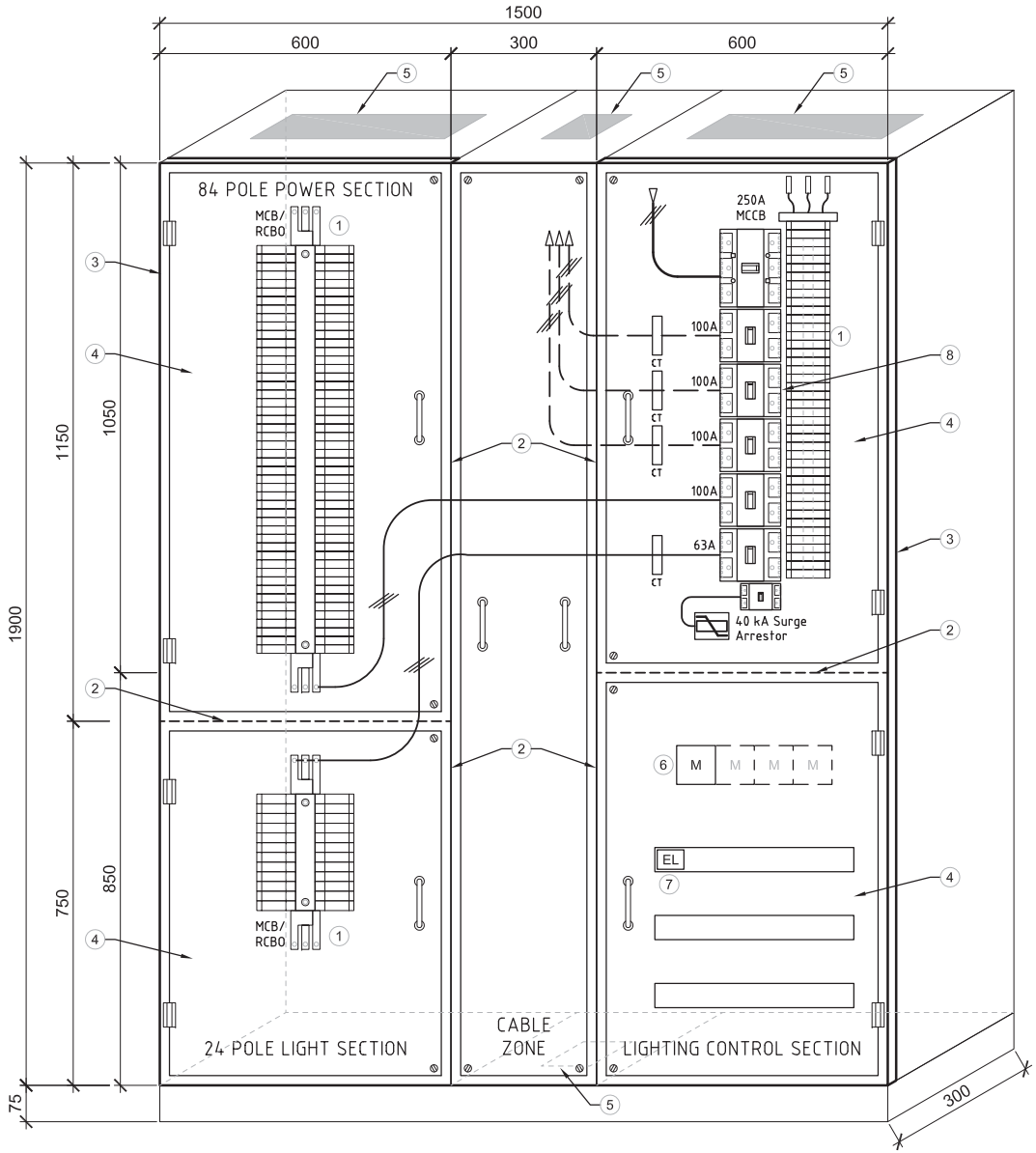
ATTACHMENT 1 DEEMED-TO-COMPLY UNIVERSITY STANDARD SWITCHBOARD TYPES 1-5

ATTACHMENT 1 - UNIVERSITY STANDARD DISTRIBUTION BOARD (TYPES 1 TO 5) AND TYPICAL ARRANGEMENT OF SWITCHBOARD DRAWINGS



1. 250A busbar chassis
2. Metal divider with gland plates
3. Hinged doors with University Bi-locks
4. Hinged escutcheons can be opened when main switch is in 'ON' position
5. Gland plates with gaskets
6. IME NEMO 96HD multifunction meter
7. Emergency lighting test switch

Type 1 DB
(Small DB)



1. 250A busbar chassis
2. Metal divider with gland plates
3. Hinged doors with University Bi-locks
4. Hinged escutcheons can be opened when main switch is in 'ON' position
5. Gland plates with gaskets
6. IME NEMO 96HD multifunction meter plus 3 future meters
7. Emergency lighting test switch
8. 3 x 100A MCCB spaces for supply to MSSB or DB

Type 2 DB
(General DB)

Rev	Description	Date
1	Preliminary	11/07/14

Client:

The University of Sydney
Campus Infrastructure & Services

THE UNIVERSITY OF SYDNEY

Project:

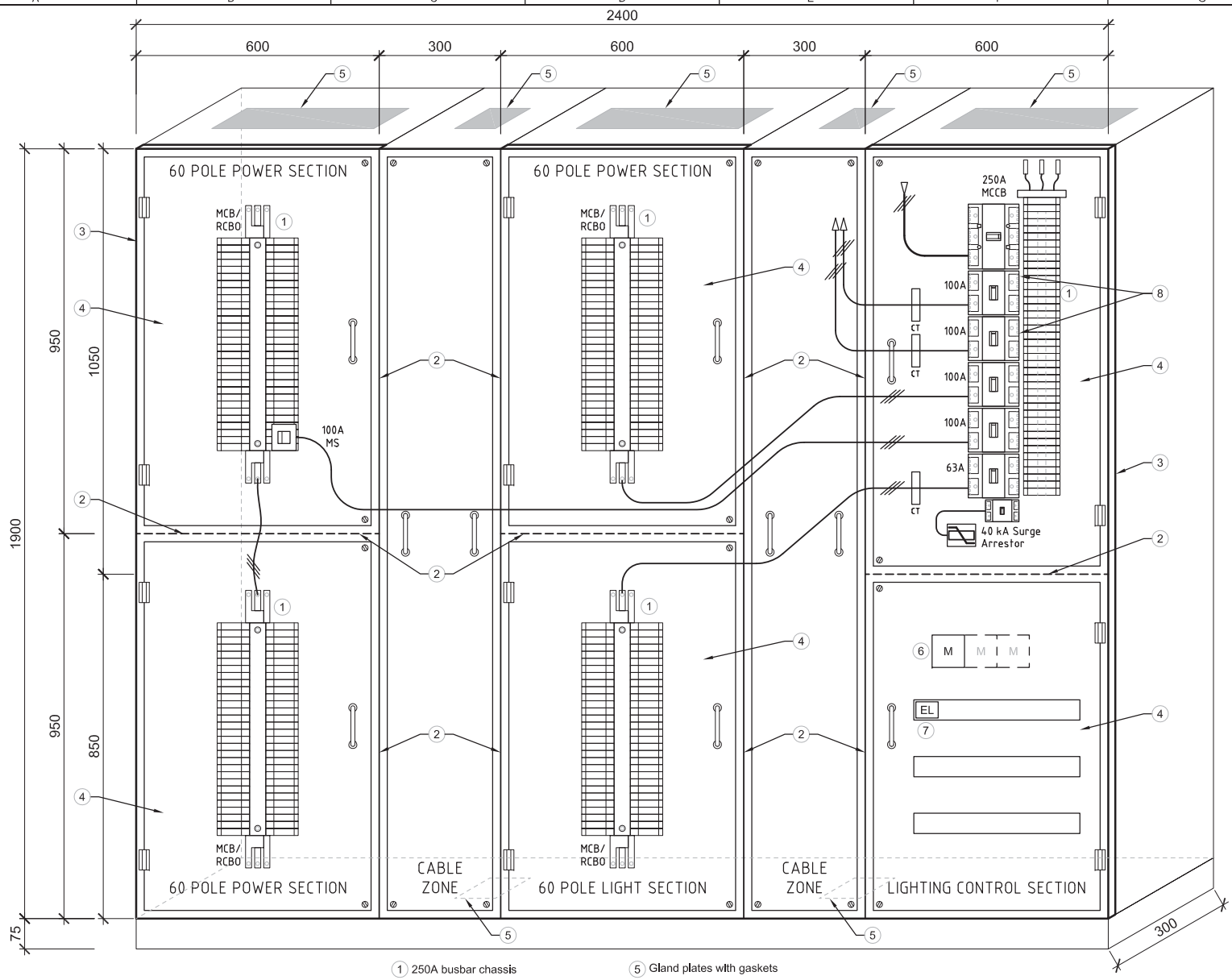
CIS Electrical Services Standard

Title:

University Standard Distribution Board
Type 1 and Type 2 Details

Scale at A3	Not to Scale		
Job No:		Drawn: RS	Checked: FT
Drawing No: E1	Rev: 1	Date: July '14	

Do not scale



1. 250A busbar chassis
2. Metal divider with gland plates
3. Hinged doors with University Bi-locks
4. Hinged escutcheons can be opened when main switch is in 'ON' position
5. Gland plates with gaskets
6. IME NEMO 96HD multifunction meter plus 2 future meters
7. Emergency lighting test switch
8. 2 x 100A MCCB spaces for supply to MSSB or DB

Type 3 DB

(Large DB)

Allow provisions for Solar PV connection

Rev	Description	Date
1	Preliminary	11/07/14

Client:

The University of Sydney
Campus Infrastructure & Services

THE UNIVERSITY OF SYDNEY

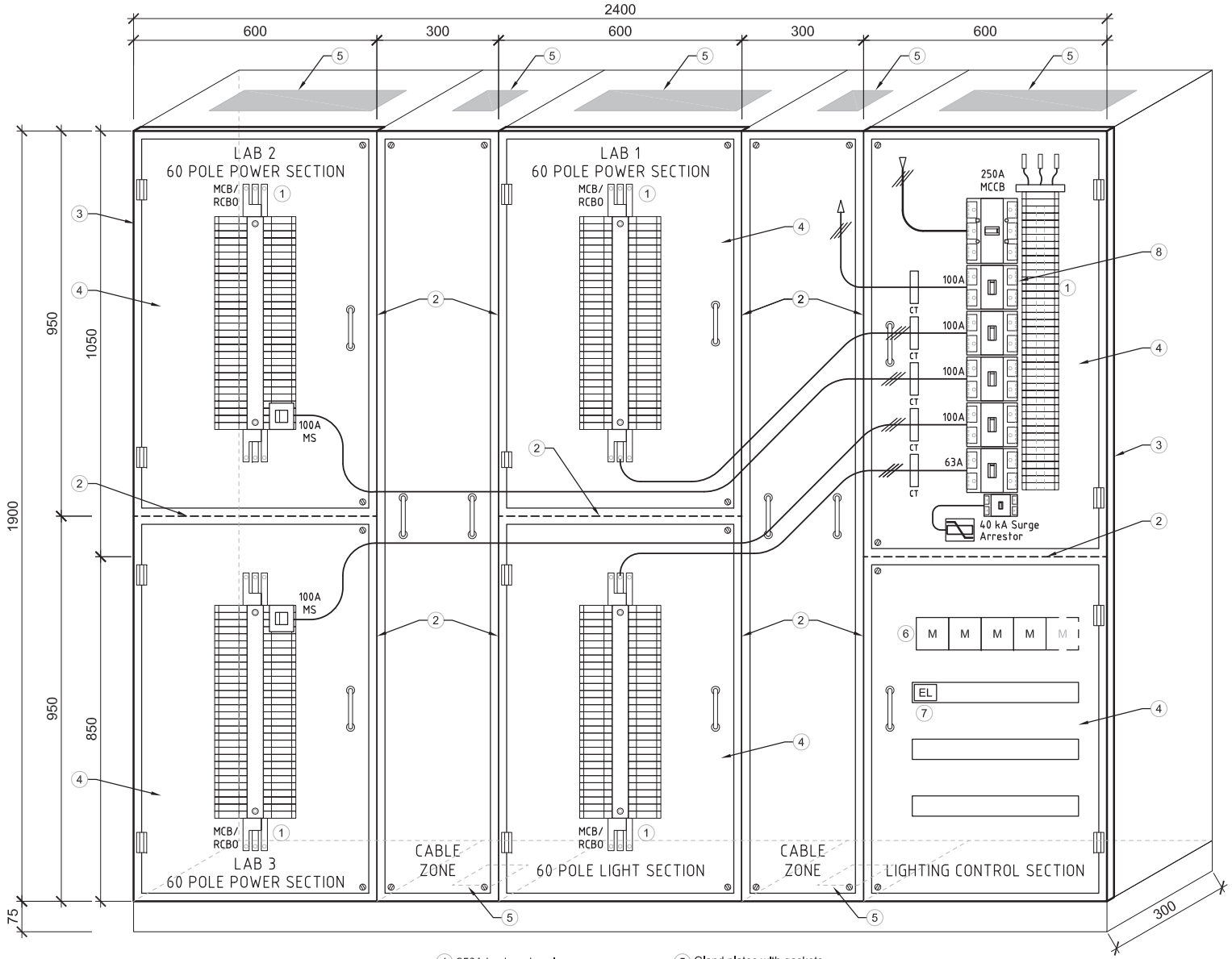
Project:

CIS Electrical Services Standard

Title:

University Standard Distribution Board Type 3 Details

Scale at A3: Not to Scale		
Job No:	Drawn: RS	Checked: FT
Drawing No: E2	Rev: 1	Date: July '14



1. 250A busbar chassis
2. Metal divider with gland plates
3. Hinged doors with University Bi-locks
4. Hinged escutcheons can be opened when main switch is in 'ON' position
5. Gland plates with gaskets
6. IME NEMO 96HD multifunction meters plus 1 future meter
7. Emergency lighting test switch
8. 100A MCCB space for supply to MSSB or DB

Type 3a DB
(Laboratory DB)

Rev	Description	Date
1	Preliminary	11/07/14

Client:

The University of Sydney
Campus Infrastructure & Services

THE UNIVERSITY OF SYDNEY

Project:

CIS Electrical Services Standard

Title:

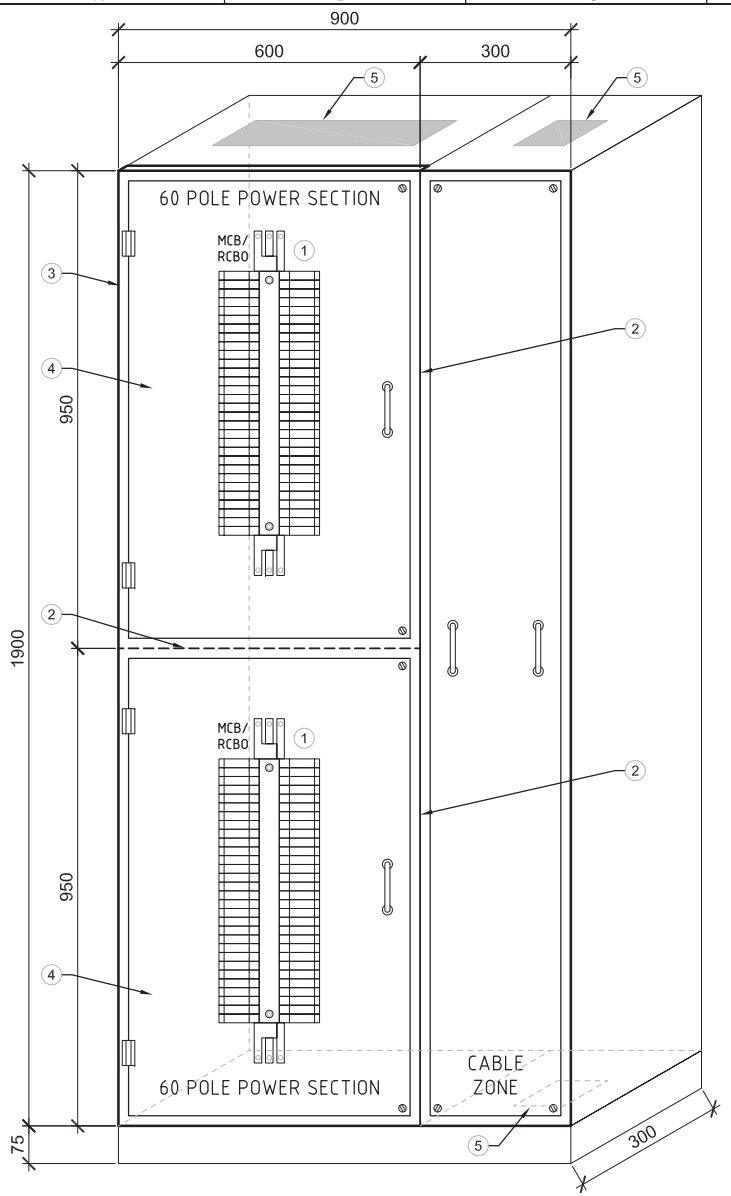
University Standard Distribution Board Type 3a Details

Scale at A3: Not to Scale

Job No:	Drawn:	Checked:
	RS	FT

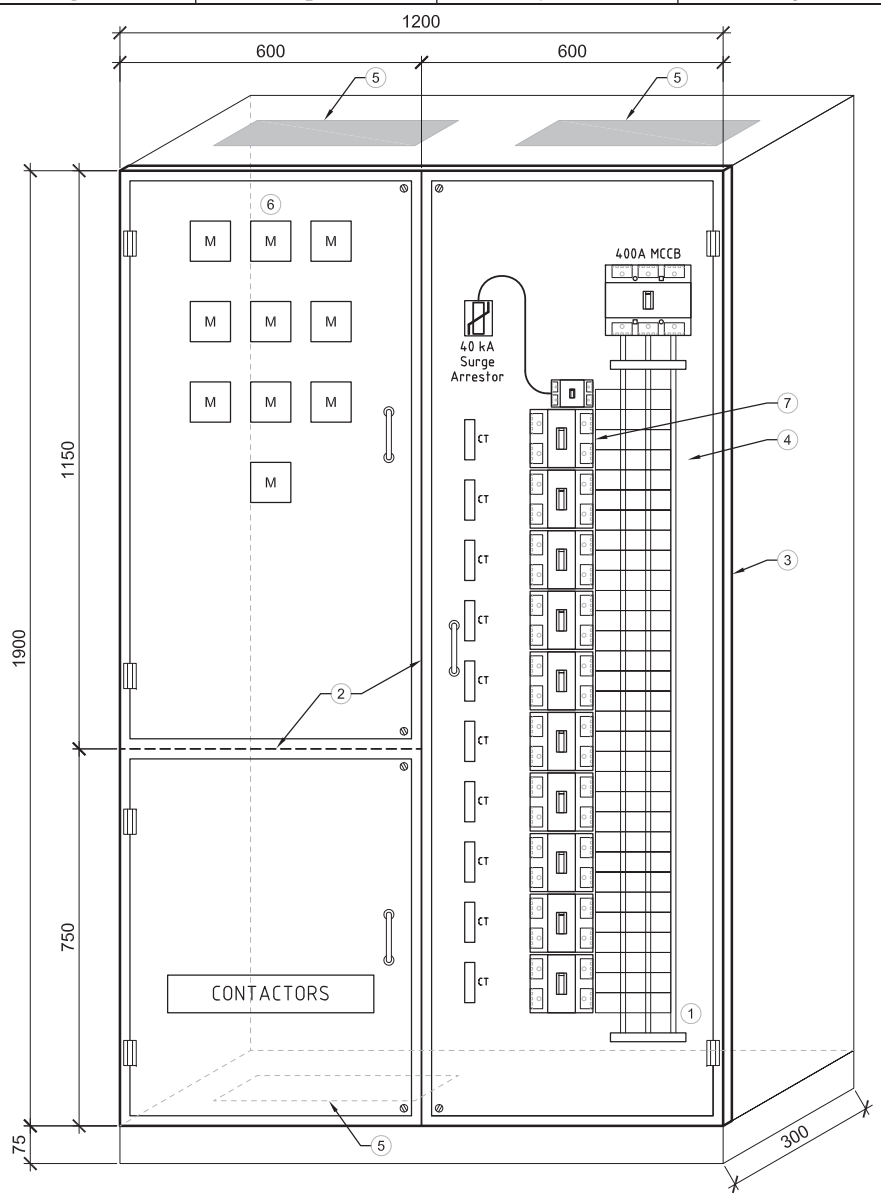
Drawing No:	Rev:	Date:
E3	1	July '14

Do not scale



1. 250A busbar chassis
2. Metal divider with gland plates
3. Hinged doors with University Bi-locks
4. Hinged escutcheons can be opened when main switch is in 'ON' position
5. Gland plates with gaskets

Type 4 DB
(DB extension only)



1. Maximum 630A busbar chassis
2. Metal divider with gland plates
3. Hinged doors with University BHocks
4. Hinged escutcheons can be opened when main switch is in 'ON' position
5. Gland plates with gaskets
6. 10 x IME NEMO 96HD multifunction meters
7. 10 x 250A MCCB's

Type 5 MDB

Rev	Description	Date
1	Preliminary	11/07/14

Client:

The University of Sydney
Campus Infrastructure & Services

THE UNIVERSITY OF SYDNEY

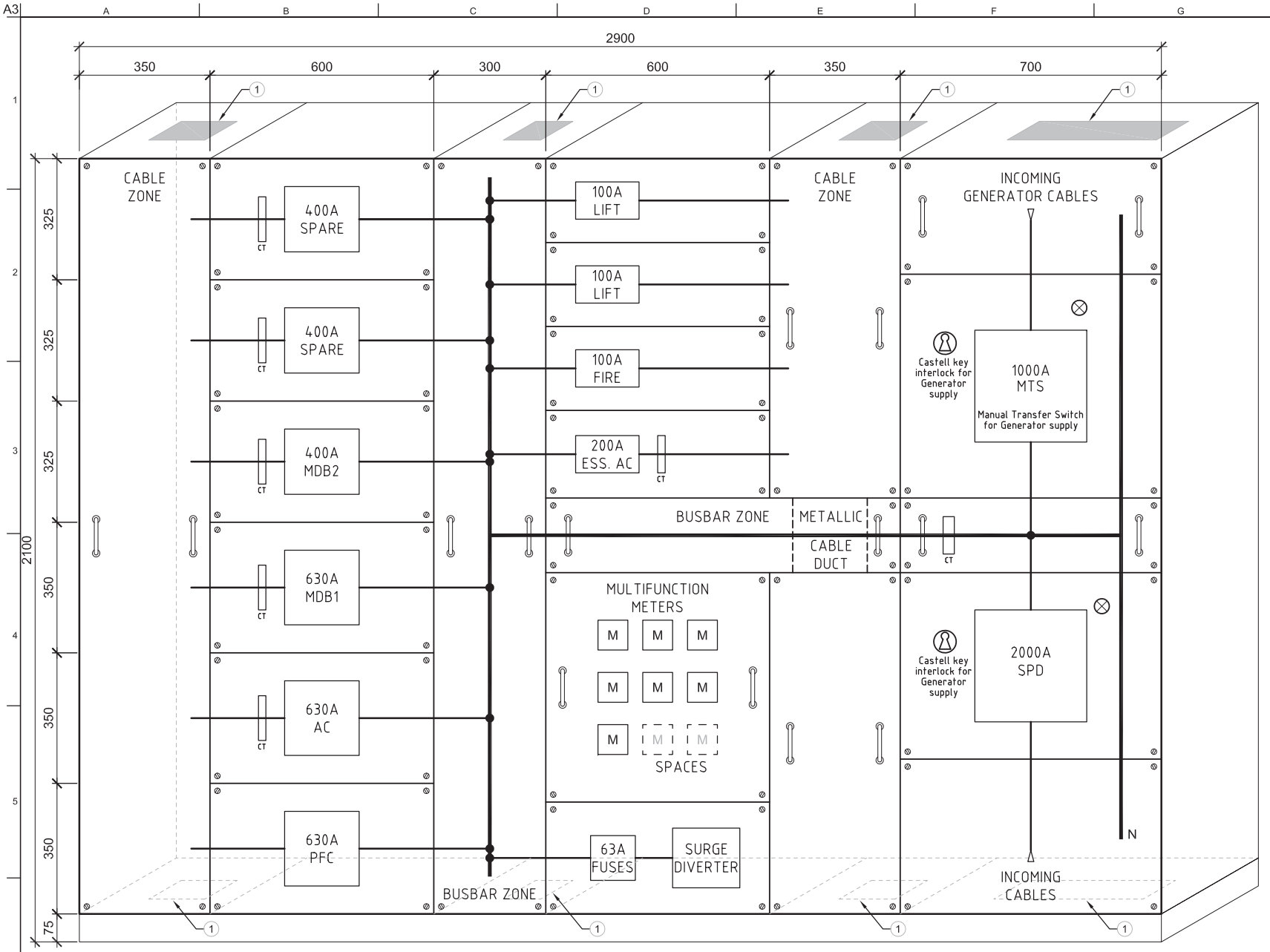
Project:

CIS Electrical Services Standard

Title:

University Standard Distribution Board
Type 4 and Type 5 Details

Scale at A3	Not to Scale	
Job No:	Drawn: RS	Checked: FT
Drawing No: E4	Rev: 1	Date: July '14



1 Gland plates with gaskets

Building Main Switchboard

2000A Capacity Maximum , Form 3B , IP42 , Fault Level 35 kA
(No utility metering , front connected)

Rev	Description	Date
1	Preliminary	11/07/14

Client:

The University of Sydney
Campus Infrastructure & Services

THE UNIVERSITY OF SYDNEY

Project:

CIS Electrical Services Standard

Title:

University Standard Building Main Switchboard Details

Scale at A3: Not to Scale

Job No:	Drawn:	Checked:
	RS	FT

Drawing No:	Rev:	Date:
E5	1	July '14