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As a guide only, attention is drawn to changes that have been made in the following clauses since the last revision:

<table>
<thead>
<tr>
<th>Revision</th>
<th>Clause</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>E.1.1.7</td>
<td>August 2004</td>
</tr>
<tr>
<td>4.1</td>
<td>E.3.1.2MCC section reinstated</td>
<td>November 2005</td>
</tr>
<tr>
<td>5</td>
<td>General Revision</td>
<td>February 2014</td>
</tr>
<tr>
<td>5.1</td>
<td>E.3.1.2 Metering</td>
<td>May 2014</td>
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</table>
E.3.1. LOW VOLTAGE

E.3.1.1. Electricity Supply

General
The UNSW Kensington Campus power supply is provided from the 11 KV
distribution system which is owned and operated by the UNSW.

The 11kV power is distributed around the campus via four rings, to over 25
substations where the voltage is stepped down to 415 V AC and distributed to the
main buildings and points of consumption.

The LV power supply on UNSW Kensington campus is as follows:

<table>
<thead>
<tr>
<th>Nominal supply voltage</th>
<th>415/240 V AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of phases</td>
<td>3</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Number of wires – system</td>
<td>4</td>
</tr>
<tr>
<td>Neutral connection</td>
<td>MEN</td>
</tr>
</tbody>
</table>
E.3.1.2. Metering

The university has an extensive campus-wide Energy Management and Control System (EMACS) comprising several digital meters located on both HV and LV circuits.

The HV electricity meters are installed within the 11kV main intake substations and are used to measure the consumption and demand of electricity from the Ausgrid 11kV network as well as to monitor the power flow through the UNSW 11kV rings.

The LV electricity meters are generally installed on the LV consumers mains within the LV section of the substations and on selected submains within LV main switchboards, and are used to monitor the consumption and demand of electricity within the UNSW LV network. These are remotely monitored via a purpose-built communications network.

All new metering arrangements shall comply with the requirements of the UNSW Design and Construction Guidelines, Appendix 7- UNSW Energy Management Metering Requirements Rev 4 (August 2013).

Appendix 7 of the UNSW Design and Construction Guidelines covers the following topics:
• Documentation, Approvals and Checklists for new installations and changes to existing meters or the metering network architecture.
• Meter Data Communications Network
• Electricity Meters
• Water Meters
• Gas Meters

Design planning and coordination discussions with UMSW FM Energy Management representatives shall take place at an early stage.
E.3.1.3. Main Switchroom

General

Switch rooms shall be designed to allow adequate clearances for maintenance and egress around equipment and switchgear as per the AS3000 requirements. Smoke detectors and appropriate fire extinguishers shall be installed in all switchrooms. The smoke and thermal detectors shall be connected to an alarm system that contains voltage free contacts for connection of alarms to the BMS system via the local PLC. A local bell alarm shall be installed to indicate the operation of a detector.

The switchrooms shall as a minimum cover the following items:

a) Entry door(s) suitably labelled.
b) Emergency and exit lighting.
c) Clearance around switchboards.
d) Switchboards are clearly identified.
e) MEN point(s) and main earth labelled.
f) Consumer mains/busway correctly supported.
g) Cable support system adequate.
h) Location indicated at main entrance(s)

UNSW FM Engineering has learned from past experience that the risk of fire because of the Power Factor Correction (PFC) capacitor failure and ignition is very high. Therefore FM Engineering prefers that the PFC equipment is not installed in the same room as the Main Switchboard. The PFC equipment shall be installed outside the Main Switchroom, in a separate fire rated room, well ventilated to ensure internal cabinet temperature rise does not exceed the manufacturer’s recommendations.
E.3.1.4. Switchboards & Switchgear

E.3.1.4.1. Main Switchboard

General
The switchboard shall be segregated (as a minimum) into the following sections and circuits:

a) Essential Services
b) Non-Essential Services
c) Lighting (internal and external)
d) General Power
e) Plant, Equipment and Process Heating

Each circuit shall have a minimum of 30% minimum spare capacity for space and maximum demand.

The switchboard shall be the product of a well-established switchboard manufacturer and shall be of the dead front, totally enclosed type.

The switchboard shall have a degree of protection of IP43, for interior use and IP 56 for external use.

The switchboard is to be floor mounted on a galvanised steel plinth.

The switchboard shall incorporate an earth bar and a neutral link.

Protective devices shall be interconnected by a three-phase busbar assembly that is independently supported off the switchboard enclosure.

Pay particular attention to cabling space around the circuit breaker assembly, and Current Transformers

Space around Current Transformers for any maintenance or replacement shall be included

The switchboards shall be of a modular layout having sections of standard current rated functional units related to the main busbar and busbar dropper systems in a regular fashion. The design shall be the same as a type of switchboard that has been verified as complying with the type tests specified in Section 8 of AS3439.1 the switchboard be a TTA.
Type test certificates shall be submitted with detailed particulars of the equipment tested by an approved Testing Authority. The manufacturer of the type-tested equipment shall be the manufacturer of the proposed equipment.

Should the type test documents not be available, or be inappropriate to the actual design, submit the switchboards for type testing by a NATA approved Testing Authority at no cost to the Principal and within the construction program for the contract.

The Project Officer shall be notified in writing of the name of the proposed manufacturer of switchboards before any work or drawings are commenced.

The manufacturer shall provide the UNSW the Temperature rise requirement stated in AS3439 prior to any work being started.

**Operating Conditions**
The switchboard shall comply with the requirements of AS3439.1 with the following specific Conditions of Operation to appendix BB:

a) Supply is 415/240V, 3 phase, 4 wire, 50Hz, MEN solidly earthed.
b) Control circuit voltage is 240V.
c) Minimum fault level of the assembly shall be:
d) 63 kA r.m.s. symmetrical,
e) 95 kA peak Minimum
f) Space available: 30%.
g) Segregation required is form 3b.

Preferred method of connection of equipment is Front connected (unless otherwise approved by FM Engineering).

Automatic power factor correction brand shall be supplied, (Note: protection against capacitor damage by harmonics is required).

Front connected provisions (unless otherwise approved by FM Engineering).

a) Provision for connection of stand-by generator.
b) Provision for connection of a mobile generator set.
c) Type tested design to AS 3439.1.
d) Preferred arrangement is in line.
e) Rated short time withstand current of bus-bars required is 63 kA r.m.s. for one second.
f) Diversity factor for load circuits is as per Table 1, AS3439.1.
g) Degree of protection is IP43 for interior or IP56 for external usage.
h) Form of segregation required is Form 3b
h) Possible future extensions are from one end.
i) Service and Installation Conditions Not exceeding the limits of clause 6.1, AS3439.1.
j) Switchboard safety measures shall be by mechanical means (AS3439.1 clause 7.4.2.2 Protection by barriers or enclosures) including mechanical interlocking of doors and access by tool rather than key.
k) Graded protection (upstream & downstream).
l) Full sized neutral.
m) The switchboard shall be insect and vermin proof.
n) The switchboard shall be finished Orange external; White internal.
o) The switchboard shall be mounted on or incorporate a 100 mm high galvanised steel plinth.

Submit detailed drawings, including single line diagram, of the main switchboard to the Supply Authority for approval prior to manufacture and co-ordinate the Supply Authority during the inspection of the completed switchboard to ensure compliance with their requirements.

**Switchboard Configuration**
The items described herein shall be included in the design, manufacture and installation of all switchboards.

UNSW FM Engineering must be given notice in writing of the name of the proposed manufacturer of the switchboard/s before any works and/or drawings are commenced.

Conduits and ducts shall be securely attached to the switchboard/s utilising pre-punched conduit knockouts or removable gland plates.

Where space is provided for future breakers, fuses, etc., the switchboard/s shall be fitted with the necessary bus-bars and connections to facilitate the future fitting of additional equipment without disturbance to the existing installation. Where this involves provision of unused lengths of bus-bar, this bus-bar shall be adequately supported. The escutcheon (if any) shall be cut for the future equipment and suitable filler pieces provided.

Equipment shall be firmly supported, symmetrically and neatly mounted and all wiring shall be neatly run and supported.
Connections between various pieces of equipment shall be copper bus-bar.

Terminate all incoming and outgoing cables using crimp type cable lugs or tunnel type terminals.

Doors shall be dust sealed by neoprene gaskets and ventilation openings shall be gauze screened to prevent dust and insect entry.

Doors and escutcheon panels shall cover all front adjustable settings of circuit breakers, relays and contactors.

Where multiple conduits and/or ducts, which would otherwise be visible, enter a wall-mounted switchboard they shall be covered by a removable sheetmetal panel folded and finished to match the switchboard. Alternatively, approved timber panels may be installed.

Cables and conduits run from the top and bottom of the switchboards to the floor slab below and ceiling space above shall be enclosed in neat metal duct. Ductwork shall be not less than 1 mm thick in any case.

Metal ducts shall be zincanneal of suitable thickness and painted. Pop rivets shall be used for all joints.

Where conduits or ducts required to be concealed enter a wall-mounted switchboard they shall enter the switchboard through a metal box recessed into the wall and located behind the board.

Wall mounted switchboards shall be mounted approximately 2 m from top of board to floor.
E.3.1.4.2. Mechanical Control Centre Board (M.C.C)

General
The switchboard shall be the product of a well-established switchboard manufacturer and shall be of the dead front, totally enclosed type. (See also clause “Main Switchboard General”).

Modular switchboard configuration will not be accepted.

The switchboard shall have a degree of protection of IP43, for interior use and IP 56 for external use.

Protective devices shall be interconnected by a three-phase busbar assembly that is independently supported off the switchboard enclosure.

Pay particular attention to cabling space around the circuit breaker assembly, and Current Transformers

Space around Current Transformers for any maintenance or replacement shall be included.

The switchboards shall be of a modular layout having sections of standard current rated functional units related to the main busbar and busbar dropper systems in a regular fashion.

The design shall be the same as a type of switchboard that has been verified as complying with the type tests specified in Section 8 of AS3439.1

UNSW FM Engineering must be given notice in writing of the name of the proposed manufacturer of the switchboard/s before any works and/or drawings are commenced.

The Manufacturer shall provide the Temperature Rise requirement stated in AS3439.1To FM Engineering prior any work start

The switchboard shall comply with the requirements of AS3439.1 with the following specific Conditions Of Operation to appendix BB:
All MCCB should have true RMS monitoring and will be unaffected by harmonics in the system, up to including the 19th harmonic

Construction
Supply is 415/240V, 3-phase, 4 wire, 50Hz, MEN solidly earthed.
Control circuit voltage is 240V.
Maximum fault level of the assembly shall be a minimum:
20kA r.m.s. symmetrical.
Space available: 30%.
Segregation required is form 2

The contractor/ shall provide to UNSW FM Engineering all calculation in relation to fault level prior any design, or construction. Any design/ construction of MCC board which has not been accepted in writing by UNSW FM Engineering will be rejected.

Preferred method of connection of equipment is Front connected (unless otherwise approved by FM Engineering Section).

Preferred arrangement is in line.
Rated short time withstand current of bus-bars required is 20kA r.m.s. for one second minimum.
Diversity factor for load circuits is as per Table 1, AS3439.1.
Degree of protection is IP43 for interior or IP56 for external usage.
Form of segregation required is Form 2
Possible future extensions shall be considered when MCC board is designed

M.C.C board shall have physical barrier between the isolating unit/ circuit protection and the main busbar arrangement. Segregation shall, by means of approved sheet metal physical barrier, be installed between all isolating unit/circuit protection/busbar arrangement with control units/stop/start switches and indicating lights.
All equipment mounting cubicles shall be by means of hinged lockable doors.

Full sized neutral.
The switchboard shall be insect and vermin proof.
The switchboard shall be finished Orange external; White internal.
The switchboard shall be mounted on or incorporate a 100 mm high galvanised steel plinth.

Submit detailed drawings, including single line diagram, of the main switchboard to the Supply Authority for approval prior to manufacture and co-ordinate the Supply Authority during the inspection of the completed switchboard to ensure compliance with their requirements.
E.3.1.4.3. Switchboard Components

Material
All sheet steel used in the manufacture of the switchboards shall be cold rolled, commercial, bright mild steel, free from rust and blemishes.

All structural sections used for frameworks or supports shall be first grade mild steel, truly straight and shall be thoroughly descaled and degreased. All welds shall be full fillet welds ground smooth and free of weld spatter and wire brushed clean.

Minimum thickness of steel sheets shall be as follows:
For back and sides of cabinets, cubicles, etc. - 1.6 mm.
For front and top -

Diagonal not longer than 600 mm - 1.6 mm.
Diagonal not longer than 900 mm - 2.5 mm.

Steel thickness less than 2.0 mm and 2.5 mm may be used provided the panels are stiffened by dishing, folding or bracing, but only after approval is obtained from the Superintendent.

Interchange ability of parts and equipment shall be maintained wherever practicable. Metal parts shall be machined where necessary for accurate fit and good appearance.

All bolts, screws, etc., whether used in assembling equipment or fixing it in place, shall be galvanised or made from corrosion resistant metal. Where visible on front of panels, they will be chromium plated, not cadmium plating.

Door hinges shall be of a lift-off type and for outdoor applications shall be zinc coated and fitted with hinge pins of bronze or other corrosion resistant material.

Door handles shall be chromium plated and shall incorporate a barrel type lock mechanism

Treatment of Metal Surfaces
The surfaces of switchboard enclosures shall be painted. The colour of finishes shall be as follows:

White enamel internally for both indoor and outdoor application.
Orange enamel externally, colour number N42 to AS 2700 for indoor

Doors shall be dust sealed by neoprene gaskets and ventilation openings shall be gauze screened to prevent dust and insect entry.
Doors and escutcheon panels shall cover all front adjustable settings of circuit breakers, relays and contactors.

**Termination and Connection**
Switchboards shall be complete with cable terminating boxes/glands mounted to provide ample space for making off the cable terminations; install insulated tails from these terminations to the associated switchgear and fix the tails securely to prevent any displacement.

Switchboards shall be complete with cable lugs mounted on the switchgear studs, bus-bars, extension flags etc. for all connections rated at 200A and above.

Equipment shall be firmly supported, symmetrically and neatly mounted and all wiring shall be neatly run and supported.

Connections between various pieces of equipment shall be copper bus-bar.

Terminate all incoming and outgoing cables using crimp type cable lugs or tunnel type terminals.

Any incoming existing or new cables running from the top of the switchboards to the floor slab above shall be enclosed within a ductwork. Type of ductwork shall be not less than 1 mm thick in any case and shall be zinc anneal type.

**Busbars**

**Requirement:** Busbar circuits within the switchboard, extend from the termination of the incoming unit to the line side of protective equipment for outgoing circuits. The whole busbars installation horizontal, vertical and dropper shall be fully insulated.

Where dual incoming feeds are provided, the main busbar system shall be in two sections with each incoming feed supplying a corresponding bus section. The outgoing circuits distributed evenly between the two sections. A bus section circuit breaker or switch shall be provided so that it is possible to energise both bus sections through one feed only.

**Segregation:** Where a switchboard requires “essential” and “non-essential” circuits divide the busbar system into separate ‘essential’ and ‘non-essential’ circuits, each segregated from the other by fixed and continuous barriers. Clearly label each segregated section of the busbar system.

**Standards:** To As 3768, As 3865 And As 4388.

**Definitions:** Busbars connecting incoming terminals to line side terminals of main. Busbars connecting incoming functional unit terminals, or incoming
busbars where no main switches are included, to outgoing functional unit terminals or outgoing functional unit tee-offs.

**Tee-off busbars:** Busbars connecting main busbars to incoming terminals of outgoing functional units.

**Material:** Hard-drawn high-conductivity electrolytic tough pitched copper alloy bars.

**Busbar Insulation and Protection:** The whole Busbar configuration layout shall be insulated and be in accordance with AS 3439.1. Full size neutral shall be installed. The whole busbars installation vertical and dropper shall be fully insulated.

- **Type of Insulation:** shall be polythene at least 0.4 mm thick with dielectric strength of 2.5kV rms for 1 min, applied by fluid bed process in which the material is phase coloured and directly cured on to the bars. Close fitting moulding insulation mouldings at least 1mm thick. Use heat shrink material only around edges of the busbar.

- **Taped joints:** Apply non-adhesive stop-off type tape, coloured to match adjacent insulation and half lapped to achieve a thickness at least that of the solid insulation.

**Neutral busbars and joints:** Select from the following:

Polyethylene: At least 0.4mm thick with dielectric strength of 2.5 kV r.m.s. for 1 min, applied by a fluidised bed process in which the material is phase coloured and directly cured onto the bars.

Close fitting busbar insulation mouldings at least 1mm thick.

Heat shrink material: Use only on rounded edge busbars.

Taped joints: Apply non-adhesive stop-off type tape, coloured to match adjacent insulation and half lapped to achieve a thickness at least that of the solid insulation.

**Temperature Rise Limit**

The manufacturer shall provide all Temperature Rise test as designed. The Manufacture shall provide the Temperature Rise requirement stated in AS3439.1
Main Switches and Isolating Switches
Main switches on main switchboards and isolating switches on distribution switchboards and in other locations shall comply with AS1775 and shall be suitable for fault making and load breaking duties. Switchgear and Control Gear Assembly incoming isolators shall have the same fault capacity as the assembly busbar system unless otherwise specified.

Unless otherwise specified, the following requirements shall apply:
- Type of switching shall be independent manual operation.
- Rated duty shall be uninterrupted duty for non-ventilated enclosure.
- Indicated fault capacity refers to the rated short time withstand current.
- Utilisation category shall be AC-23.
- Incorporate a primary indication of the ON and OFF positions.
- Incorporate a secondary indication of the ON and OFF positions on the switch body where the operating handle is not a fixed part of the switch.

Air Circuit Breakers
Air circuit breakers shall be in accordance with AS1930; they shall be suitable for operation on 415V, 50 Hz systems and shall be rated for continuous operation as indicated on the drawings.

Drawings are to be enclosed in the switchboard.

The main incoming ACB shall be capable of withdrawal and interlocked so that withdrawal or reconnection can be done only with the circuit breaker in the open position.

Air circuit breakers shall have the following monitoring system:

a) Single phase indication selectable for each phase
b) Earth fault current
c) Reverse power indication
d) Line voltage
e) Trip current and operating time
f) Availability of transmitting data to a PC

Molded Case Circuit Breakers
Specify current ratings for all moulded case circuit breakers.

All moulded case circuit breakers within one installation shall be of the same manufacture.
The manufacturer shall state the maximum value of current that a circuit-breaker, fitted with a specified overcurrent tripping relay, can carry indefinitely at an ambient temperature without exceeding the specified temperature limits of the current carrying parts.

The size and mounting arrangements shall be such as to permit interchange of single pole and three pole breakers of the same frame size.

Circuit breakers with current breaking capacities of 10 kA and above shall comply with AS2184.

Circuit breaker trip ratings shall be labelled or inscribed on the circuit breaker body and shall be clearly visible with the switchboard escutcheon cover in place.

**Load-break and switch fuses, motor isolators, fuses.**

All load-break & combination switch fuses should be of robust quality design and construction and be tested according to IEC947-3.

They should be designed to perform as switch disconnectors, motor circuit switches with AC ratings up to 1000 volt, main switches, local safety isolators and bus ties.

They should be pad-lockable in the off position and when in this position, both sides of the fuse link (in the case of switch fuse units) shall be isolated. Switch fuse 32 A and greater, and load-break switches 45 A and greater shall have positive drive contact position indication and quick-make/quick-break mechanisms, independent of the operator’s speed.

All switches must provide a high standard of shrouding preferably as standard. Fuse shrouds on switch fuses shall be integral and hinged to avoid misplacing when fuses are changed.

All line and load terminals shall be able to be shrouded to avoid accidental touch to a protection rating of IP 20. Unshrouded conductors on the front of the switch are unacceptable.

They shall be Stromberg OT, OETL or OS, OESA Series or approved equal.

**Operational Durability**

Mechanical endurance shall conform to the following figures as a minimum.

<table>
<thead>
<tr>
<th>Switch fuses</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 160 A</td>
<td>20,000 operations</td>
<td></td>
</tr>
<tr>
<td>200 A to 400 A</td>
<td>16,000 operations</td>
<td></td>
</tr>
<tr>
<td>630 A to 800 A</td>
<td>10,000 operation</td>
<td></td>
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</tbody>
</table>
Load break

<table>
<thead>
<tr>
<th>Current Range</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 160 A</td>
<td>20,000</td>
</tr>
<tr>
<td>200 A to 400 A</td>
<td>16,000</td>
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<tr>
<td>400 A to 800 A</td>
<td>10,000</td>
</tr>
<tr>
<td>1000 A to 1600 A</td>
<td>6,000</td>
</tr>
<tr>
<td>2500 A to 3150 A</td>
<td>1,200</td>
</tr>
</tbody>
</table>

Enclosed Motor Isolators

All enclosed motor isolators shall have published AC23 kW ratings and shall conform to the following standards; IEC 947-3, AS3947-3.

They should be IP 65 protection rating and be supplied with a safety red and yellow rotary padlockable handle. The units should be available in polycarbonate, cast aluminium or sheet steel boxes with interchangeable internal switch components for product compatibility. The switches should be able to accept 2 auxiliary contacts minimum.

The handle and cover positive contact indication of the true position of the contacts. All switches from smallest to “teasing” of the contacts in either direction is not possible. They shall be Stromberg OT/OETL Series, NHP “Ioswitch”, Sprecher + Schuh LY3 Series or approved equal.

Motor Starters and Contactors

Motor starters shall be of the magnetic contactor type, fitted with triple pole double break contacts and thermal overload protection on each pole. Overload protection shall be of the differential single-phase protection type.

Overload protection shall be sized suitable for adjusting the set point sufficiently low enough to test operation.

Under no circumstances will relays be accepted as motor starters or power duty of any kind.

Motor starting and other contactors shall comply with AS 1029 and AS 1202 or the equivalent local standard.

Selection of motor starters and contactors shall be according to the duty required. All contactors shall be noise-free when energised

Relays

All relays shall be plug-in type.
Fit relays with clear plastic dustproof covers that enclose the complete relay.
Use contactors for switching current in excess of 6A. Contactors used as relays shall have clear plastic dustproof covers that enclose the complete assembly. Provide twin contact spring sets for relays used for light duty switching (under 1A).

Use the constant resistance contact type, eg. gold contact or reed relays for where relay contacts are to be used for mixed voltages, contacts shall be adequately isolated from each other.

Clearly mark voltage type on each contactor, eg. 24 V.D.C, 240 V.A.C.

**Switches**

For Mechanical Services and Hydraulic Services control systems, all manual switches except main switches shall be the rotary type suitable for the voltage and current controlled.

**Contactors & Overloads**

**General**

Contactors and overloads used in this installation shall be of the same brand and be of consistent high quality. They shall be rated to a minimum 690 Volts and conform to the relevant standards, namely IEC 947 and Australian Standard AS 3947

**Contactors**

Where nominated Type 1 or Type 2 co-ordination shall be demonstrated. Contactors shall be rated to AC 3 switching category at an ambient temperature of 60°C. For contactors above 250 kW, AC 3 ratings at 55 °C will be allowed providing operation at 60 °C is acceptable with a de-rating of no more than 15% applied.

**Contactor Coils**

For contactors up to 55 kW standard AC coils are preferred. For contactors above 55kW AC controlled, contactors with DC coil mechanisms shall be used. The DC coils shall be controlled via an electronic circuit to precisely control the pick-up and dropout voltages of the contactor coil. It must not be possible for the contactors to “chatter”.

Maximum pick up power for these contactors shall not exceed 700 VA to minimise burden on the supply. Contactor coils above 250 kW shall have facilities for adjusting the drop out times on loss of supply. The pick-up power shall not exceed 2500 VA. All contactor coils must be accessible from the front of the contactor.

Contactors shall be Sprecher + Schuh type or an approved equal.

**Thermal Overloads**

Thermal and electronic overloads must be of the same brand as the contactors. For currents up to 90 amps, directly heated thermals or electronics can be used.
Above 90 amps the thermal overloads must be current transformer operated. Electronic overloads can be used providing they comply with clause 5.4

Thermal overloads must be of the ambient temperature compensated type and for motors above 7.5 kW, must have a differential mechanism for phase loss protection. They shall be provided with a test facility and a N/C and N/O auxiliary contact. They shall be Sprecher + Schuh type CT 3 or CT 3 K, CT 7 or approved equal.

**Electronic Overloads**

Electronic overloads must be used above 110 kW but can be additionally be used on all drives, where nominated, in place of standard thermal overloads.

Electronic overloads must also be the same brand and manufacture as the contactors for mechanical compatibility. Whenever possible, electronic overloads must be fitted directly to the contactors.

Electronic overloads for drives above 11 kW shall include the following functions and be constructed with integral current transformers:

- 15 selectable trip curves
- Test button
- Current adjustment in 1 amp steps
- Optional thermistor relay function
- Trip cause indication retained on power loss less than 30 minutes
- Remote electrical reset facility
- Phase asymmetry detection

**Critical Motor Drives**

High level electronic relays shall be used on critical motors and shall be standard on all drives above 350 kW. Such drives must comply with a separate specification written for that purpose and forming part of this set of specifications.

**Electronic Motor Protection Unit.**

The motor protection units will be required to comply with the following standards and tests:

- Impulse Voltage Withstand to IEC 255.4 Appendix E
- High Frequency Disturbance to IEC 225.4 Appendix E
- Noise Emission to EMC Standard EN 50082-1/2
- Noiseproof to EMC Standard EN 50082-1/2
- Electrical Test
- Motor Circuit to IEC 947-1 Uimp 6 kV
- Control Circuit to IEC 947-1 Uimp 4 kV
- Dielectric to IEC 255.5
- Insulation Resistance to IEC 255.5
• Operating Temperature Range –5 ºC to +60 ºC
• Degree of Protection IP 65

All programmable set points shall be adjusted via a sealed keypad on the front of the unit. Adjustment of the set points via potentiometers or dip switches will not be accepted.

The motor protection set points shall be user selectable and shall have the facility to prevent the operator from changing any set point data.

Motor protection for the following shall be incorporated as standard and shall be user adjustable:

• I²t thermal
• Overcurrent/stall
• Undercurrent (to start over-ride timer)
• Current Unbalance (asymmetry)
• Earth Fault
• Run-up time protection
• Number of starts per hour protection
• Adjustable cooling constant ratio

The motor protection shall be fitted with trip and alarm relays where nominated. Each alarm relay shall be independent of the other and each relay must have programmable set points for the modes of protection. A digital display shall be incorporated as standard for trip indication, alarm indication, read out of set point values, read out of measured values and pre-trip conditions. The alpha /numeric display shall be of English text read-out. Short form code will not be acceptable. Indication of the following functions shall be provided via the digital display;

(i)  I²t thermal capacity
(ii) Motor current in % of full load setting
(iii) Phase current in % for each phase
(iv) Current asymmetry
(v)  Earth fault current
(vi) Temperature (PT100) for each sensor input where fitted
(vii) Time to trip and reset after a thermal trip

When a trip occurs the conditions which caused the trip should be displayed. Other conditions that occurred just prior to the trip should be stored in a non-volatile memory for recall to allow fault analysis, including the last 5 starts and the last 5 trips and their causes.

The set point data, stored and running data and trip indication shall be retained in the event of a loss of power to the motor protection unit, including loss of power elapsed time recorder.
Indication available following a trip shall include:

- Motor current prior to the most recent trip
- Current imbalance prior to the last trip (asymmetry)
- RTD temperature prior to the last trip
- RTD temperature during the most recent emergency thermal reset
- Earth leakage prior to the most recent trip

**Communications**
Serial communications shall be available via optional plug-in cards for one of the following protocols:

- Modbus

**Thermal Magnetic Over-Current Relay**
Thermal Magnetic types of MCCB shall be available up to 800 A rating. All thermal-magnetic MCCBs will have an adjustable rating ($I_r$) between 63% and 100% of the MCCB nominal rated current ($I_n$).

Adjustable magnetic (Instantaneous) will be standard on all 400 A MCCBs and above, with a setting range of $5 – 10 \times I_n$

**Electronic/Microprocessor Over-Current Relay**
Electronic/Microprocessor type MCCBs will be available in ratings from 250 A to 2500 A. The adjustable ranges should be as follows:

<table>
<thead>
<tr>
<th>Current (x $I_n$)</th>
<th>Time (secs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Time Delay (LTD)</td>
<td>0.8 – 1.0</td>
</tr>
<tr>
<td>Short Time Delay (STD) *</td>
<td>2 – 10</td>
</tr>
<tr>
<td>Instantaneous (INST)</td>
<td>3 – 10</td>
</tr>
<tr>
<td>Ground Fault Trip (GFT)</td>
<td>$0.1 – 0.4 \times I_n$</td>
</tr>
</tbody>
</table>

* An $I^2t$ Ramp function will be standard, for the purposes of grading with other devices.

**Led Indication**
LED indicators are to give the type of fault interrupted by the MCCB, namely an overload (LTD), short-circuit (STD/INST) or ground fault (GFT).

**Control Wiring**
Control wiring shall be stranded conductor of minimum size 7/0.50. TPI. Flexible connections to door mounted equipment shall be 30/.025 TPI flexible cord. (Wiring systems other than the above may be accepted -particularly for
connection of solid-state components - however such departures will be by approval of the Superintendent only).

Differentiate between ac. and dc. conductors by continuous colour coding of the insulation.

Identify each end of every conductor by slip on ferrules (not clips) numbered to correspond with the circuit drawings.

Install multiple runs of control cable in slotted plastic ducting that shall be complete with clip on covers.

Terminate all incoming and outgoing control circuit cables using crimp lugs on numbered rail mounted clip-on terminal blocks.

**Miscellaneous Switchboard Components**

**Indicating Instruments**
The main switchboard and main distribution board shall be fitted with an electronic meter for current, voltage, watts & power factor. The meter shall be an IQ Data Plus from Email Westinghouse or similar.

**Indicating Lights**
Indicating lights shall be coloured in accordance with AS1431 and shall have a "Lamp Test" button facility.

**Push Buttons**
Push buttons shall be coloured in accordance with AS1431.

**Terminals**
Terminals shall be clip-in rail mounting and mounted not less than 400 mm from bottom of board.

**Surge Protection Devices**
Surge protection devices shall protect all phases and neutral. Surge protection devices shall be provided Critec Movtec MT-275V/120K connected between active conductors and earth and between neutral and earth.

**Power Factor Correction Equipment**
Power factor correction equipment is to be provided and capable of maintaining the power factor to 0.97 min.
E.3.1.4.4. Distribution Boards

General
All distribution boards shall:

- Be designed to fully comply with AS/NZS 3000 and AS/NZS 3439
- Be 3-phase, 415V, 50Hz, IP 42 rated if installed within a cupboard or IP 43 if installed within a room provided with sprinklers.
- Be Form 2 (or Form 1 with the UNSW approval) except where supporting emergency equipment (e.g. lift, etc) in which case the board will have an increased form of separation.
- Be designed to have 30% spare capacity
- Be designed to withstand the fault levels specified

Residual Current Protection shall be provided as follows:

All circuit breakers protecting “Blue” cleaning GPO’s
All circuit breakers protecting “White” GPO’s in laboratories and workshop areas
All circuit breakers protecting any outlets which are located in wet areas

All circuit breakers connecting sensitive equipment shall be equipped with surge diverter protection. The designer shall coordinate with UNSW to assess if any surge diverter protection is required.

Dedicated circuits shall be used for each different type of GPOs. Connection of dissimilar types of GPO to the same circuit is not allowed.

Where possible, circuit breakers protecting “Red GPO” circuits shall be positioned at the bottom end of the Distribution board.

Where a new Distribution Board is installed for connection of new power outlet circuits, a space of 150mm shall be provided between “White GPO” circuits and “Red GPO” circuits.

Active Harmonic Filter provisions
In areas where solid-state power supply units are used for computers or instrumentation (for example, in laboratories, server/IT rooms, data centres, etc.), the distribution board design shall be based on the effect of harmonics. In such cases, the design shall include provision for Active Harmonic Filter installation including space for CTs installation and AHF power supply. The rating of the AHF power supply should be equal to approx. 1/3 (one third) of the DB incoming supply rating.

Where possible, the Active Harmonic Filters will be installed within the distribution board cupboard or in a separate room.
To ensure the proper operation and to enhance the operating life span of the AHF, the designer shall coordinate with the architect that the AHF is installed in a dust free environment where temperature and humidity are maintained at the values specified by the AHR manufacturer.

**BCA compliant power meters provisions**

To comply with the requirements of the BCA Part J, all new distribution boards without exception shall have a split bus bar chassis arrangement (one for lighting circuits and the other for power circuits). This may be incorporated into one distribution board or may be via separate distribution boards. Each section shall have its own isolating switch and shall be fitted with provision for future installation of BCA-compliant power meters, should this become desirable for the UNSW.

The above provision shall be such that the installation of meters would only require the installation of current transformers. A space between the two chassis sections should be provided to accommodate current transformers to the UNSW EMACs standard.

**Miniature Circuit Breakers**

The miniature circuit breakers (MCB), as shown on the drawings, shall comply with AS/NZS 60898.1 and AS/NZS 60947-2. The miniature circuit breakers shall be DIN rail mounted type and available in 1, 2, 3, or 4 pole versions. They shall be of the fault current limiting design. MCBs shall be available in the range 5A to 63 Amps in a DIN format and be available with breaking capacities up to 15kA.

The breaking capacities of the MCB’s shall be equal to the prospective fault level at the point of the distribution system where they are installed or 10kA whichever is greater. When cascading with an upstream circuit breaker the characteristics of the two devices must be coordinated in such a way that the energy let through by the upstream device is not more than that which can be withstood by the downstream device and the cables protected by these devices without damage. Full details shall be available regarding co-ordination (cascading and discrimination) with upstream devices. Detail shall be either published tables or software based.

The MCB’s shall be able to be reverse-fed without reduction in performance, and be capable of being chassis mounted in either position.

The MCBs shall have the following features:

- Positive contact indication to IEC/EN 60947-2
- Fault tripping indication by a red mechanical indicator in circuit breaker front face
- Safe operation indication by a green mechanical indicator on the toggle to indicate that the contacts have opened
- Fast closing independent of the speed of actuation of the toggle
- Thermal reference temperature 50oC
• Class 2 front – improved personnel protection
• Large circuit labeling area
• Double clip for dismounting with comb busbar in place

It shall be possible to padlock the operating handle in the “ON” or “OFF” position. An easy clip on side mounted locking device shall be available with the following features:

• Locks MCB in the off position.
• Permanently attaches to the circuit breaker, so it cannot be lost.
• Have the same profile as the MCB, therefore no need to modify the enclosure or escutcheon.
• Suitable for installing in moulded plastic enclosures and standard chassis without modification.
• Available in left and right hand configurations
• be 9mm wide

Each pole shall be provided with a bi-metallic thermal element for overload protection and a magnetic element for short circuit protection. It shall be possible to fit on-site, auxiliaries of the following type: shunt trip coil, under voltage release, auxiliary switch, alarm switch or residual current device (add-on RCD) rated at 30mA. Field fixable add-on RCD’s shall comply with AS/NZS 61009.1.

Where applicable the MCBs should be distinguished with one of the following instantaneous magnetic trip type characteristics.

<table>
<thead>
<tr>
<th>Type</th>
<th>General applications such as:</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>- Lighting</td>
</tr>
<tr>
<td></td>
<td>- GPO’s</td>
</tr>
<tr>
<td></td>
<td>- Small motors</td>
</tr>
<tr>
<td>D</td>
<td>Control and protection of circuit having important</td>
</tr>
<tr>
<td></td>
<td>transient inrush currents (large motors)</td>
</tr>
</tbody>
</table>

**Residual Current Devices**

RCCB – Residual Current Operated Circuit Breaker Without Integral Overcurrent Protection

All RCCBs shall comply with IEC 1008 (AS 3190) Standard and carry an appropriate state regulatory prescribed approval No. The RCCB shall have a current rating capable of interrupting the connected load between 40 – 100 A, 2 or 4 Pole. All RCCBs will have an integral test button to test the functioning of the earth leakage detection circuit. RCCB shall accept DIN T side mounted auxiliary / alarm contacts.
RCBOs - Residual current operated circuit breaker with integral over current protection.

All RCBO’s shall comply with IEC 1009 (AS 3898 AS 3190) Standard and carry on an appropriate state regulatory prescribed approval No. 
RCBO’s shall be of the fixed thermal magnetic type with fixed earth leakage sensitivity ($I_n$) and trip time characteristics. 
RCBOs should be capable of field installation of clip on accessories such as shunt trip and auxiliary and alarm switches. 
They shall meet the back-up and selectivity criteria when used downstream with moulded case circuit breakers (MCCB) in accordance with published tables from manufacturer technical literature.
E.3.1.5. Emergency Standby Power Generator

General
An emergency stand-by power generator will be provided for a project, based on the extent of critical facilities in the project. Facilities can include animal holding rooms, server rooms, data centres, laboratories, communications facilities, and critical processes. Where emergency standby power generators are installed, a packaged type acoustically-attenuated containerised type system is preferred. The following items are to be considered in every emergency stand by power generator installation:

- Fuel storage tank/s with sufficient capacity to provide generator running time of minimum 12 hours at generator 100% load or as advised by the FM Engineering
- All fuel piping and transfer facilities to the engine together with float type signalling to the filling pumps.
- The fuel fill point needs to be in a readily accessible location at ground level.
- The fuel line pipes are to be installed into a dedicated riser.
- A permanent artificial load bank for automatic supplementary loading and for regular load testing will be provided when the generator is installed in locations non-readily accessible such as roof tops.
- Where the generator is readily accessible, such as at road level, an artificial load may be deleted, subject to the FM Engineering approval and the project requirements.
- Noise levels are to be considered in the design.
- The discharge of the engine exhaust is to be considered in relationship to any air intakes or building openings.

E.3.1.5.1. Artificial Load Bank

The load bank shall:
- have a capacity of approximately 40% of the generator prime rating in kVA for the generator to operate efficiently and reduce bore glazing.
- be automatically switched on when the external loads fall below 40% of the generator prime rating in kVA.
- be fan cooled, free standing units incorporating a fan failure or air flow restriction protection system.
- Incorporate switchgear and circuit breaker protection
- have a weatherproof construction, incorporating full stainless steel resistors and corrosion proof housing.
Installation of load banks on the discharge side of the radiator is subject to the
generator rating capacity and space requirements therefore, this arrangement
requires FM Engineering approval.

E.3.1.6. Mobile Emergency Power Generator Connection

In order to ensure continuity of power supply during times of extended power
outages, UNSW FM Engineering requires the Main Switchboards to be provided
with a Mobile Generator Connection Box in addition to the permanent connection
of a standby emergency power generator.

The mobile generator may be required to supply only specific sections of the
MSB or the entire load supplied by the MSB however, the standby emergency
power generator and the mobile generator must never be connected in parallel.
The exact configuration of the two generators will be determined and advised by
the FM Engineering on a project by project basis.
Mechanical interlocking is to be provided to ensure supplies are not paralleled
when a generator is connected.

The generator connection point shall be rated to meet the power requirement of
all the equipment that needs to be maintained in operation and shall incorporate
a phase rotation relay (with LED indicator) to provide visible indication when
generator wiring matches building wiring.

The generator connection box can be either wall mounted or free standing and
shall be positioned and secured at a suitable locations determined by the FM
engineering.
The final location of the generator connection box and the mobile generator
parking bay shall ensure that:

- cable length is minimized
- the generator connection box and the mobile generator will not obstruct
  public circulation spaces and access or egress to the facility
- noise or vibration from the generator will not have an adverse impact on
  the facility.
E.3.1.7. Wiring and Cables

General
All wiring and cables shall:

- comply with the latest requirements of AS/NZ3008
- have copper conductors. Aluminium conductors shall not be installed in any new installation unless specific permission is granted, for specific applications, by the UNSW.
- be insulated with 0.6/1 kV grade PVC compound type V75 or higher
- have an insulation temperature rating of 90 degree C
- be installed with a suitably sized earthing conductor. Metallic conduit systems shall not be used as the earthing conductor

All circular main and submain cables installed on cable ladders/trays shall be installed in trefoil arrangement. All submains to distribution boards are to be installed within electrical risers as much as possible or in common areas. Submains shall never be installed through CATS, offices or other occupied rooms.

Cables shall be installed within the floor that it is to service, unless specific permission is granted by the UNSW.

E.3.1.7.1. Cable selection

Provide cable calculations using proprietary software equivalent to POWERCAD. Provide output documents showing:

- Protective device type and setting
- Cable installation method (trefoil, spaced, etc)
- Cable current rating for the method of installation
- Maximum cable length
- Voltage drop at rated maximum demand load
- Earth fault return impedance
- Fault current at the load end

E.3.1.7.2. Voltage Drop

The maximum acceptable voltage drop values, calculated at the rated maximum demand including any future spare capacity shall be as follows:

The total maximum voltage drop on all mains, submains and final circuits - 5% or 6% where a substation is located on the premises
Mains – 0.5%, or 0.75% where a substation is located on the premises
Submains – 2.5%
- Final Subcircuits - 2.5%
The maximum total voltage drop on both submains and final circuits to the farthest outlet shall not exceed five percent (5%).

E.3.1.7.3. Cable support systems

General
The cable support system shall comprise:

- Cable Tray; and/or
- Cable Ladder tray; and/or
- Cable Mesh tray; and/or
- Cable Ladder
- Cable Ducts

Cable trays, ladders and ducts shall be fully galvanised and fitted with the manufacturer's standard bends, risers, curves, reducers and fishplates. All cable trays, ladders or ducts leaving switchboards or load centres shall have 100% spare capacity up to the ceiling space. All cable trays, ladders and ducts shall have 50% spare carrying capacity.
E.3.1.8. Locking and Labelling

E.3.1.8.1. Locking
In this clause the word “Switchboard” shall also mean “Distribution Board”

All new switchboards shall be equipped with a lockable door. When locked the door shall prevent access to circuit breakers and / or fuses, and shall prevent the removal of any cover which would otherwise expose the live conductors within the switchboard.

The lockable door shall be capable of accepting a Bilock lock, which will be fitted by the UNSW Locksmith. Initially, however, the switchboard shall be delivered with the supplier’s lock and the UNSW Locksmith will subsequently change this lock to the Bilock lock.

The following locking mechanisms are suitable for conversion to the Bilock system:

i. Standard Lockwood 100 Nightlatch with 60mm Backset and 32mm hole in door
   Standard “Double D” hole for a L&F cam lock 19.5mm diameter (Various backsets are available, approx 40mm cam preferred.
   Standard cut out for L&F padlockable L-handle to accept padlock.

ii. Abus hasp & staple part no 110/155 to accept a padlock

Where a contractor is required to work on an existing switchboard which has been fitted with a Bilock lock, the contractor will be required to apply to the Zone Manager for a key. In these circumstances the contractor may be required to sign an undertaking to return the key by a specified date or to meet the cost of re-keying should the key be lost or stolen. Other conditions may be imposed in the undertaking depending on the circumstances.

E.3.1.8.2. Labelling
In this clause the word “Switchboard” shall also mean “Distribution Board”

A labelling system has been adopted for the campus to meet the following objectives:

To have a uniform switchboards Labelling System across the campus.
To uniquely identify each switchboard.
To identify the location of the switchboard.
To be adaptable to change of location name (i.e. room number)

E.3.1.8.3. Locations of the Labels
The Switchboard label wording will appear in the following places:
On the door of the cupboard, or the door of the switchboard if not mounted in a cupboard.
On the switchboard circuit schedule.
In all other references to the switchboard.
On the door of the room containing the switchboard. This will be determined by UNSW on a case by case basis.
On the door of the room leading to the room containing the switchboard. This will be determined by UNSW on a case by case basis.
On the Electrical Fixtures circuit labels (but without the building reference number, see later) which are affixed either to each fixture or in the vicinity thereof. The exception to this is where the switchboard and fixture are in different buildings, in which case the building reference number shall be included.

E.3.1.8.4. Label Elements
The switchboard labels shall be of the following format and by way of example the label shall contain the following elements

A particular label is “D26 DB-G.01 (G21)”

The elements of this label are as follows:

“D26” – Building reference number
“DB” – Distribution board. Other possibilities are “DBR” – Riser board, “MSB” – Main Switchboard, “MCC” – Mechanical Services Board
“G” – Location of the board is on Ground level. Other possibilities are “LG” – Lower ground, “01” Level 1, “02” – Level 2 etc.
“01” – A sequential number for that type of board starting with 01.
“(G21)” – Room number of the room in which the board is located

All numbers less that 10 shall have a leading zero.

E.3.1.8.5. Electrical Fixtures Circuit Labelling
The fixtures circuit labelling shall follow the main number with an end qualifier denoting the circuit breaker number. The building grid reference is not included unless the switchboard and fixture are in different buildings, in which case the building reference number shall be included.

Therefore the circuits connected to circuit breakers 1,2,3, and 4 etc. in the distribution board “D26 DB-G.01 (G21)” will carry the following labels:

DB-G.01 CB01
DB-G.01 CB02
DB-G.01 CB03
DB-G.01 CB04, Etc.
In the case of light fittings controlled by a wall switch, it shall be sufficient to label the wall switch rather than each light fitting.

**E.3.1.8.6. Circuit schedule**
The fuses or circuit breakers shall be numbered sequentially on each distribution board as shown on the *as installed* drawings.

The UNSW will supply a circuit schedule form in Microsoft Excel format for the Contractor to fill in and return to the UNSW.

A hard copy of each circuit schedule shall be mounted in the circuit schedule holder in the cubicle door for each board. Enclose the circuit schedule with a clear Perspex cover.

The board shall be clearly zoned by scribing or neat painting or other approved means. Adhesive tapes are NOT acceptable. Each zone shall be clearly labelled using white lettering minimum 10 mm high on black labels of same material.
E.3.1.9. General Purpose Outlets

E.3.1.9.1. Types of Outlet

Generally power outlets will fall within the following four categories:

10 Amps Single Phase Outlets for connection of general electrical equipment to which any interruption or any interference of the supply will not create a loss of data information or damage to the equipment such as photocopy machines, desk-lamps, general laboratory equipment.

10 Amps Single Phase Outlets for the connection of electrical equipment to which any interruption or any interference of the supply will create a gloss of data information and/or damage to equipment. Examples include computer equipment, server high tech monitoring, and laboratory equipment.

10/15 Amps Single Phase Outlets for the connection of electrical equipment powered by electric motors. Examples include vacuum cleaners and other cleaning equipment.

15/20 Amps Three Phase Outlets For the connection of industrial electrical equipment. For example workshop machinery.

Power outlet circuits in any design for new buildings or upgrading of existing facilities are to reflect the above requirements.

E.3.1.9.2. General Purpose Outlets

Power Outlets are to be flush combination type, 10A, Single pole switch 3 flat pin receptacle unless specified otherwise.

The General Purpose Outlets shall comply with the following standard:
AS 1428 Design for Access and Mobility

The height of the GPO above floor level shall be 1000 mm nominally

The layout drawings shall indicate clearly the purpose and colour of the outlets

Outlets shall be impact resistant plastic mouldings unless otherwise specified.

Flush plates shall be coloured as follows:
(To be noted: Painted plates are not acceptable)

WHITE for outlets where electrical equipment for general purposes any interruption or any interference of the supply will not create a loss of information
or damage to the equipment. (e.g. photocopy machines, desk-lamps and general laboratory equipment)

RED for outlets where the connection of electrical equipment to which any interruption or any interference of the supply will create a loss of information and some damage to the equipment. (e.g. computers)

BLUE for cleaning equipment

Colour for any 3 Phase outlets is not critical.

Mounting height of general-purpose outlets shall be determined in relation to the type, application and usage.

Any weatherproof type outlets shall be heavy duty, high impact resistant polycarbonate or metal-clad construction with degree of protection IP 56.

Different types of GPO's shall not be ganged under a common flush plate.

**E.3.1.9.3. Accessories**

Accessories shall conform to the following Standards:

Generally: to AS 3000.
Plugs and Socket outlets: to AS 3112.
Socket outlet: to AS 3133.

**E.3.1.9.4. Mounting Arrangements**

The outlet shall always be mounted with the earth pin at the 6 o’clock position.

**E.3.1.9.5. Labels, Signs and Notices**

Unless otherwise stated by the FM Engineering Project Officer, the construction and application of labels, signs and notices shall be as follows:

Multi-layered plastic laminates with the core a contrasting colour to the faces; lettering shall be engraved to reveal the contrasting coloured core; edges shall be bevelled. Use for interior or internal applications within office and teaching areas. Labelling on final subcircuits may be of durable stick on type affixed to either the fixture or in the immediate vicinity of the fixture.

Fibreglass or rigid vinyl products with embedded legends or graphics and resistant to abrasion or impact, corners shall be rounded edges smoothed and with reinforced fixing holes. Use for safety signs for the laboratory.
Brass or bronze plates with engraved painted filled lettering. Use in exterior applications.

**E.3.1.10. Testing and Commissioning**

The electrical installation shall be fully tested