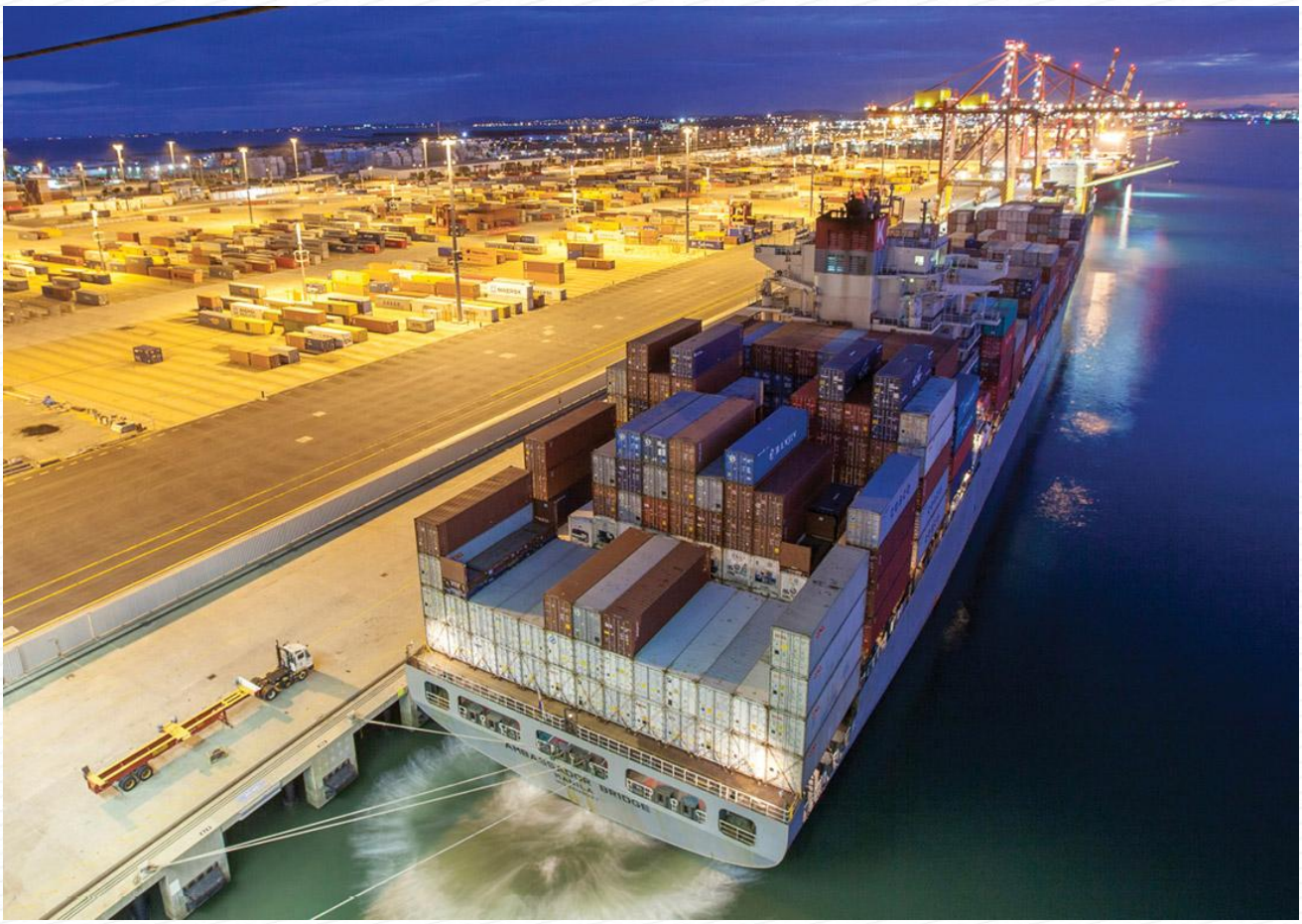
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Electrical Standard

Low Voltage Switchboards - General Requirements

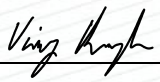
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C	Andrew Coombs ConsultJR	Updated for AS61439 requirements and PBPL preferences		11/07/2026
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F	Jun Kim Port of Brisbane	Updated PBPL Template		16/09/2026
G	Vinny Kavanagh Port of Brisbane	PBPL Issue Review		17/09/2026

Approved By

Name	Vinny Kavanagh		
Position	Manager – Power & Renewables		
Signature		**Date**	17/09/2026

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Summary of Changes

Revision	Section	Revision Details	Date
B	6.8	Added Surge Protection	12/05/2020
B	6.11	Added Generator Connections	12/05/2020
B	6.12	Added PV Systems	12/05/2020
C	Various	Updated for AS 61439 Compliance	11/07/2026
D	Various	Updated to PBPL Stakeholder Comments	25/07/2026
E	Various	Updated to PBPL Stakeholder Comments	24/08/2026
F	Template	Updated PBPL template	16/09/2026
G	Full Report	PBPL Issue Review	17/09/2026

1. GENERAL

1.1 Purpose of Scope

This specification covers the general requirements for the construction of low voltage electrical switchboards, and similar cubicle type enclosures, associated with the site power and lighting distribution only.

1.2 Key Definitions

The following definitions have been provided as normative references from AS 3000, AS 61439 and other applicable Australian Standards for key equipment.

1.2.1 Switchboard

An assembly of circuit protective devices, with or without switchgear, instruments or connecting devices suitably arranged and mounted for distribution to, and protection of, one or more submains or final subcircuits or a combination of both.

1.2.2 AS 61439 Compliant Switchboard

AS 3000 amendment 2 requires that all switchboards shall comply with AS/NZS 61439 where one or both the following exists:

- The total of the connected load at the point where the switchboard is installed exceeds 125A per phase.
- The prospective fault current at the incoming terminals of the switchboard is greater than 10kA.

The Queensland Electrical Safety Office (ESO) has specified that as of 25 November 2022, all switchboard installed within Queensland Electrical Installation must comply with the requirements of AS 61439.

1.2.3 Alteration

A modification to part or parts of an electrical installation. Alterations to electrical installation shall not cause any portion of the original electrical installation or electrical equipment connection to carry currents or sustain voltage in excess of those permitted by the applicable design standard.

Any modification (alteration) to the switchboard requires the switchboard meets AS61439 and the latest issue of AS3000. Therefore, the modification itself will require that section to be upgraded to the new standard, which may require upgrading to a whole new switchboard.

1.2.4 Repair

The work to restore the electrical installation to safe and sound working condition after deterioration or damage has occurred.

- Like for like replacement of components.
- If the component is available, new components must be better in electrical characteristic (watts loss, let-thru energy, etc).
- New doors/ covers can be manufactured providing the original fittings and fixtures are reused or replaced with current items as direct replacements.

Replacing like for like electrical components is allowable. Requires the switchboard requires the switchboard meets its design standard of the day exactly (which is usually impractical).

1.3 Acronyms and Abbreviations

Term	Description
ACB	Air Circuit Breaker
AC	Alternating Current
AF	Arc Flash
AFA	Arc Flash Analysis
AS	Australian Standard
ATS	Automatic Transfer Switch
CB	Circuit Breaker
CT	Current Transformer
CSA	Cross Sectional Area
CEC	Clean Energy Council
DB	Distribution Board
DC	Direct Current
DVR	Design Verification Report
ELV	Extra Low Voltage
FAT	Factory Acceptance Test
IEC	International Electro-technical Commission
IP	Ingress Protection
ITP	Inspection Test Plan
LCP	Local Control Panel
LED	Light Emitting Diode
LV	Low Voltage
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MEN	Multiple-Earthed Neutral
MSB	Main Switchboard
PPE	Personal Protective Equipment
NATA	National Association of Testing Authorities

Term	Description
PBPL	Port of Brisbane Pty Ltd
PSA	Power System Analysis
RCBO	Residual Current Circuit Breaker with Over Current Protection
RCD	Residual Current Device
SAT	Site Acceptance Test
SLD	Single Line Diagram
VT	Voltage Transformer

2. STANDARDS AND REGULATIONS

All equipment and workmanship shall conform to the most recent requirements of the relevant statutory Local, State and Commonwealth Authorities and current applicable Australian Standards. Alternatively, where no Australian Standard exists, work shall conform to the most current and applicable International standard. Where conflict exists between different Codes, Standards or Regulations, the higher requirement shall apply.

The Contractor shall not deviate from the provisions of the relevant standard without first obtaining agreement in writing from PBPL.

Particular standards and regulations relevant to the work include but are not necessarily limited to the following:

2.1 Australian Standards

The equipment shall be designed, manufactured and tested in accordance with the latest edition of all relevant Australian and International Standards, Codes and Regulations except where modified by this specification.

Standard	Description
AS 1284	Electricity Meters
AS 1319	Safety Signs for the occupational environment
AS 1580	Paints and related materials
AS 1627	Metal Finishing – Preparation and Pre-treatment of Surfaces, series of standards
AS 1768	Lightning Protection
AS 1939	Classification of Degrees of Protection Provided by Enclosures for Electrical Equipment
AS 2184	Low voltage switchgear and controlgear
AS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS 3008.1.1	Electrical Installations – Selection of Cables – Cables for Alternating Voltages up to and Including 0.6/1kV – Typical Australian Installation Conditions
AS 3010	Electrical Installations – Generating sets
AS/NZS 3017	Electrical Installations – Verification Guidelines
AS/NZS 3111	Approval and Test Certification for Miniature Overcurrent Circuit Breakers
AS 3715	Metal finishing - Thermoset powder coatings for architectural applications of aluminium and aluminium alloys
AS 3851	The calculation of short-circuit currents in three-phase a.c. systems
AS/NZS 4836	Safe working on or near low-voltage and extra low voltage electrical installations and equipment

Standard	Description
AS/NZS 4777	Grid connection of energy systems via inverters
AS/NZS 5033	Installation and safety requirements for photovoltaic (PV) arrays
AS/NZS 5139	Electrical installations - Safety of battery systems for use with power conversion equipment
AS 60044.1	Instrument transformers - Current transformers
AS 60529	Degrees of Protection Provided by Enclosures (IP Ratings)
AS 60947	Low-voltage switchgear and controlgear, series of standards
AS 61000	Electromagnetic Compatibility (EMC)
AS 61439	Low-voltage switchgear and controlgear assemblies, series of standards

2.2 International Standards

Standard	Description
IEEE 1584	Guide for Performing Arc-Flash Hazard Calculations
NFPA 70E	Standard for Electrical Safety in the Workplace
IEC TR 61641	Enclosed low-voltage switchgear and controlgear assemblies - Guide for testing under conditions of arcing due to internal fault
IEC 61643	Low-voltage surge protective devices
IS9001	Quality Management Systems.

2.3 Regulations and Statutory Requirements

The current regulations and statutory requirements of the State of Queensland, Australia, shall be complied with, including:

- Queensland Electrical Safety Act 2002,
- Queensland Electrical Safety Regulations 2026,
- Queensland Workplace Health and Safety Act 2011,
- Queensland Environmental Protection Act – 1994,
  - Environmental Protection Regulation 2008,
  - Environmental Protection (Air) Policy 2008,
  - Environmental Protection (Noise) Policy 2008,
  - Environmental Protection (Water) Policy 2008,
- Building Code of Australia Volume 1 and 2,

- National Electricity Rules,
- Queensland Electrical Connections Manual (QECM) 2025,
- Workplace Health and Safety Regulation 2011,
- Work Health and Safety (Codes of Practice) Notice 2011,
- Electrical Safety (Codes of Practice) Notice 2013,
- Managing Electrical Risks in the Workplace Electrical Safety Code of Practice 2021,
- Works Electrical Safety Code of Practice,
- Professional Engineers Act 2002.

3. DESIGN CRITERIA

3.1 General Design Requirements

Designs shall be robust and practicable having regard to all constraints. The designs shall be carried out using current best practice design procedures in common use in Australia and using, wherever applicable, codes and standards published by Standards Australia. Where no appropriate Australian Standard exists, the specification or design procedure of another national equivalent body shall be used.

Design services shall be performed under the control and direction of a Registered Professional Engineer/s of Queensland (RPEQ) with substantial demonstrated experience in the design of similar works to those required under the contract.

The Contractor shall ensure that the RPEQ shall perform professional engineering services within the meaning of the Professional Engineers Act 2002, Queensland.

The Queensland Electrical Safety Office has mandated that as of 25 November 2022, all switchboards installed within Queensland Electrical Installations or designed within Queensland must comply with the requirements of AS 61439.

3.2 Design Life

Electrical designs shall create assets having a physical life of at least 25 years, excepting normal routine maintenance and supply of consumables, before major overhaul is required.

3.3 Voltage Levels

The switchboards under this contract, unless stated otherwise in the PBPL specific project documentation, shall be designed for the following voltage levels:

Table 1: Site Operating Voltages

Condition	Detail
Low Voltage Supplies	3 Ph, 4 Wire, 400 Volt +10%/-6%, 50 Hz ± 2%, MEN System Voltage Unbalance <5%.
Single Phase Power Supplies	230 VAC..
Control Power Supplies	24 VDC

3.4 Site Climate Conditions

The switchboards under this contract, unless stated otherwise in the PBPL specific project documentation, shall be designed for the following site climatic conditions:

Table 2: PBPL Site Climatic Conditions

Condition	Detail	Value
Location	Southeast Queensland	-
Atmospheric Conditions	Coastal/Marine	-
Altitude	Above mean sea level	0-150 m
Ambient Temperature (Dry bulb)	Minimum	-5°C
	Typical maximum	36°C
	Extreme maximum	40°C
Solar Radiation	Maximum for a flat roof	1030 W/M^2
	Maximum for an east or west facing vertical wall	660 W/M^2
	Maximum for a vertical wall out of direct sun	160 W/M^2

3.5 Materials

All materials shall be as detailed in the PBPL specific project documentation. When materials are not specified the Contractor may offer standard materials suitable for the environmental and operating design conditions.

All materials shall be new and free of defects.

3.6 Workmanship and Personnel

Personnel engaged in the manufacture of switchboards shall be accredited, suitably experienced, competent and skilled in the particular field of work in which they are engaged. All works shall be completed by or under the direct supervision of fully qualified tradespeople holding trade qualifications and certificates adequate for the work and licensed under the Queensland Electricity Board regulations.

3.7 Weather and Ingress Protection

All switchboards shall be Ingress Protection (IP) rated as specified in the PBPL specific project documentation.

Switchboards are susceptible to damage or failure due to moisture and dust ingress and shall be IP rated as follows unless otherwise specified:

- For outdoor installation - minimum IP56.

- For indoor installation - minimum IP44.

All outdoor equipment and installations shall be suitable for un-protected exposure to the weather and direct sunlight. Where not specified in the PBPL specific project documentation weather hoods and/or sun-shades shall be provided for UV and weather protection.

3.8 Atmospheric Condition

The site is in a coastal/marine environment therefore particular care shall be taken to minimise the exposure of equipment to salt. If this is unavoidable, switchboards or pillar boxes shall be appropriately rated for the environment they are installed.

3.9 Design Verification

The test certificates shall be held in the name of the original Manufacturer or Assembly Manufacturer. Test certificates must be issued with an ISO9001 certified test laboratory, tests performed in Australia shall be undertaken by a NATA certified testing laboratory.

A device may be substituted with a similar device to that used in the verification test if the substitution complies with the conditions of AS/NZS 61439.1. The Assembly Manufacturer shall provide the switchboard DVR on completion of manufacture as detailed below.

The DVR shall outline in detail how the assessment was undertaken. All relevant third-party test certificates must be provided in the DVR. The test reports shall be provided as standalone documents for PBPL to review.

The DVR shall also include the following:

- AS/NZS 61439.1 Table D.1 List of design verifications to be performed.
- AS/NZS 61439.1 Table 13 Short Circuit Verification by Comparison with a reference design check list where comparison to a tested design is proposed.

The Switchboard being supplied must be in no way inferior to the design specimen verified, and as a minimum must be checked for the following:

- Busbar ratings must not be less than those tested,
- Busbar supports must be identical in material and mounting method to those tested,
- Busbar support spacings must not be greater than those tested,
- Phase centres must not be less than those tested,
- Creepage and clearance distances must not be less than those tested.

Design verification shall include testing for the containment of internal arc faults where required by the following table.

Table 3: Arc Fault Testing and Verification Requirements

Criteria	Internal Arcing Fault Tests
Arc flash incident energy load side of incoming over-current protection device less than 1.2 cal/cm²	None required
Arc flash incident energy load side of incoming over-current protection device equal to or greater than 1.2 cal/cm²	Internal arcing fault tests to AS/NZS 61439.1 Appendix ZD

Criteria	Internal Arcing Fault Tests
Arc flash incident energy on the line side of incoming over-current protection device equal to or greater than 8 cal/cm² OR Rated load current equal to or greater than 800 A	Internal arcing fault tests to AS/NZS 61439.1 Appendix ZD including ZD6 Special Tests

3.9.1 Design Verification Test Certificates

The design verification process must be established to comply with Section 10 of AS61439.1 covering Construction and Performance. Certificates of test for protective devices and other components in accordance with Australian Standard or another recognised equivalent international standard must be provided.

The LV switchboard design shall be provided with the following verification test certificates:

- Short Circuit Withstand,
- Dielectric Properties,
- Degree of protection of enclosures,
- Temperature rise limits,
- Arc fault containment.

The test certificates and the verification parameters supplied shall be equivalent or greater than the reference tested switchboard assembly.

3.9.2 Design Verification Report

All switchboards must be accompanied with a Design Verification Report (DVR) signed and approved demonstrating compliance with AS 61439.1. The DVR must be provided at design time and marked up to as-built status with submission of the switchboard's as-built documentation. The DVR must outline in detail how the assessment was undertaken and must provide cross reference to all documents reviewed to make the assessment including design drawings. All third-party test certificates must be provided in the DVR.

The DVR must be provided as a standalone document and include the following:

- Short time fault current tests on busbars,
- Temperature rise tests,
- Degree of ingress protection and internal separation of the enclosure (IP Ratings),
- Mechanical operation of circuit breakers and isolators,
- CB making and breaking capacity,
- Enclosure resistance to corrosion,
- Enclosure resistance to UV radiation.

The DVR supplied must be in a similar format and contain all chosen verification methods as detailed in the example provided in the Appendix – Example DVR.

4. SWITCHBOARD PERFORMANCE AND RATINGS

4.1 General Design Requirements

This specification details performance and construction requirements for switchboards. Should any requirement of this specification require the Contractor to deviate from these requirements, then the Contractor shall specify this in their offer. Otherwise, it will be assumed that the switchboard being offered complies with the specification and the project specific switchboard specification utilising the AS 61439.0 Annex D Technical Schedule as provided within the Appendix of this document.

The switchboards shall be designed, constructed, verified and supplied in accordance with AS 61439.1:2016 clause 10 and Annex D and is to meet the following performance and construction requirements.

Adequate derating of equipment and/or ventilation of the cubicles shall be provided to protect the equipment against the effects of excessive temperature rises within the cubicles. Any ventilation shall not compromise the IP rating and form of segregation of the cubicles.

With the doors open, all accessible internal live parts shall be protected against accidental contact to not less than IP2X.

4.2 Short Circuit Performance

The main circuit shall be constructed to withstand, without thermal or mechanical damage for 1 second as a default unless the short circuit stresses generated by the fault level stated in the PBPL specific project documentation requires a project specific rating.

Design verification shall be by testing in accordance with AS 61439.1 Clause 10.11.5, or by comparison with a reference design in accordance with IEC 61439.1 Clause 10.11.4 utilising the check list specified in Table 13.

4.3 Arc Containment Performance

4.3.1 Arc Fault Containment

The switchboard supplied under the Contract shall be a tested design for arc fault containment where the Power System Analysis for the site calculates that the Arc Flash incident energy at the point of installation of the switchboard in the power network is equal to or exceeds 1.2 cal/cm^2.

The arc fault containment test of the referenced design shall be to a tested fault current the same or higher level than the main bus bar fault current rating and shall have been tested to the line and load side of the protective devices associated with the following:

- functional units,
- bus bar compartments.

The compartments shall each provide 'acceptable protection' for operators in the event of an internal arcing fault occurring on both the line and load side of the protective device in each switchboard compartment. The design being offered shall have been performance tested by a recognised testing authority in accordance with the test procedures detailed in AS 61439.1 Annex ZC and Annex ZD.6 Special tests.

Arc fault containment testing of the switchboard design to IEC-TR61641:2008 will also be considered by PBPL, however testing to AS 61439.1 is preferred.

The construction methods used in the tested switchboard (e.g. IP rating, venting, door bracing, door mounted equipment shrouding, form of segregation) 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 type and manufacturer as those tested in accordance with Annex ZD of AS 61439.1, although not every protective device rating need have been tested.

4.3.2 Alternative Arc Fault Containment Ratings

Switchboards that are not a certified arc fault contained tested design and do not meet the conditions outlined in clause 4.3.1 shall only be accepted where the Power System Analysis for the site calculates that the Arc Flash incident energy at the point of installation of the switchboard in the power network is less than 1.2 cal/cm^2.

4.4 Main Circuit Rating and Temperature Rise

The main circuit supply rating required is shown in the PBPL specific project documentation. The main circuit shall provide this rating with a busbar temperature rise within the temperature rise limits detailed in Table 6 of AS 61439.1.

The busbar size shall be determined in accordance with the ratings and derating factors detailed in Appendix C of AS 3000. 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.

5. SWITCHBOARD CONSTRUCTION DETAILS

5.1 Switchboard Layout

Where switchboard 'Layout' drawings are issued with the Scope of Work, the Contractor shall maintain, where possible, the layout and dimensions specified, but shall be responsible for the detailed design of the switchboard.

5.2 Module Design

The switchboard module design is to be based on demountable fixed functional unit modules, unless otherwise specified in the PBPL specific project documentation.

5.3 Busbars

Busbars shall be formed from hard drawn, high conductivity, solid round-edged rectangular copper bar. Main busbars shall have the same current rating for the full length of the switchgear assembly. The temperature rise of busbars and busbar connections shall comply with the requirements of AS 61439.1.

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 joining. Connections shall be secured with high-tensile steel bolts and bevelled washers tensioned in accordance with manufacturer's instructions. Tension witness marks shall be provided to all bus bar bolts with paint or permanent marker pen.

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 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.

All joints, take-off points and other connections to the busbars shall be tinned and made with a bolted assembly and shall be adequately prepared to avoid high contact resistance. All busbars shall be identified at regular intervals (not exceeding 600 mm) in phase, neutral and earth colours of red, white, blue, black and green/yellow in accordance with the table below.

Table 4: Busbar Colour Coded Bands

Busbar	Colour
Phase A (L1)	Red
Phase B (L2)	White
Phase C (L3)	Blue
Neutral	Black
Earth	Green & Yellow

The insulating material shall be non-hygroscopic and not liable to 'weeping' during ageing. Insulation in the form of taping is not accepted.

Main busbars shall be completely enclosed except for power take-offs and shall be completely segregated from all other equipment and wiring, including extra-low-voltage busbars and wiring. All wiring passing through busbar chambers shall be double insulated or enclosed in supported conduit and shall not touch the busbars.

Busbar supports shall be fabricated from rigid, non-hygroscopic insulating material. Number, location and method of installation shall be in accordance with the design for the fault level and duration specified and the tested reference design.

The busbars for main switchboards and distribution boards which are required to connect to solar export connections or will be required to be connected to solar export in the future must be adequately sized to accommodate the two-way current flow per the requirements of AS 4777.1 2024. The nominal capacity and rating of the busbars must be sufficient for the existing load plus the future solar capacity.

5.4 Earthing

All parts of the switchboard which are required to be earthed shall be effectively connected to the main earth bar. The main earth bar and risers shall be provided with suitable termination facilities for the connection of the earth conductors on all incoming and outgoing cables and shall be provided in each vertical terminating zone. An earth bar shall extend the full length of the switchboard adjacent to the outgoing cable gland plates. The earth bar shall be sized to suit maximum earth fault currents and must have a minimum cross-sectional area of not less than 120mm2 and shall extend the full length of the switchboard adjacent to the outgoing cable gland plates. The earth bar shall be fitted with bolts, washers and spring washers to accommodate the earth connections for all incoming and outgoing cables.

The earth bar shall be colour-coded with green/yellow bands at maximum 600 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. Bolt hole diameter of 10mm and larger shall be drilled through the earth bar and earth cables fixed with suitable nut, bolt and spring washers.

All metal parts of the switchboard shall be bonded to the main earth bar. All doors fitted with control and/or indicating equipment shall have an independent flexible earth strap connected to a welded stud on the door. All secondaries of current transformers shall have one lead earthed. All equipment panels shall be provided with a main earthing welded stud directly connected to the main earth bar.

All metal cases of instruments, relays, selector switches, etc. shall be connected by an unbroken insulated flexible earth cable of minimum size 4mm2 to the earth bar. The earthing connections shall be arranged so that removal of one component shall not affect continuity of the earthing conductor associated with any other component. Earth conductors insulated shall be coloured green/yellow.

For termination of field earth cables 4mm2 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 a 120mm2 earth cables at each end of the board, and for suitable terminals for connection to an earth core on all other incoming and outgoing cables. For switchboards that do not contain solid copper bus bars there shall be cable access and termination provisions for 2 off minimum 16mm2 earth cables.

For termination of field earth cables 2.5 mm² 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.

For a custom design LV enclosure with an LV Switchboard and LV Distribution Board functional units or sections, the MEN link shall only be connected at one point in the LV Switchboard neutral and earth bars.

5.5 Operating Parameters

Table 5: Switchboard Operating Parameters

Item	Value
Current & Frequency	AC 50Hz
Rated Operational Voltage Ue	400 VAC
Rated Insulation Voltage Ui	660 V
Rated Auxiliary Voltage	230 VAC
Control Voltage	24 VDC
Earthing System	Solidly Earthed (MEN System)

5.6 Form of Segregation

The form of segregation of the switchboard shall be as per the PBPL specific project documentation.

When the form of segregation is not specified by PBPL, the contractor shall design detail design a switchboard with Form 3b segregation for the functional units and Form 4a for the main incomer(s).

Form 3bih shall not be accepted under any circumstances.

5.7 Locks and Handles

All doors shall be held closed with chrome plated lockable recessed handles. For doors up to 450 mm high, one handle is sufficient. For doors above 450 mm and up to 1000 mm high, two handles are sufficient, but doors over 1000 mm high shall have three handles or a Tri-lock.

5.8 Metal Work

5.8.1 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 2.0 mm, 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 500 mm x 500 mm. Where panels are larger, 3 mm 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.

Doors, Removeable Covers and Escutcheons

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.

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

Door stays and document holders etc are to be fitted. 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.

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.

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 switchboards installed in corrosive areas, the plinth shall be 75 mm 'U' mild steel channel with a paint coat system.

Paint Treatment

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 AS2700, gear trays and escutcheons shall be gloss white.

5.8.2 Outdoor Switchboards and Corrosive Environment

Switchboard enclosures for outdoor locations or corrosive environments shall be IP56. Cubicle construction is to be minimum 3 mm marine grade aluminium (5251) or 2 mm SS316. pacified steel welds shall be provided throughout the SS316 cubicle. Plinth construction shall have 160x60 channel 6061 T6 Grade Aluminium. All panels are to be folded, "Pulse MIG" and "TIG welded with all visible seams and joints fully welded, free from splatter and ground smooth where needed. External doors and covers are to be fitted with Emka 1011-207 self-grip seal. M6 Earth studs are to be fixed to the interior of all doors and hinged escutcheons and on adjacent cubicle interior surfaces.

Door stays and document holders etc are to be fitted. Door stiffeners are to be SS316 and a minimum of 3 mm and of sufficient strength to prevent being deformed when subjected to reasonable loads. Lift-off covers and mounting panels are to be fixed with M8 studs & stainless-steel dome nuts & stainless steel "D" Handles are to be fitted.

Gland plates are to be manufactured from 5mm aluminium. Inspection/Access plates are to be manufactured from 3mm aluminium. Gland/Inspect/Access plate openings are to be fitted with M6x1.0 flat head closed end rivet nuts. Cable glands are to be fitted with the compression side installed within cubicle.

Gland/Inspection/Access plates are to be fitted with seals attached to the cubicle.

Gland/Inspection/Access plate fixings are to be fitted at no more than 100mm.

Gland/Inspection/Access plates are to maintain a 50mm clearance from section dividers.

Gland/Inspection/Access plates are NOT to be split. Inspection/Access plates are NOT to be earthed. Hinges (external) are to be Selectrix HIB650ss-316 stainless steel. SS316 star washers are to be fitted under all hinge screws. Hinged escutcheons are to be fixed with Emka 1/4 turn 1000-U142.

All equipment is to be removable via the front access.

On installation the switchboard plinth shall be levelled using chemical anchors with SS316 threaded rod and jacked high enough to prevent the plinth being contact with water ponding. The spacing between the concrete slab and the plinth shall be filled with a non-hydroscopic, non-shrinkable material to prevent corrosion and ingress of vermin.

All escutcheons are to open to a minimum of 90°. All sheet metal edging is to be de-burred.

Switchboards located in outdoor locations exposed to the weather shall be provided with a sloped rain hood.

Paint Treatment

Aluminium and stainless steel surface preparation shall be:

Finished smooth and all exposed welds are to be cleaned, descaled, and all surfaces are to be degreased. Surfaces pre-treatment is to be in accordance with AS 1580 & AS 3715 using Novox LF acid etch cleaner, Novacoat 12 conversion coating, & clean water rinses.

Apply Dulux Alphatech 3000 powder coat to manufacturer's recommendations. Alternative surface preparation and paint coating systems will only be accepted where Company has provided written permission to deviate from this specification. Cubicle and External Components are to be coloured according to PBPL requirements including finish colours. The final colour shall be determined by the installation location and PBPL preference as detailed in project specific items. Interior items (mounting panels, escutcheons, etc.) are to be coloured Dulux Bright White (32166). Minimum Dry Film Thickness on all surfaces is to be 50 microns.

5.8.3 Gland Plates

Gland plates shall be single piece, 5 mm aluminium. A 3mm thick aluminium gland plate can be accepted only where all cables proposed to be installed in the gland plate are maximum 32mm2 cross sectional area. The gland plate shall be effectively earthed to the switchboard enclosure. Fit 25 mm wide neoprene gaskets to all gland plates, secure with 6 mm bolts at maximum 150 mm centres. Gland plate fixing bolts shall not be used for connection of the earth cable to the gland plate.

5.9 Cable Zones

Unless otherwise specified by 'Layout' drawings issued in the PBPL specific project documentation, switchboards 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 300 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.

Bottom entry of cables shall be provided for cable access to the switchboard unless accepted otherwise in writing by PBPL.

5.10 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.

5.10.1 Modules

Demountable switchboard module doors covering low voltage equipment shall have defeatable door interlocks by the use of a standard flat bladed screwdriver. The interlocking switch shall be pad lockable in the off position. Control circuits shall be housed in fully sealed compartments.

5.10.2 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 lockable 'T' type handles.

The circuit breakers and isolators shall be pad lockable 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 cannot be opened unless the incomer is in the off position. A defeat mechanism for this interlock shall be provided should it be necessary to gain access to inspect the unit without interrupting the service.

5.10.3 Solar Feeder Compartment

A dedicated section for a future feeder compartment shall be provided. The size and capacity of this compartment will be specified in the project specific requirements or under the direction of the PBPL project representative. The compartment shall be called “PVDB Solar Connection”. All provisions shall be made to facilitate parallel operation with the grid and the solar feeder compartment.

5.11 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.

5.12 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 50 VAC shall be

shrouded to IP2X to protect against accidental contact when the enclosure doors or escutcheons are open. Provide warning labels on shrouds that state DANGER XXV where XX nominates the maximum voltage of exposed live components behind the shrouds.

5.13 Incoming Feeder

Where the size of the incoming feeder is shown on the drawings issued in the PBPL specific project documentation, 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.

5.14 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 only be necessary to open the main compartment door, and not required to remove any covers, to operate or reset any item of plant equipment under normal operation.

No item 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 switchboard 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.

When designing switchboard layout and door swing openings the Contractor shall make consideration for access and egress around the switchboard where it will be installed.

5.15 Spare Capacity

Unless otherwise specified by 'Layout' drawings issued in the PBPL specific project documentation, space shall be provided in the switchboard equivalent to 20% of the total space allocated to supply equipment/modules (excluding cable zones) as detailed on the single line diagrams forming part of this specification. This space shall be placed at one end of the switchboard and provision for future expansion shall be allowed from this end of the switchboard. To facilitate expansion, a removable blanking plate shall be installed over the end of the busbar chamber and cable zone.

The main bus bars shall be pre-drilled to permit extension in future as required. As-manufactured drawings shall show details of the extension arrangement of the bars. Pre-drilled holes shall be covered with heat shrink or some other mechanical barrier to inhibit corrosion of the copper bars in corrosive environments. Cover plates with WARNING signs shall be provided to prevent access to otherwise exposed equipment.

5.16 Control Section

Provision for a dedicated Control Section. The dimensions and equipment within the Control Section shall specified by the project specific requirements. Where no project specific requirements are made, at a

minimum a dedicated Control Section as shown in the example switchboard design drawing shall made for these switchboards.

5.17 Switchboard Internal Wiring

Wiring insulation shall be non-hygroscopic, incapable of supporting combustion and shall have a glossy finish. It shall be capable of withstanding the service conditions to which it is subjected.

All wiring is to be PVC V90 HT 0.6/1kV Grade with tinned conductors.

Control, protection, metering, alarm, where subject to movement, e.g. across hinged door joints and indication shall be not less than 1.0 mm cross section (unless stated below) tinned copper conductors with a 32/0.20 mm construction.

Hinged joints carrying wiring shall be provided with a flexible earth bonding strap of adequate size.

Earth cables are to be a minimum of 2.5mm² flexible.

Doors and hinged escutcheons are to be bonded with flexible tinned copper braiding.

The switchboard is to have a dedicated earthing cable bonding directly to main earth bar.

Table 6: Table of Cable Colouring and Size

Function	Colour	Size (CSA)
400 V AC Power Wiring	Red, White, Dark Blue	2.5 mm² (minimum)
Potential Metering (400/230V AC) Supply Authority	Red, White, Dark Blue	2.5 mm² (minimum)
Potential Metering (400/230 V AC)	Red, White, Dark Blue, Black	1.5 mm²
Current Metering (Secondary) Supply Authority	Red, White, Dark Blue, Grey	4.0 mm²
Current Metering (Secondary)	Red, White, Dark Blue, Grey	2.5 mm²
230 V AC Active	Red	1.5 mm²
230 V AC Neutral	Black	1.5 mm²
24 V AC or DC Positive Supply to Distribution Terminals or Fuses and up to the first point where the circuit activates a contact or device.	Orange	1.0 mm²
24 V AC Neutral or DC Negative Supply to Distribution Terminals or Fuses and to all negative connections on all devices	Violet	1.0 mm²
Earth	Green/Yellow	2.5 mm²
Door & Escutcheon Earth Bonds	Green/Yellow	4.0 mm²

5.18 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 method accepted by PBPL.

Ensure minimum clearance of 100mm is maintained between cable ducting & gland plates.

Adhesive backed plastic mounting bases for securing wiring looms with cable ties are not accepted.

5.19 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.

5.20 Terminations and 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.

5.21 Numbering of Wires and Cables

Wire numbering will be equal to Grafoplast SI2000 system.

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.

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.

Cable numbers in accordance with the Project Documentation shall be provided for each cable that terminates both ends inside the switchboard.

5.22 Labelling and Identification

The switchboard and all modules shall be labelled with assigned equipment number and title in accordance with the Single Line Diagram. Labels shall be installed as per the label schedule drawing for the switchboard. Switchboards installed in public accessed areas shall have danger labels fixed to the external door. 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.

All device labels, other than proprietary legend and escutcheon plates on devices, are to be engraved from white/black/white ABS plastic 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:

Table 7: Switchboard Label Schedule

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

A label list shall be submitted and accepted by PBPL prior to label manufacture commencing.

Labels manufactured and not accepted by PBPL shall be replaced at no cost to PBPL.

Label colouring shall be:

Table 8: Switchboard Label Colour Schedule

Label Location	Colour / Material
Internal Labels	White/Black engraved ABS plastic
Warning Labels	Red/White engraved ABS plastic

Internal labels on gear trays or escutcheon panels shall be secured by M3 chrome plated metal threads or glued into position. Double sided tape shall not be accepted for fixing labels.

CB's to be identified with individual labels as per the label schedule.

Labels obstructed by switchboard wiring are to be relocated to adjacent duct lid and secured by M3 nylon threads. The lid is to be secured by a single cable tie at one corner.

External labels are to be 1mm thick 316 grade s/steel secured by M3 316 s/steel metal threads.

Danger and Warning Labels

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 400VAC ISOLATE ELSEWHERE".

Equipment connected to the line side of a switchboard incoming switch (e.g. voltmeters) shall be marked.

"DANGER - LINE SIDE CONNECTION – ISOLATE ELSEWHERE".

Primary Nameplate

The primary name plate shall be fitted in a prominent location and secured by stainless steel screws or rivets. The following information shall be given in all cases:

- Port of Brisbane Pty Ltd,
- Project Name,
- Purchase Order or Contract number,
- Equipment Title,
- Equipment Number,
- Certified Weight,
- Serial Number,
- Date of Manufacture.

Rating Plate

The switchboard rating plate shall be fitted in a visible position. Entries on the rating plate shall be indelibly marked, by etching, stamping or engraving. The following information shall be given in all cases:

- Manufacturer's name and Company Logo,
- Type, Model and Serial Number,
- Standard to which apparatus is manufactured,
- Nominal Operating Voltage,
- Nominal Operating Current,
- Rated short circuit time withstand current,
- Rated peak withstand current,
- Degree of protection (IP Rating),

- Form of Segregation.

5.23 Current Transformer Wiring (CT's)

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 4 mm2 minimum CSA.

CT's for tariff metering on switchboard incoming supplies shall be connected to a test block as detailed in Supply Authorities Conditions of Supply and Customer Metering, namely as specified within the Queensland Electrical Connection Manual (QECM) and as detailed in section 7.10.5 of this document. The voltage connections shall also be made.

5.24 Generator Installations

The Job Specifications will detail the requirement for a mobile generator connection or a permanent generator installation. A set of three indicator lights are to be wired to the grid line side of the change-over switch via a suitably rated isolatable fuse-carriers. The purpose of these lights is to alert operators that grid power has been restored. A suitable warning label is required to show these indicators are not isolated by the change-over switch.

The cable connecting the generator inlet to the changeover switch, neutral link and earth link shall be flexible cable. The conductors on the socket end shall be terminated with bootlace pins. The cable shall be long enough to allow easy disconnection and reconnection between the inlet socket and the inlet terminals.

Provision shall be made in the side of the changeover section for temporary generator cable entry. Any holes or doors provided must not compromise the IP rating of the panel. The cable entry shall incorporate means to support the incoming cable (e.g., gland or clamp).

Easy access shall be provided for viewing all instruments and indicator lights.

5.24.1 Permanent Generator Installations

The generator will have a circuit breaker to protect and isolate the generator output. This shall be a 4-pole device.

A single selector switch shall be provided to allow operations personnel to test the generator and change over function. This switch shall simulate a mains failure, start the generator and transfer site loads on to the generator. A contact from this switch shall be wired to a telemetry input for monitoring purposes.

A stand-alone external load bank may be required the load bank shall be controlled by a load sensing controller. The Job Specification will detail requirements. The following voltage free signals to be made available at a terminal strip for indication.

- Generator running,
- Generator fault,
- Generator failed to start; Generator low fuel warning (approx. 2 hours run-time left),
- Generator starting battery voltage low (1 x DI via suitable relay),
- Generator circuit breaker closed,
- ATS Mains supply position,
- ATS Generator supply position,
- Solar system generator changeover for isolation of system from grid (1 x DI via suitable relay, future solar provision),
- Load bank healthy.

5.24.2 Mobile Generator Installations

For sites which require mobile generator connections, a Decontactor type socket inlet with a rating greater than the capacity of the mobile generator shall be provided.

6. DISTRIBUTION BOARD CONSTRUCTION DETAILS

6.1 General

All Distribution Boards shall meet all general switchboard requirements as specified in sections 3, 4 & 5.

The distribution board shall be constructed of materials capable of withstanding the mechanical, thermal and electrical stresses that are likely to be encountered in the specified service conditions. Protection against corrosion shall be ensured using suitable materials or protective coatings to the exposed surface.

6.2 Form of Separation

Distribution boards rated at not greater than 250A shall have a form of separation of 2Bi. Switchboards. Switchboards containing an integral distribution section rated at not greater than 250A shall have a form of separation of 2Bi.

6.3 Busbars and Chassis

Distribution Board busbars shall meet the operating parameters specified in section 5.3 and shall be provided with colour coded busbars as specified in Table 4.

The distribution board busbar shall be fully encapsulated tee-off style chassis with available spares. Spares shall be covered with tee-off caps.

The busbar chassis design shall be able to accommodate combinations of single, double and triple pole of DIN devices including miniature circuit breakers (MCBs), RCDs and RCBOs. A connection kit that allows the connection of the chassis to a main incomer switch without the need to modify the distribution board shall be available.

6.4 Spare Capacity

Distribution Boards and distribution sections in the switchboard shall be provided with 20% spare unused space for extension of the distribution bus bar or 20% spare poles in the bus bar for future use. Provision for distribution bus bar extension shall be provided.

6.5 Circuit Schedule

The distribution board shall contain a copy of the circuit schedule located within the document holder internal to the switchboard. The schedule shall denote the following:

- The switchboard,
- Circuit numbers,
- Ratings of switches and protective devices,
- Load types and locations,
- Spare poles,
- Date of schedule updates.

6.6 Control Section

Provision for a dedicated Control Section. The dimensions and equipment within the Control Section shall specified by the project specific requirements. Where no project specific requirements are made, at a minimum a dedicated Control Section as shown in the example switchboard design drawing shall made for these switchboards.

6.7 Equipment Details

6.7.1 General

The Distribution Board shall meet all equipment device requirements as detailed in section. 6.4.

6.7.2 Surge Protection Devices

The Distribution Board shall have a surge protection device installed where it is a stand-alone enclosure and shall meet the requirement specified in section 7.8.

An AS 1768 compliant lightening protection risk assessment shall be completed for any outdoor switchboard and shall be available for review by PBPL representatives prior to design completion. The outcome of the risk assessment shall dictate whether the switchboard is designed and constructed with lightening protection.

6.7.3 Moulded Case Circuit Breakers

In addition to the specification detailed in section 7.2.4, the main isolating MCCB shall be lockable in the off position. The escutcheon door can only be opened if the main isolating MCCB is in the off position.

6.7.4 Miniature Circuit Breakers

In addition to the specification detailed in section 7.2.5, the MCBs shall be lockable in the off position regardless of escutcheon door open or close position.

6.7.5 Residual Current Devices and Circuit Breakers

All distribution boards shall be fitted with a main switch comprising either a load break/fault make isolator or circuit breaker. The fault rating of the distribution board shall be suitable for the area in which it is to be installed. All outgoing circuits, as required by AS 3000, shall be protected by 30mA earth leakage protection on a per circuit basis.

To facilitate the testing of RCD circuits, a dedicated, round earth pin, unswitched socket outlet shall be provided on the Switchboard/MCC escutcheon. All RCD circuits shall be connected to this test socket via one or more selector switches mounted adjacent to the socket. This will allow the test technician to carry out injection tests quickly and safely for all RCD circuits by plugging the test instrument into the socket outlet and using the selector switch to switch individual circuits to the socket for testing. A suitable warning label is to be fitted adjacent the socket outlet to distinguish its function from a standard GPO.

7. SWITCHBOARD EQUIPMENT

7.1 General

The electrical equipment installed in the switchboard shall be new equipment complying with relevant Australian Standards and be suitable for the duty indicated in the specific project documentation.

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.

All equipment and materials shall be new and comply with the relevant specifications, regulations, codes and standards.

All components and materials supplied by the Contractor shall be free from:

- Asbestos,
- Ceramic fibre,
- Chlorofluorocarbons,
- Polychlorobiphenyls (PCB) and their isomers,
- Radioactive materials (unless specified otherwise in Project Documentation),
- Mercury.

The Contractor shall maintain up to date inventory list of all components and consumable and procure additional materials as required well in advance so as not to delay the manufacturing schedule due to shortage of materials.

7.2 Circuit Breakers

7.2.1 Discrimination

Where circuit breakers are installed in series, every effort should be made to provide discrimination for tripping currents up to the maximum prospective fault current for the installation. Discrimination through manufacturer's cascading and selectivity tables is considered an acceptable form of discrimination.

7.2.2 Motorised Circuit Breakers for Solar and Embedded Generator Connections

Motorised circuit breakers shall be used for any circuit which connects to solar, permanent generators or BESS feeders and embedded generation. The allowance is required for automatic disconnection and switching of the normal supply and generator supply as well as disconnection of the parallel connected solar systems.

This provision shall be for connection of any installation which will be required to include future solar and BESS and embedded generating units.

7.2.3 Air Circuit Breakers (ACB's)

ACB's shall have been tested and manufactured in accordance with AS 60947.2. 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 comply with the following requirements:

- Shrouding over incoming terminals to prevent accidental contact.

- ACB's for feeders shall be of the High Interrupting class as defined in AS 2184 and shall have adjustable an electronic trip unit for long time, short time, earth fault and instantaneous protection.
- Be capable of being padlocked in the 'OFF' position only.

ACB's shall have the following classification characteristics in accordance with AS 2184:

Table 9: MCCB Rating

Specification	Rating
Rated Frequency	50 Hz
Rated Voltage	400 V AC
No. of Poles	3 or 4
No. of Phases	3
Trip Units	Electronic
Overload/Overcurrent Protection	Long Time Inverse Time, Short Time, Instantaneous, Earth Fault (minimum)
Rated Continuous Current	Rating Shown on Drawings
Interrupting Rating	Greater Than Fault Level on Drawings
Auxiliary Contacts	2 N/O, 2 N/C (minimum)
Rated Service Short Circuit at 440 V	P2 to AS60947-2

The above general information applies unless otherwise specified in the specific project documentation.

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

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

ACB poles shall operate simultaneously.

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

7.2.4 Moulded Case Circuit Breakers (MCCB's)

MCCB's shall have been manufactured in accordance with AS 60947.2 and tested by a recognised testing authority for compliance with AS 60947.2. If this testing was not carried out within Australia, then a Certificate of Approval shall be provided from an approved Australian Electrical Distribution Authority.

MCCB's shall comply with the following requirements:

- Shrouding over incoming terminals to prevent accidental contact.
- MCCBs for feeders shall be of the High Interrupting class as defined in AS 2184 and shall have adjustable thermal overload and adjustable magnetic short circuit protection.
- Be capable of being padlocked in the 'OFF' position only.

MCCB's shall have the following classification characteristics in accordance with AS 2184:

Table 10: MCCB Ratings

Specification	Rating
Rated Frequency	50 Hz
Rated Voltage	400 V AC
No. of Poles	3 or 4
No. of Phases	3
Trip Units	Thermal Magnetic or Electronic
Overload/Overcurrent Protection	Inverse Time, Instantaneous (minimum)
Rated Continuous Current	Rating Shown on Drawings
Interrupting Rating	Greater Than Fault Level on Drawings
Auxiliary Contacts	To Suit Circuitry
Rated Service Short Circuit at 440 V	P1 to AS60947-2

The above general information applies unless otherwise specified in the specific project documentation. 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.

7.2.5 Miniature Circuit Breakers (MCB's)

Single-pole and multi-pole miniature circuit breakers (MCBs) shall be in accordance with AS/NZS 3111. MCB's shall have a current interrupting capacity suitable for the prospective fault current and not less than 10 kA symmetrical. MCB's shall be lockable in the open position via a permanently fixed locking device.

7.3 Isolators

Switchboards and Distribution Boards shall be provided with a main switch as specified in the Project Documentation. Fused isolators maybe installed where fault current limiting to the distribution board is required.

The main switch shall be labelled as specified in AS 3000. The minimum rating of the switch and any fuse shall be as shown in the specific project documentation. The main switch shall have terminals sized to accommodate the incoming cable.

Isolators are accepted for bus-ties and Automatic Transfer Switches (ATS's) between multiple supplies. Fortress key interlocks or equivalent captive key interlocks shall be provided between incomers and bus ties unless shown otherwise in the specific project documentation.

7.4 Contactors

Contactors shall provide Type 2 co-ordination with their respective circuit breakers under short circuit conditions.

Contactors shall have utilisation category applied in accordance with AS 60947.4.1 for the type of load. A mechanical life of 10 x 106 operations and be suitable for uninterrupted duty.

All contactor coils shall be continuously rated at 24V DC unless otherwise specified in the specific project documents.

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

7.5 Control Relays

All control relays shall be of the electronic type with screw or clip retainers. All relays shall be supplied with integral push-to-test buttons and LED indicators.

7.6 Current Transformers

The CT's for Power Utility revenue metering shall be specified and installed to meet the Power Utility requirements.

Metering CTs shall be in accordance with AS 60044.1. The total burden shall not exceed the CT burden at the specified accuracy class and shall be capable of withstanding through fault equivalent to the single-phase prospective fault current at the switchboard.

7.7 Fuse and Links

Fuse links shall be HRC type. Bases for small fuses shall be coloured black and bases for links shall be coloured white. Bolted links shall be used for circuit neutral, control circuit and current transformer earthing links.

The Power Utility direct metering fuses and circuit components shall be installed as per the Power Utility installation guidelines and circuit included in the specific project documentation.

7.8 Surge Protection Devices

A surge protection device (SPD) shall be provided at the load side of the incoming main switch on all switchboards and DB's unless specified otherwise in the Project Documentation.

The SPD shall offer protection to Installation Category II in accordance with IEC 61643-11 and shall have a surge rating as specified in the Project Documentation. The installation of SPD's shall be in accordance with IEC 61643-11.

Fuses shall be installed between SPD's and the phase conductors.

The status of SPD's shall be monitored by the local PLC/RTU using a volt free contact unless specified otherwise in Project Documentation.

7.9 Indication Lights

Indicating lights shall be 24 Volt DC LED type provided with a lamp test facility. Indicator lights will be of an IP66 industrial type with a diameter of 22.5mm. Colours shall comply with AS 60947.5.1 as per the following table:

Table 11: Indicator Light Colours

Lamp Colour	Function
Green	Off, Available, Safe condition
Red	Dangerous condition
Amber	Fault
White	Motor run
Blue	Miscellaneous, e.g., Duty selection

7.10 Meters

7.10.1 General

All meters shall be Q96 format, with 2% reading accuracy. CT driven ammeters shall be 5A units.

All meters used for private or PBPL specific metering shall be provided with dual ethernet ports and connectivity capabilities.

7.10.2 Power Meters

At a minimum, power meters shall be provided on the incoming circuit of all switchboards downstream of the main switch and as detailed in project specific documentation.

Power meters shall measure and display voltage, current and power in a single integral unit with an accuracy not less than 1%. Power meter shall be provided with the following standard functionality:

- Energy (kWH),
- Apparent Power (kVA),
- Real Power (kW),
- Reactive Power (kVAr),
- Voltage (V),
- Current (A),
- Power Factor,
- THDi harmonic (%),
- THDv harmonic (%),
- Individual harmonic up to 50th order.

Power meters data shall be stored in non-volatile memory and shall be retained in the event of power loss.

7.10.3 Voltmeters

Voltmeters shall be provided with a selector switch to allow selection of individual phase voltage selection. Each phase voltage shall be protected by potential fuses or circuit breakers. Voltmeters shall be scaled to read between 0 and 500V. Voltmeters shall be provided with insulating shrouds to cover exposed terminals.

7.10.4 Ammeters

Ammeters shall be provided with a selector switch to allow selection of individual phase currents as well as an OFF position. Ammeters shall be scaled to correspond to the rated primary current and in accordance with the circuit to which it is connected. Ammeters shall be provided with insulating shrouds to cover exposed terminals.

7.10.5 Energy Queensland Limited Compliant Metering for Solar, EG and BESS Installations

Solar, BESS and other embedded generation systems shall meet the metering requirements of the QECM at the DNSP service connection point. The EG system connections shall be compliant to Table 49 and Sections 8.15, 10.6 and 10.7 of the QECM.

The physical layout of the QECM metering panel and the mounting arrangements of the panel shall be provided as detailed in the drawings specified by Sections 8.15.1 and 9.11.2 of the QECM.

7.10.6 Supply Authority Metering

Where QECM compliant Supply Authority metering is required, a box comply with the requirements of the latest version of the QECM and detailed in Table 49 of the QECM shall be provided. The meter configuration and location shall comply with the QECM.

Adequate arrangements shall be made within the Switchboard to mount the electricity supplier's metering current transformers in an enclosure which is capable of being sealed by the electricity supplier. The facilities shall be acceptable to the electricity supplier and shall allow for the on-site fixing, connecting and changing of the metering transformers without disturbing the incoming cables.

Potential wiring for the electricity supplier's metering shall be protected by fuses, or approved equivalent, in accordance with the electricity supplier's requirements. The fuses shall be enclosed within the sealed current transformer enclosure and located so that they do not interfere with the installation of the main service cable or the installation and/or removal of the current transformers. Adequate provision shall be made for the outgoing potential and current transformer secondary wiring to the electricity supplier's meters.

7.11 Active Neutral and Earth Links

All links shall be manufactured from brass or copper and have studs and/or tunnels of correct capacity for the wiring to be terminated. Each link shall have at least 20% spare capacity for the termination of future circuits.

Active and neutral links shall be mounted on insulated supports and be fitted with a coloured insulated cover (red for active links, black for neutral) over all live surfaces. Neutral and earth links shall have capacity for the individual termination for the maximum number of circuits that can be supplied from the Switchboard/MCC.

7.12 Push Buttons

Pushbuttons shall be a heavy duty, IP66 industrial type with a shroud to prevent accidental operation. Contacts shall be rated at 10A minimum and be of the double make-break type with definite over travel limits. Pushbuttons will generally be 22.5mm diameter. Colours shall comply with AS 60947.5.1.

7.13 Selector Switches

Selector switches shall be cam operated with a rotary snap action. Contacts shall have a minimum rating of 10A at 250V. Switches shall be suitable for flush mounting and incorporate an engraved escutcheon indicating switch function and its respective positions.

7.14 Phase Failure Relays

Phase failure relays shall detect loss of phase, phase reversal, undervoltage and phase imbalance and sequence. The relay shall have an integral time delay to prevent spurious operation during momentary fluctuations and shall be self-resetting on restoration of supply. The phase failure relay shall be protected by a suitably rated circuit breaker or isolatable fuse carrier if connected to the line side of a main switch.

Where the Switchboard incorporates a change-over switch (either manual or automatic) a separate phase failure relay shall be provided to indicate the status of the grid mains supply. A voltage free NC contact from the phase failure relay shall be available as a digital input to the telemetry unit to indicate loss of supply.

7.15 Generator Transfer Switch

An automatic transfer switch and logic panel is to be provided to detect loss/restoration of grid supply and switching to/from the generator supply. The transfer switch would typically be located within the site's main Switchboard. The transfer switch can utilise circuit breakers, contactors or motorised switches to suit the installation requirements. If the automatic transfer switch is also the main switch for the installation, it must comply with AS/NZS 3010 clause 2.7.

The three positions of the change-over switch shall be clearly labelled "Mains"-"Off"-"Generator". It shall be padlockable in the off position. The requirements of AS/NZS 3010:2017 Clause 2.7.4. shall be complied with. The manual change-over switch shall have two auxiliary contacts, one that is closed when the switch is closed on mains and the other that is closed when the switch is closed on generator.

The generator transfer switch shall be electrically or mechanically interlocked to inhibit both circuit breakers being closed at the same time.

7.16 Manual Change-Over Switch

For Switchboards that incorporate a generator inlet socket or link connection bars it may be preferable to utilise a manual change-over switch as the main switch upstream of the main circuit breaker. The manual change-over switch, whether used as a main switch or not, shall comply with the requirements of clause 5.4.1 above and the following additional provisions: The neutral conductor from the generator connection must be switched (AS/NZS 3010). The neutral conductor from the grid supply must not be switched.

7.17 Generator Connections

Switchboards shall be supplied with an emergency generator connection unless specified otherwise in the project documentation.

The connection cubicles shall be designed to accept an external three phase power supply from an emergency generator having sufficient capacity to supply all site-specific essential loads.

The connection point shall include labels clearly indicating the maximum allowable generator rating for the switchboard.

The Supplier shall design the connection cubicle to either utilise lugged type connections with appropriate insulation panels to avoid accidental contact with live conductors or a proprietary plug and socket system.

The generator connection, isolation and protection shall comply with AS 3010 Electrical installations—Generating sets.

7.18 Photovoltaic (PV) Systems

All solar panel system installations shall be protected by load break disconnection devices on the Direct Current side (if above ELV) by either:

- An inverter with integrated load break disconnection devices, or
- An external DC load break disconnection device installed as per the inverter manufacturer's recommendations.

The PV system shall be designed in accordance with the latest regulatory requirements and comply with the requirements of the local supply authority. The protection relay for the PV system is to be selected from the local supply authority approved list.

The Contractor/Supplier shall be responsible for managing the application for the PV system with the supply authority and obtain supply authority approval for energisation.

The design and installation shall be completed by suitably qualified and experienced personnel for performance of the works, including RPEQ and CEC accreditation.

The busbars for main switchboards and distribution boards which are required to connect to solar export connections or will be required to be connected to solar export in the future must be adequately sized to accommodate the two-way current flow per the requirements of AS 4777.1 2024. The nominal capacity and rating of the busbars must be sufficient for the existing load plus the future solar capacity.

A dedicated section for a future feeder compartment shall be provided. The size and capacity of this compartment will be specified in the project specific requirements or under the direction of the PBPL project representative. The compartment shall be called "PVDB Solar Connection". All provisions shall be made to facilitate parallel operation with the grid and the solar feeder compartment.

Solar system generator changeover for isolation of system from grid (1 x DI via suitable relay, future solar provision).

Motorised circuit breakers shall be used for any circuit which connects to solar and PVDBs. The allowance is required for automatic disconnection and switching of the normal supply and the parallel connected solar systems.

Solar systems and PVDBs shall meet the metering requirements of the QECM at the DNSP service connection point. The EG system connections shall be compliant to Table 49 and Sections 8.15, 10.6 and 10.7 of the QECM.

The physical layout of the QECM metering panel and the mounting arrangements of the panel shall be provided as detailed in the drawings specified by Sections 8.15.1 and 9.11.2 of the QECM.

8. INSPECTION AND TESTING

All materials and workmanship will be subject to progressive inspection and testing by PBPL at both the Contractor's workshop and site. PBPL reserves the right to reject any material, which does not comply with the specifications, set forth herein or which contain defective materials or workmanship. Rejected materials shall be promptly removed at the expense of the Contractor and shall be replaced as soon as practical at no cost to PBPL.

The Contractor shall at all times provide PBPL with free access to the workshop facility for the safe and convenient inspection, examination, and testing of any part of the Work, including the relevant materials and documentation.

8.1 Routine Test and Factory Acceptance Test

Routine tests and a final Factory Acceptance Test (FAT) shall be carried out in accordance with the relevant Australian Standards. The Contractor shall provide written notice to advise PBPL, five business days prior to the commencement of testing so that testing may be witnessed by PBPL. PBPL will not attend the factory testing until the FAT Plan and supporting check sheets have been accepted by PBPL. The Routine tests must comprise all the categories as per section 11 of AS 61439.1:

Certified test records consolidated in the FAT Report for each switchboard shall be provided immediately after completion of the tests. The test records shall clearly describe the details of the tests and the test results. All supporting calculations shall be provided.

The routine test and FAT shall include the following:

- Completeness check,
- Quality of the manufacture,
- Checking of rating plates,
- Testing of all protection devices as primary or secondary injection test,
- Insulation resistance tests,
- Special tests when required and mutually agreed,
- Busbar systems shall be Ductor tested across all individual connections,
- Dielectric tests,
- Earth continuity tests,
- Measure the contact resistance of the main current carrying paths including the main busbars, bus-section breakers etc. and verify acceptable values,
- Primary injection to demonstrate correct ratio and polarity of CTs and correct operation of instrument and protection circuits,
- Functional check of circuit breaker and switch operation and control circuits,
- Functional test of all interlocking between switches, doors, and earth switches.

Power circuit insulation shall be tested using a 1000 V 'Megger'. Control wiring shall be tested at 500 V only.

High current micro-ohm resistance tests shall be carried out individually on all joints in the main circuit supply including connections to each outgoing unit. For outgoing units larger than 150 A, all power connections in the outgoing unit shall be tested. Resistance measurements shall be recorded and examined for inconsistent and unusually high readings.

Acceptance by PBPL of any equipment does not relieve the Contractor from any of their performance guarantees or other obligations under the Contract or purchase order.

8.2 Verification Testing

Verification tests establishing the performance criteria of the switchboard shall be carried out in accordance with the requirements of AS 61439.1. The test certificates shall include the following tests:

- Short time current tests on busbars,
- Temperature rise tests,
- Type 2 coordination test between contactors and short circuit protection motor starters,
- Verification of making and breaking capacity,
- Mechanical operation of circuit breakers, and switches.

Were applicable, and for the assembly or part of assembly, the design may either by verified by use of comparison or assessment. The Contractor shall present PBPL with the details of the verification(s) chosen for acceptance by PBPL.

8.3 Inspection

Equipment shall be checked against the PBPL accepted design documentation to ensure that the correct type, rating and number of circuits has been installed. The design drawings shall be updated to properly reflect the finished switchboard and copies of the drawings forwarded to PBPL.

The following items shall be checked:

- busbar configuration and support system for consistency with Type Test design drawings and certificates,
- sealing of fully welded seams is satisfactory,
- equipment mounting and cable supports to ensure adequate fixing and bracing,
- operating handles and interlocks for correct functioning,
- withdrawable equipment for free movement, operation of shutters and interlocks,
- clearance and creepage distances and degrees of protection,
- doors and access covers for sealing,
- bolted and screwed connections for tightness and adequate contact,
- label text against relevant schedules.

8.4 Function Checking

All control wiring in the switchboard shall be checked for correct function and marked off on the schematic drawings. These drawings shall be amended to reflect the final connections of the switchboard as despatched from the workshop.

If PBPL carries out spot checks of the completed switchboard and discovers inconsistencies with the drawings provided, then the Contractor shall retest the whole switchboard in the presence of a PBPL representative.

All control circuits shall be energised at their operating voltage and pushbuttons, and indicating lights and switches installed to fully simulate all field devices. Each feature of the circuit shall then be checked by operation of the switches and pushbuttons.

All current transformers and direct connected metering and protection equipment shall be tested by primary injection to prove correct polarity and CT ratios for ratio error and phase angle error.

The Contractor shall provide marked up red-line drawings and completed test and inspection sheets within five (5) business days of completing the FAT. A complete copy of the red line drawings shall be placed inside the switchboard enclosure and delivered to site with the switchboard.

8.5 Site Acceptance Testing and Commissioning

Inspection, site acceptance testing (SAT) and commissioning will be carried out to check the correct installation and prove the operation of each switchboard, in accordance with the Contractor's recommended SAT and commissioning procedures. Where specified in the scope of supply, the Contractor shall provide a SAT plan as well as supervision of the tests, which will include but not limited to:

- Verification of the installation work e.g. check mechanical installation, check electrical installation including all cables, terminations, identification, check external controls and interfaces,
- Perform SAT to the PBPL accepted SAT Plan,
- Insulation resistance tests,
- Earth Loop Impedance tests,
- Secondary injection tests,
- Functional test to prove the operation of each item of switchgear,
- Adjust all necessary settings, e.g. relay settings.

The Contractor shall submit a list of all test records and settings for all parameters associated with main incomer all the way through to the feeders in the SAT Report.

On completion of the site installation of the equipment, and before the equipment has been put into regular use, PBPL may repeat selected site tests. Should any equipment fail any tests, then the Contractor will be notified of such failure and the cost of replacements, repairs, and further SAT shall be covered by the Contractor.

The Contractor shall provide all testing of the site installation works to AS3000 and includes circuits to existing equipment fed from the new or modified switchboard. The Contractor has an obligation to advise PBPL in writing of all existing circuits and equipment that does not meet AS3000 current standard, along with a certificate of conformance for the installation works completed by the Contractor.

9. PACKING, HANDLING AND SHIPPING

The Contractor shall be responsible for preparation for shipment including packing, protection, preservation, labelling and marking of all items.

All test certificates shall be shipped with all lifting equipment, spreader bars, slings and shackles.

Switchboards shall be fabricated, fully assembled and tested at the factory. Large switchboards shall only be disassembled for shipping where indicated on the accepted design drawings.

All equipment shall have been fully tested and inspected prior to packaging. No packaging activities shall commence without the prior consent of PBPL. PBPL shall be notified of the dates of packaging with sufficient notice to allow attendance for completion of inspection and release certificates without affecting the required delivery schedule.

No equipment shall be allowed to leave the Contractor's premises without such certificate being signed, or a written waiver issued.

Temporary storage arrangements prior to site delivery shall be provided by the Contractor and included in the contract works. The storage location, preservation and duration of storage allowed shall be agreed prior to contract award with PBPL.

10. DOCUMENTATION

10.1 Documentation After Contract Award

After the award of the Contract, the Contractor shall supply the information specified in the specific project documentation for the contract. Switchboard manufacture shall not commence until all the design documentation related to the switchboard has been accepted by PBPL.

10.2 Drawings

The Contractor shall submit design drawings detailing the switchboard construction. This shall include but not limited to the following:

- General Arrangements (internal and external),
- Single Line Diagrams,
- Schematics,
- Termination Diagrams,
- Installation Details,
- Cable Schedule,
- Equipment List.

The Contractor shall submit documentation which shows that switchboard construction requirements are being met. This shall include:

- Full construction drawings of the switchboards and LCP's being supplied. For switchboards, these shall include busbar sizes, busbar support materials, spacing and phase centres, as well as sealing, hinging and fixing details for metalwork fabrication
- Layouts showing location of all power and control equipment shown on the schematic diagrams as well as cabling and glanding areas.

Where switchboard 'Layout' drawings are issued by PBPL with the specific project documentation, they shall be used as a guide only; the Contractor shall remain responsible for the detail design of the switchboard and shall produce workshop drawings.

10.3 Equipment Lists

Equipment lists shall detail the equipment type and quantity of every item of equipment being installed in the switchboard. This shall include all minor equipment such as control relays, lamps and terminals.

10.4 Label Lists

Label lists shall be provided for all labels indicating label text and text size as well as label overall dimensions, colour, material and fixing method.

10.5 Manuals

The contractor shall provide Operations and Maintenance (O&M) Manuals for all new equipment. This includes two (2) hard copies and one (1) electronic copy in pdf format. The O&M manual must be provided within five (5) business days after the switchboard FAT is completed.

The hard copy manuals shall be neatly presented in 2 ring binders, where hole punching is not suitable, or the manual is not provided with supports the manual is to be restrained by use of document holder with annotated dividers separating the different sections

Loose sheets and drawings not forming part of individually bound booklets within the manual shall be protected in individual plastic pockets. A maximum of two single sided sheets shall be placed back-to-back in each pocket, allowing them to be read without removal from the pockets.

Each folder shall have the following identifying information on the front cover giving:

- Project name,
- Switchboard asset number and title,
- Contract number and year of installation,
- Contractor's company name, address & phone number.

Electronic copy of O&M Manual shall be supplied and to be structured in directories that reflect the layout provided in the hard copy manuals.

All files shall be in one of the following formats to allow PBPL easily reprint portions or all of the O&M Manual.

- Adobe Acrobat (*.pdf),
- Microsoft Word (*.docx),
- Microsoft Excel (*.xlsx).

The following minimum information shall also be provided in the O&M manuals:

- Equipment schedule detailing the make, model and number of all separate items of equipment within the control panel. This shall describe exactly the equipment installed, including which manufacturer's options and accessories are included,
- Equipment manufacturer's maintenance information,
- Preventative maintenance schedule,
- Complete description of the control panel including all information shown on the rating plate,
- Details and names of equipment suppliers,
- Drawing list showing number, title and revision,
- Drawings including relevant Contract Drawings,
- List of spare parts provided,
- FAT Report,
- SAT Report,
- AS 61439 compliant Design Verification Report.

11. APPENDIX – Arc Flash PPE Categories

The table below details the site arc flash PPE categories and clothing requirements when accessing switchboards within the PBPL site.

Table 12: Summary of Arc Flash PPE Requirements

PPE Category	Cal/Cm²	**PPE Equipment**
0	1.2>	• PPE for the task being performed.
1	<4	• Minimum arc rated PPE 4 cal/cm² • Arc rated long sleeve shirt and pants. • Arc rated face shield with chin return. • Arc rated leather or voltage rated rubber gloves with leather protective outer. • Safety Glasses.
2	<8	• Minimum arc rated PPE 8 cal/cm² • Arc rated long sleeve shirt and pants. • Arc rated face shield with balaclava or arc flash suit with hard hat. • Arc rated leather or voltage rated rubber gloves with leather protective outer. • Safety Glasses.
4	<40	• Minimum arc rated PPE 40 cal/cm² • Arc flash suit and hood. • Arc rated leather or voltage rated rubber gloves with leather protective outer. • Hearing protection. • Safety Glasses and leather boots.

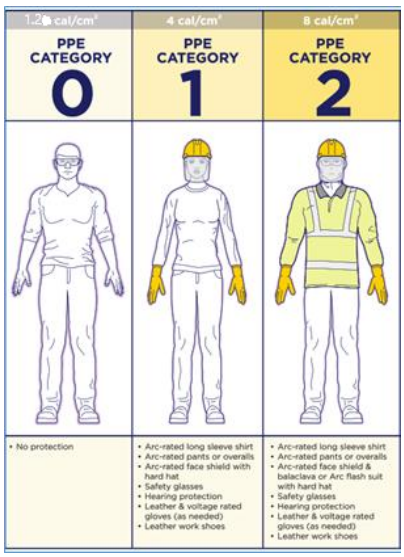


Figure 1: Arc Flash Label Type 1

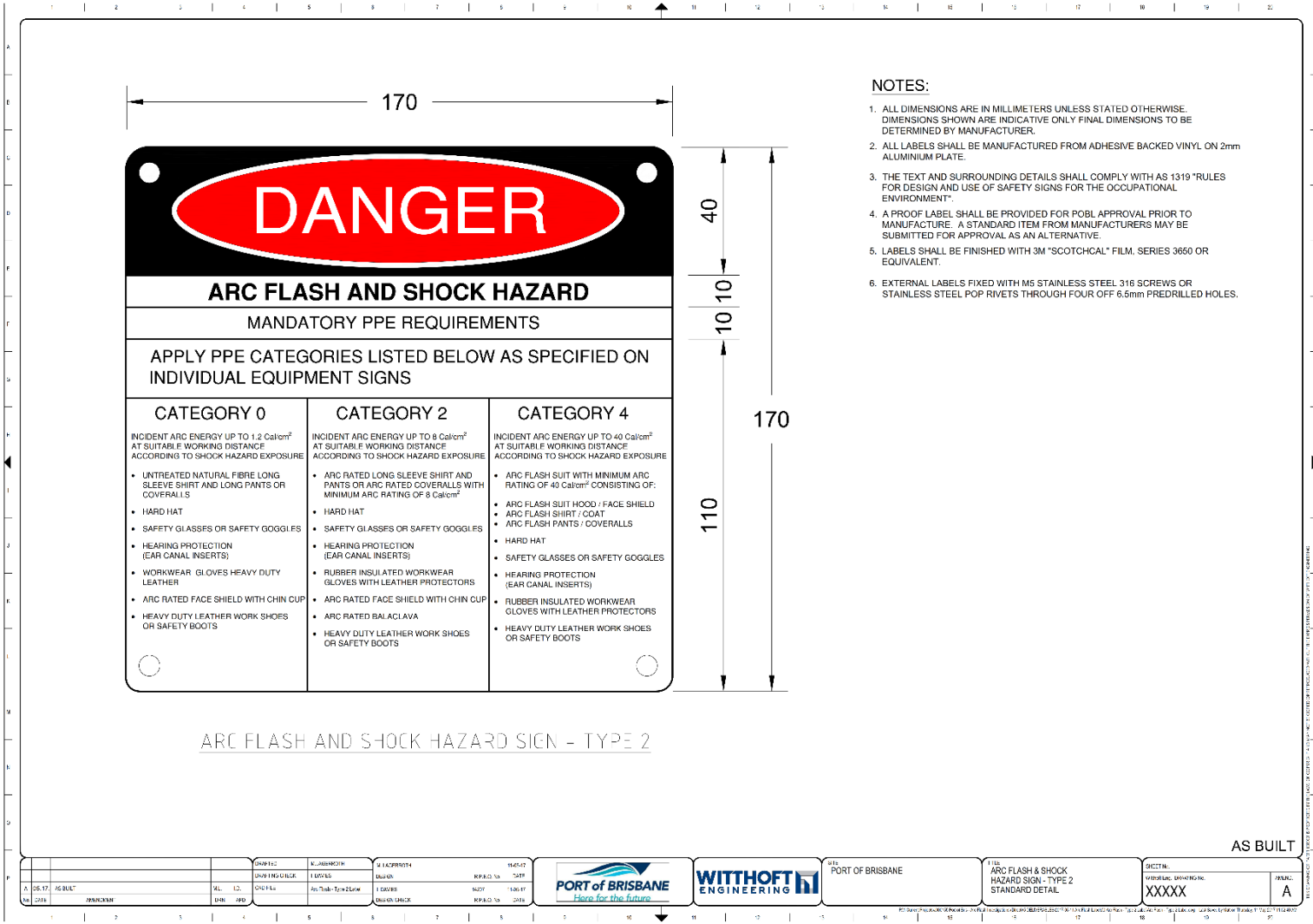


Figure 2: Example Arc Flash Label Type 2

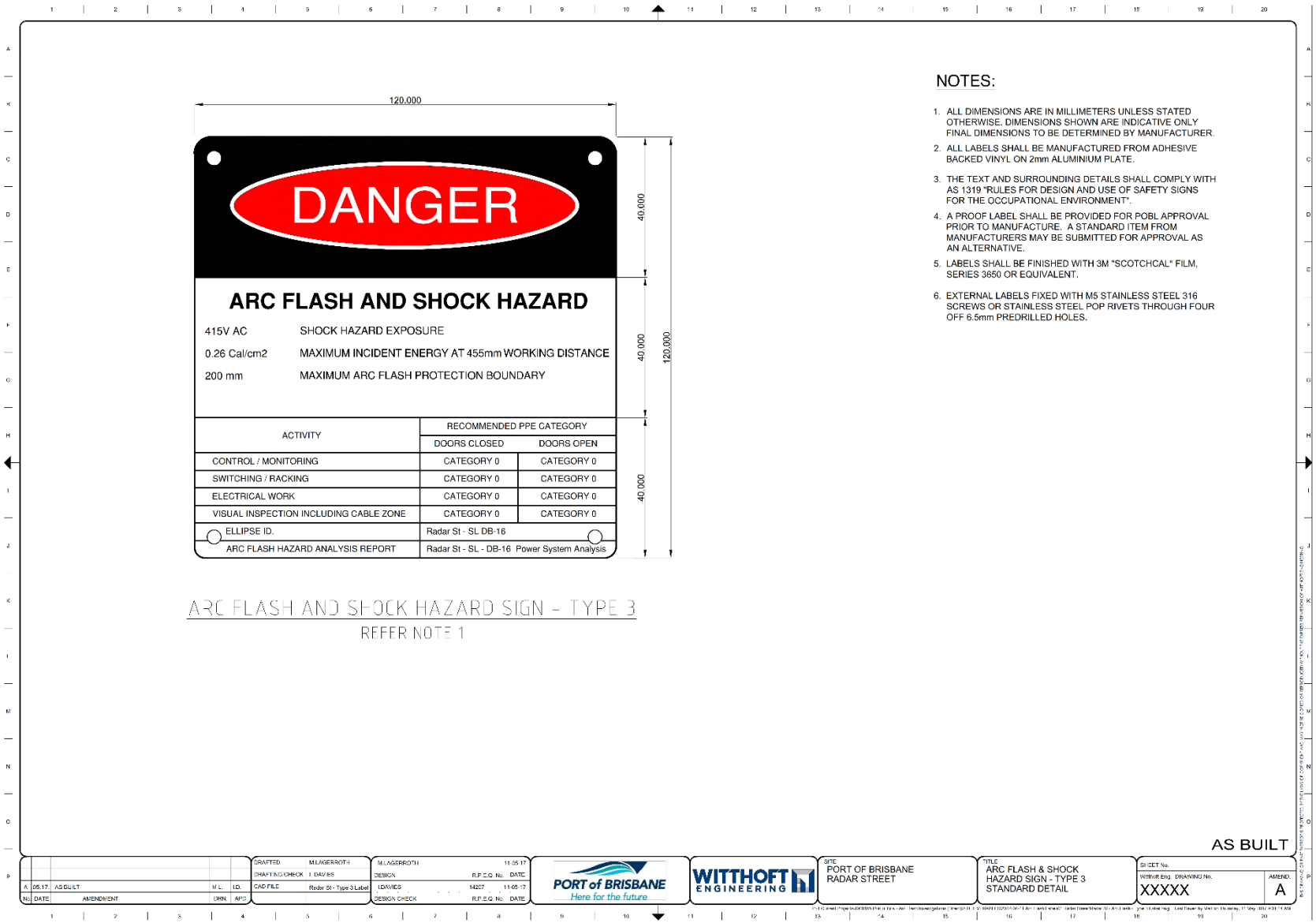


Figure 3: Example Arc Flash Label Type 3

12. APPENDIX – Technical Schedule

Table 13: AS 61439.2 Annex BB Technical Schedule

Item	Characteristic	Units	AS/NZS 61439 Reference	Default Arrangement	Options Listed in AS/NZS 61439	User Requirements
1.0	**Electrical System**					
1.01	Earthing System		• 5.6 • 8.4.3.1 • 8.4.3.2.3 • 8.6.2 • 10.5 • 11.4	Manufacturer's standard, selected to suit local requirements	• TT • TN-C • TN-C-S • IT • TN-S	TN-C-S (MEN)
1.02	Nominal Voltage	V AC	• 3.8.9.1 • 5.2.1 • 8.5.3	Local, according to installation	• Max 1000Vac • Max 1500Vdc	400Vac
1.03	Transient Overvoltages		• 5.2.4 • 8.5.3 • 9.1 • Annex G	Determined by the electrical system	• Category I • Category II • Category III • Category IV	Category III
1.04	Temporary Overvoltages	V	• 9.1	Nominal system voltage	• None	Manufacturer's Standard
1.05	Rated frequency fn	Hz	• 3.8.12 • 5.5 • 8.5.3 • 10.10.2.3 • 10.11.5.4	According to local installation conditions	• 50Hz • 60Hz • DC	50Hz
1.06	Additional onsite testing requirements: wiring, operational performance and function		• 11.10	Manufacturer's standard according to application	• None	Default and project specific requirements
2.0	**Short Circuit Withstand Capability**					
2.01	Prospective short circuit current at supply terminals Icp	kA	• 3.8.7	Determined by the electrical system	• None	Per switchboard SLD & Per project documentation
2.02	Prospective short circuit current in the neutral	kA	• 10.11.5.3.5	Max 60% of phase values	• None	60% of phase values
2.03	Prospective short circuit current in the protective circuit	kA	• 10.11.5.6	Max 60% of phase values	• None	60% of phase values

Item	Characteristic	Units	AS/NZS 61439 Reference	Default Arrangement	Options Listed in AS/NZS 61439	User Requirements
2.04	SCPD in the incoming functional unit requirement		• 9.3.2	According to local installation conditions	• Yes • No	Yes
2.05	Coordination of short circuit protective devices including external short circuit protective device details		• 9.3.4	According to local installations	• None	Yes, Per switchboard SLD & Per project documentation
2.06	Data associated with loads likely to contribute to the short circuit current		• 9.3.2	No loads likely to make a significant contribution allowed for	• None	None
3.0	**Protection of Persons Against Electric Shock in Accordance with IEC 60364-4-41**					
3.01	Type of protection against electric shock – Basic protection (protection against direct contact)		• 8.4.2	Basic protection	• According to local installation conditions	Basic protection
3.02	Type of protection against electric shock – fault protection (protection against indirect contact)		• 8.4.3	According to local installation conditions	• Automatic disconnection of supply • Electrical separation. • Total insulation.	Automatic disconnection of supply
4.0	**Installation Environment**					
4.01	Location type		• 3.5 • 8.1.4 • 8.2	Manufacturer's standard according to application	• Indoor • Outdoor	Outdoor/ Indoor
4.02	Protection against ingress of solid foreign bodies and ingress of water		• 8.2.2 • 8.2.3	Indoor (enclosed) IP2x Outdoor (min) IP23	• IP00 • IP2x • IP3x • IP4x • IP5x • IP6x	IP56 (Outdoor) IP44 (Indoor)
4.03	Protection after removal of withdrawable part		• 8.2.101	Manufacturer's standard	As for connected position/ reduced protection to manufacturer's standard	Manufacturer's Standard
4.04	External mechanical impact (IK)		• 8.2.1 • 10.2.6	None	• None	None

Item	Characteristic	Units	AS/NZS 61439 Reference	Default Arrangement	Options Listed in AS/NZS 61439	User Requirements
4.05	Resistance to UV radiation (applied for outdoor assemblies only unless specified otherwise)		• 10.2.4	Indoor: N/A Outdoor: Temperature Climate	• None	Outdoor: Powder Coated Aluminium
4.06	Resistance to corrosion		• 10.2.2	Normal indoor/ outdoor arrangement	• None	Severity A (Indoor) Severity B (Outdoor)
4.07	Ambient air temperature – lower limit	°C	• 7.1.1	Indoor: -5oC Outdoor: -25oC	• None	-5°C
4.08	Ambient air temperature – Upper limit	°C	• 7.1.1	40oC	• None	40°C
4.09	Ambient air temperature – Daily average maximum	°C	• 7.1.1 • 9.2	35oC	• None	36°C
4.10	Maximum relative humidity	%	• 7.1.1 • 9.2	Indoor: 50% @ 40oC Outdoor: -100% @ 25oC	• None	Up to 100%
4.11	Pollution degree (of the installation environment)		• 7.1.13	Industrial: 3	• 1 • 2 • 3 • 4	Min 3
4.12	Altitude	M	• 7.1.4	<1000m	• None	0-150m
4.13	EMC environment		• 9.4 • 10.12 • Annex J	A B	• A • B	A
4.14	Special service conditions (e.g. vibration, exceptional condensation, heavy pollution, corrosive environment, strong electric or magnetic fields, fungus, small creatures, explosion hazards, heavy vibration and shocks, earthquakes)		• 7.2 • 8.5.4 • 9.3.3 • Table 7	No special service conditions	- None	None
5.0	**Installation Method**					

Item	Characteristic	Units	AS/NZS 61439 Reference	Default Arrangement	Options Listed in AS/NZS 61439	User Requirements
5.01	Type		• 3.3 • 5.6	Manufacturer's standard	• Floor standing • Wall mounted • Open • Dead front • Enclosed • Cubicle • Multi-cubicle • Desk • Box • Multi-box	Floor standing, Multi-cubicle assembly
5.02	Stationary/ Movable		• 3.5	Stationary	• Stationary • Movable	Stationary
5.03	Maximum overall dimensions & weight		• 5.6 • 6.2.1	Manufacturer's standard, according to application	• None	Manufacturer to specify
5.04	External conductor type(s)		• 8.8	Manufacturer's standard	• Cable • Busbar • Trunking system	Cable
5.05	Direction(s) of external conductors		• 8.8	Manufacturer's standard	• None	Manufacturer's standard
5.06	External conductor material		• 8.8	Copper	• Copper • Aluminium	Copper
5.07	External phase conductor sections & terminations		• 8.8	As defined within the standard	• None	Per switchboard SLD & Per project documentation
5.08	External PE, N, PEN conductors cross sections and terminations		• 8.8	As defined within the standard	• None	Per switchboard SLD & Per project documentation
5.09	Special terminal identification requirements		• 8.8	As defined within the standard	• None	Per switchboard SLD & Per project documentation
6.0	**Storage and Handling**					
6.01	Maximum dimensions and weight of transport units		• 6.2.2 • 10.2.5	Manufacturer's standards	• None	Manufacturer's Standard
6.02	Methods of transport		• 6.2.2 • 8.1.6	Manufacturer's standard	• None	Manufacturer's Standard

Item	Characteristic	Units	AS/NZS 61439 Reference	Default Arrangement	Options Listed in AS/NZS 61439	User Requirements
6.03	Environmental conditions different from the service conditions		• 7.3	As service conditions	• None	Not applicable
6.04	Packing details		• 6.2.2	Manufacturer's standard	• None	Manufacturer's Standard
7.0	**Operating Arrangements**					
7.01	Access to manually operated devices		• 8.4		• Authorised persons • Ordinary persons	Authorised persons
7.02	Location of manually operated devices		• 8.5.5	Easily accessible	• None	Easily accessible
7.03	Isolation of load installation equipment items		• 8.4.2 • 8.4.3.3 • 8.4.6.2	Manufacturer's standard	• Individual • Groups • All	Individual
8.0	**Maintenance and Upgrade Capability**					
8.01	Requirements related to accessibility in service by ordinary persons; requirement to operate devices or change components while ASSEMBLY is energised		• 8.4.6.1	Basic protection	• None	Basic protection
8.02	Requirements related to accessibility for inspection and similar operation		• 8.4.6.2.2	No requirement for accessibility	• None	None
8.03	Requirements related to accessibility for maintenance in service by authorized persons		• 8.4.6.2.3	No requirements for accessibility	• None	None
8.04	Requirements related to accessibility for extension in service by authorised persons		• 8.4.6.2.4	No requirements for accessibility	• None	None
8.05	Method of functional units connection		• 8.5.1 • 8.5.2	Manufacturer's standard	• None	Manufacturer's standard

Item	Characteristic	Units	AS/NZS 61439 Reference	Default Arrangement	Options Listed in AS/NZS 61439	User Requirements
8.06	Protection against direct contact with hazardous live internal parts during maintenance or upgrade (e.g. functional units, main busbars, distribution busbars)		• 8.4	No requirements for protection during maintenance or upgrade	• None	Manufacturer's Standard
8.07	Gangways		• 8.4.6.2.101	Basic protection	• None	Basic protection
8.08	Method of functional unit's connection Note – this refers to the capability of removal and re-insertion of functional units		• 8.5.101		• F – Fixed • D – Disconnect-able connections • W – Withdrawable connections	W – Withdrawable (refer SLD)
8.09	Form of separation		• 8.101		• Form 1 • Form 2 • Form 3 • Form 4	4a (Main Incomers) 3b minimum
8.10	Capability to test individual operation of the auxiliary circuits relating to specified circuits while the functional unit is isolated		• 3.1.102 • 3.2.102 • 3.2.103 • 8.5.101 • Table 103		• None	None
9.0	**Current Carrying Capacity**					
9.01	Rated current of the ASSEMBLY Ina (amps)	A	• 3.8.9.1 • 5.3 • 8.4.3.2.3 • 8.5.3 • 8.8 • 10.10.2 • 10.10.3 • 10.11.5 • Annex E	Manufacturer's standard according to the application	• None	Per switchboard SLD
9.02	Rated current of circuits Inc (amps)	A	• 5.3.2	Manufacturer's standard, according to the application	• None	Per switchboard SLD
9.03	Rated diversity factor		• 5.4 • 10.10.2.3 • Annex E	As defined within the standard	• RDF for groups of circuits	N/A

Item	Characteristic	Units	AS/NZS 61439 Reference	Default Arrangement	Options Listed in AS/NZS 61439	User Requirements
					• RDF for whole assembly	
9.04	Ratio of cross section of the neutral conductor to phase conductors: phase conductors up to and including 16mm^2	%	• 8.6.1	100	• None	100%
9.05	Ratio of cross section of the neutral conductor to phase conductors: phase conductors above 16mm^2	%	• 8.6.1	8.6.1 50% (minimum 16mm^2)	• None	100%
10	***Requirement for Short Circuit Withstand Capabilities for Arc Fault Contained Switchboards**					
10.1	Protection against internal arcing fault currents Applies to switchboards rated >800A	None	AS/ NZS 3000	Mandatory	None	Yes
10.2	Guidelines for assemblies intended to provide increased security against the occurrence or the effects of internal arcing fault.	None	ZC	Informative only	Refer ZC6	Implement the principals of ZC6 a) and c) and ZC6 b), d) and e) as required.
10.3	Internal arcing fault tests	None	ZD	Subject to arrangements	Standard or special tests to ZD or to IEC TR 61641	ZD standard
10.4	Selection of components	None	ZE	Manufacturer's standards	None	Manufacturer's standard
10.5	Internal arcing fault current rating of assembly	None	ZD	Subject to arrangements	None	Per switchboard SLD

13. APPENDIX – Example DVR

No.	Characteristic to be verified	Relevant Clauses	Testing	Comparison with reference design	Assessment	Verified by	Comments/ Notes	Document ID
1	Strength of materials and parts resistance to corrosion.	10.2						
	Resistance to corrosion	10.2.2	YES	NO	NO			
	Properties of insulating materials	10.2.3						
	Thermal stability	10.2.3.1	YES	NO	NO			
	Resistance to abnormal heat and fire due to internal electric effects	10.2.3.2	YES	NO	YES			
	Resistance to ultraviolet (UV) radiation	10.2.3.4	YES	NO	YES			
	Lifting	10.2.5	YES	NO	NO			
	Mechanical impact	10.2.6	YES	NO	NO			
	Marking	10.2.7	YES	NO	NO			
2	Degree of protection of enclosures	10.3	YES	NO	YES			
3	Clearances	10.4	YES	NO	NO			
4	Creepage distances	10.4	YES	NO	NO			
5	Protection against electric shock and integrity of protective circuits.	10.5						

No.	Characteristic to be verified	Relevant Clauses	Testing	Comparison with reference design	Assessment	Verified by	Comments/ Notes	Document ID
	Effective continuity between the exposed conductive parts of the assembly and the protective circuit.	10.5.2	YES	NO	NO			
	Short circuit withstand strength of the protective circuit.	10.5.3	YES	YES	NO			
6	Incorporation of switching devices and components	10.6	NO	NO	YES			
7	Internal electrical circuits and connections	10.7	NO	NO	YES			
8	Terminals for external conductors	10.8	NO	NO	YES			
	Dielectric properties	10.9						
9	Power-frequency withstand voltage	10.9.2	YES	NO	NO			
	Impulse withstand voltage	10.9.3	YES	NO	YES			
10	Temperature rise limits	10.10	YES	YES	YES			
11	Short circuit withstand strength	10.11	YES	YES	NO			
12	Electromagnetic compatibility (EMC)	10.12	YES	NO	YES			
13	Mechanical operation	10.13	YES	NO	NO			