TWEED SHIRE COUNCIL

ELECTRICAL DESIGN SPECIFICATION

EL14

GENERAL SWITCHBOARD REQUIREMENTS

Table of Contents

1 CITATION

This document is named "Tweed Shire Council, Electrical Design Specification EL14 - General switchboard Requirements"

2 ORIGIN OF DOCUMENT, COPYRIGHT

3 VERSIONS

VERSION	AMENDMENT DETAILS	CLAUSES AMENDED	DATE ISSUED (The new version takes effect from this date)	Authorised by the Director of Engineering Services
1.1	Original version		1 November 2005	

4 STANDARDS

The equipment and materials supplied under this Specification must comply with the latest relevant Australian Standards, or, in their absence, with the latest relevant IEC Standards, together with the requirements of competent Authorities having jurisdiction over all or part of their manufacture, installation and operation.

In particular, all equipment and materials supplied must comply with the relevant requirements of the following Regulations, Standards and Reference Specifications.

AS 1023	Low Voltage Switchgear and Controlgear - Protection of Electric Motors
AS 1033	High Voltage Fuses (for Rated Voltages exceeding 1000V) Part 2 – Current Limiting (Powder-filled) Type
AS 1243	Voltage Transformers for Measurement and Protection.
AS 60044	Instrument Transformers
AS 1675	Current Transformers - Measurement and Protection
AS 1939	Degrees of Protection Provided by Enclosures for Electrical Equipment (IP Code)
AS 2067	Switchgear Assemblies and Ancillary Equipment for Alternating Voltages above 1kV
AS 2184	Low Voltage Switchgear and Control Gear - Moulded-case Circuit Breakers for Rated Voltages up to and including 600 V ac and 250 V dc
AS 2380	Electrical Equipment for Explosive Atmospheres - Explosion Protection Techniques

AS 2650	Common Specifications for High Voltage Switchgear and Controlgear Standards.
AS 3000	Electrical Installations (Australian Wiring Rules)
AS 3108	Approval and Test Specification - Particular Requirements for Isolating Transformers and Safety Isolating Transformers
AS 3190	Approval and Test Specification - Residual Current Devices (Current-operated Earth Leakage Devices)
AS 3439	Low-Voltage Switchgear and Control gear Assemblies Part 1 – Type-Tested and Partially Type-Tested Assemblies.
AS 3947	Low-Voltage Switchgear and Controlgear
AS 4680	Hot-Dip Galvanised (Zinc) Coatings on Fabricated Ferrous Articles
AS 60269	Low Voltage Fuses
AS 60470	High-Voltage Alternating Current Contactors and Contactor-Based Motor Starters

5 GENERAL SWITCHBOARD REQUIREMENTS

5.1 Design Capacity

All switchboard enclosures, cable ways, ladders, ducts and trunking must incorporate 30% additional electrical and physical capacity for expansion, in addition to "spare" capacity shown on drawings.

For switchboards, the spare physical space must be calculated as follows:

- (Total of Tier Heights – Used Tier Height) / (Total of Tier Height)

Light and power, Programmable Controller, and Incomer cubicles are NOT Included in this calculation

5.2 Fabrication

All cubicles must be constructed from folded sections of zinc annealed mild steel sheet of minimum 2.0 mm gauge. Large panels and module doors must be adequately stiffened, using minimum of 100 mm wide and 20 mm deep folded sheet metal, spot welded to the door or panel.

All electrical equipment must be designed for the environment in which it is installed, but must have, as a minimum, the following degree of protection in accordance with AS 1939:

- Indoor Switchrooms IP54
- Outdoor IP65
- Wet Areas Indoors IP56

Enclosures must be designed with at least 20% spare capacity both in terms of space and thermal loading rating. Terminal strips must have a minimum of 20% spare capacity.

Outdoor enclosures shall be completely constructed of 316 stainless steel or marine grade aluminium.

Weather-proof enclosures must have sloping roofs and guttering which direct water away from doors.

A resilient door gasket of skinned neoprene must make continuous contact around the cubicle door openings. Gaskets must be glued and held in place by continuous retaining strips. On outdoor switchboards, doors must seal by closing onto a 45 degree return fold rain gutter panel, all around the fixed door frame. Door hinges must be chrome plated lift off type with stainless steel pins, and with one pin longer than the others. Rotary type latch handles must be fitted to secure the door.

Large doors (over 600 mm) must have latches top and bottom. A 3 point locking system is to be used for all doors on the switchboards. All doors of field cubicles in plant areas must be lockable. Doors must be capable of opening at least 135o, and, for outdoor boards, have stays at the 90^{o} and 135^{o} positions.

Small indoor light and power distribution boards may be supplied as standard manufactured items.

All outdoor cubicles that require ventilation must be double skinned to allow hosing.

Self tapping screws must not be used.

The switchboard support channel must be more than adequate to provide rigid support to minimise flexing, and must be minimum 75 mm high, 3 mm thick and of hot-dipped galvanised steel.

Where hot dip galvanised finish is specified, surface preparation and galvanising must be in accordance with AS 1650. The galvanised coating must only be applied after all welding and machining has been completed and all welding slag and machining chips removed.

No equipment, including cable ducts, must be mounted within 200 mm of the gland plates to provide access for cable termination and glanding.

Switchboard compartments must have all exposed 240/415 V AC terminals and exposed terminals of any equipment, fully shrouded by means of proprietary cable core shrouds or device terminal shrouding accessories, or by other appropriate means such that accidental contact with live surfaces is minimised.

Equipment tiers must be of sufficient size to allow ready routing and termination of power and control cables. Generally, outgoing power cable terminations must be located towards the front of the tier for easy access and must be either direct connected to the contactor or be of the terminal strip type fully shrouded. It is preferred that the larger kW drive equipment have priority for ease of cable connection.

All equipment used on power circuits must be a type tested arrangement for arc fault containment to a level specified in any attached data sheets.

Provision must be made in the design of the equipment to prevent, as far as possible, the occurrence of an arcing fault by provision of the following features:

- adequately rated components;
- suitable insulation techniques;
- adequate creepage and clearance distance;
- suitable interphase barriers;
- suitable cable terminations;

No hygroscopic insulating material must be used.

All labels, indicating lights and other external equipment, must be neatly mounted to provide a uniform appearance of the complete assembly. All operational equipment (switches, isolators, etc.) must be mounted at a maximum height of 1,900 mm and minimum height of 450 mm above floor level.

The switchboard must be provided with lifting facilities and jacking screws to facilitate levelling during erection.

The switchboard must be manufactured in transportable sections.

The Contractor must submit drawings for approval prior to commencement of construction, in accordance with the Specification timing requirements.

Drawings for approval, but not limited to, must include:

- Dimensional general arrangement;
- Sectional views;
- Gear tray and door layouts;
- Label details.

Locknuts or shakeproof washers must be provided on all cable, busbar and wire connections, terminals, mounting screws and bolts for all electrical equipment, except where approved tunnel type terminals are used.

Doors for all cubicles including VSD cubicles, PLC distribution and marshalling cubicles, must incorporate a three point locking mechanisms.

Main incoming cable zone and end bus bar zones access panels must be bolted in place.

5.3 Painting

Finished sheet metal fabrications must have all welding scale removed and exterior surface imperfections filled. Welds must be dressed and filled. The structure must be cleaned of all rust, grease and foreign materials.

Minimum thickness of coatings must be 40 micron and must completely cover all edges. All materials and paint must be recommended and supplied by one manufacturer.

5.4 Wiring

All control wiring must be 0.6/1 kV, V105 grade, PVC insulated cables, of 30/0.25 (1.5 mm^2) minimum size flexible tinned copper conductors.

All metering and protection wiring, in current transformer and potential and transducer connected circuits, must be 0.6/1 kV, V105 grade, PVC insulated cables of 50/0.25 (2.5 mm_2) minimum size flexible tinned copper.

Wiring for load carrying circuits must be 0.6/1 kV, V105 grade PVC insulated cables of 7/0.67 minimum size (2.5 mm^2). Power circuit conductors must be PVC insulated, Elastomer sheathed, stranded copper cable.

All wiring must be oil resistant.

All control wiring in the enclosure must be sized such that it must not contribute to a voltage drop greater than 3% in any part of the circuit.

Where PLC module duct space prohibits the use of 1.5 mm^2 wiring, the Contractor may use 0.75 mm^2 tinned copper wiring for digital input wiring between the modules and the marshalling terminals.

Analog input and output wiring from the PLC module terminals to the marshalling terminals must be 0.5 mm^2 tinned copper twisted pair with foil shield and drain wire. The shielding must be terminated near the PLC module to an insulated "neutral" bar (such as Nilsen Federal 90 LS), with a minimum 4 mm^2 cable to the earth bar.

Control power supply bus (for internal MCC unit cell control) must extend the full length of the MCC. Active, neutral, positive and negative links must be provided at the top of each tier. Individual supplies must be taken into the unit cells from these links as shown on the drawings. Each control supply bus must be protected by a suitably rated circuit breaker.

Multicore cabling may be used between the modules and the marshalling tiers.

Wireways must be of sufficient size to run wires in PVC type cable ducts and not in wiring looms.

Where normal construction renders ducts to be impractical, looms may be used, for example on hinged doors.

Flexible conductors of equivalent current carrying capacity and insulation level must be used where power wiring crosses from fixed to hinged panels. These cables must be bound and protected with "Spiroflex" between the two fixed points.

Twisted pair wiring must have one black wire and one white wire to each pair.

Wiring from CT secondary terminals must have the respective phase identification colours for actives (i.e. red, white, blue). Wiring from the earth terminal stud to earth must be green/yellow.

Wiring or insulation which has been damaged or nicked will not be accepted.

Each individual motor control circuit must have at least one direct connection to the neutral busbar.

Operation of all protection and safety devices must be included in hardwired circuits to ensure all protection trips occur independent of software programmed functions, except as specifically approved by the Council.

Each hardwired circuit must be monitored by the PLC at each point along the circuit to detect the operation of each element. Monitoring via additional contacts must only be used if approved by the Council.

All wiring must be adequately supported and all clips used to support and position the wiring are to be of non-conducting material.

All control and earth leakage test conductors passing through C.T.'s must be terminated in a suitably rated terminal strip adjacent the C.T. designed to allow removal of the C.T. without need to remove the conductors from looms or duct.

All wiring must be continuous – no joining of conductors will be accepted.

All control circuit within enclosures containing contactors, relays, etc, that connect to external circuits must be brought to a terminal strip. The wiring from the contactors must be formed around the periphery of the contactor panel within the enclosure. The terminal strip must be located at the front of the enclosure for ease of fault finding and for maintenance purposes. Spare cables and/or cable cores must be terminated in the terminal strips, one core per terminal, and must be labelled "spare" for identification.

Where any connection is made using a nut, bolt or stud, a cadmium plated star washer must be used.

All conductors and cabling must be shrouded over metalwork edges by a compliant insulating barrier so as to prevent damage to the cabling by cutting or vibration wear.

Neutral or negative conductors to relay, contactor and timer coils supplied from the same circuit breaker or fuse may be looped by using appropriate type compression lugs provided that not more than two conductors are jointed in the one terminal.

Separate neutral or negative conductors must be run for each different voltage system installed.

Plastic ducting may be used to carry wiring within the switchboard provided that, when the installation is complete, the wiring ducts must not be filled to more than 80% of their rated maximum wire capacity. Sheet metal ducting must not be used.

The principles of wiring identification and the arrangement of test terminals for current transformers must be in accordance with AS 1675.

Wiring must be adequately ferruled so that incoming and outgoing wires can be identified, as per the Drawings.

Wiring carrying signals sensitive to external interference must be separated from other wiring systems (e.g. control cables and data/voice transmission cables).

All control wiring must be completely separated from all power wiring.

All wiring must be colour coded as per Standard Specification EL01.

5.4.1 Noise Immunity

All cabling and wiring within the enclosures must be carried out so as to prevent disturbance of sensitive circuits by electro-magnetic/radio-frequency emissions, particularly with the use of variable speed drives and solid state starters.

Installation of these drives must be carried out in accordance with the drive manufacturer's recommendations.

Installation of cabling, wiring and components for control, instrumentation and communications must be carried out with particular attention to:

- earthing;
- cable/wiring routes;
- segregation/separation;
- shielding.

5.5 Termination

At each point of termination, each conductor/wire must be provided with an indelibly marked identification ferrule of the thread-on type which must be a firm fit over the insulation and must be manufactured from a non-combustible material. Spares must be identified with core and cable numbers. Ferrule numerals must be as shown on the wiring drawings.

The distance between power cable terminations and gland plates must be:

- Up to 25mm² : 250 mm
- Over 25mm² up to 95mm² : 350 mm
- Over 96mm² up to 185mm² : 400mm
- Over 185mm² : 450 mm

Power and control cable conductors, including spare conductors, must be terminated in correctly sized rail mounted tunnel type terminals with conductor clamping plates. Wiring must be such that not more than two wires must be connected to any one terminal, one wire from each side. Adjacent terminals may be coupled using a spring washer secured connecting bridge or comb produced by the manufacturer to provide additional wire terminations where required.

A minimum gap of 45 mm must be left between terminals and cable ducts.

Creepage and clearance distances at all terminals and terminations must be as per AS 3439.

Intrinsically safe terminations must be strictly in accordance with AS 2380 Part 7, particularly regarding the segregation of intrinsically safe and non-intrinsically safe cabling, apparatus, terminals and terminations.

All terminals, including those forming part of proprietary equipment, must be labelled with a terminal number in accordance with the Council's approved circuit schematic.

The terminals for all outgoing cables must have, in addition to terminal number, engraved labels nominating the function of the outgoing termination. The wording of this labelling must be approved in writing by the Council.

Test blocks must be provided to enable injection of signals for testing and calibration of all metering and protection circuits and for the purpose of connecting recording and test instruments.

Terminals with shorting links must be provided on current transformer secondary circuits.

Conductors of control and indication cables entering the switchboard which receive a voltage supply in excess of extra low voltage from an external source must be connected inside the cubicle to terminals which are suitably grouped, shrouded and fitted with warning labels to prevent the possibility of maintenance personnel touching live terminals.

The ends of flexible conductors must be terminated by the use of compression type lugs. Each wire must be crimped individually.

All terminations must be suitably locked for protection against loosening by vibration. Wiring terminations of all multi-strand conductors must be made without sealing the end solid.

Unused terminals in equipment must not be used for looping control and power cables.

All terminals must be grouped and labelled separately for power, control, signal supplies, etc., and barrier plates fitted to distinguish between different supply sources.

Fifteen per cent spare terminals must be provided in all terminal strips.

Where lugs are used for connections, suitable full size bolts must be used. Where lug holes are not big enough they must not be enlarged, but copper flags used. Solder lugs must not be used.

Arc barriers must be fitted between terminal blocks having different voltages, and where indicated on the termination diagrams.

Current test terminals and earth test terminals must be of the rail mounted tunnel terminal type with conductor clamping plates. Barriers must be provided between phases.

5.6 Switchboard Earthing

On multi-sectional switchboards incorporating busbar systems, the main earthing bar must be fitted along the full length of the switchboard. All gear trays, module frames, panel doors and other metal fitted with electrical equipment must be adequately earthed.

All secondary windings of current transformers must have one lead earthed.

All connections to the main earth bar must be readily accessible without disturbing other internal or external wiring.

All electrical equipment must, even where not required by AS 3000, be provided with an earth termination.

Doors and removable panels in enclosures must be bonded to the frame of the enclosure using flat braided conductors.

For inside cable zones the earth bar must be provided with the following;

- 4x 12mm bolted connections
- 3x 8mm bolted connection for each starter cell serviced by the cable way
- 1x 36 hole double screw earth link

For inside compartments where gland plates are provided the earth bar must be provided with the following;

- 4x 12mm bolted connections

- 3x 8mm bolted connections
- 4x 6mm bolted connections

5.7 Cable Gland Plates

Removable cable gland termination plates, manufactured from 6mm brass plate, must be provided on the top and/or at the bottom of the switchboards. A neoprene gasket must be fitted to the gland plate. The gland plates must be solidly bonded to the earth bus with earth conductors.

5.8 Identification and Labelling

Identification and labelling must comply with Standard Specification EL01.

5.9 Bus Ducts and Busbars

Busbars and busbar markings must comply with AS 2067 in the following respects:

1) Ratings to Section 4 of AS 2067.
2) Busbar jointing to Clause B3.2.3 of AS 2067 using Belleville washers torqued to the manufacturer's recommendation.

The busbar system must be designed to withstand the specified fault level without overheating or distortion.

Where required, switchboards must include suitable bus duct flanges and the necessary transitions and enclosed bus ducts, to provide connections through the main circuit breakers on to the transformer terminal chambers.

The bus duct enclosures must be metal of adequate rigidity and non-ventilated. Outdoor sections must be weatherproof, to IP65. Bus ducts longer than one metre in length must be fitted with an expansion joint.

Design of the switchboard busbar system must permit future expansions to both ends of the switchboard. Switchboard extension tiers must have busbars arranged in a matching configuration to existing switchboards. Transition tiers for busbar joints must not be permitted unless otherwise specified.

All busbars must be of high conductivity flat copper bars. Busbars must be mounted on nonhygroscopic insulators in a separate compartment. Busbars must be colour coded by 25mm wide bands to standard phase colours red, white and blue. Neutral and earth busbars must also be colour coded, black and neutral, and green/yellow for earth.

Busbars must be tinned at all joints on both sides.

Busbar joints must be multibolted with suitably spaced bolt assemblies. The components of each bolt assembly must be fully machined and must be high tensile (8.8), zinc plated. Each bolt must have a Belleville type washer under each bolt head and under each nut, and be torqued to fully compress the washers.

Busbar rated normal current must be a minimum of 120% of connected load. The neutral busbar must have a continuous current rating of not less than half the phase busbar rating. An earth bar of 6 x 25 mm minimum size and sized to AS 3439 Annexe B, copper bar must be run the full length of the MCC, immediately adjacent the glanding area.

5.10 Voltage Transformers and Control supply Transformers

Voltage transformers must comply with AS 1243.

Each voltage transformer and control supply transformer primary winding must be connected to the switchgear through fuses which must be replaceable while the circuit is alive.

5.11 Current Transformers

Current transformers must comply with AS 1675. Class and VA rating must be as required for the protection, measuring or controlling function and as a minimum:

1) Metering transformers must have Class 1.0 accuracy and 10VA minimum burden, 5 Amp, rated secondary output.

2) Protection transformers must be selected to suit the appropriate protection relay, and must have a 5 Amp rated secondary current.

Terminals with shorting links must be provided on current transformer secondary circuits.

Current transformers must be foot mounted using a metal bracket. Large protection current transformers must have additional supports when mounted on a vertical surface.

5.12 Protection Relays

In general, relays must be of the draw out flush mounted type with rear connections.

Tripping relays must operate between the limits of 50% and 120% of nominal rating.

5.13 Earth Leakage Protection

The incoming circuit and each outgoing circuit from the MCC must be protected by an Earth Leakage device.

All circuits not contained wholly within the ‘Equipment’ enclosures and above the limits of ‘Extralow Voltage’, must be protected by a suitable, approved earth leakage device.

Independent adjustable test facilities must be provided for each E/L device. The Main E/L must be tested by actual application of an Earth Fault current at 20% above the trip current setting. In all other cases it is preferred that E/L testing be carried out by toroidal (primary) injection.

All earth leakage devices must be capable of being tested and reset externally.

The analogue output function of the Earth Leakage Relay must be used to provide a percentage (%) of trip current input signal for monitoring purposes to the PLC.

All earth leakage relays provided must be of the core balance type, with the necessary relays and toroids. Earth leakage equipment must comply with AS 3190 and AS 2081 and the following:

- Motor and outgoing feeder circuit earth leakage equipment must be provided with test, reset and indication facilities on the front of each unit cell door. The sensitivity must be adjustable from 180 to 1,000 mA and initially set at 500mA;
- Outgoing circuits to distribution boards must have earth leakage protection of 500 mA sensitivity and time delay of 0 to 500 ms;
- Outgoing circuits, welding outlets and vulcanising outlets must have earth leakage protection of 30 mA sensitivity and time tapping from 0 to 500 ms;
- General Purpose Outlets, GPO's, must have earth leakage protection from integral circuit breakers of 30 mA;
- Cables must be located centrally and symmetrically within the toroid bore with at least 100 mm of straight cable on either side of the toroid.

5.14 Main Circuit Breakers

Every switchboard, regardless of its function must be equipped with a major main circuit breaker which must isolate the load of the board. A means must be provided for padlocking the main circuit breaker in the "open" position.

Incoming circuit breaker units must be three pole withdrawable air or moulded case circuit breakers, and must comply with the following requirements:

1. Where the main circuit breaker is of the withdrawable type, it must be fitted with safety shutters and a means must be provided for padlocking the shutters and circuit breaker in the "isolated" position.
2. The required fault interrupting capacity of all circuit breakers must be established by the Contractor from data supplied by the Council for upstream supplies. Fault level calculations must be submitted to the Council for approval.
3. The current rating of any major main circuit breaker must equal the rated secondary current of the transformer supplying it, but must never be less than the diversified maximum demand of the switchboard.
4. The line side of the main circuit supply zone must be fully shrouded so that no exposed surface is at a higher potential than 50 V AC with the door open.

5.14.1 MCC Incoming Air Circuit Breakers

These circuit breakers must be installed where the connected load exceeds 500 kVA and must incorporate the following features:

1. Circuit breakers must incorporate "Service", “Test” and “Isolated" positions, with provision for padlocking the circuit breaker in the "isolated" position.
2. Where specified, closing by a motorised or manually charged, stored energy spring closing mechanism with mechanical release.
3. Circuit breaker must be fitted with safety shutters and a means must be provided for padlocking the shutters and circuit breaker in the “isolated” or “0” position.
4. Opening by an under voltage release or shunt trip coil. A minimum of one under voltage release or shunt coil must be provided per circuit breaker. A mechanical trip facility must also be provided. The voltage of the coil must be as approved by the Council.
5. Four normally open and four normally closed auxiliary contacts.

6. Interlocks to prevent the following:
    - racking in with the spring mechanism charged;
    - door opening with the circuit breaker closed;
    - operation of the circuit breaker with the door open except in the test position.
7. Controls and indications consisting of the following, and mounted on the front panel of the circuit breaker:
    - manual "Close" push button;
    - manual "Trip" push button;
    - closed – trip indication;
    - spring charged – discharged indicator;
    - service, test, isolated position indication.

8 Protection relays and associated current transformers providing for the following protection:

- inverse definite minimum time overcurrent and earth fault protection with "Very Inverse" characteristics;
- high set instantaneous protection for both overcurrent and earth fault with the following settings:
    - 10% to 70% for earth fault;
    - 400% to 1600% for overcurrent;
    - full adjustment over the protection curve characteristics.

5.14.2 Incoming Moulded Case Circuit Breakers

Where the connected load is less than 500 kVA fixed moulded case circuit breakers shall be provided.

5.14.3 Moulded Case Circuit Breakers

Moulded case circuit breakers for outgoing feeder circuits must comply with the following requirements:

1. Circuit breakers must be of the High Interrupting class as defined in AS 2184 Clause 3.2 and must have adjustable thermal overload and adjustable magnetic short circuit protection.
2. Circuit breakers must be rated for the relevant load under the service conditions indicated in this Specification.
3. Circuit breakers which are used for circuit isolation must be provided with an operating handle with door interlock and interlock defeat, and with "ON/OFF" indication and padlocking facilities.
4. Circuit breakers must be fitted for 240 Volts AC shunt trips. One shunt trip coil must be provided per circuit breaker.
5. Circuit breakers must also be fitted with 2 N/O auxiliary contacts suitable for switching 24V DC, 10 mA PLC signals with no loss of signal integrity.

5.15 Motor Control Centre Equipment

5.15.1 General

The Contractor must ensure that sufficient space is allocated in the motor control centre cells, and in particular:

- Starters are sized to accommodate not less than one (1) cable size larger than those listed in the cable schedule.
- Contactor coils can be removed and replaced without removing the contactors or any other components.
- Clearance from starter components to motor control centre partitions, with doors in closed or any open position, not less than 20mm.
- Clearance between starter components not less than 20mm.

5.15.2 Unit Cell/Motor Isolating Devices

Motor / cell isolating devices must be moulded case circuit breakers of the motor short circuit protection type, conforming to AS 3947 and the following requirements:

1. All motor isolating devices must be of fault break, fault make type capable of interrupting, without damage, a locked rotor current equal to seven times full load current of the respective motors, and the anticipated 3 phase fault level of the circuit.
2. Motor isolating devices must be provided with two normally open auxiliary switches. The switch contacts must be suitable for 24 V DC 10 mA PLC signals with no loss of signal integrity and 110 V AC, 10A for motor control.
3. All motor isolating devices must have their incoming line terminals (415V and 240V) shrouded to prevent human contact.
4. The motor isolating device operating handle must be fixed to or have positive action linkage with the isolating switch and must indicate very clearly whether the isolating switch is in the "ON" or "OFF" position, with the unit cell door both open or closed. The handle must be captive with the door in the open position.
5. Provision must be made for padlocking the isolating device operating handle in the "OFF" position, by means of at least two padlocks.
6. A door interlock latch must prevent opening of the unit cell door when the isolating device is in the "ON" position. However, an interlock defeat must be provided for authorised personnel.

The Contractor must set the circuit breaker to the current detailed in the Type 2 Co-ordination table.

5.16 Contactors

Contactors must be to AS 1202 Part 1 and AS 1029 and Type 2 Coordination. Unless otherwise specified, the coils must be 240 volt, 50 Hz for all drives. Each contactor must be fitted with auxiliaries as shown on the schematic diagrams, and every contactor must be provided with at least one.

The minimum size contactor used must be suitable for 5.5 kW and all contactors must be derated if necessary for operation at the temperatures likely to be attained inside the cubicle. The switchroom ambient temperature will be 45°C unless otherwise specified. All contactors must operate without damage or welding (refer AS 1202) when supplied through the maximum setting of the upstream circuit breaker.

All contactors and their respective wiring connections must be selected such that the temperature rise on the conductor terminals is limited to a maximum of 50°C. The temperature limitation must be achieved in accordance with the standard specification (refer Clause 5.4 of AS 1029, AS 1202 and AS 1864) by either of the following methods:

- derating of the contactor to 80% of its maximum thermal rating;
- increasing the size of the conductor, where it can be demonstrated as reducing the conductor temperature at the terminals.

Auxiliary contacts must have a rating of not less than 6 A at 240 V AC.

415 V contactors must comply with the following classifications under AS 1029 Part 1 and AS 1202 – Part 1.

Rated Duty:	Continuous and Class 3
	(300 operations per hour)
Utilisation Category	AC3
Mechanical Duty	Class 10 (10 million operations)

Contactors for motor control units for reversing duty must be electrically interlocked.

5.16.1 Overload Relays

(a) General

A blank overload setting label must be attached to the rear of each starter cell door for recording overload set points. The material must be suitable for marking with a pencil or whiteboard marker.

All overload relays must be provided with not less than one normally open and one normally closed contact to activate trip and indication conditions. A single changeover contact is not acceptable.

(b) Thermal Overload Relays

Thermal overload relays must be of the ambient compensated, three-element bi-metal adjustable type, with phase loss protection.

Such devices must be capable of withstanding the let through fault of the upstream circuit protection.

Thermal overload relays must be selectable for manual or automatic reset. Thermal overloads must be set to automatic reset. The Contractor must set the thermal overload to suit the Type 2 co-ordination table.

(c) Electronic Overload Relays

Electronic overload relays must be capable of being flush door mounted, and of being reset remotely from a programmable controller or communication link.

During normal operation, electronic overload relays must indicate motor load as a percentage of full motor rated load.

Under fault conditions, the following indications must be provided:

1. Motor overload;
2. Phase loss;
3. Locked rotor;

4. Motor earth leakage.

5.16.2 Thermistor Relays

Thermistor relays must be selected to suit the thermistor characteristics which must be of the positive temperature coefficient type with a thermistor in each phase winding of the motor.

Thermistor relays must be suitable for operation with a power supply voltage ranging from 70% to 130% of the control circuit voltage.

Thermistor relays must be provided with not less than one normally open and one normally closed contact to activate trip and indication conditions. A single changeover contact is not acceptable.

Thermistor relays must be selectable for automatic or manual reset. Thermistor relays must be set to automatic reset.

5.16.3 Resistance Temperature Detector Relays

Where required, Pt 100 RTDs providing 4 – 20 mA outputs. must be provided.

RTD relays must have ambient temperature compensation, and the outputs must be calibrated for a temperature range of 0º to + 100º, or 0º to +200º in the case of motor windings.

RTD relays must be suitable for operation with a power supply voltage ranging from 70% to 130% of the control circuit voltage.

RTD relays must be provided with not less than one normally open and one normally closed contact to activate trip and indication conditions. A single changeover contact is not acceptable.

RTD relays must be selectable for automatic or manual reset. RTD relays must be set to automatic reset.

5.17 Power Supply Metering

Each main distribution board or MCC must be equipped with the following instrumentation:

- A voltmeter with selector switch to read the 3 interphase and 3 phase to neutral voltages, connected to the line side of each incoming feeder.
- An ammeter with selector switch to read the 3 line currents for each incoming feeder.
- A 3 phase kWh meter for each incoming feeder (where required)

The above must be connected through a set of metering links mounted on the front door or dead front panel and fitted with a removable insulated cover.

5.18 Fuses and Fuse Switches

The fuse switch units must be rated as specified. Generally fault make – load break.

Fuse switch units must be of the chassis type and must be designed to accommodate HRC fuse links. Fuse switch units must be of the double air-break, quick-make, quick-break, and must have a mechanism smoothly driven by springs on both sides.

The fixed contacts must be shrouded and the arrangement must be such that when the switch is in the open position, the double-break isolates the HRC fuse links so that they can be replaced in complete safety.

The fuse switch must have a hand-operated lever and an "ON/OFF" position indicator must be provided and must be operated mechanically by the moving contacts to ensure accurate and positive indication

Fuse switch units must be provided with interlocks and the arrangement must be such that:

1. The cover panel cannot be opened whilst the switch is closed.
2. The unit cannot be operated with the cover open unless an interlock is purposely defeated.

Fuse switches must be capable of breaking the rated current and must have a short circuit rating equal to or higher than the associated busbar.

Fuse switches with the fuses mounted in the lid of the unit will not be accepted.

All components must be capable of continuously carrying rated normal current without excessive temperature rise (board doors all closed).

All fuse switches must have facilities for padlocking in the off position.

In all cases, the top terminal of fuses must be the live terminal.

The use of fuses must be minimised, with preference being given to the use of circuit breakers wherever possible. Fuses must only be used where there is no circuit breaker of a suitable size, current rating, voltage rating or fault capacity available.

All fuse elements for voltages up to and including 1,200 VAC (1,000 V AC nominal) must be in accordance with AS 2005.

All fuse elements for voltages above 1,000 VAC nominal must be in accordance with AS 1033.2.

Fusegear for use from 660 VAC up to and including 1,200 VAC (1,000 VAC nominal) must be English Electric type T.A.C. retained in English Electric type R.S.L. front connected wedges and bases.

Control circuit fuses for use up to and including 250 Volt (nominal) and in the range 2 Amp to 32 Amp must be selected from the GEC N.S. series of fuse elements.

Suitable provisions such as retaining brackets must be made on all fuses to prevent malfunction due to the fuse wedge vibrating or falling out.

In addition to other labelling as detailed by Specification, all fusegear must be labelled detailing the fuse rating and fuse type.

5.19 Control Power Supplies

5.19.1 AC Control Power Supplies

Unless otherwise specified, contactor coils must be supplied at 240V AC with one leg earthed.

Control transformers must be double wound dry types with an earth screen between primary and secondary windings, and a dedicated earth terminal. The secondary centre tap must be connected to the main earth bar.

Regulation must not exceed 5%.

All AC control power supplies must be of the same make and type. Labels must include primary and secondary voltages, and VA rating.

5.19.2 DC Control Power Supplies

Unless otherwise specified, all PLC inputs and outputs must be at 24V DC.

Direct current power supplies must be provided in accordance with the following:

- Each power supply must be of the same make and type;
- Voltage ripple from the power supply must not exceed 3% of the rated output voltage for an output current range of 0 to 100%;
- Output of power supply must be over-voltage protected.
- Labels must include input and output voltages and power ratings.

Direct current power supplies will be supplied from an uninterruptible power supply, which will also supply the following equipment:

- Programmable Controller
- SCADA
- Instrument Transmitters

5.20 Indicating Instruments

Indicating instruments for panel mounting must be of the flush mounting type. They must comply with AS 1042 accuracy Class 1.0 with 96 mm minimum square face and external zero adjustment.

All indicating panel instruments must have a maximum scale deflection of at least 240º.

Ammeters must be provided with red lines on the scales to indicate the full load current of the circuit. The full load current of the circuit must be between twenty-five per cent (25%) and eightyfive per cent (85%) of the effective range of the ammeter. Ammeters for motors must be rated for indicating momentary overloads of up to six times their rated current.

All panel instruments must be capable of carrying their full load currents without undue heating.

They must not be damaged due to the passage of fault currents up to the maximum fault current of the switchgear. All panel instruments must be back connected.

Panel instruments connected to dual ratio current transformers must be provided with reversible scales. Panel instrument movements of the tautband type are preferred. Panel instrument glasses must be coated with anti-reflective material.

5.21 Push Buttons

Pushbuttons must be in accordance with Standard Specification EL01.

5.22 Indicating Lamps

Indicating lamps must be in accordance with Standard Specification EL01.

5.23 Shrouding

All electrical components must be shrouded to provide IP2X protection, irrespective of door interlocks and switch isolation.

Switchboard compartments must have all exposed 240/415V AC terminals and exposed terminals of any equipment fully shrouded. This must be by means of proprietary cable core shrouds, device terminal shrouding accessories, or by other appropriate means, such that accidental contact with live surfaces is prevented.

5.24 Control Relays and Devices

Auxiliary control relays and timers must be heavy duty, plug in type, and must be capable of "hold-in" down to 80% of nominal voltage.

Control voltage for all circuits must be 24 V DC or 240 V AC unless otherwise specified.

The DC operating coils of control relays powered by a PLC output must be protected by surge suppression diodes.

Unless otherwise specified, control relays must have a minimum of two normally open and two normally closed contacts.

5.25 PLC Equipment

Individual MCC's must include a separate tier or cell containing a dedicated PLC system controlling all drives and ancillary equipment fed from the MCC. The tier or cell must be fitted with I/O racks and/or marshalling terminals for the MCC I/O and field I/O.

5.25.1 Arrangement

The processor and I/O racks must be arranged in the top of each cubicle with the marshalling terminals mounted below. The terminals must be mounted on three (3) full height rails with 100 x 100 duct between and outside each rail for wiring.

Terminals must be located in groups to match the drive arrangements in the MCC. All analogues must be terminated together. Each drive must have a minimum of 20 terminals with labelled spacers. Each terminal must have its own discrete number mounted on the wiring arms.

A 240 V AC general purpose outlet must be installed in, or adjacent to, each PLC cubicle.

An 18 W florescent lighting fitting must be provided for each PLC compartment interlocked with the associated door.

I/O racks must be supplied with spare capacity made up as follows:

1. 10% spare I/O points contained within the installed cards i.e. if the total number of I/O equals 200 points as determined from the drawing, then cards must be installed for a total of 210 points.
2. Rack spares must allow 25% additional spare slots in addition to the total derived in item 1.

An adequately sized uninterruptible power supply (UPS) for the PLC equipment must be provided.

The individual I/O addresses must be ferruled onto each wire from the PLC wiring arm to the marshalling terminals and from the unit cell equipment interlocks to the cable zone control terminals.

Each different voltage coming into the cubicle must be separately marshalled and segregated as required in the lower portion of the right hand terminal rail.

Typically, each PLC compartment must comprise the following equipment:

- I/O racks sized complete with 8 function analogue card and 16/32 function digital cards. The numbers required must be determined in accordance with this specification or as advised;
- 1 off Processor complete with battery backup;
- EEPROM memory module;
- rack power supplies rated for a complete installation with all slots filled;
- marshalling terminals complete with labels;
- 24 port optical fibre patch panel;
- serial communication converter and power supply (e.g. RS232/RS485);
- internal wiring;
- fibre optic to ethernet converter and power supply;
- cooling in accordance with PLC manufacturer's requirements;

- double GPO.

The PLC system must be separately earthed to the instrument earth. The power supply system, instrument and I/O wiring earths must be connected via terminals to a separate insulated pre-drilled earth bar located within the processor tier.

5.25.2 Communications

Efficient data communications must be established between the PLC and all intelligent devices used within the MCC, such as overcurrent relays, earth leakage relays, motor protection relays, variable speed drives and the like.

Status, parameter settings and live operational data must be monitored as a minimum. In addition, it is preferred to be able to make parameter changes across this communications link.

5.26 Marshalling, Control and Relay Panels

The panels must be front connected, with hinged panel doors.

Relays, timers and other control equipment must be mounted in one panel. Each horizontal row of equipment must be separated by PVC wiring duct.

The marshalling terminals must be mounted vertically. In large marshalling panels each vertical terminal strip must be designated as 'Field', 'MCC', 'P.L.C.' or 'Miscellaneous' connections.

Interpanel wiring must connect each terminal strip.

Cable entry must be bottom entry. Earth bars the complete length of the marshalling panel must be installed on the bottom of the cubicles.

MCC's must contain a dedicated marshalling tier containing columns of DIN-rail-mounted terminals (strips) for interface to the field/control system. All motor starter control circuit wiring which interfaces to devices external to the MCC or to another starter circuit or to the control system must be wired to these terminal strips. The interface terminals must be grouped by starter circuit and in a logical and sequential order. The interface strips must be prioritised for ease of field cable installation.

No core of a field cable must have another wire (field or panel) in the same terminal hole. The field cables will be brought in on the one side only of a vertical strip. Where the MCC drives are under PLC control, the PLC hardware must be located within a dedicated PLC tier of the MCC. Installation and wiring of the PLC items must be performed by the Contractor. Installation and wiring must be done in accordance with the PLC manufacturer’s manuals. The Tenderer must allow for a PLC tier width to suit a PLC rack width of 700 mm if the PLC rack has not been specified.

All PLC I/O points, including spares, must be wired to the MCC/field termination strips.

The PLC tier must be adjacent to and on the same side of the MCC as the marshalling tier.

5.27 Testing and Adjusting Facilities

Provision must be made, by means of external operators, for the testing and resetting of protective devices, where these devices are required to be routinely tested by the appropriate standards. e.g. earth leakage test and reset.

Where adjustments or calibrations are required to be carried out while the equipment is powered, provision must be made to carry out these adjustments without the need to open “live” enclosures.

5.28 Control Switches

Control switches must be heavy duty types and comply with AS 1431.

The size and mounting distances must be as recommended for size D30 in AS 1431, Part 2.

Actuators must have a minimum IP rating to AS 1939 equivalent to that of the enclosure.

5.29 Testing

Certificates of all type tests must be provided, including:

- Tests for temperature rise
- Test for short circuit
- Test for ARC fault containment

Preliminary and Simulation Testing must include the following:

- Primary injection testing must be carried out on all protective relays (except thermal overloads) and each relay must be proved to operate in accordance with the manufacturers data and in line with the requirements of the system protected.
- The CT polarity and ratio must be confirmed by the primary injection test.
- Earth leakage testing.
- Insulation testing of switchboard wiring, busbars and busbar droppers with a megger tester. (Care must be taken to ensure that electronic cabling is not megger tested).

The following voltage levels must be used for insulation measurement (Where electronic equipment is used, insulation tests must be carried out at voltages not exceeding the manufacturer’s requirements).

- 240V Circuits - 500V dc
- 415V Circuits - 1000V dc
- 1000V Circuits - 2500V dc
- High Voltage Circuits - Refer to AC 2560
- A power frequency withstand test must be carried out. The test must be performed with all circuit breakers and switches closed and the three phases shorted together. The power frequency test voltage must be applied for sixty (60) seconds.

The following voltage levels must be used for the power frequency withstand test:

- 415V Circuits - 2.5kV
- 1000V Circuits - 3.5kV
- High Voltage Circuits - Refer to AS 2650

The completed unit must be megger tested before and after the test. The allowable change in insulation resistance measured before and after the test is ten per cent (10%).

The minimum insulation resistance value acceptable is 100 Megohm.

Busbar ductor test.

- All data must be logged and recorded and copies forwarded to the Council.
- Full operating checks on all control circuits and interlocking including checking the electrical functioning of all equipment

The Council reserves the right to carry out inspection at any time and to witness any or all of the above testing.

The Contractor must advise the Council at least 48 hours prior to any tests.

Point to point wiring checks must be performed. Functional tests must be performed to verify wiring.

6 METALCLAD SWITCHBOARDS & ENCLOSURES

6.1 Scope

This section details the technical requirements for design, construction and testing of metal clad switchboards and enclosures including Motor Control Centres (MCCs) and Local Control Stations (LCSs).

6.2 Design Criteria

6.2.1 Operating Conditions

The switchboard and all components will be required to operate continuously at full load for 24 hours per day, 365 days per year under the climatic conditions detailed in this specification.

All equipment shall be designed to perform this duty safely and without being attended.

6.2.2 Operating Requirements

The equipment ratings shown on the drawings are the required ratings after all derating factors have been applied.

All components of the switchboard shall be selected and installed so that all circuits can operate simultaneously at the full load rating shown on the drawings at the worst climatic extreme.

The full load rating for motor circuits shall be taken as the motor full load current while the rating for other circuits shall be the circuit breaker rating.

6.3 Switchboard Performance and Ratings

6.3.1 General

The switchboards supplied under this contract shall be Type Tested Assemblies in accordance with AS 3439.1. Type Test certificates shall be held in the name of the company manufacturing the switchboards.

This specification details performance and construction requirements for switchboards. Should any requirement of this specification require the Contractor to deviate from the Contractor's Type Tested design, then the Contractor shall specify this in their offer. Otherwise, it will be assumed that the switchboard being offered is both a Type Tested design and a design which complies with the specification.

6.3.2 Short Circuit Performance

The main circuit shall be constructed to withstand, without thermal or mechanical damage for 1 second, the short circuit stresses generated by the fault level stated on the drawings and in the Schedule of Technical Requirements.

The switchboard design shall have been successfully type tested in accordance with AS 3439.1 by a recognised Australian testing authority. The design tested shall be applicable to the switchboard being supplied; i.e. it shall include feeders and motor starters if these are being supplied.

The switchboard being supplied under the Contract shall be in no way inferior to the type tested switchboard, i.e.

1. busbar ratings shall not be less than those type tested;
2. busbar supports shall be identical in material and mounting method to those type tested;
3. busbar support spacings shall not be greater than those type tested;
4. phase centres shall not be less than those type tested;
5. creepage and clearance distances shall not be less than those tested;
6. the feeder and motor starting equipment (circuit breakers, switch fuses, contactors, and overloads) shall preferably be the same equipment and in the same combination as that used in the type test (however, not every rating need have been tested).

6.3.3 Arc Containment Performance

Arc containment switchboards, including motor starting and feeder equipment, being supplied under this Contract shall provide “acceptable protection” for operators in the event of an internal arcing fault occurring on the load side of a protective device in any switchboard compartment. The design being offered shall have been tested by a recognised testing authority in accordance with the Standard Test procedures detailed in Appendix “EE” of AS 3439.1. “Acceptable protection” shall be as defined in Section EE7 of this Appendix. The construction methods used in the tested switchboard (eg venting, door bracing and door mounted equipment shrouding) shall be the same as in the switchboard being supplied under this Contract.

The protective devices (circuit breakers and fuses) offered under this Contract shall preferably be the same as those tested in accordance with Appendix EE of AS 3439.1, although not every protective device rating need have been tested.

6.3.4 Main Circuit Rating and Temperature Rise

The main circuit supply rating required will be determined by the Contractor. The main circuit shall provide this rating with a busbar temperature rise of not more than 30 degrees C above ambient and within the temperature rise limits detailed in Table 3 of AS 3439.1.

The busbar sizes shall be determined in accordance with the manufacturer's type test certificate.

Smaller busbars than those determined by the above method may be used only if the Contractor has had an approved testing authority carry out temperature rise tests on a switchboard with the same busbar sizes and similar internal configuration to the switchboard being supplied under this Contract. Should this be the case, the Contractor shall provide details of the test design with the Tender.

Regardless of busbar sizes, the temperature rise limits specified above shall not be exceeded.

Cables shall not be used in the main circuit supply except as permitted by clause 7.5.5.1.2 of AS 3439.1. When cables are used in the main circuit, they shall be double insulated.

6.3.5 Equipment and Fault Co-ordination

It shall be the Contractors responsibility to ensure that every item of equipment in the switchboard is suitable for operation at the fault level shown on the Contract drawings or is protected by upstream fault limiting or co-ordinating devices supplied by the Contractor within the switchboard.

Protective equipment shall be fully co-ordinated so that no item is called upon to break fault current in excess of its fault rating. This shall include control circuit breakers if 240V AC control is used. Control circuit shall be fault limited to less than 5 kA.

Power and control cable protection shall be such that the energy let through by the protective device does not exceed the level permitted for that cable by AS 3008.

If fault limiting devices or co-ordinated circuit breakers are proposed, then these shall be specified in the offer. If these are not specified then only equipment which is fully rated for the required fault level shall be used.

6.4 Switchboard Construction Details

6.4.1 Switchboard Layout

The Contractor shall maintain, where possible, the layout and dimensions specified in the switchboard layout drawings, but shall be responsible for the detailed design of the switchboard.

6.4.2 Busbars

Busbars shall be formed from hard drawn, high conductivity, solid round-edged rectangular copper bar.

The current carrying surfaces of busbar joints shall be thoroughly cleaned to remove all traces of dirt and grease, and shall be coated with a layer of corrosion-inhibiting jelly immediately prior to jointing. Connections shall be secured with high-tensile steel bolts and Belville washers tensioned in accordance with manufacturer's instructions.

Dust and vermin proofing of the busbar chamber shall not be dependent on a seal between the cubicle walls and the floor, but shall be by a complete metal enclosure. If ventilation is required in the bus chamber, then the openings shall be covered with grade 316 stainless steel insect and vermin proof screens.

A half capacity neutral busbar shall extend the full length of the switchboard and shall have take off points sufficiently separated from live conductors to allow safe connection of circuit neutrals. The neutral bar shall be colour-coded using bands at maximum 300 mm intervals. A full size neutral bar is to be supplied if the main neutral cable is full size.

A minimum 31.5 mm x 6.3 mm earth bar shall extend the full length of the switchboard adjacent to the outgoing cable gland plates. The earth bar shall be colour-coded with green/yellow bands at maximum 300 mm intervals. The earth bar shall be tapped and fitted with bolts, washers and spring washers to accommodate the earth connections for all incoming and outgoing cables, with 20% spare connections.

For termination of field earth cables 2.5 mm and smaller, an earth link bar with at least ten terminals shall be mounted on the earth busbar adjacent to each cable zone. Only one earth cable will be terminated at each earth terminal.

All parts of the switchboard which are required to be earthed shall be effectively connected to the earth busbar. Provision shall be made for the entry and termination of an earth cable at each end of the board, and for suitable terminals for connection to an earth core and/or steel armouring on all other incoming and outgoing cables.

6.4.3 Metal work

6.4.3.1 Internal Switchboards (Non-Corrosive Environment)

The switchboard shall be a completely self supporting fully welded rigid structure, constructed from formed zinc annealed mild sheet steel, of minimum thickness 2.0mm, free from rust, dents and any surface defects.

Equipment mounting panels shall be a minimum 2.0 mm thick mild sheet steel for those panels up to an area of 500mm x 500mm. Where panels are larger, 3mm thick mounting plates shall be used, supported by studs of adequate size welded to the case. Large equipment mounting panels, i.e. exceeding 1000 mm in any direction, shall be secured by a minimum of six welded studs and nuts.

Heavy equipment shall be supported by separate independent framework and shall not rely on the enclosure sheeting.

Equipment mounting panels are to be powder coated gloss white.

All nuts, bolts and studs shall be cadmium plated mild steel.

6.4.3.2 External Switchboards (IP56)

The switchboard shall be completely self supporting fully welded rigid structure, constructed from formed 316 stainless steel No. 4 finish, of minimum thickness 1.6 mm, free from dents and surface defects.

Equipment mounting panels shall be a minimum 2.0 mm thick mild sheet steel, supported by studs of adequate size welded to the case. Large equipment mounting panels, i.e. exceeding 1000 mm in any direction, shall be secured by a minimum of six welded studs and nuts.

Heavy equipment shall be supported by separate independent framework and shall not rely on the enclosure sheeting.

All nuts, bolts and studs shall be 316 stainless steel.

Fitted with a rain hood which overhangs a minimum of 75 mm - all round.

6.4.3.3 Doors, Removable Covers and Escutcheons - Internal Switchboards (Non-Corrosive Environment)

(a) Doors shall be constructed from formed zinc annealed mild sheet steel, of minimum thickness 1.6 mm, free from rust, dents and any surface defects. Door sealing shall be achieved by 120 degree return on case, sealing against neoprene gasket glued to the inside of the door and held in place by a gasket retaining angle.

Stiffeners shall be fitted to all doors with dimensions in excess of 1000 mm high and 450 mm wide, or as required. Doors shall open a minimum of 100 degrees for equipment access, and shall be fitted with door stays.

All doors are fitted with chrome plated pintle hinges. A minimum of three shall be fitted if the door is over 1200 mm in height. All doors shall be held closed with chrome plated lockable `T' handles, keyed L & F 92268. For doors up to 450mm high, one ‘T’ handle is sufficient. For doors above 450mm and up to 1000mm high, two ‘T’ handles are sufficient, but doors over 1000mm high shall have three ‘T’ handles.

All doors shall be effectively earthed to the switchboard case by means of flexible connection not less than 4 mm^2.

(b) Escutcheons shall be constructed from formed zinc sealed mild sheet steel, of minimum thickness 1.6 mm, free from rust, dents and any surface defects, powder coated gloss white. They shall be hinged and removable in the fully open position. Hinges to be of the concealed or chrome plated pintle type. All escutcheons shall be held closed by means of chrome plated tool type latches, a minimum of three is required if over 1000 mm in height. Fit all escutcheons with chrome plated `D' handles.

(c) Covers shall be constructed from formed zinc sealed mild sheet steel, of minimum thickness 1.6 mm, free from rust, dents and any surface defects. All covers shall be secured using acorn nuts. A minimum of six are required if the cover is over 1000 mm in any direction. Fit all covers with chrome plated `D' handles.

Acorn nuts shall only be used for covers for busbar zones and horizontal cable zones and the top and bottom of switchboards. Covers for vertical cable zones carrying LV terminations shall have pintle hinges and be secured with coin locks.

Covers for vertical cable zones with only ELV terminations shall have pintle hinges and be secured with ‘T’ handles.

6.4.3.4 Doors, Removable Covers and Escutcheons - External Switchboards (IP56)

(a) Doors shall be constructed from formed 316 stainless steel or marine grade aluminium, of minimum thickness 1.6 mm, free from dents and surface defects. Door sealing shall be achieved by a double return on case, sealing against neoprene gasket held by a retainer to the inside of the door.

Stiffeners shall be fitted to all doors with dimensions in excess of 1000 mm high and 450 mm wide or as required. Doors shall open a minimum of 100 degrees for equipment access, and shall be fitted with door stays.

All doors are fitted with chrome plated pintle hinges, a minimum of three to be fitted if over 1200 mm in height. All doors shall be held closed with Selectrux semi flush type 1107SSCUI swing handles keyed Lockwood 71. Supply Authority meter panels shall be pad-locking type keyed 177. They shall be 3-way latching if over 1000 mm in height.

All doors shall be effectively earthed to the switchboard case by means of flexible connection not less than 4 mm2.

(b) Escutcheons shall be constructed from formed zinc sealed mild sheet steel, of minimum thickness 1.6 mm, free from rust, dents and surface defects, powder coated gloss white. They shall be hinged and removable in the fully open position. Hinges to be of the concealed or chrome plated pintle type. All escutcheons shall be held closed by means of chrome plated acorn nuts, a minimum of three is required if over 1000 mm in height. Fit all escutcheons with chrome plated `D' handles.

(c) Covers shall be constructed from formed 316 stainless steel No. 4 finish, of minimum thickness 1.6 mm, free from dents and any surface defects. All covers secured using acorn nuts, a minimum of six is required if over 1000 mm in any direction. Fit all covers with chrome plated `D' handles.

6.4.3.5 Gland Plates

Gland Plates shall be single piece, 6 mm aluminium. The gland plate shall be effectively earthed to the switchboard case. Fit 25 mm wide neoprene gaskets to all gland plates, secure with 6 mm bolts at maximum 150 mm centres.

6.4.3.6 Plinth

Shall be a minimum 75 mm ‘U' channel, hot dipped galvanised. Plinth to have M12 clearance holes for bolting to the floor, and 50 mm diameter holes for inserting lifting bars, pipes to be welded between holes to stop the entry of vermin into the base of the board, alternatively, fit galvanised covers over holes after installation. Plinth shall be toe out.

For corrosive internal and external switchboards, the plinth shall be 75mm ‘U’ mild steel channel with an appropriate paint coat system contained in Standard Specification EL06 “Corrosion Protection for Mechanical and Electrical Equipment and Structures.”

6.4.3.7 Paint Treatment (Mild Steel Switchboards)

The surface of the switchboard metalwork shall be degreased and cleaned with solvent, then coated with electrostatically applied powder coat in accordance with paint manufacturers' recommendations.

Internal and external surfaces shall be orange X15 to AS 2700, gear trays and escutcheons shall be gloss white.

6.4.4 Cable Zones

Unless otherwise specified by layout drawings issued with this specification, motor control centres shall be supplied with vertical cable zones adjacent to each tier, and with a horizontal wiring enclosure running the length of the board.

Adequate access shall be provided from each vertical zone to the wiring enclosure.

Cable zones shall be adequately sized, of minimum opening width 400 mm, and shall be designed for ease of installation and maintenance of cables.

Cable tray shall be mounted over the full length of all cable zones to allow fastening of cables.

6.4.5 Switchboard Compartments

Switchboard Compartments shall have standardised width and depth and an interchangeable standardised set of heights. Compartments shall be designed and sized for ease of access for maintenance.

6.4.5.1 MCC Modules

Module doors covering low voltage equipment shall have defeatable door interlocks. The interlocking switch shall be padlockable in the off position. Control circuit shall be housed in fully sealed compartments.

6.4.5.2 Distribution Boards

Compartments enclosing circuit breakers and distribution boards shall be fitted with a hinged metal escutcheon mounted behind the compartment door, and the operating handles of the devices shall protrude through holes in the escutcheon. The escutcheons shall be latched with chrome plated tool type latches, and the overall door shall be equipped with non-lockable 'T' type handles.

The circuit breakers and isolators shall be padlockable in the off position. The padlock facilities shall not be dependent on the position of the escutcheon, which shall be able to be opened with padlocks present. Where the distribution board incoming circuit breaker or switch fuse is mounted on the escutcheon, the escutcheon shall be interlocked so that it can not be opened unless the incomer is in the off position.

6.4.5.3 Variable Frequency Drives/Soft Starters

The requirements of Standard Specification EL09 “Variable Speed Drives” shall be adhered to when providing switchboard compartments for variable speed drives.

VSD’s supplied as part of a motor control centre shall have upstream protection devices installed, as per the VSD manufacturer’s recommendations.

Drive compartments shall provide the clearances around the drive recommended by the drive supplier. Cooling fans shall be provided to maintain the manufacturer's required air flow through the compartment.

Cubicle (or drive compartment) ventilation shall be designed and sized to ensure that the heat generated by the variable speed drive(s) is fully dissipated from the cubicle and that the internal drive components and other apparatus included in the cubicle do not exceed the temperatures recommended by the equipment suppliers.

Where the drive does not have external heatsinks but requires cooling fans, then these shall draw air from outside the switchboard and shall vent to the rear or top of the board. Cooling fans shall be mounted at the inlet vent.

All inlet vents shall be filtered. Filters shall be accessible for cleaning or replacement. Outlet vents shall be 316 stainless steel screens fitted to stop the entry of vermin.

Control keypads for variable frequency drives shall be door mounted for operation without the need to open the cubicle door.

The construction and layout of the switchboard or motor control centre shall allow for the segregation needed for input and output power and control cables to limit electro-magnetic Interference (EMI). Internal layout drawings of the switchboard or motor control centre shall be submitted to the Council for approval prior to construction commencing.

6.4.5.4 Programmable Controller and Instrument Enclosures

The PLC compartment shall have the following equipment installed:

1. 24 V dc external power supply;
2. single phase GPO with RCD protection to be used by the programming laptop PC;
3. fold up, or draw out, metal tray for the programming laptop PC to sit on;
4. thermostat controlled fan and filter;
5. PLC equipment ;
6. A HMI shall be installed on the internal door of the PLC Cubicle to provide interfacing facility with the system parameters;
7. The enclosure shall be lit by a minimum of an 18 Watt fluorescent lamp to provide acceptable illumination level for detailed work.

The Programmable Logic Controller (PLC) shall have a dedicated marshalling terminals strip located in the PLC cubicle. Each individual input or output (I/O) of all installed PLC cards shall be wired to the PLC marshalling terminal strip including those I/O designated as “spare”.

6.4.6 Sealing

All switches, control devices or instruments protruding from a panel shall be sealed to match switchboard degree of protection or mounted behind a sealed perspex window in the panel to achieve higher rating.

Switchboard modules shall be sealed to restrict arc transmission in the event of a fault. Each phase of the connections between the busbars and the line side of functional unit protective devices shall be individually supported and sealed to achieve better sealing i.e. the three phases shall not be brought through the same hole into the module. In addition, provision shall be made for sealing switchboard modules after the installation of field cabling. Module cable entry points shall be bushed to prevent cable damage.

6.4.7 Shrouding

All live parts (including terminals, busbars, and control devices and meters mounted on the doors) which are behind hinged non interlocked doors or escutcheons and which carry a voltage higher than 55V shall be shrouded to IP20 to protect against accidental contact when the enclosure doors or escutcheons are open. Provide warning labels on shrouds.

6.4.8 Incoming Feeder

Where the size of the incoming feeder is shown on the drawings issued with this Contract, the Contractor shall install busbar flags, cable lugs and cable glands suitable for these cables in the incoming termination area. Cable glands (including those for neutral and earth cable) shall be mounted on the incoming gland plate suitable for the incoming circuit. The distance from cable lugs to the gland plate shall be a minimum of 300 mm, but in any case shall facilitate the ease of installation of large cables.

6.4.9 Equipment Mounting

No piece of equipment which is to be operated or viewed by an operator (pushbuttons, switches, meters) shall be mounted more than 1900 mm or less than 400 mm above floor level. It shall not be necessary to open any door or remove any cover to operate or reset any piece of equipment, except thermal overloads.

No piece of equipment shall be mounted behind other equipment or in any manner denying free access for removal or maintenance. All equipment within modules shall be mounted on equipment panels. Equipment within small modules (less than 250 mm high opening) shall be mounted within 200 mm of the front of the MCC to allow better access to terminals.

Items of equipment or terminals shall be no closer than 300 mm measured vertically from outgoing gland plates.

The Contractor shall ensure that the equipment and devices are installed in such a manner that all necessary electrical clearances are observed and that the rating accuracy of devices is not impaired either thermally or electro-magnetically by the proximity of other devices or cables.

6.4.10 Wiring Duct and Strapping

Where wiring is not run on cable tray in cable zones, wires shall be run in slotted insulated wiring duct fitted with a snap-on lid. The slots shall be of the "open" type so that it is possible to install or remove a wire without threading it through a slot.

Ducts shall not to be filled to more than 75% of their full wiring capacity to allow additional wiring to be accommodated in the future.

Where ducts are mounted upside down, the wiring shall be tied/supported to prevent the duct lid being forced open by the weight of wiring upon it.

Plastic duct or cable trays shall also be provided for accommodating the incoming cable cores from the point of cable entry, to the unit terminal block.

Where it is not practicable to run the wiring in ducts, wires shall be run in looms using flexible plastic spiral and cable ties at suitable intervals.

Wiring looms shall be supported adequately by a suitable approved means.

6.4.11 Arrangement of Wiring Duct and Looms

Ducts shall be arranged to allow wiring passing through the slots to be taken as directly to the terminals as possible. Access to terminal studs shall not be impeded by the ducts.

Ducts shall not interfere with the mounting of equipment on any surface and vice versa. Duct fixings shall not have sharp projections inside the duct which could damage cable insulation. Nylon set screws or nylon dome nut duct fixings are preferred.

The weight of wiring looms shall not cause any undue strain on the conductor strands or insulation. In particular, where a wiring loom crosses a door joint, the loom shall be arranged so that flexing across the hinge point is reduced to a minimum, and the wiring is firmly anchored on both sides. Permanent cable fixing supports shall be supplied on all hinged panels.

All groups and bunches of wires shall be run on sections of the cubicle that are free from projections such as small studs, etc., that may damage the conductor insulation. Where wires pass through holes in panels, suitable bushes or plastic grommets shall be used.

6.4.12 Terminations and Connections

6.4.12.1 Control Wiring Terminations

All conductors shall be terminated with approved crimping lugs or crimping pins. Crimping lugs or pins shall be applied using an approved certified tool with a ratchet action. Separate lugs or pins shall be used for each conductor. The size of the lug or pin shall be suited to the size of the conductor to be terminated.

Lugs shall be of the type most suited to the device terminal eg. fork tongue for stud terminals, and wire pin type for tunnel type terminals. Only one wire shall be crimped in each terminal lug or pin.

There shall be no jointing or teeing of wires between terminals.

Not more than two wires shall be connected to any terminal. Not more than one wire shall be connected on one side of any tunnel type terminal.

Where multiple connections are required on tunnel terminals, multiple terminals linked with proprietary terminal link bars shall be used. Only when more than one link is required, will wire bridges be permitted.

Screws shall not directly contact the conductors.

Terminals shall be generously spaced to provide easy access to the terminals of any circuit, and to prevent accidental contact with live circuits in the same compartment. Terminals shall be numbered consecutively from top to bottom and left to right. The numbering for each new terminal group shall start at one (1).

Control terminals shall be mounted so that the wire numbers on both sides of the terminal are readable from the front of the switchboard with covers or doors open. Control terminals in Form 3 switchboards shall be mounted in cable zones (not within the modules), within 150 mm of the front of the switchboard for easy access.

6.4.12.2 Power Circuit Connections

All power cables within the switchboard shall be connected with a suitably sized lug unless the equipment (circuit breaker or contactor) has tunnel type terminals.

Power circuit connections shall be made with high-tensile, electroplated steel or phosphor bronze bolts, with a large flat washer and spring locking washer under the bolt head.

It shall be possible to check the tightness of all connections, by removing covers if necessary, when the switchboard is completely assembled.

Provision shall be made in the termination area to allow circuits to be checked with clip-on type ammeters.

Power cables to the load shall be terminated directly on their source of supply.

6.4.13 Numbering of Wires

'Grafoplast' ferrules shall be fitted to each end of all separate lengths of control wire. Ferrules shall have black letters on a background of white insulating material. Circular type, slip-on ferrules, or saddle type clip-on numbers shall not be used. Grafoplast SI2000 series ferrules are the preferred make. “Brady” style ferrules are not acceptable.

The same ferrule number shall be used on wires forming connections directly in series or parallel in the same panel.

Wires shall be numbered in accordance with the Contract drawings. Wire numbers on wires which leave the equipment module (in form 3 switchboards), shall be prefixed with the equipment number.

Ferrules shall be arranged to read from left to right and from bottom to top.

6.4.14 Labelling

The switchboard and all modules shall be labelled with equipment number and title in accordance with the Single Line Diagram.

In addition every exterior and interior device, including terminals, terminal strips, fuses, switches, test blocks, indication lamps, relays and other equipment, shall be identified by a label fixed near the device and oriented so that it is readable from the appropriate access door. The label shall give both the device title or function and a unique alphanumeric identification code. Within a single drive module, the power circuit breaker, contactor and thermal overload shall be labelled as per the circuit diagrams.

All device labels, other than proprietary legend and escutcheon plates on devices, are to be engraved from white/black/white Gravoply laminated engraving material. External labelling is to be fixed by stainless steel threaded screws. Labels longer than 30 mm shall have clearance fixing holes to allow differential expansion of label and mounting. Where labels are mounted on standoffs they shall be suitably backed to prevent breakage.

Label letter height shall be generally as follows:

Switchboard Equipment Number:	30 mm
Switchboard Title:	20 mm
Module Labels:	10 mm
Equipment Labels:	5 mm
Pushbutton Designation	3.5mm

All removable covers and protective shrouds which give access to exposed busbars or live terminals shall be labelled with red/white/red labels marked 'DANGER 415V ISOLATE ELSEWHERE'.

Equipment connected to the line side of a switchboard incoming switch (eg. voltmeters) shall be marked "DANGER - LINE SIDE CONNECTION - ISOLATE ELSEWHERE".

A label list shall be submitted for approval prior to manufacture. Labels not so approved by Council shall be replaced at no cost if required by the Contractor.

6.4.15 Current Transformer Wiring (CTs)

All CT secondary wiring except motor CT wiring shall be connected to test links which allow testing with 2 mm banana plugs. CT wiring shall be 4mm² minimum CSA.

CTs for tariff metering on switchboard incoming supplies shall be connected to an ESAA test block as detailed in Supply Authorities Conditions of Supply and Customer Metering. The voltage connections shall also be made.

6.5 Switchboard Equipment

6.5.1 General

The electrical equipment installed in the switchboard shall be new equipment complying with relevant Australian Standards and be suitable for the duty indicated on the drawings issued with this Contract.

The equipment shall be installed so that it has the rating shown on the drawings when the switchboard is in its fully operational and fully loaded condition i.e.: all covers and doors are closed, all circuits are at full load (as defined in this specification), and ambient temperature is at maximum (as defined in this specification).

The equipment shall be installed strictly in accordance with the manufacturer’s instructions in all regards, particularly concerning clearances, enclosure sizes, temperature rise and maximum continuous current rating.

Equipment shall be securely mounted and braced so that movement cannot occur during operation under normal or fault conditions and so that adjacent equipment is unaffected and personnel operating the equipment are not endangered.

Equipment offered shall satisfy the following requirements:

1. the equipment shall meet the requirements of this specification;
2. equipment selection shall be consistent i.e.; all moulded case circuit breakers shall be from the one manufacturer and all contactors shall be from the one manufacturer;
3. equipment co-ordination shall satisfy the requirements of this specification, eg. Type "2" co-ordination between circuit breakers, contactors and backup protection of circuit breakers.

6.5.2 Air Circuit Breakers (ACB's)

Air circuit breakers shall have been tested by a recognised testing authority for compliance with AS 1930. If this testing was not carried out within Australia, then a Certificate of Approval shall be provided from an approved Australian Electrical Distribution Authority.

ACB's shall have the following classification characteristics in accordance with AS 1930:

Rated Frequency:	50Hz
Rated Voltage:	415V AC
No. of Poles:	3
No. of Phases:	3
Interrupting Medium:	Air
Mounting:	Withdrawable
Open/Close Mechanism:	Independent Manual
Trip Units:	Overcurrent/Earth Fault
Rated Continuous Current:	Rating shown on drawings or in the Schedule of Technical Requirements
Interrupting Rating:	Fault level on drawings or in the Schedule of Technical Requirements
Auxiliary Contacts:	1 N/O & 1 N/C
Short Circuit @ 440V:	P2 to IEC 947-2

The above general information applies unless otherwise specified in the tender drawings.

6.5.3 Moulded Case Circuit Breakers (MCCB's)

Moulded case circuit breakers shall have been tested by a recognised testing authority for compliance with AS 2184. If this testing was not carried out within Australia, then a Certificate of Approval shall be provided from an approved Australian Electrical Distribution Authority.

MCCBs shall have the following classification characteristics in accordance with AS 2184:

Rated Frequency:	50Hz

Rated Voltage:	115V AC
No. of Poles:	3
No. of Phases:	3
Trip Units:	Inverse time, instantaneous
Rated Continuous Current:	Rating shown on drawings
Interrupting Rating:	Fault level on drawings
Auxiliary Contacts:	To suit circuitry
Rated Service Short Circuit at 440V:	P1 to IEC 947-2

The above general information applies unless otherwise specified in the tender drawings.

MCCBs used in motor power circuits shall be combined with the motor starter specification in Clause 6.5.4 and shall be selected in accordance with the MCCB manufacturer's recommendations for the motor size. Instantaneous only trip units may be used for motor power circuits. Instantaneous trip units shall have a maximum setting of at least 15 times the motor full load current.

MCCB contacts shall have high resistance to welding with action designed to reduce wear.

MCCB switch mechanisms shall have a positive making/breaking action independent of the operating handle.

MCCB poles shall operate simultaneously.

Provision shall be made for padlocking each MCCB in the off position with door interlocking handle and padlock attachment.

6.5.4 Motor Starters

Motor starters shall have been tested by a recognised testing authority for compliance with AS 1029 and AS 1202. If this testing was not carried out within Australia, then a Certificate of Approval shall be provided from an approved Australian Electrical Distribution Authority.

Motor starters shall have the following classification characteristics in accordance with AS 1202:

Rated Frequency:	50Hz
Rated Operating Voltage:	415V AC
No. of Poles:	3
No. of Phases:	3
Interrupting Medium:	Air
Control Method:	Electrical
Type of Release:	Thermal Overload & Undervoltage
Rated Duty:	Uninterrupted
Rated Operational Current:	Motor full load current plus 20%
Utilisation Category:	AC3
Mechanical Endurance:	10 Million operations

Electrical Endurance:	1 Million operations
Co-ordination with protective device:	Type "2"
Rated Control Supply Voltage:	Refer Schedule of Technical Requirements
Auxiliary Contacts:	1 N/O & 1 N/C (minimum)

The above general information applies unless otherwise specified on the Contract drawings.

Contactors shall be of the block type with modular design suitable for vertical mounting. Mounting screws shall be accessible from the front.

Contactors over 37kW shall have replaceable contacts and removable arc chutes.

The coil shall be easily removable and magnet surfaces accessible for inspection and cleaning.

Thermal overload relays shall provide protection against single phasing.

6.5.5 Current Transformers (CTs)

Current Transformers shall comply with the requirements of AS 1675 and shall have the following characteristics in accordance with this standard:

Construction:	Window
Number of Primary Turns:	1
System Voltage:	415V
Rated Frequency:	50Hz
Rated Primary Currents:	Refer drawings
Rated Secondary Currents:	5A

Additional Information - Measurement CTs

Type:	M
Accuracy Class:	1
Rated Burden:	0.6ohms
Rated Output:	15VA

Additional Information - Protection CTs

Classification:	P
Accuracy Limit Factor:	10
Composite Error:	2.5
Secondary Reference Voltage:	10

Polarity markings shall be marked on each CT along with other information as required by AS 1675.

6.5.6 Indicating Lights

Colours shall be as indicated on the Contract drawings and as specified in Standard Specification EL03

6.5.7 Panel Meters

All meters shall be Q96 format, with 2% reading accuracy.

CT driven ammeters shall be 5A units.

6.5.8 Tools

The Contractor shall supply any special tools necessary for the maintenance or operation of the switchboard equipment.

If the Switchboard includes air circuit breakers, then a lifting trolley for removing and transporting the circuit breaker shall be supplied.

6.6 Local Control Stations (LCSs)

6.6.1 General

The LCSs shall be designed, constructed, and installed in accordance with the tender drawings and clause 7.4 – *Ray, I don't know where this should refer to* of this specification except where modified below.

LCS shall preferably be proprietary units as nominated in Standard Specification EL03.

LCSs shall contain the required pushbuttons, switches and indicating lights indicated on the drawings and which are necessary to safely operate the equipment in the field. Where motor LCSs contain three phase power isolators, the isolating switch shall have an AC23 rating for the motor being isolated. This isolator shall be lockable in the off position and be interlocked to prevent the LCS door or escutcheon being opened until the isolator is in the off position.

Where indicated on schematic drawings, LCSs shall be fitted on the out going side, externally, three phase, screwed, weatherproof plugged outlet to allow disconnection and removal of the motor by maintenance staff. All lineside connections shall be shrouded when the plug is in the disconnected position.

The internal control wiring shall be terminated on rail-mounted terminals and ferruled in accordance with the Contract drawings.

Live parts shall be shrouded to IP20 to protect against accidental contact when the doors or escutcheons are open. These shrouds shall have danger labels in accordance with this specification.

A plastic label complying with this specification shall be fitted to the LCS, bearing the equipment number in 7 mm letters and the equipment title in 5 mm letters.

Buttons shall be labelled using proprietary legend plates or plastic labels complying with this specification.

Gland plates shall be one piece, manufactured from 6mm aluminium plate, suitably earthed and sealed using a neoprene gasket.