Standard Specification

Engineering Standard E-SPE-STD-001 Electrical Design and Construction

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Version History

Ver	Date	Description	Author	SME	Owner	Approver
4	21/05/2026	Amended Version				
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(Refer Controlled Document in REX for Author, SME, Owner and Approver details)

Contents

1. Purpose

This document is part of a suite of Seqwater Engineering Standards which are in alignment with the Seqwater Quality Management System. Their purpose is to provide a consistent approach to the development, modification, and management of Seqwater infrastructure that is fit for purpose, economic over the life of the asset, and meets Seqwater's risk appetite and compliance requirements including Work Health and Safety obligations.

This Standard Specification provides the minimum requirements and recommendations for design, construction, installation and testing of electrical systems.

This document must be used in conjunction with the documents it references to assist in ensuring fit for purpose infrastructure. This Standard Specification is not intended to be relied on solely for design, supply, and installation works; advice from specialist engineers and/or manufacturers may be required on a case-by-case basis.

2. Scope

This Standard Specification applies to all Seqwater employees, contractors, suppliers and consultants working for or on behalf of Seqwater unless otherwise stated. It applies to all new assets and to all existing assets undergoing refurbishment or modification. It must be used in conjunction with other relevant Seqwater Engineering Standards and project specific documents to define the technical requirements for infrastructure design and construction.

Where single or discrete components of an existing non-compliant system are to be replaced, refurbished or modified, this standard should not automatically be applied to the entire system retrospectively, however consideration should be given, in consultation with relevant stakeholders, to the extent of the application of the standard outside of the components requiring replacement, refurbishment or modification, to ensure safe, economic, and fit for purpose infrastructure.

Seqwater Engineering Standards include Standard Specifications, Drawings, Procedures, Templates, Forms and Preferred Equipment Lists. Together they detail Seqwater's minimum requirements and recommendations to provide infrastructure that will be fit for purpose, safe, and cost effective to operate and maintain. However, compliance with these requirements and recommendations does not remove, and cannot be relied on as meeting, the designer's overarching responsibility for ensuring infrastructure designed is fit for purpose and safe to construct, operate, maintain, and demolish. The designer must exercise appropriate due diligence to identify and manage hazards so far as is reasonably practicable.

Designers must also ensure compliance with relevant Australian Legislation, Standards, Codes and Guidelines (including those produced by Water Services Association of Australia). Where no Australian Standard exists for a particular application, work must conform to the most current version of an industry accepted international standard. Seqwater Engineering Standards use the International System of Units (SI), unless noted otherwise.

Deviation from meeting the minimum requirements in this Standard Specification requires written agreement from Seqwater as per the deviation process detailed in Procedure X-PRO-STD-008 Asset Standards Management and Application. That process includes completion of an X-TMP-STD-022 Asset Standards Deviation Request Form together with relevant supporting documentation, and submission by the Seqwater Project Representative to the Seqwater Engineering Mailbox. Where noted in this Standard Specification that Seqwater approval, agreement, or

acceptance shall/must be sought, such approval, agreement or acceptance must be gained through the Seqwater Asset Standard Deviation process, as outlined above.

Responsibility for ensuring compliance with Seqwater Engineering Standards lies with those engaged in the management and execution of design, construction, and modification of Seqwater infrastructure. This includes modifications to the functional design of the infrastructure including technical changes made which would extend an asset outside of its design operating envelope and/or approved operation and maintenance practices.

Any ambiguities or conflicts identified between specific requirements within this Standard and project documents, another Seqwater Engineering Standard or Australian Legislation, Standards, Codes or Guidelines, must be brought to the attention of the Seqwater Document Owner as listed in the document footer, via the Engineering Mailbox, for clarification. Where it is proposed to proceed without meeting the requirements of this standard, agreement must be obtained via the Deviation Process, as outlined above.

Seqwater undertakes regular updates of its Engineering Standards. Before utilising this Engineering Standard, the complete list of Seqwater Engineering Standards should be reviewed to ensure currency and applicability of standards to be applied to the works. These can be accessed on the Waternet Seqwater Engineering Standards & Framework page or from your Seqwater project manager, design manager, or engaging officer.

For electrical design & construction, IEC standards are preferred in the absence of an appropriate Australian Standard.

2.1. Hazardous Area Application

The requirements as specified in this standard shall also apply to installations in a hazardous area associated with explosive atmospheres, except for requirements that conflict with AS/NZS 60079 (series), in which case AS/NZS 60079 (series) takes precedence over those requirements.

3. Electrical Design Criteria

3.1. Operating Conditions

Unless otherwise specified, all electrical equipment and instrumentation will be required to operate continuously at full load for 24 hours per day, 365 days per year under the climatic conditions detailed in this specification.

3.2. Safety in Design

All equipment shall be designed to perform its intended duty safely while unattended. Wherever possible, all health and safety risks shall be “designed out” during the design phase prior to construction.

3.3. Hazardous Areas

3.3.1. Hazardous Area Standards

The classification of hazardous areas is to be conducted in accordance with AS/NZS 60079.10.1 for gas or vapour and AS/NZS 60079.10.2 for combustible dusts. The Contractor shall obtain confirmation from the Principal regarding the hazardous area classification of the worksite prior to commencement of detail design.

Electrical installations in hazardous areas shall be designed as per AS/NZS 60079.14.

Electrical equipment for use in hazardous areas shall be selected and installed in compliance with requirements as specified in AS/NZS 60079.14.

3.3.2. Hazardous Area Competency

The design of the installation, the selection of equipment, and the erection covered by AS/NZS 60079 standard shall be carried out only by persons whose training has included instruction on the various types of protection and installation practices, relevant rules and regulations and on the general principles of area classification. The competency of the person shall be relevant to the type of work to be undertaken.

Competency shall be demonstrated in accordance with AS/NZS 4761.

3.3.3. Hazardous Area Design

The design should aim to minimise the quantity of equipment that needs to be installed within a hazardous area.

3.3.4. Hazardous Area Equipment

Equipment certification shall be in accordance with the ANZEx or IECEx schemes.

Equipment certified to ATEX but not ANZEx/IECEx will be accepted only if all of the following conditions are met:

a. ANZEx or IECEx equipment is not practically obtainable for the application. This must be justified in writing by the designer, to the satisfaction of Seqwater; and

b. The equipment is accompanied with a Conformity Assessment Document (CAD) carried out by a competent person. The CAD shall follow the requirements and guidance of AS/NZS 60079.14 for Conformity Assessment Documents; and

c. If accepted for use, the justification for ATEX equipment and CAD must be included in the Hazardous Area Verification Dossier.

3.3.5. Hazardous Area Verification Dossier

For any works located fully or partially within a hazardous area, the Contractor shall produce or update as applicable a Hazardous Area Verification Dossier that meets the requirements of AS/NZS 60079.14 and AS/NZS 60079.17.

A completely new dossier will apply only to locations where there was no pre-existing or nearby hazardous area. Changes/additions to existing hazardous areas require the Contractor to update the existing Dossier for that area. It is not acceptable to produce a project-specific hazardous area dossier including only the changes to an existing hazardous area.

3.4. High Voltage Equipment and Installation

HV equipment and installations must be designed and constructed to AS 2067 and a detailed project specification endorsed by Seqwater Engineering.

HV equipment and installations shall, at a minimum, meet a standard no lower than that defined in this specification for LV equipment and installations, with adaptation where required to suit the higher voltage.

SF6 insulated switchgear is not permitted, unless a project-specific deviation is provided by Seqwater Engineering.

3.5. Design Life

Except where specified otherwise in Seqwater standards for equipment, electrical designs shall create assets having a design life of at least 20 years, excepting normal routine maintenance and supply of consumables, before major overhaul is required.

3.6. Electrical Equipment Selection

Unless otherwise approved by the Principal, all equipment provided shall be the latest released model, with guaranteed service and spares support for a minimum of ten years after the installation date. Superseded models of equipment shall not be acceptable.

Seqwater prefers equipment that has spares and support availability local to South East Queensland.

Equipment should be selected to minimise the variety of spare parts holdings needed. Contractors should:

a. Consider commonality with existing equipment and spares in service at each site/region, and

b. Aim to standardise equipment sizes and ratings.

3.7. Design Reliability Target

The target reliability figure for all electrical design shall be 99% as a minimum for the entire system. Particular care should be taken to avoid single points of failure for the system and there should be no hidden failures, especially for redundant elements in the design.

3.8. Spares Management

All design and construction work shall incorporate considerations for future proofing and spares management. This section describes Seqwater's expectations pertaining to spare capacity allowance for multiple facets of all electrical works.

3.8.1. Spare Power Capacity

Where a power supply upgrade is required, the upgraded power system including the supply transformers, generators, associated cabling, distribution boards and switchboards shall be sufficiently sized to allow for the current project, foreseeable future projects within the design life of the assets plus a minimum of 20% spare capacity in apparent power (kVA).

All 24 VDC power supplies shall be sized to provide capacity for the full load within the designed system plus a minimum 50% spare capacity in real power (W).

All uninterruptible power supplies (UPS) shall be sized to provide capacity for the full load within the designed system plus a minimum 50% spare capacity in apparent power (VA).

3.8.2. Spare Short Circuit Withstand

LVSCAs including main bus circuits shall be designed and selected to have a short circuit withstand rating no less than the [worst-case calculated prospective short circuit current at the LVSCA incoming terminals, considering foreseeable future projects within the design life of the assets] * 120%. This allowance shall be met for both peak and short-time withstand capability.

The corresponding duration of the short-time withstand capability shall be no less than the following, whichever is greater:

a. [worst-case maximum upstream protection clearing time considering foreseeable future projects within the design life of the assets] * 120%, or

b. 0.2s for Form 1 or 2bi control panels or DBs, ≤250A, with upstream instantaneous protection, or

c. 1s for LVSCAs other than those covered in (b) above.

3.8.3. Spare Space

A minimum of 25% useable spare space shall be included in a switchroom layout for future equipment. For example, if a switchroom was designed to house a four tier switchboard, the room shall allow for future expansion of the switchboard by at least one tier. MCCs and modular free standing switchboards shall be provided with facilities for future extension of the assembly and busbar at one end (minimum), whilst remaining compliant with all other requirements of this specification including design verification and arc fault containment if applicable.

All terminal rails within switchboards, junction boxes, marshalling panels and control panels shall include a minimum of 25% spare rail length (in mm) and surrounding space for future rail mounted equipment.

Cable ducts shall include a minimum of 20% spare space above manufacturer's recommended maximum wire capacity for future additional wiring, for example, if manufacturer recommends maximum 60% duct utilisation, then design shall be for 40% utilisation.

Modular MCCs with provision for future extension shall include a minimum of 10% space in the MCC for additional starter and feeder/modules.

MCCs that cannot practically be extended in future shall include minimum of 20% space in the MCC for additional starter and feeder/modules.

3.8.4. Installed Spare Equipment

All earth bars and neutral bars shall include a minimum of 25% spare connection terminals.

Distribution boards shall include a minimum of 25% spare poles at the time of practical completion.

Gland plates shall be sized to accommodate the full future capacity of the assembly including spares.

All cable conduits shall not be utilised more than 75% of its usable space at the initial installation.

Within underground cableways, at least one spare conduit for each conduit type shall be installed unless otherwise approved by the Principal.

Terminals shall be installed for all I/O modules including unused channels. The installed spare terminals shall not form part of the 25% spare rail space.

3.8.5. Spare Stock

All equipment provided shall have guaranteed spares from the supplier for a minimum of ten years after the installation date. Critical equipment not stocked locally in Australia or pre-existing Seqwater stores shall not be accepted unless:

a. The equipment is warranted in Australia, and

b. Sufficient spare units are provided during project delivery to cover for the worst-case lead time of procuring additional replacement units.

3.9. Voltage Levels

Electrical systems shall be designed for the voltage levels in accordance with AS 06638 as detailed in Table 1 below.

Table 1 Voltage Levels

Condition	Detail
High Voltage	33,000 V, 50 Hz, 3 Wire
	11,000 V, 50 Hz, 3 Wire
	6,600 V, 50 Hz, 3 Wire
	3,300 V, 50 Hz, 3 Wire
Three Phase Low Voltage	3 phase, 4 Wire, 400 V +10% -6%, 50 Hz ± 2%, MEN System Voltage Unbalance <5%
Single Phase Low Voltage	230 V +10% -6%, 50 Hz ± 2%
HV Switchboard Trip & Control Power	48 VDC
Control Power	24 VDC

Low voltage electrical equipment shall be suitable for operation at a utilisation voltage of 400 V +10% -11% or 230V +10% -11%.

3.10. Site Climatic Conditions

All electrical components shall be selected and installed so that all circuits can operate at the design load plus specified allowance for future expansion, at the worst climatic extreme detailed in Table 2 below. The full load rating for motor circuits shall be taken as the motor full load current while the rating for other circuits shall be the circuit breaker rating.

Table 2 Site Climatic Conditions

Condition	Detail	Value
Location	South East Queensland	-
Altitude	Above mean sea level.	≤ 1000 m
Ambient Temperature (Dry bulb)	Minimum	-5°C
	Maximum	45°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
Corrosivity Category	Select as per AS 4312	C3 minimum; or higher as required for chemical areas and locations near a shoreline

3.11. Electrical Equipment Location

Electrical equipment such as switchboards must not be installed within areas where they may be influenced by corrosive chemicals except when such a location is necessary for the function of that equipment.

3.12. Ingress Protection (IP)

The minimum IP rating of switchboards, distribution boards, control panels, marshalling and junction boxes shall be determined based on the installation conditions as detailed in Table 3.

The requirements in Table 3 shall also apply to electrical equipment enclosures in general that do not have a different IP Rating specified in Seqwater Standards.

Table 3 – Electrical Enclosure IP Rating

Installation Condition	Minimum IP Rating
Indoor - Dry, air conditioned switchroom	IP54*
Indoor - Dry, clean location where contact with water or chemical is implausible	IP54
Indoor – Areas where contact with water or chemical is possible, e.g. due to hose down, proximity of pumps or pipework	IP56
Outdoor	IP56
Temporary Immersion < 1m (Potential for brief immersion under normal operations)	IP67

*If the target cooling requirements cannot be achieved without forced ventilation, then IP44, IP43 or IP42 are acceptable upon approval by the Principal.

3.13. Power Quality

Power factor on the main plant load shall be maintained to a minimum of 0.95.

The total harmonic voltage distortion shall be limited to 5% maximum at each plant 400 V switchboard. Total site harmonic distortion levels shall also meet the requirements of the local DNSP (Energex).

3.14. Lighting and Small Power

3.14.1. Equipment General Requirements

Single phase LV plugs and socket-outlets shall comply with AS/NZS 3112.

Three phase LV outlets and plugs shall comply with AS/NZS 3123.

LV air break switches shall comply with AS/NZS 3133.

3.14.2. General Purpose Outlets (GPO)

GPOs are to be used to supply portable equipment, tools, office equipment and other applications which are not designed to be permanently installed. The following specifications shall apply to all GPO installations at Seqwater sites.

a. All GPOs rated at 32 A or below shall be protected via a 30mA Type A RCD.

b. Individual RCDs shall be provided. “Collective” or “group” RCDs across multiple circuits shall not be permitted.

c. GPOs with a rated current of above 32 A shall not be accepted. Socket outlets with a current rating above 32A may only be used for specific equipment according to the requirements of section 3.14.3.

3.14.3. Special Purpose Outlets (SPO)

For permanent installations, the preference is to have equipment supplied via fixed wiring, unless an operational need warrants the use of a Special Purpose Outlet (SPO). SPOs may be used for applications where the supplied equipment is intended to be installed permanently but may require disconnection by non-electrical workers for maintenance purposes.

The following specifications shall apply to all SPO installations on Seqwater assets.

a. All SPOs rated at 32A or below shall be protected by a 30mA RCD, unless the nature of the equipment has been justified to meet one of the allowable exceptions for additional protection by RCDs (see 6.7.27).

b. Where there is a need for an SPO final subcircuit rated above 32A, the Contractor shall provide justification for the inclusion or exclusion of RCD protection as part of the design documentation for review by the Principal.

c. SPO final subcircuits with a rating exceeding 32A shall only be installed where there is an operational need for frequent disconnection of equipment with a load requirement above 32A.

d. SPOs shall be used exclusively for its labelled equipment.

e. All SPOs (with or without RCD protection) shall be located in a position that is not likely to be accessed for general use.

f. All SPOs (with or without RCD protection) shall be labelled in accordance with section 3.14.5.

g. Single phase 10A SPOs shall have a round earth pin to ensure incompatibility with standard 3 pin plugs.

Non-VSD operated submersible pumps and mixers under 5.5kW shall be supplied from an IP66 AC-23 SPO located in an accessible position to facilitate pump/mixer replacement by non-electrical workers. Include seal failure, over temperature and all other protection devices as recommended by the pump/mixer supplier.

3.14.4. Lighting Circuits

All lighting circuits shall be fitted with 30mA RCDs and injection test points. The test point shall have a round earth pin.

If the test point is not incorporated into the distribution board, it shall be located at the furthest most practical point of the circuit, at a minimum height of 2.3 m or beyond normal reach.

Emergency lighting and illuminated emergency exit signage systems, and the inclusion of RCDs, shall be designed in accordance with AS/NZS 2293.

Area lighting circuits shall include provision for control by photo-electric cell, electronic clock, GPS clock or PLC; and manual override.

Emergency lighting circuits shall have a timer relay for emergency light testing.

3.14.5. Labelling and Identification

GPOs and SPOs shall be affixed with a label clearly indicating the supplying distribution board number and circuit breaker number. In addition, SPOs shall also be affixed with a permanent label in accordance with 6.5.12 which includes the following information:

a. The device supplied by the SPO including its equipment tag where applicable
b. A statement to indicate that the outlet is to be used exclusively for its labelled equipment
c. The current rating of the SPO
d. The presence or absence of RCD protection. In the case where RCD protection is absent, include wording "WARNING - THIS SPECIAL PURPOSE OUTLET IS NOT RCD PROTECTED" in black text on a yellow background.

Lighting circuit test points shall be affixed with a clearly visible permanent label which reads "CAUTION - LIGHTING TEST POINT ONLY – DBRxxx CBxx" where DBRxxx represents the distribution board equipment number and CBxx represents the circuit breaker number, in black text on a yellow background.

Isolators and light switches shall be affixed with a permanent label clearly indicating its supplying distribution board and circuit breaker number.

3.15. Motor Control Circuit Design

3.15.1. Motor Field Controls

Provide a local control station for each motor with the following minimum requirements.

a. A local whole current isolator (AC-23 rated) for motors up to 50kW:
   i. Isolates any auxiliary equipment associated with the drive including heater, fan, brake etc.
   ii. Includes control pole interlocks
   iii. Is lockable in the off position
b. A local emergency stop (compliant with 6.7.25) – unless the risk assessment conducted in accordance with AS/NZS 4024 shows it to be not required (see 3.15.6)

3.15.2. Direct On Line (DOL) Starter Features

DOL starters are not preferred for LV motors >50kW. Such motors should be connected to a VSD or Soft Starter.

DOL starters are not permitted for applications where DOL start would cause a supply voltage drop of more than 5%.

All DOL LV motor starter control circuits shall include the following control interlocks:

a. MCC motor circuit breaker
b. Motor overload protection
c. Temperature protection – where required (Thermistor PTC for motor greater than 50kW up to 150kW; RTD PT100 for motor greater than 150kW)
d. Whole current field isolator– where required

e. Emergency stop – where required

DOL starters may be specified with or without local control as per the functional needs. Refer to I-SPE-STD-013 Control Systems Design and Construction – Equipment Control Modes.

Where local control is required, the following controls and indications shall be provided on the MCC starter cubicle door as a minimum:

f. Local/Remote selector switch

g. Start and Stop push buttons

h. "Available", "Running" and "Overload" indication lamps, controlled directly by the starter control circuit independent of the PLC. All indication lamps shall be LED type.

When the drive is in "Local" mode, it shall be started and stopped directly by start and stop buttons on the MCC panel, with no sequence interlocking and fully independent of the PLC/SCADA system.

In "Remote" mode, the drive shall be started and stopped by the plant PLC/SCADA system via an interposing relay. Operating local start and stop buttons in this mode shall have no effect.

The "Available" light shall illuminate when the MCC circuit breaker, field isolator, emergency stop and Thermal Overload are all healthy and control circuit power is supplied.

The "Overload" light shall illuminate whenever there is an overload trip active.

3.15.3. Variable Speed Drive (VSD) Units

LV VSDs and the associated electrical and control design and installation shall comply with Standard Specification E-SPE-STD-010 Low Voltage Variable Speed Drives and Soft Starters.

MV/HV VSDs and the associated installations must be designed and constructed to a detailed project specification endorsed by Seqwater Engineering. MV/HV VSDs and the associated electrical and control design and installation shall at a minimum meet the equivalent standards as for LV VSDs in E-SPE-STD-010, with adaptation where required to suit the higher voltage.

3.15.3.1. Dosing pumps

Small variable speed dosing pumps shall preferably be digital type, supplied via dedicated SPOs which in turn shall be supplied by a dedicated circuit breaker in the distribution section of the relevant MCC. All dosing pumps which connect to an SPO shall be fitted with an IP rated plug with locking ring in accordance with section 3.14.3.

Digital dosing pumps shall be controlled via a 4-20mA analogue signal, with integral flow monitoring and communication interface to the PLC/SCADA system.

3.15.4. Soft Starters

LV Soft Starters and the associated electrical and control design and installation shall comply with Standard Specification E-SPE-STD-010 Low Voltage Variable Speeds and Soft Starters.

For applications where MV/HV Soft Starters may be used, consult Seqwater Engineering for requirements.

3.15.5. PLC I/O for Motor Control

Provide as a minimum the following digital PLC inputs for each motor:

a. Circuit Breaker Closed
b. Remote - indicating that the Local / Remote switch is in Remote
c. Running
d. Starter Ready / DOL overload relay healthy
e. Local Isolator Closed – (if field isolator is provided)
f. Emergency Stop OK – (If E/Stop is provided) Contact opens when field emergency stop is activated
g. All other protective devices associated with the motor e.g. seal failure, electronic shearpin relay etc.

Provide as a minimum the following digital PLC outputs for each motor:

h. Run
i. For VSDs and Soft Starters: Allow hardware for Remote Reset. Functionality to be disabled by default and enabled where required by application specific risk assessment.

Provide as a minimum the following analog PLC outputs for each motor:

j. For VSDs: Speed reference

Provide at a minimum the following monitoring functions via control system field device LAN:

k. For VSDs and Soft Starters: Motor and drive/starter monitoring functions and alarms as listed in I-SPE-STD-013.

3.15.6. AS/NZS 4024 Compliance

Perform a risk assessment in accordance with AS/NZS 4024 to confirm the appropriate motor control system risk categories for equipment as soon as physical arrangements of the relevant equipment are available. The Contractor shall ensure that the motor controls for all equipment provided are of the appropriate safety category rating and in accordance with all machine guarding requirements.

Provide copies of all risk assessments and calculations as part of the engineering deliverables for review and handover.

3.16. General Requirements for Proprietary Systems

All proprietary and packaged systems shall comply with all requirements of this specification except as modified in this section.

Wherever practical, the motor control circuit design shall comply with all requirements of Section 3.15 “Motor Control Circuit Design” of this specification, however as a minimum, the motor control circuit design shall comply with the following minimum requirements:

a. All control circuits shall be 24 VDC
b. Provide local manual controls for testing and maintenance
c. Motor control circuits shall meet the appropriate safety category as determined by AS/NZS 4024
d. Where Safety type relays are provided, they shall be supplied from a UPS system so that a local reset of the safety system is not required after a plant power failure.

Control systems for proprietary process equipment shall use Seqwater prescribed equipment as detailed in I-LST-STD-001 unless otherwise approved by Seqwater. Proprietary type control systems may be proposed, however wherever possible the additional cost to use Seqwater prescribed equipment shall be provided as an option.

All proprietary systems rated at over 250 amps, or which include motors over 22 kW, shall include power monitoring in accordance with the requirements of this specification.

All proprietary systems with monitoring and control functionality, except for cranes, shall include a communication interface to the site control system LAN, compliant with I-SPE-STD-013, to provide:

- Indication of all status and individual alarms
- All necessary process controls
- Power monitoring as required

3.17. Earthing

Earthing systems shall comply with AS/NZS 3000 and AS 2067 as appropriate for LV and HV installations. Modifications and additions to existing earthing systems shall account for and be fully integrated with the entire earthing system of the site.

For installations above 1kV, detailed design shall comply with the procedures described in section 8 of AS 2067. For recreational sites or locations subject to reasonable public access, the earthing system shall be designed to location class C1 (Special Location – High public contact likelihood) as detailed in section 8.2.1 of AS 2067.

Equipment required to be earthed shall be connected directly to an approved earthing conductor (not an earthed metal panel) by a copper conductor. Copper earthing conductors shall have a minimum cross sectional area in accordance with guidelines as per AS/NZS 3000 and AS 2067. Earthing conductors on LV systems that are not mechanically protected and fully contained within enclosures shall not be smaller than 6 mm^2.

Movable switchboard equipment requiring earthing shall be of withdrawable type with either a flexible earth connection from the movable portion to the fixed portion, or a plug socket connection which makes no later and breaks no earlier than any other electrical connection between fixed and moving portions.

Where mounted on a hinged metallic door, earth equipment with a flexible conductor connected to the earth bar or stud, in which case earth the door by the same conductor. Non-flexible conductors shall not be used on components subject to movement. All conductor installation shall comply with the manufacturer's minimum bending radii.

VSDs shall be earthed and bonded in accordance with manufacturer's recommendations.

All exposed conductive parts of electrical equipment, panels and switchgear shall be securely bonded to earth. Bolted earth studs shall be provided on all panel enclosures.

All earthing conductors shall be suitably designed to account for mechanical damage and corrosion impacts from its installation environment.

3.17.1. Instrument Earthing

Electrical separation shall be maintained between the plant power and instrumentation/signal earthing systems, except at the single point of connection as detailed below. The instrument/signal earth system shall connect to the plant power earth system only at the associated substation main earth bar. A PVC (Green & Yellow) earth cable, sized to meet site-specific earthing design considering electrical noise performance, fault current & AS/NZS

3000, but no less than 16mm^2 (whichever is greater), shall be connected from the main power earth bar to the main instrument earth bar.

Instruments and process control equipment shall be earthed according to manufacturer's recommendations. Unless otherwise specified by the manufacturer, signal cable screens shall be connected to the instrument earthing system. Continuity across cable screens shall be maintained on interconnecting cables through field instrument terminal boxes if used.

The completed instrument earthing system shall be tested to determine the resistance to earth prior to connection to the equipotential bonding system. The earthing resistance shall not exceed 10 ohms.

3.18. Lightning Protection System (LPS)

For the design of lightning protection systems, a Lightning Risk Assessment shall be carried out in accordance with AS 1768 to determine the measures required for protecting personnel, structures and equipment from lightning damage and provide a lightning protection system in accordance with these requirements.

All personnel, structures and equipment in the premises shall be protected against lightning strikes to the extent required to reduce the risk to as low as reasonably practicable. Risk assessment, detailed design calculations and schematic diagrams shall be submitted to the Principal for review.

The LPS design and installation shall meet the following minimum requirements:

a. Compliance with Australian Standard for lightning protection AS 1768.

b. Design shall use the rolling sphere method (RSM) outlined within AS 1768.

c. Where air terminals are required, they shall be proprietary copper type and shall not exceed 2 m in height.

d. Lightning arrestors claiming enhanced performance shall not be accepted. Early Streamer Emission (ESE) air termination systems have not been adopted, as the applicable standard AS 1768 is based exclusively on conventional (passive) air termination systems and does not recognise or provide design rules for ESE technology.

e. Down conductors shall be selected and installed to minimise any aesthetic visual impacts on the buildings.

f. Surge Protective Devices (SPD) shall be installed at both ends of instrument loops in accordance with AS 1768 where the instrument is susceptible to a reasonable risk of surge damage.

g. HV surge arresters where used, shall be of metal oxide type with polymer or synthetic housings.

3.19. Power System Modelling and Arc Flash Analysis

Power system modelling and arc flash analysis shall comply with E-SPE-STD-007 Power System Modelling and Arc Flash Analysis.

The Contractor shall complete power system modelling and arc flash analysis where any of the following conditions apply:

a. where specified in project documentation, or

b. the scope of the project includes new/altered equipment that would change the results from existing Seqwater accepted power system modelling and arc flash analysis, or

c. the scope of the project includes new/altered equipment that is within the scope of E-SPE-STD-007 but not covered by an existing Seqwater accepted power system model and arc flash analysis.

Power systems must be designed to limit arc flash incident energy and minimise arc flash risk as specified in E-SPE-STD-007.

4. Detailed Design Documentation

4.1. General

The Contractor shall prepare all electrical engineering detailed design report and documentation for all electrical components of the site and associated works including but not limited to the following:

a. Electrical supply and metering from the Supply Authority.
b. UPS system including loading calculations for autonomy time
c. Design of all power and control circuits.
d. Design and specification of load centres
e. Design of all instrumentation loops and circuits.
f. Area lighting design
g. Earthing and lightning protection design including:
    i. Physical location details
    ii. Electrical assumptions
    iii. Design decisions
    iv. Commissioning data
    v. Supervision, testing & maintenance requirements
h. Design of equipment layout, cable routes and cable containment.
i. Temperature rise and ventilation calculation report
j. Completed Engineering Statement 'ES1 - Design' certified by the RPEQ responsible for the design in accordance with procedure X-PRO-STD-009 Engineering Design, Construction, Operation and Maintenance.

4.2. Design Report

The electrical detail design report shall include as a minimum:

a. Copies of all correspondence with the supply authority (Energex) and any other statutory authorities
b. All site loading and maximum demand calculations
c. All fault level calculations, protection discrimination curves and protection setting schedule
d. Arc flash analysis report

e. All switchboard rating data

f. All cable current rating calculations including derating factors used

g. All UPS and control power supply loading calculations

h. Cable ladder, conduit size, cable pulling calculations

i. All earthing system design documentation

j. All lightning protection system design documentation

4.3. Electrical Drawing Submission

Submit to the Principal drawings and information in accordance with this Specification and as specified elsewhere in this contract.

4.4. Switchboard Drawings and Documentation

For the plant switchboards/MCCs/LVSCAs, provide the following drawings and documentation:

a. AS/NZS 61439 Design Verification Report or Statement of Compliance (see Section 6.2 for requirements);

b. Single-line diagram showing equipment numbers, design fault current, circuit breaker ratings and curve types. Also show phase failure relay and surge protection where provided;

c. General arrangement of the plant switchboard/MCC showing overall dimensions (including top views), depth, equipment tiers, cable zones and proposed cable entries and arrangements for the installation. Include annotations showing drive numbers in each cubicle in the switchboard as well as manufacturer specifications (e.g. material, IP rating, form factor, weight, etc.);

d. Sectional drawings for switchboards showing all cut-out details ;

e. Gland plate drilling / punching layout details identifying cable numbers to minimise cross-over in ducts;

f. For each drive cubicle provide a general layout drawing showing the location of all fittings, and components. These drawings shall contain an itemised material list, showing part numbers and quantity of each item being supplied;

g. Individual full circuit diagrams for each drive. Typical drawings are not acceptable. Motor schematics shall show communications cables to the PLC for monitoring purposes. Annotate and number all equipment in accordance with the approved equipment /drive numbering scheme;

h. Interconnection wiring diagrams. Wiring diagrams shall show cables, cable numbers, cable core numbers, equipment, equipment numbers and terminals. Wiring diagrams shall be shown in full for every drive;

i. Cable duct size calculation spreadsheets;

j. Certified floor work drawings confirming space requirements for all support frames and their fixings;

k. Certified dimensioned arrangement drawing showing all installation and maintenance clearances required.

The Contractor shall be responsible for the submission of all relevant drawings to the Distribution Network Service Provider (DNSP) and for obtaining approval of the DNSP for all equipment shown therein.

4.5. Field Control and Instrument Panels

Submit full construction and general arrangement details for each type of panel installed. Include details of all equipment installed. Ensure that front panel and internal layout drawings are fully annotated with equipment names and identification numbers.

4.6. Cable Schedules

Submit full cable schedules including all details prompted in E-TMP-STD-004 Cable Schedule Template (TEM-00283).

4.7. Site Equipment and Cable Routes

Submit plant layout drawings showing all cable routes, conduits size, cable pits, local plant locations, motor and equipment locations. Identify all such equipment with tag or equipment ID numbers as appropriate.

4.8. Proprietary Equipment Packages and Control Panels

Submit full details of proprietary equipment packages and control panels in the same format and detail as for switchboards and MCCs. All drawings for proprietary equipment shall be fully integrated into the plant drawing set.

4.9. Light and Power

Submit general power and lighting layouts for the site and within all buildings. Detail equipment type, location, brand and catalogue number.

4.10. Additional Details

Submit the following details:

a. Complete record of all programmable control equipment settings, e.g. VSDs, soft starters, valve actuators, chemical dosing pumps, etc.

b. Information giving details of the calibration and testing procedures for all instrumentation and control equipment, including all setting adjustments;

c. Testing and calibration certificates from equipment suppliers and field testing results of all equipment;

d. All other documentation necessary to maintain the electrical equipment and electrical installation.

4.11. Drafting Requirements

4.11.1. Drawings Standards

All electrical drawings shall comply with the requirements of procedure X-PRO-STD-007 Drawing & Spatial Data Standards and X-PRO-STD-014 Drawings Management.

Electrical drawings shall use standard symbols as per IEC 60617 Graphical symbols for electrotechnical diagrams and Seqwater standard legend sheets E-DWG-STD-00003 and E-DWG-STD-00004.

4.11.2. Presentation

All electrical drawings shall be drawn on the grid system. Electrical control schematic diagrams shall be drawn with the circuit ladder rungs horizontal.

All electrical drawings shall be produced at A1 size and plotted to A3 size.

4.11.3. Wire Numbering

All wires on the drawing shall be uniquely numbered.

Control wiring numbers shall not change at normal connection terminals. They shall change across fuses, circuit breakers and disconnection links. A control wire number shall be the same at each end of the wire.

4.11.4. Cable Numbering

Refer to E-PRO-STD-001 Cable Numbering Convention.

4.11.5. Cross Referencing

All electrical drawings shall include cross referencing.

All associated contacts and coils shall be cross referenced. All relays and contactor coils shall include a table of interlocks cross referenced to indicate their position on the drawings.

Cross referencing shall use an XY reference system formatted in accordance with the applicable Seqwater standard electrical and instrumentation drawings.

Drawing cross references shall also be included where items shown link to other drawings.

4.11.6. General Electrical Requirements

Single line diagrams shall include the prospective fault levels at the incoming supply to the plant. The protection type and setting will be displayed next to each protection device.

All electrical schematic drawings shall clearly identify the type and operating range of the electrical or instrumentation device used in the circuit. All analogue measurement devices are to fully detail the range and unit of measurement.

4.11.7. Drawing Revisions

All drawing changes shall be noted on the drawing as a revision number in the revision box on the drawing sheet.

When changes to the previously submitted design drawing have been made, amendment triangles, containing the revision number, shall be placed adjacent to the modified section. For additional clarity, revision cloud/s shall also be used to highlight the modifications. Refer to X-PRO-STD-014 Drawings Management for detailed revision control requirements.

5. Power and Emergency Generator Supply

5.1. Main Power Supply Upgrade

When required, and included as a part of their scope, the Contractor shall be responsible for managing the upgrade of the existing site power supply.

The Contractor shall arrange and fully manage with Energex to upgrade the power infrastructure necessary to meet the plant power supply requirements under all operating conditions.

The Principal will assist the Contractor with the Energex application processes only to the extent of submitting the application as the Principal is the customer. The Principal shall not be required to prepare any documentation for the upgrade of the power supply.

5.2. Emergency Generator Supply

Where required or identified by risk assessment, switchboards shall be supplied with an emergency generator connection.

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 facilities.

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

The Contractor shall design the connection cubicles to utilise lugged type connections with appropriate insulation panels to avoid accidental contact with live conductors.

Generator sets and the associated electrical installation works shall comply with AS/NZS 3010.

5.3. Generator Starter Batteries

All starter batteries for generators shall be approved by the generator manufacturer in compliance with AS 4086 and meet the following minimum requirements:

a. Batteries shall be Absorbed Glass Mat (AGM) type, unless otherwise approved by the Principal.

b. Vented Lead Acid (VLA) batteries may also be accepted, subject to Principal Approval and the following conditions:

   i. The selected battery has provision for refilling the electrolyte.

   ii. The selected battery has electrolyte level indicators to show the current, highest and lowest permissible levels of electrolyte.

   iii. The battery is located at a site that is attended by electrical maintenance personnel at least once per week.

c. ‘Maintenance free’ wet cell batteries are not acceptable.

d. The battery size and ratings shall be as per the generator manufacturer’s recommendations including:

   i. Battery Type

   ii. Supply Voltage (V)

   iii. Cold Cranking Amps (CCA)

   iv. Ampere-Hours (A.h)

   v. Reserve Capacity

   vi. Installation date and replacement date

   vii. Last service and inspection date

e. The designer shall provide maintenance manuals for the battery systems which cover periodic maintenance procedures in accordance with manufacturer's recommendations, AS 4086 and AS/NZS 4029.

5.3.1. Battery Installation

The installation and maintenance of generator starter batteries must be carried out in accordance with AS 4086 and meet the following minimum requirements:

a. Batteries must be properly protected and enclosed as per manufacturer's recommendations, and the surrounding area protected from potential acid spills.

b. Battery enclosures must be well ventilated. The ventilation design must permit air to enter the enclosure at the base of the batteries and exit at the highest point. Ventilation to outside air, whether active (forced air) or passive (air slots or limber holes) is compulsory.

c. Batteries must be installed in a location that allows for regular and safe access/maintenance.

d. Battery enclosures must have a removable lid or at least 500 mm clearance above the batteries to allow for a hydrometer to check the charge level.

e. Safety signs in accordance with Appendix B of AS 4086 shall be fitted in visual proximity of battery installations.

f. The installation must include an isolation switch or quick disconnect fuse near the batteries to electrically isolate the bank from the rest of the system.

g. Batteries must be mounted on stands to keep clear of the ground; otherwise they must be thermally insulated from the ground temperature.

h. Batteries must not be installed directly on concrete or in direct sunlight.

i. Batteries must be installed in a location with minimal vibrations from operating equipment.

j. Battery terminals must be sufficiently covered or shrouded to prevent accidental short circuiting.

k. Batteries shall not be installed around combustible materials.

l. Batteries shall be installed in a location as distant as practical from general work areas including control panels and workstations.

5.3.2. Battery Charger

The installation and maintenance of generator starter battery chargers must be carried out in accordance with AS 4086 and meet the following minimum requirements:

a. The charger shall be installed as per the manufacturer's recommendations.

b. The charger shall include an ammeter to provide charging current indication.

c. The battery charger must be the correct type of automatic multi-state charger for the batteries used and re-adjusted / calibrated to suit the particular battery they are charging.

d. Battery chargers used with lead acid batteries must automatically return to float mode once charging is complete.

e. The battery charger must be fitted with automatic temperature compensation that adjusts the voltage based on measured battery temperature.

f. If the charger features compatibility across multiple battery types (e.g. Lead Acid, NiCd, Li-ion) care shall be taken to ensure that the charging profile is configured for constant voltage charging.

g. The battery charger must be installed close to the batteries and be either wall mounted or installed in the transfer switch enclosure.

h. Battery charger output leads must be connected to starter terminals or a proper location on the engine's electrical system. Battery charger output leads must not be connected directly to the batteries.

i. Cables connecting to the battery shall be adequately strain relieved to avoid damage. Cable bends shall not exceed the manufacturer's recommended minimum bending radii.

j. All cables electrically connected to battery terminals shall be rated to withstand the prospective short circuit current of the battery for at least one second.

k. The periodic maintenance procedure for generator batteries shall be developed in accordance with the manufacturer's recommendations and AS 4086.

5.4. Generator Transfer Switch

The generator shall be connected via a transfer switch change-over mechanism satisfying the requirements of Section 6.7.4.

Installations incorporating a permanent backup generator set include an approved automatic transfer switch with a compatible isolating main switch, unless specified otherwise in project requirements.

Installations incorporating a connection point for a temporary backup generator shall include an approved manually operated transfer switch change-over mechanism, unless specified otherwise in project requirements.

If the generator or generator connection point is specified to be sized for essential loads only, the switchboard shall be separated into separate bus sections for essential and non-essential loads based on process requirements.

For applications that require closed transition (make-before-break) between supplies, synchronisation check protection is required.

5.5. Solar Photovoltaic Systems

Solar photovoltaic systems shall be designed, installed and tested to satisfy E-SPE-STD-024 Solar PV.

5.6. Uninterruptible Power Supply

5.6.1. Scope

Unless otherwise specified, the instrumentation and control system shall be supplied with electrical power from static uninterruptible single phase AC output Power Supply System (UPS) that provides an isolated, filtered and stable power supply.

AC UPSs and the associated works shall be designed, selected, installed and tested as per Standard Specification E-SPE-STD-004 AC Uninterruptible Power Supply (UPS).

5.6.2. Location of UPS

The Contractor shall supply and install AC UPS systems in a room with suitably sized air conditioning to provide optimum operating conditions, and adequate ventilation to prevent a potentially hazardous atmosphere due to hydrogen release. The room shall not be shared with general access and amenities.

The UPS shall not be located in a location exposed to dust, water or chemicals.

The UPS shall not be located within the arc flash boundary of other equipment.

5.6.3. Equipment Supplied by UPS

UPS shall continuously supply the equipment including but not limited to:

a. all PLC equipment including input and output circuits

b. all instruments listed in the instrument schedule including any existing instruments to be reconnected and any supplied by others

c. all SCADA servers and Operator Station equipment

d. Telemetry system

5.6.4. Capacity

UPS shall be capable of energising and continuously supplying all the equipment connected to the UPS, plus spare capacity as specified in section 3.8.

Battery capacity shall meet or exceed minimum requirements of E-SPE-STD-004.

5.6.5. Power Distribution

Power distribution from UPS to supplied equipment shall be via a metal enclosed miniature circuit breaker distribution board in accordance with Section 6 “LV Switchgear and Controlgear Assemblies”. Ensure all power outlets supplied from UPS are appropriately identified.

6. Low-voltage Switchgear and Controlgear Assemblies

6.1. Scope and Terminology

This section describes requirements for Low-voltage Switchgear and Controlgear Assemblies (LVSCA) as defined in AS/NZS 61439.

The terms “Low-voltage Switchgear and Controlgear Assembly”, “LV Assembly” and “LVSCA” are used interchangeably in this specification.

General references to the term “Switchboard” also include Motor Control Centres and Distribution Boards.

Common names for types of low-voltage switchgear and controlgear assemblies at Seqwater may include:

a. LV Switchboard

b. LV Motor Control Centre (MCC)

c. LV Drive Enclosure
d. Distribution Board (DB)
e. PLC/RIO Control Panel
f. Marshalling Panel
g. Field Control, Instrumentation or Dosing Panel containing switchgear and/or controlgear

The requirements of Section 6 also apply to extra-low voltage switchgear and controlgear assemblies.

Certain requirements of Section 6 also apply to junction boxes – see Section 7.

6.2. Design and verification

All LV assemblies shall be designed and constructed in accordance with AS/NZS 3000 and the AS/NZS 61439 series of standards.

6.2.1. Where DVR is Required

A design verification report (DVR) showing compliance to AS/NZS 61439.1 shall be produced for each LV assembly that meets any one or more of the following conditions:

a. Total rated load exceeds 125A r.m.s. per phase; or
b. Prospective r.m.s. short-circuit current at the incoming power terminals of the assembly is greater than 10kA r.m.s., or
c. Arc flash incident energy (calculated to E-SPE-STD-007) at the incoming power terminals of the assembly is 1.2 cal/cm² or greater

6.2.2. Where DVR is Not Required

A design verification report to AS/NZS 61439.1 is not required for LV assemblies that do not meet the criteria listed in Section 6.2.1.

For all such LVSCAs that do not require a DVR, the Contractor shall provide a written statement of compliance prepared by the assembly manufacturer, verifying that the assembly is fit for purpose and meets the performance characteristics listed on the equipment nameplate and in documented performance specifications.

6.2.3. Design Verification Report – AS/NZS 61439

Each individual assembly (identified by a unique Seqwater asset ID and nameplate) requires an individual design verification report.

Minimum requirements for the design verification report include:

a. Summary matrix, based on Annex D of AS/NZS 61439.1, listing specific performance characteristics for the assembly and citing specific testing records or verification documents.
b. Copies of all cited testing records, calculations and comparisons, and verification documents.
c. Test certificates, calculations and comparisons must reconcile with performance characteristics of the assembly.

A completed Table 13 (AS/NZS 61439.1) is required if verification by comparison to a reference design is to be made.

The DVR shall be issued for Seqwater review and acceptance prior to manufacture of the LV Assembly and prior to delivery of the LV Assembly to Seqwater's site.

The Contractor shall also include the final DVR in handover documentation.

All versions of the DVR issued to Seqwater shall be signed by an RPEQ responsible for its contents.

6.2.4. No DVR - Written Statement of Compliance

Design verification of LV assemblies that do not require a DVR (to AS/NZS 61439) according to the criteria outlined in Section 6.2.1, shall be provided by the assembly manufacturer in the following format:

a. Written statement of compliance, in the form of a dossier that includes:

b. Written statement that the assembly meets the necessary performance characteristics of the application and the operational environment; and

c. Key performance characteristics listed on the LVSCA nameplate; and

d. Applicable test certificates and calculations that verify performance characteristics.

6.3. Service Conditions

6.3.1. Normal Service Conditions

LV assemblies shall be designed for the conditions noted in section 3.10 Site Climatic Conditions and AS/NZS 61439.1 default normal service conditions with alterations and additions as noted in this specification.

6.3.1.1. Temperature

Table 4 Ambient air temperature conditions for LV assemblies

Location	Maximum ambient temperature	Minimum ambient temperature	Average temperature over 24 h
Indoors	**45 °C ***	−5 °C	35 °C
Outdoors	**45 °C ***	**−5 °C ***	35 °C

* Value has been changed from the default listed in AS/NZS 61439.1 to reflect SE Queensland climate conditions.

6.3.1.2. Humidity

Indoors:

As per AS/NZS 61439.1 normal service conditions, i.e.: Upper limit 50 % at 40 °C for clean air. Higher relative humidity may be permitted at lower temperatures, for example 90 % at 20 °C. Moderate condensation which may occasionally occur due to variations in temperature is taken into account.

Outdoors:

Upper limit 100 % at **30 °C** * for clean air.
* Value has been changed from the default listed in AS/NZS 61439.1 to reflect SE Queensland climate conditions.

6.3.1.3. Pollution

Pollution degree 3 unless approved otherwise by Seqwater.

6.3.1.4. Altitude

As per AS/NZS 61439.1 normal service conditions, i.e., the altitude of the site of installation does not exceed 2000m.

6.3.2. Special service conditions

Where special service conditions exist, the measures taken to mitigate the risk of injury, economic loss or loss of service must be outlined in project design documentation. Special service conditions include:

a. Hazardous areas
b. Location prone to flooding
c. Lightning strike or surge risk (AS 1768)
d. Location exposed to heavy pollution by dust, smoke, water spray or corrosive gases
e. Location exposed to temperature variations at such speed that condensation can be expected to occur
f. Locations exposed to heavy vibration
g. Locations exposed to strong electric or magnetic fields
h. Locations in the vicinity of machinery movement that could cause mechanical damage to the assembly.
i. Exposure to direct sunlight

6.3.2.1. Exposure to direct sunlight

Exposure to direct sunlight is not included in the ambient temperatures specified in section 6.3.1.1.

LVSCAs should preferably be installed in locations where they are not exposed to direct sunlight.

Where LVSCAs are exposed to direct sunlight, the heat gains from solar radiance (3.10) must be allowed for in the design.

6.3.3. Conditions during transport, storage and installation

LV Assemblies shall be designed or otherwise be prepared for transport, storage and installation to withstand the environment and forces experienced during transport, storage and installation, which may include:

a. Rain
b. Dust
c. Rapid changes in temperature or humidity
d. Vibration
e. Wind forces
f. Securing forces

6.4. Performance Requirements

6.4.1. General

LV assemblies shall meet minimum performance and verification requirements contained in this standard specification and where applicable the AS/NZS 61439 series of standards.

6.4.2. Arc Containment Performance

The LV assembly shall be of the Arc Containment type if any one or more of the following criteria are met:

- Arc Flash Incident Energy (calculated per E-SPE-STD-007) at the incoming terminals is 1.2 cal/cm² or greater, or
- Prospective fault current is greater than 20kA, or
- LV assembly is rated at 800A or greater

Arc Containment switchboards, including motor starting and feeder equipment shall provide 'acceptable protection' to the operator in the event of an internal arcing fault occurring on the load side of a protective device in any switchboard compartment, including the load side of the incomer.

Arc containment testing for a fault at the incomer line side is not required as standard, however is preferred where feasible. In all cases, LV assemblies shall be designed to minimise the likelihood of an arcing fault occurring at the line side of the incomer.

The design being offered shall have been tested by a recognised testing authority in accordance with the Standard Test procedures detailed in Appendix 'ZD' of AS/NZS 61439.1. 'Acceptable protection' shall be as defined in Appendix 'ZD' of AS 61439.1. Furthermore:

a. The construction methods in the switchboard being supplied must match those used in the tested switchboard (e.g. venting, door bracing, door mounted equipment shrouding).

b. The protective devices (circuit breakers and fuses) offered shall preferably be the same as those tested in accordance with Appendix 'ZD' of AS/NZS 61439.1, although not every protective device rating need have been tested. Any substitution of protective devices from those tested must be verified to not compromise the arc containment performance to AS/NZS 61439.1. Such verification must be included in the DVR and approved by an Electrical RPEQ.

c. The DVR shall include relevant extracts of the original arcing fault test reports sufficient to:

   i. validate that the test was successful to demonstrate 'Acceptable protection' to the operator, and

   ii. demonstrate that the configuration and conditions of the switchboard as tested is a valid comparison to the configuration and conditions of the switchboard to be supplied to Seqwater.

6.4.3. Remote Operation

Circuit breakers shall be provided with facilities for remote operation if any one or more of the following criteria are met:

- Calculated incident energy at the circuit breaker line side is 7.9 cal/cm2 or higher, or
- Circuit breaker rated current (In) ≥ 1250A
- Specified to meet site-specific operational or maintenance requirements

Exception: Remote operation at the circuit breaker is not required if it can be selectively de-energised using upstream Seqwater remotely operable switchgear.

Remote circuit breaker operation shall be via a proprietary pendant controller or wired remote control panel located in a nearby safe and secure location well outside of any arc flash boundary, but within 20m of the switchboard.

The remote operation pendant or panel shall include as a minimum:

a. Enable switch
b. Open and close control switch or buttons
c. Indication of open and closed status
d. For withdrawable CB: Controls to rack in and rack out incomer CB(s) through isolate/test/connect positions
e. For withdrawable CB: Indication of CB(s) isolate/test/connect position

Remote operation panels shall include an outer door locked for electrical worker access only.

If remote operation is via pendant, each switchroom shall be supplied with at least one of each pendant type required for the switchgear in that switchroom. The Contractor shall supply the remote operation pendant(s).

Remote operation facilities shall not restrict the capability to manually operate and rack the circuit breaker.

Remote operation facilities must be designed with independent auxiliary power that remains available during an extended isolation of the remotely operable circuit breakers.

6.4.4. Short Circuit Withstand

LV assemblies shall be selected and designed with a rated short-circuit withstand strength and duration exceeding the prospective short-circuit current and duration at the installation location, as determined by the power system study. (See Section 3.8.2.)

All LV assemblies that are required to be design-verified by AS/NZS 61439.1 (see Section 6.2) shall have a verified short-circuit withstand strength on phase, neutral and protective conductors. Phase short circuit withstand r.m.s. current and duration shall be listed on the assembly nameplate and shall correspond to the DVR for that assembly.

For all LV assemblies, the listed short-circuit withstand strength shall indicate the maximum allowable value of prospective short-circuit current at the incoming terminals of the assembly, listed as a r.m.s. value.

The manufacturer of an assembly that is not required to be design-verified according to AS/NZS 61439.1 (e.g. small office DB or dosing control panel), shall provide a written statement that the assembly can withstand the rated prospective short-circuit current and duration at the incoming power terminals of the assembly.

6.4.5. Equipment and Fault Coordination

It shall be the Supplier's responsibility to ensure that every item of equipment in the LVSCA is suitable for operation at the maximum fault level or is protected by upstream fault limiting or co-ordinating devices supplied by the Supplier within the LVSCA.

Protective equipment shall be fully co-ordinated so that no item is called upon to break fault current in excess of its fault rating. This shall include control circuit breakers for miscellaneous 230 V AC control supplies. Control circuit shall be fault limited to less than 5 kA.

Power and control cable protection shall be such that the energy let through by the protective device does not exceed the level permitted for that cable by AS/NZS 3008.1.1.

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

6.4.6. Temperature-Rise

All assemblies shall be capable of continuous operation at their rated current load under the ambient temperature conditions specified by this standard specification.

Temperature-rise refers to the difference in temperature between an LV assembly element or part and the ambient temperature outside the assembly. It is measured in accordance with AS/NZS 61439.1 for assemblies where this standard applies.

The temperature-rise limit of an LV assembly element or part shall be the temperature corresponding to the manufacturer listed maximum operating temperature for the assembly including installed equipment.

Natural or passive ventilation is the preferred method for meeting operating temperature requirements. However, in some instances natural ventilation may not reasonably be sufficient to satisfy the required operating temperature limits. In these instances, fan forced ventilation may be used if the designer can demonstrate the need.

The design of ventilation systems shall be based upon heat load studies accepted by Seqwater prior to enclosure fabrication. The study shall include as a minimum:

a. Itemised heat loss for each device within the functional unit.
b. Maximum temperature rise for an unventilated cabinet.
c. Maximum temperature rise for a naturally ventilated cabinet.

6.4.7. Forced Ventilation

Where required, (see Section 6.4.6), fan forced cooling and ventilation systems shall comply with the following criteria:

a. Fans shall be mounted at the inlet vent unless otherwise specified by the manufacturer
b. Inlet and outlet vents shall be located at the bottom and top of the LV assembly, respectively.
c. All fan forced inlet vents shall be fitted with suitably sized dust filters. Each filter shall be accessible for cleaning or replacement without the use of tools. Where heat shields are provided as a second skin, a removable cover shall be fitted for filter access.
d. For functional units or assemblies containing sensitive electronic equipment such as VSDs or soft starters, the fans shall be controlled and monitored via a thermostat installed within the cabinet.
e. For functional units or assemblies that contain critical or multiple pieces of equipment, the fans shall be N+1 redundant.
f. The fans and air circulation ratings shall comply with the equipment manufacturer's recommendations where applicable.
g. Silent centrifugal type cooling fans shall be used unless otherwise specified by the equipment manufacturer.
h. Fan forced cooling systems shall maintain positive pressure within the LV assembly.
i. Fans mounted to doors of LV assemblies or Control System enclosures shall be supplied at ELV.

j. Stainless steel weatherproof hoods must be used on outdoor switchboards or switchboards requiring protection from wash down hosing. The stainless steel weatherproof hoods must be removable without the use of tools.

6.4.8. Earthing Continuity

The exposed conductive parts of an LV assembly shall be effectively bonded to the main earth bar and verified, through testing, that the resistance from the exposed conductive part and the main earth bar of the assembly does not exceed 0.1Ω.

Acceptable methods of bonding LV assembly movable or removable parts such as doors, escutcheons, mounting panels and gland plates to the enclosure are:

For assemblies design verified according to AS/NZS 61439.1:

a. Design verified method that meets requirements of AS/NZS 61439.1

For other assemblies:

b. Flexible copper braid (minimum 6mm²)

c. Flexible copper wire (minimum 6mm²)

6.4.9. Ultraviolet (UV) radiation

Enclosure coatings and parts of an assembly installed outdoors shall withstand the effects of UV radiation for the assembly design life as defined in this specification.

For LV assemblies or parts thereof exposed to the sun, preferred methods of withstanding the effects of UV radiation include:

a. Performance verification as described in AS/NZS 61439.1 (this is required for assemblies that must adhere to this standard).

b. Use of UV stabilised materials and coatings.

c. Shielding of sensitive parts that might degrade if exposed to UV radiation (e.g. displays, push buttons, switches).

For clarity, these requirements apply also to Local Control Stations.

6.5. Construction Requirements

6.5.1. General

Low Voltage Assembly construction shall meet the minimum requirements of the AS/NZS 61439 series of standards where applicable.

6.5.2. Form of Internal Separation

LV Assemblies shall have the form of internal separation as per Table 5 below.

Table 5 Forms of Internal Separation

Rated load current & prospective fault current	Equipment type	Form of Internal Separation
>250A	Switchboard / MCC	Form 4a
≤250A	Switchboard / MCC other than the special cases listed below	Form 4a
	Switchboard with motor starters that are all ≤7.5kW and non-critical to the process	Form 2bi*
	Switchboards with motor starters that are all ≤7.5kW and separated in redundant duty and standby pairs in separate enclosures	Form 2bi*
	Distribution board with no motor starters	Form 2bi*
≤63 A and <10kA	LV Control Panel**	Form 1
	Electrical or Instrument Junction Box	Form 1
	PLC/RIO Control Panel**	Form 1
	Communication Panel	Form 1

* Alternative forms of segregations with suffixes “h” and “ih” are not considered equivalent.

** A Control Panel is defined as a LVSCA that has the primary function of system control functions, not distribution of electrical energy.

6.5.3. Ingress Protection

Refer to Section 3.12.

6.5.4. Materials

The minimum construction materials for LV assemblies are outlined in Table 6.

Table 6 LV assembly construction materials

Application	Assembly component	Standard material	Minimum thickness*	Coating	Comment
Indoor	Outer enclosure	Zinc annealed mild steel	1.5 mm* for enclosures > 1000 mm* high. 1.2 mm for enclosures ≤ 1000 mm* high.	Powder coating paint	

Application	Assembly component	Standard material	Minimum thickness*	Coating	Comment
Indoor	Outer enclosure	Polymer. Opaque parts: Noryl, Glass Reinforced Polyester, Polyester, Polyamide. Transparent parts: Polycarbonate		None	Permitted only where specified by Seqwater elsewhere in this specification or in project specification.
Indoor	Door hardware, fastening hardware	Mild Steel OR Brass		Chrome	
Indoor	Plinth	HDG Mild steel			Lifting pipes with vermin-proof covers
Outdoor	Outer enclosure	Marine grade Aluminium 5251 OR	2.0 mm*	Powder coating paint	
		Stainless Steel 316	1.5 mm*		
Outdoor	Door hardware, fastening hardware	Stainless steel 316			
Outdoor	Plinth	HDG Mild steel OR Aluminium 5251			Lifting pipes with vermin-proof covers. Provide neoprene protection for dissimilar metals.
Indoor & Outdoor	Internal equipment mounting pans	Zinc annealed mild steel	1.5mm*	Powder coating paint	
Indoor & Outdoor	Escutcheon	Zinc annealed mild steel	1.5 mm* for enclosures > 1000 mm* high. 1.0 mm* for enclosures ≤ 1000 mm high	Powder coating paint	

Application	Assembly component	Standard material	Minimum thickness*	Coating	Comment
Indoor & Outdoor	Gland Plates	Marine grade Aluminium 5251 OR	3mm*		
		Brass	3 mm*		

*Material thicknesses specified in Table 6 are an absolute minimum. The manufacturer shall determine and verify the material thickness necessary for the application and to meet the other requirements of this specification. The actual material thickness required may thus exceed but shall not be less than the values specified in Table 6.

6.5.5. Colours and Finish

All metal enclosure surfaces shall be finished to a smooth, cleaned, descaled, and degreased state in accordance with the application-appropriate surface preparation within the AS 1627 series.

For all metal enclosures, excluding stainless steel enclosures, an appropriate electrostatically applied powder coated paint shall be applied in accordance with AS 2312.1, for steel and AS 3715, for aluminium.

All coatings and external enclosure surface finishes shall be verified for resistance to mechanical impact and corrosion according to AS/NZS 61439.1.

All painted enclosure colours shall comply with Table 7 below with reference to AS 2700 or the RAL colour standard.

Table 7 Electrical Enclosure Colour Scheme

Application	Surface	Colour
Indoor	LV enclosure external and internal surfaces	X15 Orange (preferred), or RAL2000 Yellow Orange
	ELV only enclosure external and internal surfaces	N35 Light Grey (preferred), or RAL7035 Light Grey
	Escutcheon and mounting panel	N14 White (preferred), or RAL9010 Pure White, or B33 Mist Blue, or Manufacturer's standard gloss bright white
Outdoor*	Enclosure external and internal surfaces	N42 Storm Grey (preferred) ** OR RAL7032 Pebble Grey **
	Escutcheon and mounting panel	N14 White (preferred), or RAL9010 Pure White, or B33 Mist Blue, or Manufacturer's standard gloss bright white

*Stainless steel LV assemblies shall not be painted and shall have a natural brushed stainless-steel finish.

** In some applications, a site-specific external colour or finish may be desirable to cater for the local site visual amenity. Alteration to the standard colours requires a written deviation approved by the Principal.

Plastic enclosures may be appropriate for some indoor applications; these will be specified in project-specific design documentation or elsewhere in this specification. The preferred material for all enclosures is metal and outdoor enclosures shall not be constructed of plastic unless specified in an Seqwater standard or a written deviation approval from the Principal.

6.5.6. Clearances

Appropriate clearances inside an assembly shall be provided to achieve:

a. Impulse voltage withstand (AS/NZS 61439.1)

b. Ventilation for electronic equipment, according to the original equipment manufacturer installation instructions.

c. Electromagnetic compatibility, complying to the relevant product or generic EMC standard and installed in accordance with the original equipment manufacturer's instructions (e.g. cables, screening, earthing, mutual influences)

d. Accessibility for operations and maintenance (see Section 6.6 Ergonomics and Accessibility)

For assemblies that do not require an AS/NZS 61439 DVR, the minimum clearance between live terminals and conductive parts inside an assembly is 6mm.

6.5.7. Barriers

This section outlines the minimum standard for providing barriers to protect personnel from harmful voltages.

The assembly form of segregation must meet the requirement of Section 6.5.2. In addition to the form of segregation, barriers are required to meet the requirements detailed in Table 8 below.

Table 8 Barriers

Equipment	Accessible through an open door	Accessible through an open escutcheon	Accessible by removing a fixed barrier
LV terminals	IP2X	IP2X	IP00
Busbars (L/P/N)	IP2X	IP2X	IP00
Earth bar	IP00	IP00	IP00

Shrouding systems by the OEM shall be used wherever this is possible. Custom fabricated shrouding is acceptable where OEM does not have a suitable system.

Interphase terminal barriers shall be applied to all manual switching devices with front-facing LV terminals, unless these barriers are already included in the design of the device.

6.5.8. Anti-condensation heaters

To manage rapid temperature fluctuations in non-climate-controlled environments (e.g. outdoors or indoors without air-conditioning), anti-condensation heaters shall be installed for functional units containing sensitive electronic equipment. The heater shall be controlled using a thermostat, set to 20°C, which is above the average summer dewpoint in South-East Queensland (BoM, 2023).

Anti-condensation heaters are not required to be installed in assemblies that are installed in a masonry or concrete-walled building unless the building environment is calculated or expected to present rapid temperature fluctuations.

6.5.9. Animal barriers

All openings in an enclosure that are intended for ventilation, lifting (i.e. lifting pipes) or expelling arc-flash gases shall be fitted with vermin-proof gauze. The intended performance of such openings shall not be impacted by inclusion of the vermin-proof gauze.

6.5.10. Mounting and lifting provisions

Suitable mounting provisions shall be provided for all assemblies.

All floor-mounted assemblies shall be provided with a dedicated plinth that facilitates lifting of the assembly and raises the assembly at least 75mm from ground level. Lifting pipes shall be fitted with vermin protection.

The full perimeter of the LVSCA base shall be effectively vermin proofed.

For non-floor-mounted assemblies, the assembly design shall incorporate suitable mounting and lifting facilities for the intended installation location.

6.5.11. Floor standing enclosure installation

The footing for floor/ground mounted enclosures shall be selected and designed to preclude pooling or ingress of water.

The spacing between the concrete slab and the plinth shall be filled with a non-hygroscopic, non-shrinkable material to prevent corrosion and ingress of vermin.

Where enclosures are installed over cable trenches and do not completely cover the trench, aluminium checker plate covers cut into convenient lengths and incorporating lifting slots, shall be placed over the exposed trench. This plate shall be fixed in position for external installations.

6.5.12. Labelling and identification

6.5.12.1. Labels external to the assembly.

a. All LV assemblies shall have a primary nameplate with the following details:

i. Manufacturer's name

ii. Manufacturer's serial number or type designation

iii. Date of manufacture

iv. Standard (e.g. AS/NZS 61439.1)

v. Rated voltage, volts

vi. Rated current, amps

vii. Rated r.m.s. short time current, kA for s (phase conductors)

viii. Maximum ambient temperature rating, deg. C

ix. Degree of protection (i.e. IP rating)

x. Form of Internal Separation (where applicable; required for DBs, Switchboards, MCCs and any other AS/NZS 61439.2 LVSCA)

The following external labels shall be included:

b. Equipment number

c. Equipment name

d. Identification of LV assembly sections and functional units, including equipment number and equipment description for field devices.

e. Electric shock and warning labels on covers or doors for compartments that contain LV terminals.

f. Live Busbar Behind danger labels on covers or doors for busbar compartments.

g. Arc Flash Hazard label, where required as per E-SPE-STD-007

h. Cabinets that contain exclusively ELV equipment and wiring shall be fitted with an EXTRA LOW VOLTAGE EQUIPMENT label on the door as per Seqwater drawing template.

6.5.12.2. Labels internal to the enclosure

LV assemblies shall have the following internal labels:

a. All cable cores

b. All wires

c. All control and marshalling terminals

d. Device ID for all major equipment corresponding to drawings accepted by the Principal, examples include:

i. Circuit Breakers
ii. Fuses
iii. Surge protective devices
iv. Power monitors
v. Current transformers
vi. Contactors
vii. Drives
viii. Control relays
ix. Programmable controllers
x. Communications network hardware
xi. Protection relays
xii. Power supplies
xiii. Batteries
xiv. Earth, Neutral and Active links

e. Escutcheons and barriers installed to protect against contact with live LV busbars, terminals or parts shall have adhesive labels for voltage level and electric shock danger.

f. Equipment connected to the line side of an incoming switch shall be fitted with a ‘DANGER – LINE SIDE CONNECTION – ISOLATE ELSEWHERE” label

g. Electric shock and warning labels on internal barriers and Perspex shrouding for compartments that contain LV terminals.

h. Live Busbar Behind danger labels on covers or doors for busbar compartments.

6.5.12.3. Updates to Existing Labels

Where modifications/additions are made to existing LV assemblies, distribution boards or control panels, existing labels must be removed and replaced with new labels as required (e.g. spare cell of switchboard is repurposed to supply power to a new load as part of a plant upgrade).

6.5.12.4. Cable Duct Labels

Warning labels must be provided adjacent to a cable duct that contains a mixture of LV and ELV wires.

Labels must not be mounted on cable duct lids.

6.5.12.5. Label Materials

Labels installed on the external surfaces or internal to a LV assembly shall include labels adhering to the requirements detailed in Table 9 below.

Table 9 Label Materials

Label Type	Material and Colour
Manufacturer's nameplate	Deep engraved SS316
External identification and description labels – outdoor or wet/chemical area	Deep engraved SS316 with black filled text
External identification and description labels – indoor clean and dry area	Black text on White background engraved traffolyte or ABS plastic
Internal identification and description labels	Black text on White background engraved traffolyte or ABS plastic
E/Stop labels, emergency devices/components	Black text on Yellow background engraved traffolyte or ABS plastic
Custom text danger labels, e.g. multiple sources of supply, line side connection	White text on Red background engraved traffolyte or ABS plastic
Intrinsically safe circuit labels	White text on blue background engraved traffolyte or ABS plastic
Arc flash hazard labels	Heavy duty laminated vinyl, traffolyte or ABS plastic Colours as per E-SPE-STD-007
Safety signage – outdoor or wet/chemical area	Laminated reflective aluminium or stainless steel Colours as per AS 1319
Safety signage – indoor clean and dry area or internal	Heavy duty laminated vinyl, traffolyte or ABS plastic Colours as per AS 1319

Traffolyte and ABS plastic labels shall be secured with M3 chrome plated metal threads.

SS316 and aluminium labels shall have bevelled edges and be secured with M3 SS316 threads.

Exception: Where threaded fasteners would compromise AS/NZS 61439 compliance, affix the label with suitable permanent adhesive.

All labels for outdoor use shall use UV resistant materials or treatments.

6.5.12.6. Labelling text

All lettering on assembly labels must be in block capitals (excluding manufacturer nameplate.)

Lettering shall be no smaller than the minimum heights listed in Table 10 below.

Table 10 Text size

Label Type	Minimum Letter Height
Assembly Equipment Number	30 mm
Assembly Equipment Name	20 mm
Module Labels	10 mm
Device Labels	5 mm
Pushbutton Designation	3.5 mm

6.5.12.7. Distribution Board Labelling

Circuit breakers on a Miniature Circuit Breaker distribution board shall be labelled adjacent to the circuit breaker switch. A continuous label shall be installed according to the following:

- Each chassis pole is labelled in consecutive order from top to bottom for vertically mounted chassis and from left to right for horizontally mounted chassis.
- Circuit breaker Device ID and load description shall be printed adjacent to the relevant chassis poles. If the circuit supplies equipment required to be named under X-PRO-STD-006, include here the Seqwater issued equipment number and name of the load equipment.
- For chassis with two rows of poles, a continuous label is required for each row. This applies to horizontally and vertically mounted chassis.

These requirements apply to standalone distribution boards and chassis installed integral to LV assemblies.

A written legend describing all sub-circuits shall be provided on the inside of the assembly door.

The legend card shall be computer printed, protected by clear plastic or glass. The legend card shall include the label data as above, arranged in the order of the pole numbers, along with each circuit breaker nominal amps.

6.5.13. Busbars, Internal Cabling and Wiring

All busbars and power cables installed inside an assembly shall be suitably rated to satisfy the performance specifications of the AS/NZS 61439.1 design verified assembly, including:

a. Temperature rise

b. Short circuit withstand current

c. Power-frequency withstand voltage

Assemblies for which AS/NZS 61439.1 does not apply, shall utilise busbars and cables rated to withstand 125% of the expected load at the target temperature rise of the assembly.

Busbars shall be formed from hard drawn, high conductivity, solid rectangular copper bars with straight or rounded edges. All sharp edges resulting from cutting shall be deburred.

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.

Vertical busbar droppers shall be design verified. These droppers shall have a current carrying capacity either identical to the assembly nameplate or have sufficient capacity for the documented future load allowance. Reducing the current carrying capacity of under-utilised busbar droppers by applying a process diversity factor is not acceptable.

Busbars shall have colour coded identification bands at maximum 300 mm intervals. Colour coding will be a 25 mm minimum width with preferred PVC sleeve or heat shrink encircling each busbar, with colours as detailed in Table 11 below.

Table 11 Busbar colour identification

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

6.5.13.1. Neutral and Earth Bars

The Neutral and Earth bars shall run the full length of an LV switchboard or MCC.

The location and accessibility of the assembly neutral and earth bars shall be in accordance with the following.

Specific requirements for Form 4a segregated assemblies:

a. Main neutral bar is parallel to phases and segregated from functional units.
b. Main earth bar is segregated from functional units.
c. Outgoing neutral and earth terminals are inside the functional units.
d. Earth conductors as part of field multicore cabling will terminate to DIN rail terminals adjacent to the power terminals. This is to ensure that double insulation is provided within the cable zone as close as possible before the conductors are connected to the terminals. Where single core cables are used, the earth conductor will terminate directly to the main earth bar.

For termination of field earth cables 2.5 mm² and smaller, an earth link bar (or tunnel type earth bar) with at least ten terminals shall be mounted on the earth busbar. Only one earth cable will be terminated at each earth terminal.

Neutral conductors shall have the same current carrying capacity as associated phase conductors.

A maximum of one neutral circuit per bolt to the neutral bar shall be made.

All connections to the earth bars will be readily accessible without disturbing the internal or external wiring.

All parts of the switchboard which are required to be earthed shall be effectively connected to the earth busbar.

For distribution boards, the protective earth bar will:

- Be of the tunnel type;
- Tunnels will be numbered;
- Sufficient number of tunnels including spares to allow the distribution board to be fully populated in future;
- Tunnels will accept a conductor cross sectional area of 16mm²; and
- Have two studs to suit termination of 70 mm² green/yellow earth cable.

6.5.13.2. Internal Cabling and Wiring

Internal cables and wires shall have minimum size and colour as detailed in Table 12 below.

Table 12 Cable Colour Code and minimum CSA

Cable Type	Insulation Colour	Sheath colour for multicore	Minimum CSA
400 V AC (A, B, C & Neutral)	Red, White, Blue, Black	Orange	2.5 mm^2
230 V AC (A/B/C & Neutral)	Red, Black	Orange	1.5 mm^2
48 V DC Distribution (Positive & Negative)	Grey, Grey	Black	1.0 mm^2
24V DC Distribution (Positive & Negative)	Orange, Violet	N/A	1.0 mm^2
24V Digital I/O	Grey	Grey	0.5 mm^2
4-20mA Analogue I/O (Positive and Negative) twisted pair	White, Black	Black	0.5 mm^2
Intrinsically safe	As per applicable field cable type	Light Blue	1.5 mm^2
Earth	Green/Yellow	N/A	2.5 mm^2

In the case of an MEN link, the maximum permissible cable CSA is 120mm². Should a greater current carrying capacity be required, this shall be provided by solid bar conductor.

As far as practical, control cables and cores, data cables and power cables shall be segregated to avoid unexpected electromagnetic coupling causing interference.

The requirements of Section 9 Cables and Wiring also apply to Cables and Wires within an electrical enclosure.

6.5.14. Cable Duct

The preferred method of wire management inside LVSCAs is the use of slotted, insulated cable duct fitted with a snap-on lid.

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

Cable duct shall be so arranged inside the enclosure to allow the necessary clearances to be maintained and for wire to be taken as directly to the necessary terminals as possible.

Access to terminal studs shall not be impeded by the ducts, and duct fixings shall not have sharp projections inside the duct which could damage cable insulation.

A minimum clearance of 100 mm is required between cable duct and gland plates.

Cable ducts shall be installed with spare capacity for future wiring consistent with the enclosure provision for additional circuits and equipment.

Cable duct 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.

Where wires pass through holes in panels, suitable bushes or plastic grommets shall be used.

6.5.15. Wiring Looms

Where it is not practicable to run the wiring in ducts, wires shall be run in looms using slit wall corrugated loom tubing and fixed with cable ties at suitable intervals.

The weight of wiring looms shall not cause any undue strain on the conductor strands or insulation. 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 enclosure that are free from projections such as small studs, etc., that may damage the conductor insulation.

6.5.16. Cable Zones

Motor control centres shall be supplied with vertical cable zones adjacent to each tier, and with a horizontal wiring enclosure running the length of the board.

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

Cable zones shall be adequately sized, of minimum opening width 300 mm, and shall be designed for ease of installation and maintenance of cables.

Cable zones shall not be used for any form of LV termination.

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

6.5.17. Gland Plates

Cable glands may be fitted directly to the enclosure at small local control panels and junction boxes designed for such use, with 5 or fewer cable entries. Otherwise all cable entries shall be made at gland plates.

Gland plates shall maintain a minimum 50mm clearance from section dividers.

Gland plates are not to be split.

Gland plates shall be effectively earthed to the assembly enclosure.

Gland plates shall be sealed against the enclosure with an EPR or neoprene gasket.

Unused or spare holes in cable gland plates shall be sealed using purpose-made blanking devices of equivalent standard to a gland for that location, considering IP rating, material compatibility, and hazardous area certification if applicable.

6.5.18. Internal Lighting

LVSCAs (indoor or outdoor) shall be provided with appropriate internal cabinet lighting to allow visibility of internal equipment. Internal cabinet lighting is required for LV main switchboards, MCCs, PLC/RIO enclosures and marshalling panels. Internal cabinet lighting may not be required for light and power DBs and equipment local control panels if these are adequately illuminated by external lighting. Internal LV assembly lighting shall be LED supplied at 24VDC. Each light fitting shall be controlled by a switch activated by the enclosure door. Each door shall control the respective light fitting individually, such that the light is on when the door is open.

Equipment behind an escutcheon does not require illumination by the cubicle light.

6.5.19. Doors and Covers

Doors and covers shall be fabricated with the same material and finish as the main assembly enclosure.

Doors and covers shall be fitted with durable seals that maintain the enclosure IP rating.

Stiffeners shall be fitted to all LV assembly doors with dimensions in excess of 1000 mm high and 450mm wide.

Doors shall open to a minimum of 100 degrees.

Door stays shall be fitted to all doors with height greater than 1000 mm, and all doors where inadvertent movement of an unstayed door could be hazardous.

Light and power distribution boards shall be fitted with a document holder inside the door to hold the distribution board legend card.

All document holders shall be fitted such that the opening is clear of any overhanging electrical equipment which could potentially drop heated elements into the holder in the event of an insulation failure.

6.5.20. Escutcheons

Escutcheons shall be hinged and shall open to a minimum of 90 degrees.

6.5.21. Latches, Handles and Locks

Doors and covers shall be fitted with handles and/or latches as detailed in Table 13, except where this would conflict with another requirement of this specification.

If the requirements of Table 13 are incompatible with the assembly manufacturer's tested arc fault containment design, the Contractor shall notify Seqwater and seek Seqwater approval of the latches/handles/locks that can be provided while maintaining verified arc fault containment performance.

Latches, locks and handles shall maintain the IP rating of the assembly.

Table 13 Latches, Locks and Handles

Lock/Handle	Specification	Application
D Handles	Chrome Plated Steel or Stainless Steel	All lift-off covers. All escutcheon panels. All switchboard withdrawable units.
Quarter Turn Tool Lock	Stainless Steel 8 mm Solid Square Key Preferred	All escutcheon panels. Minimum two required for panels over 450 mm high. Minimum three required for panels over 1000 mm high. MCC functional cell and vertical cable zone doors - located within secure switchroom or behind outer MCC door. ELV junction boxes not subject to public access
Keyed Flush or Semi-Flush Handle	Stainless Steel (outdoor) Chrome Plated Steel or UV stable plastic (indoor) Keyed L&F 92268	Outer doors and covers up to 600 mm high
Keyed 3 Point L Handle	Stainless Steel (outdoor) Chrome Plated Steel (indoor) Keyed L&F 92268 Internal 3 Point Locking Rod Mechanism	Outer doors and covers greater than 600 mm high
Padlockable Swing Handle	Stainless Steel Vandal Proof Suit padlocks up to 13 mm 90^{O} Left and right stopper Internal 3 Point Locking Rod Mechanism if greater than 600mm high	Assemblies subject to public access. Electricity meter panels to be fitted with a 45 mm brass pin tumbler ENERGEX padlock. All other panels to be fitted with the appropriate Seqwater issued padlock.

6.5.22. Heat Shields

All external LVSCAs with any exposure to direct sunlight at any time of day at any time of year shall have heat shields installed to reduce the effects of solar radiation.

The attachment of the heat shield shall not penetrate the enclosure and shall not compromise the I.P. rating of the enclosure.

The heat shields shall be removable to allow for easy replacement in the event of damage.

6.5.23. Assembly general arrangement

In general, the assembly general layout shall be such as to meet the design verified construction of the assembly system being offered.

Indoor and outdoor LV assemblies shall be arranged for bottom entry of cables only.

Space for mains cable entry to the assembly shall allow for ready handling, manoeuvring and terminating of the cable using standard tools without the need to remove fixed equipment. Bending of mains incoming cables inside the switchboard should be limited.

For motor control centres, motor starters shall be grouped based on process function with duty and standby motors segregated. This requirement applies to Form 4a and Form 2bi constructions. In assemblies with separate buses joined by a bus-tie, duty and standby drives should be fed from separate buses.

6.5.24. Equipment layout requirements

This section describes specific layout requirement for functionality, safety, reliability and maintainability. The requirements of AS/NZS 61439.1 must be upheld while conforming to these additional requirements, for example creepage distances, clearances and other verified elements of an assembly. In cases where requirements cannot be met, a written deviation to this standard is required.

6.5.24.1. Equipment device installation

All equipment device shall be installed in accordance with the manufacturer's specifications. All necessary clearances shall be achieved and the equipment device rating shall not be thermally or electro-magnetically degraded by the proximity to other devices or cables.

All equipment devices protruding through the enclosure or escutcheon door shall match the specified enclosure ingress protection.

6.5.24.2. Cable ducting

Equipment inside cubicles must be arranged such that a minimum of 20% of the width of the cubicle is reserved for cable management and ducting.

Cable ducting must be kept to a minimum of 30mm from marshalling and equipment terminals.

Outgoing power or control terminals located in a functional unit cubicle should be located to minimise the lengths of outgoing cable in the cubicle.

Control wiring must be accessible without the need to remove equipment or bolted cover plates to access, remove, replace or re-terminate wires. This requirement does not apply to shrouding, as described in Section 6.5.7.

6.5.24.3. Isolation switch orientation

All isolation switches that are operable on an assembly must operate in a consistent and predictable direction.

MCBs mounted on a distribution chassis shall all switch in the same direction on each side of the chassis.

Rotary-motion isolator handles that protrude through an escutcheon or assembly outer door must switch in a consistent direction and orientation through the whole assembly (i.e. 90 degrees rotation = "On" OR 90 degrees rotation = "Off" consistently throughout the whole assembly).

6.5.24.4. Minimum tier and cabinet sizes

Tier and cabinet sizes must be adequate to accommodate the ergonomic and accessibility requirements described in Section 6.6 and the spare capacity described in Section 3.8.

6.5.24.5. Gland plates

LV assemblies shall be fitted with bottom entry gland plates sized to accommodate the full future capacity of the assembly including spares. Cable entries shall be laid out in a manner that does not obstruct space reserved for future circuits.

6.5.24.6. Equipment accessible for maintenance

All equipment devices or terminal inside the enclosure shall not be mounted directly to the enclosure without the use of a mounting panel.

All equipment shall be removable via the front access and shall not be mounted in any manner denying free access for removal or maintenance.

Equipment and terminals shall not be mounted on the sides or top of enclosures – except where necessary for the function of that equipment, e.g. internal lighting.

Enclosure and escutcheon doors shall be arranged such that equipment device terminals are easily accessible.

Equipment devices and terminals shall be mounted at least 200 mm from the gland plate. Greater separation will be required for larger diameter cables.

6.5.24.7. Door mounted equipment, indication and controls

Low voltage equipment, indication, controls and/or wiring may not be fixed to the inside or outside of LV assembly panel doors. All equipment (e.g. fans, switches, indication lamps) and wiring mounted to LV assembly doors shall be ELV.

6.6. Ergonomics and Accessibility

General principles for equipment installation and access provisions are outlined in AS/NZS 61439.1 and shall be adhered to, plus the following requirements.

6.6.1. LVSCA Operation

The centreline of the LV assembly parts or elements that are intended to be operated or viewed by personnel shall be mounted according to the following limits.

Table 14 Equipment height

Operation	Height above finished floor level	
	Maximum	**Minimum**
Switching, indicator lights, instrument indicator, control buttons and switches	1900mm	400mm
Touchscreen / HMI Display	1900mm	800mm
Actuators for Emergency Switching	1600mm	800mm
Revenue meter*	1900mm	900mm
Key or tool operated lock**	1900mm	400mm

* Confirm installations requirements also with the latest Queensland Electricity Connection Manual and National Metering Installation Requirements.

** This applies to functional units only. Cable zones or bus zones that are not accessed under normal, expected operations do not need to adhere to this limit.

6.6.2. LVSCA Inspection and Maintenance

Unless otherwise agreed with the Principal, or specified in project documentation, the following limits shall apply to all other elements of an LVSCA, which are not intended to be operated.

All cabinets of a LVSCA shall be suitably sized to allow access for maintenance.

For LVSCAs with an overall length greater than 1100mm, dimensional limits for segregated cabinets are:

a. Minimum height of a functional unit, horizontal cable zone or bus zone shall be 180mm. Higher functional units may be required for deep panels, or at the lowest panel of the assembly, to maintain accessibility.

b. Minimum width for a vertical cable zone or bus zone shall be 300mm.

Cable and wire terminals shall be located and arranged to be accessible for mounting, wiring and for maintenance or replacement.

Terminals shall be suitable for termination of copper conductors. Generally, terminals shall be sized to accommodate the smallest and largest size individual conductors that correspond to the appropriate rated current, according to Annex A of AS/NZS 61439.1.

Removable parts of an assembly that require maintenance (such as access plates, cooling fans, vents and dust filters) shall be located such that clearances are maintained during removal and ensuring that the part is secured against unauthorised access for removal.

6.6.3. Separation from Electrical Hazards

Operational controls shall be accessible without opening compartments that contain LV terminals or exposed LV parts.

Operational controls shall be accessible without opening arc fault containment doors or latches.

PLCs, RIO, network switches, and any other control system equipment that may require access by a control system technician, shall be located in dedicated ELV control system compartments that:

a. do not contain LV terminals, LV wiring or LV equipment, and

b. are accessible without opening compartments containing LV terminals, LV wiring or LV equipment, and

c. are separated with sheet metal from compartments containing LV terminals, LV wiring or LV equipment, and

d. are not located inside an arc flash boundary, and

e. maintain the conditions above whilst the system is online, to allow for safe ELV online fault-finding and maintenance access by non-electrical-worker control system technicians.

6.7. Equipment and Devices

6.7.1. General

Electrical equipment installed in LV assemblies shall be new equipment complying with relevant Australian Standards and be suitable for the duty indicated in this specification and project specific documentation.

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.

Each category of equipment in an assembly shall be selected from one consistent and compatible manufacturer & model range. E.g. all MCCBs and MCBs from the same manufacturer's tested combination.

6.7.2. Air Circuit Breakers (ACBs)

ACBs are preferred for all incomer, bus-tie and outgoing feeder protection on circuits rated at 800A and above. This is due to the ability of ACB's to withstand higher fault levels for longer durations, compared to alternative circuit protective devices of the same current carrying capacity.

ACBs shall have been tested by a recognised independent testing authority to IEC 60947-2.

ACBs shall have the classification characteristics as per Table 15 below.

Table 15 ACB Classifications

Detail	Value
Rated Frequency	50 Hz
Rated Voltage	400 V AC
No. of Poles	per design
No. of Phases	per design
Interrupting Medium	Air
Mounting	Withdrawable (unless specified otherwise by Seqwater)
Open/Close Mechanism	Independent Manual (minimum) Remote operation where required for arc flash risk reduction (section 6.4.3)
Racking Mechanism	Manual (minimum) Remote operation where required for arc flash risk reduction (section 6.4.3)
Trip Units (minimum protection functionality) *	Externally powered** Overload, Instantaneous, Earth Fault
Rated Continuous Current	per design
Rated Short Circuit Current	per design
Auxiliary Contacts	1 N/O & 1 N/C
Selectivity Category per IEC 60947-2	Category B

* Electrical design documentation should be consulted for protection requirements. If no information is provided, then the minimum functions shall be provided.

** Electronic trip units shall not require the circuit breaker primary circuit to be energised to allow adjustment of settings.

6.7.3. Moulded Case Circuit Breakers (MCCBs)

MCCBs shall have been tested by a recognised independent testing authority to IEC 60947-2.

MCCBs shall have the classification characteristics as per Table 16 below.

Table 16 MCCB Classifications

Detail	Value
Rated Frequency	50 Hz
Rated Voltage	400 V AC
No. Of Poles	per design
No. Of Phases	per design
Open/Close Mechanism	Independent Manual (minimum) Remote operation where required for arc flash risk reduction (section 6.4.3)
Trip Units (minimum protection functionality) *	Externally powered** Overload, Instantaneous, If In ≥ 800A: Earth Fault
Rated Continuous Current	To suit design requirements
Auxiliary Contacts	To suit circuitry
Selectivity Category per IEC 60947-2	Category A

* Electrical design documentation should be consulted for protection requirements. If no information is provided, then the minimum functions should be provided.

** Electronic trip units shall not require the circuit breaker primary circuit to be energised to allow adjustment of settings.

MCCB poles shall operate simultaneously.

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

6.7.4. Transfer Switches

Installations that are intended for use with a temporary or permanent generator, for standby power supply, shall be fitted with an appropriate changeover switch facility.

Generators are not the only application where a transfer switch can be used. Any installation that can receive power from two or more alternative power sources may be supplied by a transfer switch.

Transfer switch change-over mechanisms shall be either:

a. Mechanically interlocked circuit breakers
b. Three position transfer switches

Mechanical interlocks on circuit breakers and switches shall not be disconnected from the unit if an escutcheon or outer door is opened.

The manual or automatic three-position transfer switches shall have three positions clearly labelled Mains (0º), Off (90º), and Generator (180º). In the Off position, the installation shall be effectively isolated in accordance with AS/NZS 3000 requirements for devices for isolation.

Transfer switches shall at a minimum be rated for fault-making/load-breaking duties, and for maximum out-of-phase voltages between mains and generator supplies.

The transfer switch handle shall be insulated or effectively earth, sized adequately to allow ease of operation, and lockable in the Off position. Any required extension rod shall be as short as possible and suitably supported to ensure correct alignment with the panel door.

6.7.5. Power Factor Correction (PFC)

The electrical design may require PFC to be installed as part of a LV Assembly. The PFC system shall achieve a power factor that meets the minimum requirements of the electricity connection agreement at the point of connection.

The need for PFC shall be investigated as part of the electrical system planning and design phases.

The PFC units are preferred to be housed in a dedicated enclosure that includes reactive components and any dedicated control hardware. The PFC enclosure must meet the requirements of this standard specification.

PFC equipment can be installed in a functional unit (e.g. pump starter cell) provided all access, barrier, clearance requirements and manufacturer installation requirements are met.

6.7.6. Contactors

Contactors shall have been tested by a recognised testing authority to IEC 60947-4.

Contactors shall have classification characteristics as per Table 17 below.

Table 17 Contactor Classifications

Detail	Value
Rated Frequency	50 Hz
Rated Voltage	400 V AC
No. Of Poles	3
No. Of Phases	3
Interrupting Medium	Air
Control Method	Electrical
Rated Duty	Uninterrupted
Rated Operational Current	Motor Full Load Current plus 20%
Utilisation Category	AC-3

Detail	Value
Mechanical Endurance	10 Million Operations
Electrical Endurance	1 Million Operations
Co-ordination with Protective Device	Type 2 (1)
Rated Control Supply Voltage	24 V DC (2)
Auxiliary Contacts	1 N/O & 1 N/C (Minimum)

(1) Type 2 co-ordination is required where possible. If type 2 co-ordination cannot be achieved, this must be supported by design documentation to demonstrate why.

(2) Contactors for motors up to 15kW shall use low pickup low consumption 24VDC coils with holding power ≤ 2.4W. For larger motors, a 230VAC coil shall be used with an interposing relay.

Contactors shall be of the block type with modular design suitable for vertical mounting.

Mounting screws shall be accessible from the front.

Contactors over 50kW shall have replaceable contacts and removable arc chutes.

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

6.7.7. Overload Relays

Electronic overload relays shall be used for all DOL motor circuits and provide the following motor protection functions:

a. Overload protection
b. Jam/Stall
c. Phase loss
d. Unbalance

Electronic overload relay for motors greater than 50kW shall additionally provide the following motor protection functions:

e. Underload
f. Unbalance
g. Temperature (Thermistor PTC for motor up to 150kW and RTD Pt100 for motor greater than 150kW)

Motor current and voltage monitoring functions shall be available for motor sizes greater than 150kW.

All motor protection devices shall be configured for manual reset and shall not reset automatically. Manual reset push button actuators shall be accessibly mounted on the escutcheon or enclosure functional unit door.

6.7.8. Motor over-temperature relay

Where motors are to be fitted with thermistor elements to monitor winding temperatures, the relay construction shall use the inherently non-auto-resetting type. Arrangements involving a 'hold' relay in association with auto-resetting trip relay will not be accepted.

Mount a prominent warning label on or adjacent to each thermistor unit warning that voltages in excess of 2.5 volts must not be applied to the thermistor control units.

The preferred method of connection for thermistors is direct to either a VSD or Soft Starter.

6.7.9. Earth Leakage Relays

Outgoing feeders, DOL, soft starter, and VSD circuits shall be protected with an earth leakage relay where (i) specified in design documentation or (ii) shown to be beneficial to control a specific risk for that site/application/circuit.

Earth leakage relays and injection testing points shall be accessibly mounted on the escutcheon or enclosure functional unit door.

6.7.10. Miniature Circuit Breakers (MCBs)

All internal AC or DC control power circuits shall be suitably protected with MCBs.

Fault levels shall be suitable for MCBs by utilising cascading with upstream devices or additional fault limiting devices where necessary.

6.7.11. Fuses

LV power fuses shall be of the non-rewireable, enclosed HRC fuse link 400 V general purpose cartridge type.

Fuse links shall be mounted in moulded plastic carriers and bases (unless mounted within a fuse-switch combination) and shall be mounted for withdrawal directly towards the operator.

Holders for open blade type fuses shall have suitable fixed insulating barriers between adjacent phases to prevent inadvertent electrical contact by a foreign metal object.

The fuse rating shall be selected to properly protect the equipment and wiring serviced by the fuse.

Fuse links are to have stable time-current characteristics not subject to thermal ageing or other in-service deterioration.

Fuse blown indication, where specified or provided, shall be visible when the fuse link is fitted to the carrier.

Where fuse extraction handles are required, they shall be clipped inside the LVSCA functional unit adjacent to the fuses. Where the fuses are located behind more than one cover, one handle shall be provided behind each cover.

Fuse carriers and bases shall have a continuous rating not less than the rating of the largest fuse which could be used to protect the connected circuit.

6.7.12. Power Meters

Switchboards that meet any of the following criteria shall be fitted with a digital power meter:

- Main switchboard with a current rating greater than 100A
- Any switchboard with a current rating greater than 250A
- Any switchboard containing motor starter rated above 22kW

The digital power meter read-out display and HMI functions shall be available for viewing and operation by non-electrically licenced personnel, using a remote display that avoids the need to install Low Voltage terminals or wiring on doors or escutcheons.

The power meter shall communicate via the site control system field device LAN using an I-SPE-STD-013 compliant protocol and shall provide the following information to the PLC/SCADA system:

a. Voltage - Phase to Phase and Phase to Neutral
b. Current - Per Phase
c. Power - Apparent, Active and Reactive
d. Power Factor
e. Frequency
f. THD for Voltage and Current - Per Phase
g. Average Values for Voltage & Current
h. Min/Max Values for Voltage, Current, Frequency and Three Phase average voltage and current.
i. Energy used in cumulative Kilowatt hour
j. Maximum Demand

The power meter shall have following minimum measurement accuracies:

i. ± 0.5% Voltage (V)
ii. ± 0.5% Current (A)
iii. ± 0.005 Power Factor (PF)
iv. ± 0.5% Frequency (Hz)
v. ± 0.5% Apparent Power (VA)
vi. ± 0.5% Active Power (W)
vii. ± 2% Reactive Energy (kVARh)
viii. ± 0.5% Active Energy (kWh)
ix. 1% up to the 31st harmonic THD
x. 1s response time

The power meter CTs accuracy class shall be 0.5S or better.

6.7.13. Energex Meter

Energex meter shall be installed as per project site specific and Energex requirements.

The Energex meter with all associated equipment device shall be installed in either a dedicated stand-alone or segregated metering cabinet that is accessible to Energex personnel.

For further detail on the Energex meter installation and requirements, refer to the QECM Queensland Electricity Connection Manual (QECM) and National Metering installation Requirements (MIR).

6.7.14. Surge Protection Devices

6.7.14.1. General Requirements

All LVSCAs must be protected from damage caused by a voltage surge or lightning strike.

An evaluation of the risk of loss, according to AS 1768, is required for all of the following switchboard categories:

a. Main switchboard.

b. Outdoor switchboard that is located more than 20m, by cable distance, from the closest surge protective device on the power supply line to the switchboard.

c. Outdoor switchboard supplying critical services.

d. Switchboard supplying outdoor equipment/sub-boards and critical services.

e. Indoor switchboard located more than 50m, by cable distance, from the closest surge protective device on the power supply line to the switchboard.

f. Any other switchboard where the designer or Seqwater determines that there is a plausible risk of significant damage by voltage surge or lighting strike.

Surge protective devices shall be installed where indicated by AS 1768 and the AS 1768 risk assessment.

Surge protectors shall be installed in accordance with the manufacturer's recommendations and shall be easily accessible for maintenance. System availability to meet the required level of service shall not be affected under maintenance conditions of the surge protective devices.

With reference to AS 1768, the term surge protection on *all devices* should be interpreted as all power and signal carrying cables that extend to outside of the switchboard assembly surge-protected zone with respect to the specific risk category being addressed.

6.7.14.2. LV Surge Diverters

Suitable fuses, in accordance with the manufacturer's recommendations shall be installed between the mains and the surge diverters.

Alarm contacts shall be provided that indicate surge protective device health status for any of the following installations:

a. The three-phase surge protection

b. Single phase surge protection for critical services

6.7.14.3. Analog Circuit Protection Device

The protection equipment shall be compatible with the circuit connected and suitable for use on 4-20 mA DC signals at the loop power supply voltage with a resistance of less than 40 ohms.

The equipment shall be rated to withstand a peak impulse current of at least 10 kA for an 8/20 micro-second for line-to-line and line-to-earth transients and arranged to fail to the short circuit condition. Not required to be resettable.

6.7.14.4. Communications Wiring Protection Device

The protection equipment shall be rated to withstand a peak impulse current at least a 10 kA for an 8/20 microsecond pulse and compatible with the data signalling levels and data transfer rate.

6.7.15. Voltage Presence Indicator

All main incomer circuit breakers with a rating of 800A or greater shall have a voltage presence indicator on the circuit breaker load side.

6.7.16. Harmonic Filtering

Harmonic filtering equipment shall be installed where required, in accordance with the manufacturer's installation requirements.

Alarm outputs shall be provided to the PLC for the following:

a. Harmonic Filter fault

b. High temperature alarm

For active type harmonic filters a communication interface to the PLC/SCADA system shall be provided for all alarms, operating values and status.

6.7.17. Phase Monitoring Relay

Three phase LV assemblies shall have a phase monitoring relay installed for incoming supply phase loss, phase rotation, and under-voltage monitoring.

Phase failure relays shall be connected to three phases, no neutral, via suitable circuit protection. The auxiliary supply shall be connected to the phase supply internally. The relay shall automatically reset upon restoration of the correct supply voltage and rotation.

Phase failure relays shall be wired in fail safe configuration.

Phase monitoring relays shall provide alarm contacts for PLC feedback.

6.7.18. Control Relays

Control relays shall be of moulded block construction and incorporate silver alloy contacts rated for the application. All control relays in an assembly shall be of one common manufacturer and model range.

Relays connected to 24 V DC PLC output modules shall be high impedance miniature plug in relays. All others shall be block type relays suitable for DIN rail mounting. Contacts shall be definite and positive in action and to make with a wiping and self-aligning motion without bounce.

Relays with a coil-holding power greater than 2.4W shall be actuated by 230VAC. Otherwise the coil actuation voltage shall be 24VDC.

All 24 V DC-coil relays shall include integral surge suppression and LED indication.

Relay coils shall be continuously rated and provided with double insulation. All ELV control relays and other special function relays shall be enclosed in plexiglass or similar dust tight transparent covers.

Control relays with manual override facility shall not be offered.

6.7.19. Pump Seal Failure Relays

Pump seal failure relays shall be manual reset type with a reset button mounted on the relay. A red LED on the relay shall indicate trip condition.

Contacts shall have a minimum rating of 4 A to AC-15 at 230 V AC unless otherwise required.

6.7.20. Current Transformers

Current Transformers shall comply with the requirements of AS 61869.2 and shall have the characteristics noted in Table 18 below unless otherwise specified.

Table 18 Current Transformers

Application	Description	Value
General Requirements	Construction	Window
	Number of Primary Turns	1
	System Voltage	400 V
	Rated Frequency	50 Hz
	Rated Primary Currents	As required
	Rated Secondary Currents	1A or 5A
Measurement	Type	M
	Accuracy Class	0.5M
	Rated Output	15 VA
Protection	Type	P
	Accuracy Limit Factor	10
	Composite Error	5%

Polarity markings shall be marked on each CT along with other information as required by AS 61869.2.

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

All secondaries of current transformers shall have one lead earthed.

A danger label must be installed next to the CT test terminals bearing the following text:

> DANGER – HAZARD OF ELECTRIC SHOCK, EXPLOSION OR ARC FLASH
>
> Never open circuit a CT. Use the shorting link to short circuit the leads of each CT.
>
> Use a properly rated and tested current clamp and measuring device to verify that no current is present before removing the connection from the device.

CT's for tariff metering on LV Assembly incoming supplies shall be connected to an ESAA test block as detailed in the National Metering Installation Requirements.

Busbar mounted CT's shall be installed over a removable section of bar with bolted connections to facilitate changeover. CT's will be securely clamped to the busbar with proprietary clamps. For cable installations, the CT's

shall be separately fixed to a mounting bracket and the cable will pass through the centre of the window without imparting any pressure on the body of the CT.

6.7.21. Soft Starters and Variable Speed Drives

Refer to E-SPE-STD-010.

6.7.22. AC Uninterruptible Power Supply

Refer to E-SPE-STD-004.

6.7.23. DC Power Supply Units

A suitably sized 24 V DC PSU supplied from an AC UPS shall provide control power to all control circuits.

The PSU shall be dual redundant set.

The power supply shall meet the following minimum specifications:

a. Supply shall operate successfully and at selected voltage at no load.
b. Output to input isolation of 3000 V AC.
c. Isolation of output to case exceeding 500 V AC.
d. Line regulation better than 0.4%.
e. Load regulation better than 0.8%.
f. Ripple and noise better than 150 mV peak to peak.
g. Temperature drifts less than 1% for temperature range 0º to 55 ºC.
h. Overcurrent protection to operate at 105% rated current with automatic recovery.
i. All connections shall be readily accessible.

Power supplies shall be capable of providing sufficient current to open any downstream protective device in the event of any short circuit.

6.7.24. Control Switches

Control switches shall be of the rotary switch type with cam operation and switch positions arranged with a minimum displacement of 60°.

An On/Off control switch shall have the Off at 12 o'clock position with the On clockwise from the Off position.

A Local/Remote control switch shall have the Local and Remote counter-clockwise and clockwise from the 12 o'clock position respectively.

Contacts shall have minimum rated operational current of 16 A to AC-1 and 6 A to AC-15, all at 230 V AC.

Terminals shall be arranged for rear access. Side access terminals will not be accepted.

6.7.25. Actuators / Buttons

Push button actuators shall be non-latching for general application.

Emergency stop push button shall be self-latching mushroom head with pull or twist to reset. Instructions for releasing shall be included either on the face of the button or by label/legend. Emergency stop buttons and associated relays shall comply with the relevant parts of AS/NZS 4024 Safety of Machinery.

The colours shall be as indicated in Table 19 below.

Table 19 Actuator Colours

Application	Colour
Emergency Stop	Red with yellow background
Stop/Open/Turn-Off	Red
Start/Close/Turn-On	Green
Test/Reset	Black

All terminations shall be by screw terminals accessed from the rear of the unit. Contacts shall have minimum rated operational current of 10 A to AC-1 and 3 A to AC-15, all at 230 V AC.

6.7.26. Indicator Lights

Indicating lights shall be 24 V DC LED type having a rated service life in excess of 100,000 h.

Standard indicator light colours for motor control are listed in Table 20 below. Where existing site/equipment conventions differ from these colours, the Contractor shall seek clarification from the Principal for which standard to apply.

Table 20 Indicator Light Colours

Colour	Value
Green	Motor Running
Amber	Fault/Trip
White	Status Ok/Available

All terminations shall be by screw terminals accessed from the rear of the unit.

6.7.27. Residual Current Devices and Residual Current Breakers

Additional protection by RCDs shall be provided for final subcircuits where required by AS/NZS 3000.

Where it is necessary to apply one of the AS/NZS 3000 exceptions to RCD protection, the Contractor shall provide supporting evidence as part of the design documentation for review and acceptance by the Principal - including an engineering risk assessment, technical details of the equipment, and assessment of alternative design options.

Designers should not rely on AS/NZS 3000 exceptions to RCD protection, where there is a reasonably practicable design alternative that could retain both RCD protection and the safety and reliability of the installation. For example, where possible:

a. Provide sufficient redundancy of critical equipment and instrumentation to avoid any one circuit being essential to the performance of the installation.

b. Select equipment that is not susceptible to spurious nuisance tripping through high leakage current.

Type A RCDs are approved for general use, whereas Type AC RCDs shall not be used. Other types of RCD shall be selected to suit the application.

RCDs and RCBOs shall be lockable in the off position.

All RCDs and RCBOs must be installed with facilities for connecting a plug-in RCD tester without the need to open an escutcheon or access any compartment containing live terminals. For locations with a large number of RCDs, the preferred arrangement is one RCD test point outlet at the distribution board, that can be switched to each RCD circuit (including spares provision) in turn via selector switch(s). For locations with fewer RCDs, an alternative acceptable arrangement is dedicated RCD test point outlets on lighting circuits (see Section 3.14.4) and other RCD protected circuits that do not already include a socket outlet. RCD test points shall have a round earth pin.

6.7.28. Arc Flash Relays

An arc flash relay that trips upstream protection is required for locations within line side incident energy of 40 cal/cm^2 or above.

The arc flash relay shall be a combination of excess light and current monitoring. Light sensors shall be located at minimum at the LV enclosure busbars, incomer CB section, incomer cable zone/s and outgoing cable zone/s.

6.7.29. Tools

Any special tools necessary for the maintenance or operation of the equipment shall be supplied.

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

6.8. Distribution Boards

6.8.1. Escutcheon and Door

Distribution boards shall be fitted with a hinged metal escutcheon mounted behind the outer door, and the operating handles of the devices shall protrude through cutouts in the escutcheon. Both the escutcheon and the overall door shall be latched in accordance with Section 6.5.21.

6.8.2. Switching and Isolation

The circuit breakers and isolators shall be able to be padlocked 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 fitted with a defeatable interlock such that under normal conditions, it cannot be opened unless the incomer is in the off position.

6.8.3. Distribution Board Chassis

Where the distribution board contains a circuit breaker distribution chassis, these will be of the encapsulated type providing a completely enclosed system and shrouding of live parts which in turn provides higher levels of protection against direct contact and reduce the potential hazards associated with maintenance works.

A distribution chassis shall be utilised to manage miniature circuit breaker installations of more than three miniature circuit breakers (including spares allowance) per phase, for three-phase systems, and six miniature circuit breakers (including spares allowance) for single phase systems.

Distribution Chassis shall be compliant with AS/NZS 61439 part 1 and part 2.

An earth and a neutral bar shall be provided on each side of the chassis, as opposed to a single earth bar on one side and a single neutral bar on the other side of the chassis. This requirement applies to both free standing distribution boards and to distribution boards which are integral to a LV Assembly.

6.9. Local Control Panels

6.9.1. Construction

Local Control Panels (LCPs) shall contain the required pushbuttons, switches and indicating lights where it is necessary to manually operate the equipment in the field, and the Field Isolator (AC-23 rated) if provided (see Section 3.15).

Local control panels shall be constructed as for LVSCAs to this specification except as modified below.

Prefabricated enclosed polycarbonate or polyester LCPs that meet all other requirements of this specification are acceptable for LCPs that meet the following criteria:

a. Secure dry indoor location, without significant risk of mechanical impact, and

b. If a field isolator is included, it is for a DOL motor and the motor is ≤15kW

LCPs that do not meet these criteria shall be constructed as per the requirements for an outdoor switchboard, i.e. outer enclosure shall be or Stainless Steel 316 or Marine grade Aluminium 5251.

Isolators mounted through a hinged escutcheon or door shall be interlocked with the door such that the door cannot be opened until the isolator is in the off position.

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

Where LCPs contain emergency stopping devices (see Section 3.15), these shall be mounted externally on the panel to allow for ready access.

6.9.2. Installation

All local control panels (LCPs) shall be installed as close to the motor as practicable. In no case shall the distance from the motor to the LCP exceed three metres. In all cases, the motor shall be visible from the LCP.

Where pedestal mountings are required, a suitable support column and base shall be provided. The bottom of the LCP should be at a height of approximately 1200 mm above finished floor level. The pedestal mounting shall be hot dipped galvanised. The base plate shall be raised by 50 mm and the void filled with non-shrinkable grout.

7. Junction Boxes

7.1. Application

Junction boxes shall be used where required,

a. to join up to 4 larger multicore cables to individual cables to field devices; and/or

b. to join proprietary equipment cables to standard control cables; and/or

c. to house field surge diverters where applicable

7.2. Enclosure materials

Polycarbonate or polyester junction boxes that meet all other requirements of this specification are acceptable for junction boxes that meet the following criteria:

a. Secure dry indoor location, without significant risk of mechanical impact, and
b. No more than 5 cable entries, and
c. No greater than 200x200x150mm in size, and
d. Fault level < 10kA, and
e. Dedicated to the final connections to a single item of field equipment / instrumentation

In all other cases junction boxes shall be of 316 stainless steel construction. Such junction boxes shall be fitted with a 316 stainless steel lid secured with stainless steel bolts, or a 316 stainless steel hinged door locked as per Section 6.5.21.

7.3. Design and Construction

Junction boxes shall be designed and constructed in accordance with the principles of AS/NZS 61439 where applicable.

At minimum, the following parts of Section 6 must also be applied to Junction Boxes.

- 6.3 Service Conditions
- 6.4.4 Short Circuit Withstand
- 6.4.8 Earthing Continuity
- 6.4.9 Ultraviolet (UV) radiation
- 6.5.3 Ingress Protection
- 6.5.6 Clearances
- 6.5.7 Barriers
- 6.5.12 Labelling and identification
- 6.5.13.2 Internal Cabling and Wiring
- 6.5.17 Gland Plates
- 6.7.1 Equipment and Devices General

8. Electrical Switchrooms

All electrical switchboards and PLC/RIO control panels shall be located in dedicated switchrooms unless otherwise approved by the Principal.

The following are the minimum requirements for switchroom construction.

8.1. Switchboard Position / Location

Position all switchboards and other fixed equipment located inside the switchroom to provide safe and easy access for operation and maintenance of all equipment.

The switchroom layout shall allow any individual switchboard to be removed from the building and later reinstated whilst all other switchboards and any other fixed equipment remain in place.

8.2. Construction

All electrical switchrooms shall have a Fire-resistance level of 120/120/120.

Unless approved otherwise, walls shall be masonry, and floors and ceilings shall be of non-combustible materials.

Transportable switchrooms can be used where specified in a detailed project specification approved by Seqwater Engineering.

8.3. Doors

Switchrooms shall be provided with accessibility and emergency exit facilities as detailed in AS/NZS 3000, taking into account foreseeable future equipment to be installed in the switchroom.

All switchroom doors shall be locked from the outside such that only authorised persons may gain access.

All switchroom doors shall open outwards and be fitted with panic bars that operate independently of the lock on the outside and have a 2 hour fire rating. The minimum size of personnel access doors shall be 0.75 m wide x 1.98 m high.

One set of doors shall be sized to allow for the largest individual switchboard to be installed or removed easily. The minimum height for equipment access doors shall be 2.7 m unless a shorter height is justified and supported with a detailed procedure to safely remove the tallest switchboard without the use of cranes or roof removal.

8.4. Lighting

Lighting shall be a minimum of 240 lux at ground level.

Provide exit lights above each exit point and emergency lighting.

8.5. Signage

A single sign shall be fitted externally to each set of doors of the switchroom including the following information:

a. Switchroom equipment number
b. Switchroom name
c. Danger 400 V (or High Voltage)
d. Authorised Persons Only

The signs shall have aluminium backing with PVC printing.

CPR charts and a laminated A3 single line diagram shall be placed on the wall in all switchrooms.

Each main switch shall be clearly labelled so it can be easily located in case of an emergency.

8.6. Air Conditioning

Provide an air conditioning system for each switchroom.

The air conditioning system shall consist of two separate independent air conditioning units. The air conditioning units shall be sized to maintain an internal room temperature of less than:

a. 25°C when both air conditioning systems are operating

b. 35°C when only a single air conditioner is running

The air conditioning system shall be rated to achieve the above performance levels at the maximum specified outside ambient temperature and with all electrical equipment inside the switchroom operating at full load.

Provide an air temperature transmitter connected to the plant PLC/SCADA system to monitor each switchroom temperature and have an alarm set to 30°C.

Switchroom air conditioning systems shall retain temperature settings and automatically resume operation after power supply interruption. Air conditioners shall be configured to shut down during cold weather and not switch to the heat cycle.

The condensate drain from the air conditioning units shall be connected to the site drainage system.

Air conditioners shall not be installed above switchboards, electrical enclosures or electrical equipment, unless there is no feasible alternative location and the location is approved by the Principal. In this instance, the air conditioner shall be provided with an external drip tray draining to a safe location.

8.7. Fire and Security Systems

The need for fire and security systems shall be determined based upon project risk assessment. Requirements shall be coordinated with Seqwater's Facilities group.

8.8. Miscellaneous

Provide a cabinet to store drawings and a desk with a chair to allow for reading of drawings. All cabinets, desks and other fittings shall be constructed from non-combustible materials.

Provide fire extinguishers (CO2) near each door as per AS 2444.

9. Cables and Wiring

9.1. Cables

All low voltage and extra low voltage power and control cables shall be circular, 0.6/1 kV, copper conductor, V-90 PVC or X-90 XLPE insulated, PVC sheathed type cables manufactured in accordance with the requirements of AS/NZS 5000.1 unless noted otherwise in this specification or the project specification.

Motor cables supplied from VSDs shall be specialised EMC screened VSD cable that also meet the general requirements above.

All instrument signal cables shall be 110VAC/150VDC, minimum 1.5mm² copper conductors, PVC V-90 insulated, black* PVC V-90 sheathed, twisted pair instrumentation cable with an overall aluminium-polyester screen and tinned copper drain wire. Each black and white core of the cable shall be numbered.

ELV digital I/O cables that are fully segregated from LV cables, shall be flexible 300/500V, minimum 1.5mm² copper conductors, black PVC 75°C insulated with numbered cores, PVC 75°C sheath – black* sheath if any part of the route is outdoors otherwise grey* or black* sheath.

*Intrinsically safe circuits shall use light blue sheath.

Cables with single strand (solid) cores are not permitted.

9.2. Cable Installation

Cables shall be protected from ultraviolet light damage over their entire length.

All cabling being drawn into place shall be run on sufficient rollers to ensure that it is kept clear of the ground or other obstructions. Vertical rollers shall be used at all points of change in direction.

Any winch used to pull cables shall have automatic limitation of the tension exerted. The tension shall not exceed that specified by the manufacturer for the cable and conditions applying. If winch ropes are used, they shall be attached to the cable using steel mesh stocking grips.

Any damage occurring to a cable (including the outer sheath) shall be reported to the Principal before work on the particular cable proceeds.

The Contractor shall ensure that cables are not bent to less than the cable manufacturer's recommended minimum bending radius at any time.

All cables shall be routed and terminated in such a manner to allow extra length for a re-termination.

PVC cables shall not come into contact with petroleum substances such as grease, oil or petrol which are injurious to PVC cables. Lubricants which are not injurious to the cable sheathing may be used when approved by the Principal.

The ends of cables shall be sealed in an approved manner on completion of erection or laying.

Cables shall be installed in continuous lengths without joints.

Cables on cable ladder shall be fixed to all rungs of vertical ladder and to at least every second rung on horizontal runs. They shall be fastened with saddles, clamps, or nylon cable ties which are resistant to ultraviolet light.

Power cables on cable ladder shall be spaced to achieve maximum rating. Where single core cables are installed, they shall be in trefoil formation and spaced one cable diameter apart from other cables or groups of trefoils.

Cables shall not be installed under roofing material unless fully protected in accordance with relevant sections of AS/NZS 3000.

9.3. Segregation of Conductors

LV and ELV circuits must be segregated in accordance with AS/NZS 3000.

LV cables and ELV instrument/communication cables should preferably be installed on separate ladders/trays. If run on the same ladder/tray, they must be separated by an earthed metallic barrier.

LV cables and ELV instrument/communication cables shall not be run in the same conduit.

0.6/1 kV insulated and sheathed cables for control, lighting and small power may be installed with LV motor power cables.

Earth cables shall run alongside the power cables for associated equipment.

HV cables shall not be installed in the same wiring system as LV or ELV cables.

Non-electrical services shall not be installed on or in electrical cable systems.

Cables on ladders and trays shall be installed in single layers or trefoils for three phase supplies. Stacked cables which obstruct maintenance access shall not be accepted.

9.4. Cable Ladder and Tray

Cable tray may be selected for light duty applications such as single phase power cables, control and instrument cables to individual field equipment. Cable ladder shall be selected for heavier duty applications including three phase power cables, and trunk cable routes serving multiple pieces of field equipment.

For locations with a corrosivity category C3 or C4 (refer to Table 2), cable ladder, tray and accessories (fish plates, covers, dividers, etc.), nuts and bolts shall be Hot Dipped Galvanised Steel.

For locations with a corrosivity category of C5 (refer to Table 2), cable ladder, tray and accessories (fish plates, covers, dividers, etc.) shall be Marine Grade (6061 - T6) Aluminium; nuts and bolts shall be 316 stainless steel.

The cable ladder/tray installation shall be designed to eliminate the effects of galvanic corrosion by the use of spacers where aluminium ladder is in contact with galvanised steel or stainless steel. All cable ladders shall be securely bonded to earth.

Cable ladder and associated accessories (splices, covers etc.) shall be NEMA standard.

Cable ladder and tray installations shall maintain a consistent product family from one manufacturer with all required accessories (fish plates, covers, dividers, etc.).

Changes in cable ladder/tray run directions must be made with manufactured bends, tees and risers provided by the ladder/tray manufacturer as part of a matching system.

Cable ladders and trays shall be designed, selected and installed for a load rating that exceeds the maximum cable loading including provision for future augmentation as per allowances defined in section. 3.8.

Rungs shall be welded to the ladder sidewalls.

Ladder and tray shall be supported at intervals such that the design load including spare allowance shall not result in deflection of greater than 1/180 of the span length.

Cable ladder and tray shall be supported on fabricated hot dip galvanised mild steel brackets welded or bolted to building structures.

Cable ladder shall not be supported directly under splice plates. Thermal expansion gaps shall be provided every 50 metres on straight runs exposed to direct sunlight.

Each splice plate shall be connected to the individual ladder sections using at least two (2) bolts.

Ladder and tray sections shall be bolted together, not welded, and bolts shall not protrude inside the ladder where they may damage cables during installation.

Covers shall be installed on cable ladder and tray where cables are exposed to sunlight or where exposed to mechanical damage. Where ladder or tray is run vertically, the cover shall be attached to both sides where cables are exposed to sunlight or damage.

Covers on horizontal cable ladder/tray runs shall be peaked. Vertical runs or horizontal on-edge runs may have flat covers.

Cable ladder/tray shall be mounted to maintain 300 mm vertical clearance between ladders/trays and at least 150 mm clearance under structural sections.

Cable ladders/tray shall be installed to maintain a minimum head clearance of 2100 mm above floors and walkways.

Cables leaving the ladder/tray system to connect to field equipment shall be provided with heavy duty mechanical protection, typically using up to 600mm of heavy duty flexible conduit.

Cable ladder/tray installations shall be electrically continuous and bonded as part of the equipotential bonding system. This includes bonding across fish plate connections and non-continuous cable ladder installations. The minimum size of the bonding conductor shall be as per requirements in AS/NZS 3000.

9.5. Above Ground Conduit Systems

Where cable is not installed on cable ladder/tray or in underground conduit, it shall be installed in an open conduit system for cable support and protection.

Conduit systems for various areas shall follow the recommendations of AS/NZS 3000 Appendix H, WS Classification of Wiring Systems, and the requirements of this specification, whichever is higher.

The minimum classifications are as follows:

- Office buildings, control rooms, switchrooms and laboratories – WSX1
- Outdoor locations, filter buildings, process areas, workshops and sheds – WSX2
- Car parks, driveways - WSX3

Wiring systems shall additionally be rated for protection against fire where specified in the NCC, project requirements or as required to achieve another part of this specification.

Conduits exposed to direct sunlight shall be manufactured from stainless steel or UV stabilised heavy duty PVC in accordance with AS/NZS 2053.1 or AS 61386.1. Painting of exposed non-UV-protected conduits is not permitted to meet UV protection requirements.

All conduit saddles shall be double sided saddle, fixed on both sides, manufactured in stainless steel or heavy duty hot dip galvanised steel. Half saddles are not permitted.

For WSX2 locations, flexible heavy duty corrugated UV stabilised PVC conduit or flexible stainless steel conduit may be used up to no more than 600 mm in length primarily where there is a change of direction and shall be supported by saddles at no more than 200 mm spacing.

Hot dipped galvanised steel conduits may only be installed in clean and dry indoor locations.

Metallic conduits shall be effectively bonded to earth.

For WSX1 locations, flexible medium duty corrugated PVC conduit may be used up to no more than 600 mm in length primarily where there is a change of direction and shall be supported by saddles at no more than 200 mm spacing. Flexible medium duty corrugated PVC conduit shall not be used where less than 600 mm from floors or walkways.

Ends and joints in conduit shall be properly made off, using the correct fittings and bushes for cable protection.

Heavy duty conduit fittings shall be installed at penetration points to reduce the risk of shearing.

Above ground conduits that transition into underground conduits shall be provided with additional mechanical protection from ground level to 300 mm above ground level, such as a galvanised steel cover.

Cut ends of all conduits shall be filed smooth prior to installation.

9.5.1. Conduit Systems for Unarmoured Cable

Unarmoured cable shall be installed in a wiring system which meets the requirements noted in Section 9.5 and protects and supports the cable to within 200 mm of the cable gland termination location. Typically, this will be implemented through the use of flexible heavy duty conduits. In these locations, a shroud shall be installed over the conduit and cable gland and secured with cable ties.

At motors and LCP's, flexible heavy duty conduits with suitably rated fittings shall be installed to protect the cable between the motor terminal box and the point of cable exit from the cable ladder or conduit system.

NOTE: The IP rating of the motor shall not depend on the conduit sealing to the gland plate.

Coaxial cables of ultrasonic instruments, load cell cables of heavy instruments and similar un-armoured fragile cables shall be enclosed in a continuous run of steel or flexible heavy duty conduit throughout their length. Flexible heavy duty conduit shall be used to make the final connection to the field device using proper conduit termination fittings.

9.5.2. Conduit Systems for Armoured Cable

Conduit may be used to support armoured cables only provided it has been cleared of internal projections and cut ends are filed round.

9.6. Cable Terminations

9.6.1. General

All cable entries to switchboards, equipment and enclosures shall be bottom entry unless otherwise approved by the Principal.

Note: Situations where the Principal may approve top entry include:

i. Adding new cables to an existing top entry switchboard in a clean indoor location
ii. Adding new equipment to an existing switchroom designed for top entry

All cores, including spare cores, in every cable shall be terminated at terminals in LVSCAs and electrical enclosures.

All cables shall be terminated using cable glands, lugs and fittings of the correct size and type.

9.6.2. Cable Glands

Cable entries to enclosures and equipment shall be made using cable glands conforming to IEC 62444.

Cable Glands for general application in non-hazardous and intrinsically safe circuits shall be of the mechanical compression type include facilities for securing and earthing the cable screen, braid or armour where applicable.

Cable glands shall be constructed of nickel-plated brass, unless all of the following conditions are met, in which case nylon cable glands may also be used.

Conditions for nylon cable glands:

a. Indoor location, and
b. Unarmoured unshielded cable, and
c. Gland size no greater than M32
d. Cable glands for use in hazardous areas shall be selected to meet the hazardous area requirements.

Cable glands shall include a seal against the cable sheath as a minimum and shall be IP rated at least to the IP performance required for the enclosure/equipment and location (refer Section 3.12).

Glands installed in outdoor locations shall be fitted with shrouds of the correct size attached to the gland with cable ties.

Cable glands for variable speed drives screened power cables shall be selected and installed as per the VSD manufacturer's recommendations for EMC best practice.

All glands on panel entry points shall have no more than one cable installed per gland.

Glands shall be sized appropriately to the cable as per IEC 62444 and the gland manufacturer's recommendations.

Where thread conversion fittings are required, no more than one reducer shall be used for each gland.

9.6.3. Cable Lugs

Lugs shall be manufactured from tinned copper and sized to suit the cable.

The Contractor shall use compression tools approved by the manufacturer of the lugs.

Where hand operated compression tools are used, they shall be of the type which will not release until full compression is applied. Hexagonal crimping dyes shall be used on all cables of 70 mm² cross section and above where compression tools are used.

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

All conductor strands shall be effectively crimped in the terminal lug. If strands are broken or separated during conductor preparation, the termination shall be re-made. Conductor insulation shall end well inside the lug insulation.

The Contractor shall apply a pull test to each core of each cable (including terminated spare cores) to verify that the core is properly crimped and is firmly held by the terminal.

9.6.4. Termination of Power Cables

All power cables shall be connected with a suitably sized lug unless the equipment (circuit breaker, contactor or thermal overload or field device) has tunnel type terminals and the conductor size is larger than 2.5 mm².

Lugged 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.

9.6.5. Termination of Control and Instrument Cables and Wiring

All wires and cable cores shall be terminated at a dedicated terminal. Unsecured terminals or terminations that are not made to a dedicated DIN Rail mounted terminal or secured equipment are not acceptable.

Not more than two wires shall be terminated on any one stud-type terminal. Not more than two wires fitted with twin or double pins shall be terminated in any tunnel type terminal. Where multiple connections are required on tunnel terminals, multiple terminals linked with proprietary terminal link bars shall be used.

All control cables shall be fitted with suitably sized lugs or pins for the device terminal type using an appropriate tool.

Crimping shall not be effected using the terminal screw alone.

The Contractor shall terminate every core, including spare cores, in every control and instrument cable at dedicated terminals in switchboards or electrical enclosures.

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

Terminal strips shall be mounted 30 mm off the equipment panel to aid termination. It shall be mounted so that the wire numbers on both sides of the terminal are readable from the front of the enclosure with covers or doors open. The numbering for each new terminal group shall start with one and number consecutively from top to bottom and left to right.

All cables which terminate to instruments shall have a single or double coil of cable approximately 150 mm diameter before the cable gland.

Double level terminals shall be used for digital I/O marshalling. Double level terminals are not permitted for applications other than digital I/O marshalling, unless prior approval is provided by Seqwater Engineering. Triple or higher level terminals are not permitted, unless prior approval is provided by Seqwater Engineering.

9.6.6. High Voltage Terminations

High voltage terminations shall be carried out by a certified HV cable jointer using approved high voltage termination kits (Raychem or approved equivalent) and high voltage glands, installed strictly in accordance with the manufacturer's instructions.

Cable cores shall be neatly spread and crossovers avoided. Cable armour shall be earthed using armour clamps.

Bolted connections shall be fully insulated using right angle and in line sleeves such that bushings are fully covered up to the mounting steelwork.

The Contractor shall notify the Principal so that all high voltage terminations may be inspected prior to covers being installed.

9.6.7. Terminations at LVSCAs and Enclosures

The Contractor shall ensure that when cables are terminated at LVSCAs and other enclosures, the arrangement of wiring in ducts within the switchboards complies with the segregation requirements of AS/NZS 3000. The Contractor shall supply the necessary barriers to provide segregation.

The protection (IP) rating of the enclosure shall be achieved by the glanding of the cables, not the glanding of the conduits enclosing the cables entering the enclosure.

When cables are terminated at existing switchboards which have no facilities for glanding, the cable shall be securely fastened to limit movement and shall be lugged and ferruled in accordance with this specification.

9.6.7.1. Termination of Earth Cables

All earth cables shall be terminated on a copper busbar, or an equipment earth terminal. Not more than one earth shall be terminated on any one terminal.

Instrument cable screening shall not be earthed in the field but at the control panel or MCC end only.

9.6.7.2. Terminations at Motors

a. The terminal boxes on all motors shall be provided with gland plates by the motor manufacturer. Regardless of how motor terminal boxes arrive on site, the Contractor shall be responsible for making the required modifications and providing the required equipment to carry out a proper termination. This shall include drilling of gland plates, adapting terminal boxes and reorientation of terminal boxes as necessary.

b. If the motor terminal box contains links to allow a star or delta winding connection, the Contractor shall make the appropriate connection for the supply voltage.

c. The Contractor shall be responsible for reversing the phase connections of those motors found to be rotating in the wrong direction during testing. The phase connections shall be reversed at the motor terminal box to maintain consistent phase colouring for the entire motor circuit.

9.6.8. Terminations at Field Equipment using Flexible Cords

Solenoids, proximity switches, level switches and other items of equipment with DIN type plugs or similar connections not suitable for direct termination of ordinary circular cable shall be connected in the following manner:

a. The supply cable shall be terminated at a junction box supplied by the Contractor, close to the device.

b. If the item is supplied with a plug, then flexible cord with minimum 0.75 mm² conductors shall be run from the junction box to the plug.

c. If the item is supplied with a flexible cord (e.g. level switch), the cord shall be connected to the junction box.

d. The flexible cord shall be run in conduit for the whole of its length and shrouds fastened at each end with cable ties.

9.7. Cable Core and Wire Tags

The cores of every control and instrument cable and every wire shall be ferruled with wire numbers which correspond with the relevant termination diagrams, equipment drawings and schedules.

Ferrules shall be transparent slip-on sleeve with a single strip inlay tag in black letters on white background. Circular type, clip-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.

Where cable cores or wires for different items of equipment are terminated at the one location (e.g. field marshalling panel) and wire numbers are the same for the different items, then each wire number shall be prefixed with the item equipment number to distinguish between the cores.

Where spare cable cores are terminated and no wire numbers are shown on the drawing, then a blank ferrule shall be fitted at each end. Ferrules shall be arranged to read from left to right and from bottom to top as shown in Figure 1. All ferrules shall be arranged so that they are completely visible without disturbance to the wiring.

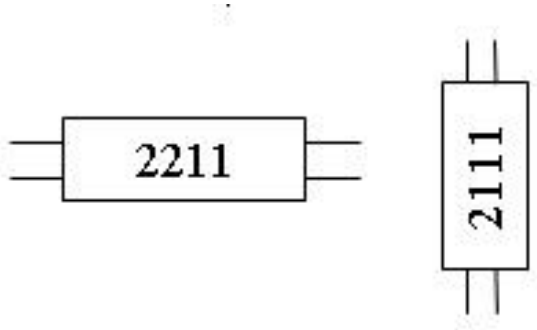

Figure 1 - Ferrule Label Orientation

9.8. Cable Number Tags

Every cable shall be identified with a permanently attached indelible highly legible cable number tags matching the unique cable number as shown in project documentation.

Cable number tags shall be fitted at each end of the cable, on either side of wall/floor penetrations, and immediately outside equipment entry points near the gland plate.

At switchboards and other places where both sides of a cable gland plate cannot be viewed simultaneously from the one location, cable number tags shall be fitted to cables both above and below the gland plate.

Cable number tags for use indoors (non-chemical areas) or internal to enclosures shall be durable, UV resistant PVC tags attached with nylon cable ties.

Cable number tags for use outdoors (non-chemical areas) shall be laser engraved stainless steel tags attached with plastic coated stainless steel cable ties.

Cable number tags for use in chemical areas shall be laser engraved stainless steel tags attached with plastic coated stainless steel cable ties, except where stainless steel is incompatible with the relevant chemical (e.g. chlorine gas), in which case the cable number tags and cable ties shall be of a durable material selected for compatibility with the relevant chemical.

10. Underground Cable Ways

10.1. Underground Conduits

All underground cabling shall be installed in underground conduits unless specified otherwise. All underground conduits shall be continuous.

Underground electrical, control and telecommunications conduits shall be compliant for underground use and shall be solid wall monolayer rigid UPVC heavy duty in accordance with (AS/NZS 2053.1 and AS/NZS 2053.2) or (AS 61386.1 and AS/NZS 61386.21).

Sandwich or composite construction conduits are not acceptable, due to risk of damage by vacuum excavation.

Underground electrical and control conduits shall be minimum 50 mm diameter and shall be orange in colour.

Underground telecommunications conduits shall be white in colour.

Only rigid UPVC conduit fittings shall be used and all joints cemented using the manufacturer's recommended adhesive.

Where a thread is required on a conduit, a suitable adaptor shall be cemented to the conduit.

All conduits shall be installed at a depth not less than 500mm below the finished ground surface level.

The bottom of cable conduits entering cable pits shall enter at a distance of no less than 100 mm from the bottom of the cable pit.

The bottom of cable conduits entering cable pits shall enter at a distance of no greater than 1000 mm from the top of the cable pit.

Conduits shall be located not less than 2 metres behind the kerb line or shoulder where applicable except where crossing the road.

The conduits shall be, as far as practicable, in a direct line between pits.

The separate conduits, such as for communications and power, shall remain segregated and not cross over. For example, if the power conduit is on the side closest to the carriageway, it shall remain this way, and the corresponding pits shall also be the closest to the carriageway.

Notwithstanding the other clauses of this Contract, the conduit may, after receiving the Principal's Approval, be placed on a radial alignment, to avoid subterranean obstructions, with a minimum radius of 50 m.

Buried underground conduit system design shall allow for separate conduits for HV, LV, control and communications wiring (i.e. these individual services shall be placed in separate conduits). Further, when the individual service is required, a minimum of 25% spare conduits are required. As an example:

- System requires 1 x HV, 1 x LV and 4 x control conduits. The spare conduit requirements are then:
    - 1 x HV
    - 1 x LV
    - 1 x control

Use of an existing spare conduit requires approval by Seqwater's Maintenance Technical Services representative prior to installation.

A 3-core polyethylene or polypropylene rope, with 5.0 mm minimum diameter, shall be installed in each conduit and suitably anchored at each end.

Conduits shall be capped at each end prior to installation to prevent foreign material entering the conduit. Special care shall be taken at all times to ensure that all conduits are free of foreign material.

Conduits with foreign material inside shall be deemed to be non-conforming until all foreign material is fully removed or a replacement conduit is installed.

10.2. Cable Pits

10.2.1. General Requirements

The Contractor shall locate cable drawing pits:

a. At changes in direction of greater than 15 degrees

b. At low points

c. At points where cables enter or exit a building

d. At a spacing of no greater than 50 metres

e. At any other intermediate point where required to maintain cable pulling tension within manufacturer's limits

Cable pits shall have an AS 3996 load rating suitable for the location.

High-density polyethylene cable pits shall NOT be installed in locations subject to vehicular traffic.

All foreign material including sand and dirt shall be removed from the pit after installation.

All pits shall have a minimum depth of no less than 800mm below the finished ground surface level.

The top of each pit shall be installed to the horizontal plane across each axis.

In non-paved areas, the top of each pit shall be above the design surface level or natural level by 50mm +/- 10mm with the localised soil within 1 metre graded up to the top of the pit.

When installed in paved areas, pit lids shall be at the same level as the surrounding pavement surface.

Cable route marker shall be securely attached to a post or bollard. The post or bollard shall be a standard Seqwater marker post as per detailed in D-DWG-STD-00003.

Heavy duty conduit fittings shall be installed at penetration points to reduce the risk of shearing.

Cable pits shall be adequately sized to accommodate the number of conduit entries.

Cable pits shall be designed and constructed to prevent the accumulation of standing water and to minimise long-term exposure of cables to moisture. Where ground conditions are suitable, this may be achieved with a 20-25mm hole at the base of the pit discharging to a suitable soakaway.

LV power conduits and ELV control/instrumentation/communications conduits should preferably use separate pits. Where necessary to co-locate in a shared pit, provide physical barriers to maintain segregation.

High voltage cable routes shall use dedicated HV pits, not shared with LV or other cables or services.

Where the conduits enter the cable pits, a clearance hole (-0 +5mm) to suit the conduit size shall be cut in the pit using a hole cutter or similar tool.

Pits with holes knocked in with a hammer or similar tool shall be rejected.

Only one hole for each conduit entering the box shall be cut.

The conduit shall be sealed to the pit with Sika-Flex construction Polyurethane Joint Sealant or similar approved sealant.

10.2.2. Non-trafficable Cable Pits:

Pits are considered non-trafficable if a vehicle could not under any condition drive over the pit.

Non-trafficable cable pit lids shall be load rated to AS 3996 to suit the application and unless otherwise specified or approved by the Principal shall be minimum class B.

Non-trafficable cable pits shall be made of high-density polyethylene, and fitted with heavy duty well-fitting metal lids, in aluminium or hot dipped galvanised steel. Cable pits shall have an internal brace preventing inward compaction from surrounding earth. The cable pit wall thickness shall be no less than 4mm.

A concrete surround shall be formed and cast around each cable pit that is not set in concrete; the surround shall be installed in accordance with the pit manufacturer's guidelines, however no less than 150 mm wide and 150 mm deep.

The concrete surround shall have a minimum 28 day compressive concrete strength of 40 MPa or a precast concrete collar from the cable pit manufacturer may be used.

10.2.3. Trafficable Cable Pits:

Pits are considered trafficable if a vehicle could under any condition drive over the pit. Grassed areas that could be accessed by vehicles must be considered trafficable.

Trafficable cable pit lids shall be load rated to AS 3996 to suit the application and unless otherwise specified or approved by the Principal shall be minimum class D.

Trafficable cable pits shall be made of Polymer Concrete or Precast Concrete, and fitted with heavy duty well-fitting aluminium or hot dipped galvanised steel or ductile iron lids. Cable pits shall have adequate capacity or bracing to prevent inward compaction from surrounding earth.

10.3. Conflict with other buried services

Prior to commencing any work, the Contractor shall certify to the Principal that all underground services within the planned excavation area have been positively identified and all necessary approvals from relevant service authorities have been obtained.

Refer to PRO-00302 Excavation and Trenching Procedure for further information.

Underground cable ways must maintain clearance from other services as specified in AS/NZS 3000 and from Seqwater water mains as specified in D-SPE-STD-001 Water Supply Networks (Supplement to WSA03-2011).

10.4. Trenching

Where cable trenches are required, the Contractor shall provide all equipment, material and labour to carry out the trenching, including excavation, supply of bedding sand, cable protection covers, warning strip and backfill material.

The trenching shall be carried out in accordance with the requirements of AS/NZS 3000 and applicable authorities for underground wiring systems. Both protective covers and warning strip shall be used. Warning strip shall be installed at a maximum depth of 300 mm.

Where trenching is carried out in areas subject to vehicular traffic, backfilling shall be carried out in 150 mm layers to achieve satisfactory compaction.

Trenches shall be treated with an approved chemical treatment to prevent termite attack on cable sheaths.

The base of trenches shall be free of debris, stones and sharp objects.

Excavations in proximity to paved areas shall be suitably shored to prevent the sides of the excavation from collapsing. Paved areas shall not be undermined by excavations from work under the Contracts. Any damage caused shall be treated as a Non-Conformance.

10.5. Road crossings

New road crossings for the cable conduits shall be installed at the locations only shown on supplied drawings.

Road crossings shall be made at 90 degrees to the road, with pits on either side of the road. Diagonal road crossing are not permitted.

Affix an electrical cable marker, made of deep engraved brass or 316 stainless steel, to each kerb above the conduit. The marker shall include wording “ELECTRICAL CABLE” and arrows showing the direction of the cable alignment(s).

10.6. Backfill

Excavations not in paths or roadway shall be backfilled and compacted to match the surrounding soil density and graded to match surrounding surface level. The top 100mm layer above the top of the conduits shall be top soil and the surface finished off in the existing surrounding surface.

10.7. Reinstatement and Cleanup

Pavement surfaces, including turf, concrete or brick paved areas and pathways, shall be reinstated to the satisfaction of the Principal.

11. Structures and Fittings

11.1. Fixing To Structural Steelwork

Structural steelwork shall not be drilled, welded or cut without the Principal’s written approval. The Contractor shall ensure that any welding to structural members does not reduce the strength of that member.

11.2. Frameworks, Fixings and Fasteners

All framework and fixing accessories for the support of cables, cable ladders, joint boxes, distribution boards and all other electrical apparatus and equipment shall be provided and fixed by the Contractor.

Details of all supports for equipment and cables shall be submitted for approval before work is commenced. All conductive fixtures which can be independently earthed shall be equipotential bonded to the main earthing system as per the requirements of AS/NZS 3000.

The Contractor shall be responsible for repairing any damage to civil works or steel, including paintwork, resulting from electrical installation works.

Framework, fixing and fasteners shall comply with M-SPE-STD-001 General Mechanical Specification.

11.3. Penetrations

The Contractor shall make all penetrations through walls and floors, other than those provided in structures by civil works, which are necessary for the installation of cables, cable ladder and conduit. Penetrations shall not be made without permission from the Principal.

After completion of erection, the Contractor shall seal all holes in floors and walls and all cable pipes through which pass cables, conduits or earth bars. Conduits installed at penetration points shall be heavy duty as per the requirements of Section 9.5.

Where a penetration is made through a weatherproof surface, adequate weatherproofing shall be carried out to seal the hole. All cable holes passing through watertight decks and bulkheads shall be thoroughly sealed against the passage of moisture or liquids.

Cable ladder/tray entries into buildings shall be sealed after completion of the cable installation. The Contractor shall test the seal to ensure its water-tightness.

12. Inspection, Testing and Commissioning

Inspection, testing and commissioning shall comply with B-SPE-STD-001 “Commissioning Requirements” and the detailed electrical requirements provided below.

12.1. Commissioning Plan

A commissioning plan shall be prepared by the Contractor to include the requirements outlined below.

The following schedule shall be used for the creation of Commissioning Plan and supplied to the Principal for endorsement:

- “Draft” version provided six (6) weeks prior to Commissioning;
- Final “For Commissioning” version provided prior to Commissioning.

The “Draft” version shall contain sufficient information to provide the Principal with a clear understanding of the Contractor’s intention for the Commissioning Plan.

All section headings, tables and figures will be provided but they may not be fully completed. The Principal shall compare the Draft version to the below list of requirements to ensure compliance.

The final “For Commissioning” version shall be fully complete and fit for purpose for the Commissioning of the plant.

The Commissioning Plan shall detail as a minimum:

a. The commissioning concept;

b. Commissioning program and timeline;

c. Commissioning personnel, their role and responsibilities;

d. Required documentation and process to be complete prior to commissioning commencement e. g. ITP complete and signed off;

e. Commissioning procedures including the expected operating limits where relevant;

f. Cut in procedures and interim operations plans taking into consideration the existing infrastructure may be operational 24/7 and any partial or complete plant shutdowns will need planning and approval from the Principal;

g. Process commissioning and acceptance testing;

h. Any temporary works and services required for Commissioning;

i. Detail of how works shall interface with the existing infrastructure; and,

j. Definition of successful Commissioning.

12.2. Factory Inspections and Testing

12.2.1. Switchboard Inspection

Equipment shall be checked against the design drawings to ensure that the correct type, rating and number of circuits has been installed. The design drawings shall be marked up to properly reflect the finished switchboard and copies forwarded to the Principal. The items on the switchboard that are to be checked include, but are not limited to:

a. Busbar configuration and support system for consistency with design verified arrangement;

b. Sealing of fully welded seams is satisfactory;

c. Equipment mounting and cable supports to ensure adequate fixing and bracing;

d. Operating handles and interlocks for correct functioning;

e. Withdrawable equipment for free movement, operation of shutters and interlocks;

f. Clearance and creepage distances and degrees of protection;

g. Doors and access covers for sealing;

h. Bolted and screwed connections for tightness and adequate contact;

i. Label wording against relevant schedules;

j. Visual inspection to verify all equipment and wiring is in accordance with the approved drawings.

12.2.2. Electrical Testing

Semiconductor equipment such as variable frequency drives, programmable controllers and instruments shall not be voltage tested.

Power circuit insulation resistance shall be tested. Control wiring shall be tested at 500 V only.

Earthing and equipotential bonding resistance shall be tested.

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.

12.2.3. Functional Testing

Each and every control wire 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. Copies of these marked schematics shall be submitted to the Principal.

If the Principal carries out spot checks of the completed switchboard and discovers inconsistencies with the drawings provided, then the Supplier shall retest the whole switchboard in the presence of the Principal.

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 circuit breakers and auxiliaries shall be checked for correct function including (but not limited to) open/closed status indication, shunt trip operation, undervoltage release operation, and fault trip indication.

Variable frequency drives shall be tested by monitoring speed changes of a small three phase motor while the VF drive input signal is being varied. The Supplier shall provide the motor for testing.

All protective relays shall be tested at three points on their protection curve by secondary injection.

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.

Each analogue loop shall be injected with a variable input signal equivalent to its specified input and the signal shall be varied over its entire range to test the operation of associated indicators, controllers and recorders. In the case of controllers, outputs shall be monitored and the setpoints checked for correct operation including the operation of any associated process alarms.

The Supplier shall provide marked up drawings and test sheets detailing the results and extent of the above tests.

12.2.4. Factory Acceptance Test (FAT)

Factory Acceptance Test (FAT) shall be carried out in the Supplier's premises and will be available to be witnessed by the Principal.

The FAT shall be in accordance with the FAT Sheets developed by the Supplier and authorised by the Principal.

A FAT report shall be submitted to the Principal within seven (7) days including the amendment records and remedy/exception sheets.

12.3. Site Inspections and Testing

AS/NZS 3000 requires that prior to placing an electrical installation or any part thereof in service following its construction, alteration, addition or repair, it shall be inspected and tested to verify that the installation is safe to energize and that it will operate correctly in accordance with the requirements of AS/NZS 3000.

AS/NZS 3017 Electrical Installations – Verification Guidelines provides inspection, test methods and test acceptance parameters to verify AS/NZS 3000 safety requirements.

The Contractor shall carry out inspections and routine testing in accordance with AS/NZS 61439 and AS/NZS 3017. The Contractor shall give written notice to advise the Principal 5 working days prior to the commencement of testing so that testing may be witnessed by a representative of the Principal.

All electrical test results shall be recorded on the statutory test forms, and where not applicable, on test report sheets. All recorded information shall be clear and legible. Forms and reports shall be fully completed and supplied to the Principal.

12.3.1. General

Comprehensive electrical tests, as listed below, shall be performed to prove correct operation of the system. All equipment that fails the tests shall be repaired and/or replaced and then re-tested until the tests are passed successfully.

All tests shall be recorded on approved test report forms. Where testing involves insulation or current measurements then actual readings shall be recorded on test report forms. Sample forms shall be submitted for approval at least 7 days prior to commencing any tests.

The Contractor shall submit a test and commissioning schedule at least 7 days before the commencement of testing and commissioning detailing:

a. Date test is proposed for
b. Type of test and details of test
c. Equipment to be tested
d. Test equipment to be used.

The Principal reserves the right to witness any test. The Contractor shall give written notice of intention to test, not less than seven days prior to commencing any test.

When conducting continuity and high voltage tests, particular care shall be taken to avoid subjecting semiconductor devices such as variable frequency drives, earth leakage circuit breakers, thermistor relays and PLC inputs and outputs to a test voltage exceeding the rating of the device.

12.3.2. Power Transformers

a. Check for correct oil level and oil leaks.
b. Check insulation resistance between windings and from each winding to ground.
c. Check dielectric breakdown strength of insulating oil.
d. Check all terminations are correct, covers applied and bolts tight.
e. Monitor for 24 hours after energisation for oil leaks and temperature rise.

12.3.3. Switchgear - Low Voltage

a. Inspect for damage and missing parts.
b. Check the IP rating.
c. Check line out of switchboard for level, vertical alignment and continuity of level between panels. Results shall be within the manufacturer's required tolerances, and no deviation will be accepted.
d. Check tightness of foundation and structural bolts.
e. Check tightness of power connection bolts and distribution board bus bar connection bolts.
f. Check tightness of cable and wire terminations.

g. Check all earth connections are correct and are connected to the earth grid. Check resistance of main earth cable from earth busbar to earth grid.

h. High voltage insulation tests on busbars between all phases and from each phase and neutral to earth, and across circuit breaker and switch open contacts using 1000 V test voltage and one minute test duration.

i. High current microohm resistance test across incomer cable termination, across incomer switch in closed position, and from incomer to outgoing terminals of every power circuit over 150 A.

j. Check phasing of all incoming and outgoing circuits.

k. Operate each device (switch, circuit breaker, contactor, overload, etc.,) to prove correct operation.

l. Check operation of door handles, mechanical interlocks, etc. and freedom of operation of electrical switches.

m. Check operation of key interlocks, where installed.

n. Check fuse holders for damage and fuses for continuity and correct rating.

o. Check and adjust setting of circuit breakers, thermal overloads, timers etc.

12.3.4. Cables - High Voltage

a. Carry out high voltage tests and insulation resistance checks between all cores and between each core and ground.

b. Carry out continuity check on each core.

c. Check tightness of all terminations.

12.3.5. Cables - Low Voltage

a. Insulation resistance test between all cores and between each core and ground, using 1000 V test voltage and minimum one minute test duration.

b. Continuity test on each core.

c. Check all cable terminations are in accordance with termination diagrams. All cabling cores shall be point to point tested. Termination diagrams shall be marked up, signed and handed to the Principal as evidence of these tests.

d. Check cable size and cable number labels against cable schedule. Cable schedules shall be marked up, signed and handed to the Principal as evidence of these tests.

e. Check tightness of all terminations.

12.3.6. Instrument Cables

a. Continuity test on each core.

b. Check all cable terminations are in accordance with termination diagrams. Termination diagrams shall be marked up, signed and handed to the Principal as evidence of these tests.

c. Check cable number label against cable schedule. Cable schedules shall be marked up, signed and handed to the Principal as evidence of these tests.

d. Check tightness of all terminations.

12.3.7. Instruments

All instruments shall be calibrated on site as part of the site testing and commissioning. All instruments shall be calibrated at a minimum of four points (0%, 25%, 50% and 100% of span).

Provide a calibration certificate including all test results to demonstrate satisfactory measurement of each instrument over the required range to the accuracy specified.

Calibration Certificates shall also be submitted for all test and measurement equipment used to calibrate the field instruments.

12.3.8. Motor Circuits

a. Insulation resistance test of motor between phases and ground, using 1000 V test voltage and minimum one minute test duration.

b. High voltage resistance test across open local isolator contacts (if applicable).

c. Resistance test of motor windings, between phases.

d. Resistance test of motor winding for each phase compensated to 25°C.

e. Earth conductor resistance measurement from motor to MCC earth busbar. Resistance shall not exceed one ohm.

f. Full simulation test of all control devices, operating all devices individually and in combination to prove correct operation.

g. Motor rotation direction test.

12.3.9. Earth System

a. Earth resistance tests shall be carried out using a recently calibrated earth tester, in accordance with manufacturer's directions.

b. Measure earth resistance at switchboard earth busbar, when connected to the station earth grid.

c. Measure instrument earthing system prior to connecting to the equipotential bonding system.

d. Where earth electrodes have been installed, the following tests shall be carried out:

e. Measure earth resistance of each electrode, with electrode isolated,

f. Measure earth resistance of local earth grid with all electrodes connected together but isolated from other earth connections.

12.3.10. Specialised Equipment

Equipment not covered by the general tests listed above shall be fully tested in accordance with the manufacturer's directions and as directed by the Principal.

12.3.11. Site Acceptance Test (SAT)

The site acceptance test for electrical equipment shall be carried out in the following manner:

a. Testing of each equipment control system shall include but not be limited to the items noted below:

b. Demonstration SCADA manual control mode for the equipment;

c. Setup and calibration of instruments at various points in their span;

d. Operation of all drives and instruments associated with each sub-system shall be proved to conform to the Functional Specification;

e. All alarms and trips shall be tested by operation of the primary initiating device;

f. Demonstration of interlocking systems shall be by simulating each condition and checking the correct operation of each circuit;

g. Verification that the PLC system operates correctly and provides the correct information on operator's display equipment;

h. Verification of SCADA alarms and status signals in accordance with the Functional Specifications;

i. Demonstration of fully automatic operation of all equipment associated with the works;

j. Demonstration of failure modes (inconsistent conditions, fail safe shutdown, for example) and plant recovery (re-sets, auto re-start, as a minimum) in accordance with the Functional Specification to include site power failure, individual drive failures, instrument failures, PLC failure and communications failure. All these tests shall be available to be witnessed by the Principal;

k. All equipment under the new PLC control shall be displayed on the HMI and tested; and,

A SAT report shall be submitted to the Principal within seven (7) days including the amendment records and remedy/exception sheets. The SAT report shall include a complete and detailed list of all individual control system interlocks, alarms and trip functions (Trip and Interlock Summary) and verification of correct operation including date and signature of testing person.

12.4. Commissioning

Commissioning is the running of the plant and equipment to demonstrate compliance with the scope of work. Commissioning involves carrying out all necessary testing and adjustments until the works are proven adequate and suitable for normal starting and running at all design conditions.

Commissioning requires the operation of all equipment to check the performance.

Commissioning requires full liaison and coordination of the program and activities with Principal. Representatives of Principal may participate in commissioning tests and may elect to record an independent set of test results for evaluation.

Throughout the commissioning process, the Contractor shall have technical personnel onsite specialising in the various aspects of the Works. The Contractor shall be responsible for the commissioning program. The Contractor shall provide continuous supervision by personnel experienced in the operation of the equipment and have qualified personnel in attendance to carry out all necessary adjustments and/or remedial work during the commissioning tests.

Prior to commencing commissioning the Contractor shall have submitted the final Commissioning Plan (including commissioning Checklists) and have received approval from the Principal to proceed.

The Contractor shall submit one signed copy of each completed commissioning checklist countersigned by the Principal's Officer who witnessed the test to the Principal for endorsement.

Final Commissioning of the system shall include the following:

a. Fine-tuning of all process parameters and set-points to confirm operation of all equipment as per the functional specifications;

b. Confirming the operation of status and alarms of all equipment;

c. Commissioning shall be performed on site and will be available to be witnessed by the Principal;

d. A test report shall be submitted within the time frame as specified in the Deliverable Schedules including the amendment records and remedy/exception sheets;

e. After the completion of final commissioning, the plant shall run for 7 days without any failure or malfunction of the new equipment. After the completion of 7 days testing, if there are not any outstanding issues then the plant shall be ready for use.

The Contractor shall liaise with all stakeholders to ensure that all outstanding items are completed as effectively as possible.

13. Documentation

13.1. Documentation with Offer

Contractors shall provide the information requested in this specification.

Suppliers shall include with their Offer, evidence that the switchboard design being offered has been tested by a recognised testing authority in accordance with the requirements of this specification. Suppliers shall indicate which of the reference design tests detailed in AS/NZS 61439.1 have been carried out and provide details of short circuit withstand and arc containment tests.

During the evaluation of offers, a Supplier shall make available for inspection the complete report from the relevant testing authority complete with drawings, photographs and authority comments.

13.2. Documentation after Contract Award

After the award of the Contract, the Contractor shall supply the information specified. The information shall be supplied in the time specified in the Schedule.

The Contractor shall submit Detailed Design Drawings and Documentation as specified in Section 4, accompanied by a completed Engineering statement 'ES1 - Design', certified by the responsible RPEQ in accordance with X-PRO-STD-009.

Switchboard manufacture shall not commence until the relevant Issued for Construction (IFC) documentation and 'ES1 – Design' have been received and accepted by Seqwater.

Site construction shall not commence until the relevant Issued for Construction (IFC) documentation and 'ES1 – Design' have been received and accepted by Seqwater.

13.3. Documentation before Completion of Contract

13.3.1. As Constructed Drawings and Documentation

The Contractor shall update all drawings to "as constructed" status including all changes that have occurred during the installation and commissioning process. This work shall be completed within one month after the end of commissioning period.

As Constructed drawings shall be signed off by the responsible RPEQ including their signature, date signed, clearly printed name, RPEQ number, and company name of the signatory.

Issue "As Constructed" electrical drawings in accordance with X-PRO-STD-007.

The Contractor shall provide a completed Engineering statement ‘ES2 - Construction’, certified by the responsible RPEQ in accordance with X-PRO-STD-009.

The Contractor shall issue the 'certificate of testing and safety' for work on electrical equipment' and/or certificate of testing and compliance' for electrical installation work.

13.3.2. Final Commissioning, Testing and Inspection Report

All finalised commissioning, acceptance testing and inspection and documentation shall be collated into a final report. The report shall include a summary of results and shall be in PDF format with all inspection and testing sheets scanned in colour and at least 400 x 400 dpi resolution.

13.3.3. Operation and Maintenance Manuals

The Contractor shall supply the final O&M manuals in electronic format.

The following information, where applicable, shall be provided:

a. Project name
b. Equipment numbers and titles
c. Contract number and year of installation
d. Company name, address & phone number
e. Equipment Calibration Schedule
f. Testing and Monitoring Schedule
g. Maintenance Schedule
h. Start-up Procedures
i. Testing and Calibration Procedures
j. Alarm Listings
k. Manufacturers Technical Information
l. Drawings
m. Troubleshooting
n. Standard vendor documentation

o. Instrumentation configuration

p. Input / output listings

q. Functional Specifications

All files shall be in one of the following formats:

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

14. Definitions and Abbreviations

Table 21 Definitions and Abbreviations

Term	Definitions
AC	Alternating Current
AC-1	Alternating Current Utilisation Category AC-1 as defined in AS/NZS 60947
AC-3	Alternating Current Utilisation Category AC-3 as defined in AS/NZS 60947
AC-15	Alternating Current Utilisation Category AC-15 as defined in AS/NZS 60947
AC-23	Alternating Current Utilisation Category AC-23 as defined in AS/NZS 60947
ACB	Air Circuit Breaker
AGM	Absorbed Glass Mat
ANZEx	Australia / New Zealand Explosive Atmospheres Certification Scheme
AS/NZS	Australian / New Zealand Standard
ASD	Aspirating Smoke Detector
Assembly	Low-Voltage Switchgear and Controlgear Assembly, unless nominated as a different type of assembly
ATEX	European Explosive Atmospheres Directive
ATS	Automatic Transfer Switch
BoM	Bureau of Meteorology
CAD	Conformity Assessment Document
CB	Circuit Breaker
CCA	Cold Cranking Amps
Contractor	An entity engaged by Seqwater to undertake work in accordance with an agreed contract with a defined scope of work.
CPR	Cardiopulmonary resuscitation
CSA	Cross-Sectional Area
CT	Current Transformer
DB	Distribution Board
DC	Direct Current

Term	Definitions
DNSP	Distribution Network Service Provider
DOL	Direct On Line
DVR	Design Verification Report (to AS/NZS 61439)
ELV	Separated Extra-Low Voltage or Protected Extra-Low Voltage, as defined in AS/NZS 3000
EMC	Electro-magnetic compatibility
Employees	Means persons employed directly by Seqwater in a permanent, temporary or casual capacity.
EPR	Ethylene Propylene Rubber
ES1	Engineering Statement – Design
ES2	Engineering Statement – Construction
ESAA	Electricity Supply Association of Australia
ESE	Early Streamer Emission
FAT	Factory Acceptance Test
Fit for purpose	Suitable for the intended purpose and meets the performance requirements set out in this standard and other project documents.
GPO	General Purpose Outlet
HDG	Hot-Dip Galvanised
HMI	Human-Machine Interface
HRC	High Rupturing Capacity
HV	High Voltage (as defined in AS/NZS 3000)
I/O	Input / Output
IEC	International Electrotechnical Commission
IECEx	International Electrotechnical Commission Explosive Atmospheres Certification Scheme
IEEE	Institute of Electrical and Electronics Engineers
IFC	Issued For Construction
IP	Ingress Protection
LAN	Local Area Network
LCP	Local Control Panel
Leader	Means any Level 1, 2, 3 and 4 Leader with responsibility for managing a functional area of the business, including people management responsibilities within their functional area.
LED	Light Emitting Diode
Low-Voltage Switchgear and Controlgear Assembly	As defined in AS/NZS 61439
LPS	Lightning Protection System

Term	Definitions
LV	Low Voltage (as defined in AS/NZS 3000)
LVSCA	Low-Voltage Switchgear and Controlgear Assembly
Manufacturer / Supplier / Vendor / Original Equipment Manufacturer (OEM)	The entity that manufacturers or supplies equipment to meet the specifications of the Contractor.
MCB	Miniature Circuit Breaker
MCC	Motor Control Centre
MCCB	Moulded Case Circuit Breaker
MEN	Multiple Earthed Neutral
MIR	National Metering Installation Requirements
MTS	Manual Transfer Switch
NEMA	National Electrical Manufacturers Association, United States
Owner / Principal / Seqwater	The entity that engages the Contractor to undertake the work and takes custody of the outcome. The Owner may delegate responsibilities to other entities to act on its behalf (e.g. a consultant).
PFC	Power Factor Correction
PLC	Programmable Logic Controller
PSU	Power Supply Unit
PTC	Positive Temperature Coefficient
PV	Photovoltaic
QECM	Queensland Electricity Connection Manual
r.m.s.	Root Mean Square
RAL	RAL Institute, Germany
RCBO	Residual current Circuit Breaker with Overcurrent protection
RCD	Residual Current Device
REX	Seqwater Electronic Document and Records Management System.
RIO	Remote Input Output
RPEQ	Registered Professional Engineer of Queensland
RSM	Rolling Sphere Method
RTD	Resistance Temperature Detector
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SEQ	South East Queensland
Seqwater Approval / Agreement / Acceptance	Written sign-off gained via the deviation process, as detailed in X-PRO-STD-008 Asset Standards Management and Application Procedure.

Term	Definitions
Seqwater Engineering Standard	Includes Standard Procedures and Standard Specifications and associated supporting documents such as Standard Drawings, Guidelines, Lists, Datasheets, Manuals, Registers, and Templates.
SF6	Sulphur hexafluoride
shall / must	Indicates a mandatory requirement.
should	Indicates a recommendation.
SLD	Single Line Diagram
SME	Subject Matter Expert
SPD	Surge Protective Device
SPO	Special Purpose Outlet
SS316	Stainless Steel Grade 316
THD	Total Harmonic Distortion
UPS	Uninterruptible Power Supply
UPVC	Unplasticised Polyvinyl Chloride
UV	Ultraviolet light
V-90	PVC insulation temperature classification 90°C
VLA	Vented Lead Acid
VSD	Variable Speed Drive
Worker(s)	Includes all permanent, temporary, and casual employees of Seqwater, and: • vocational and work experience placements • volunteers • suppliers, contractors, and consultants temporarily engaged to do work for or on behalf of Seqwater.
WSX1	Wiring System Classification X1 (AS/NZS 3000 Appendix H)
WSX2	Wiring System Classification X2 (AS/NZS 3000 Appendix H)
WSX3	Wiring System Classification X3 (AS/NZS 3000 Appendix H)
WTP	Water Treatment Plant
X-90	XLPE insulation temperature classification 90°C
XLPE	Cross-Linked Polyethylene

15. Roles and Responsibilities

Table 22 Roles and Responsibilities

Role	Responsibility
Leaders	In addition to the responsibilities of a worker, ensure compliance with this Standard Specification by those they lead.
Workers / Employees	Be aware of and comply with this Standard Specification

16. References and Related Materials

The documents listed in Table 23 below, and the requirements therein, are relevant to this Standard Specification In their latest editions, these documents form a part of this document. Note that this is not an exhaustive list of documents relevant to the works.

Seqwater undertakes regular updates of its Engineering Standards. Before utilising this document, the complete list of Seqwater Engineering Standards should be reviewed to ensure currency and applicability for the proposed works.

Table 23 References and Related Materials

Description	Location
PRO-00302 Excavation and Trenching Procedure	REX
PRO-01617 X-PRO-STD-009 Engineering Design, Construction, Operation and Maintenance Procedure	REX
PRO-01872 X-PRO-STD-002 Engineering Drawing Numbers Procedure	REX
PRO-01873 X-PRO-STD-001 Asset Standards Documentation Classification and Naming Structure Procedure	REX
PRO-01874 X-PRO-STD-004 Development and Review of Asset Standards Procedure	REX
PRO-02140 X-PRO-STD-013 Engineering Technical Hazard Study Procedure	REX
PRO-02187 X-PRO-STD-007 Drawing and Spatial Data Standards Procedure	REX
PRO-02190 X-PRO-STD-006 Asset and Equipment Identifier Procedure	REX
PRO-02205 X-PRO-STD-008 Asset Standards Management and Application Procedure	REX
PRO-02234 Management of Change (Technical) Procedure	REX
PRO-02253 X-PRO-STD-014 Drawings Management Procedure	REX
PRO-02389 E-PRO-STD-001 Cable Numbering Convention Procedure	REX
REG-01074 X-LST-STD-001 Seqwater Preferred Equipment Register	REX
SPE-00342 I-LST-STD-001 Control Systems Prescribed Equipment	REX

Description	Location
SPE-00346 B-SPE-STD-003 Commissioning Requirements	REX
SPE-00353 I-SPE-STD-015 Instrumentation	REX
SPE-00361 I-SPE-STD-013 Control Systems Design and Construction	REX
SPE-00367 M-SPE-STD-001 General Mechanical	REX
SPE-00395 D-SPE-STD-001 Water Supply Networks (Supplement to WSA03-2011)	REX
SPE-00431 E-SPE-STD-004 AC Uninterruptible Power Supply (UPS)	REX
SPE-00437 E-SPE-STD-010 Low Voltage Variable Speed Drives and Soft Starters	REX
SPE-00439 E-SPE-STD-007 Power System Modelling and Arc Flash Analysis Specification	REX
SPE-00517 E-SPE-STD-024 Solar PV	REX
TEM-00224 X-TMP-STD-022 Asset Standards Deviation Request Template	REX
TEM-00283 E-TMP-STD-004 Cable Schedule Template	REX
AS 1284 Electricity Meters	Intertek Inform
AS 1319 Safety signs for occupational environment	Intertek Inform
AS 1580 Paints and related materials	Intertek Inform
AS 1627 (series) Metal finishing – Preparation and pre-treatment of surfaces	Intertek Inform
AS 1668 (series) The use of ventilation and air conditioning in buildings	Intertek Inform
AS 2067 Substations and High Voltage Installations Exceeding 1 kV a.c.	Intertek Inform
AS 2467 Maintenance of electrical switchgear	Intertek Inform
AS 2700 Colour standards for general purposes	Intertek Inform
AS 3715 Metal finishing - Thermoset powder coating for architectural applications of aluminium and aluminium alloys	Intertek Inform
AS 4312 Atmospheric corrosivity zones in Australia	Intertek Inform
AS 4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles	Intertek Inform
AS 60038 Standard voltages	Intertek Inform
AS 60529 Degrees of protection provided by enclosures (IP Code)	Intertek Inform
AS 61386 (series) Conduit systems for cable management	Intertek Inform
AS 61869.1 Instrument transformers – General requirements	Intertek Inform
AS 61869.2 Instrument transformers - Additional requirements for current transformers	Intertek Inform
AS IEC 60038 Standard voltages	Intertek Inform
AS/NZS 1020 The control of static electricity in non-hazardous areas	Intertek Inform
AS/NZS 1111.1 Fasteners – Hexagon head bolts	Intertek Inform

Description	Location
AS/NZS 1111.2 Fasteners – Hexagon head screws	Intertek Inform
AS 1768 Lightning protection	Intertek Inform
AS/NZS 2053.1 Conduits and fittings for electrical installations - General requirements	Intertek Inform
AS/NZS 2053.2 Conduits and fittings for electrical installations - Rigid plain conduits and fittings of insulating material	Intertek Inform
AS/NZS 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)	Intertek Inform
AS/NZS 3008.1.1 Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6/1 kV - Typical Australian installation conditions	Intertek Inform
AS/NZS 3010 Electrical installations - Generating sets	Intertek Inform
AS/NZS 3012 Electrical installations - Construction and demolition sites	Intertek Inform
AS/NZS 3017 Electrical installations - Verification guidelines	Intertek Inform
AS/NZS 3019 Electrical installations - Periodic assessment	Intertek Inform
AS/NZS 3111 Approval and test specification - Miniature overcurrent circuit-breakers	Intertek Inform
AS/NZS 3111 Approval and test specification - Plugs and socket-outlets	Intertek Inform
AS/NZS 3123 Approval and test specification - Plugs, socket-outlets and couplers for general industrial application	Intertek Inform
AS/NZS 3133 Approval and test specification - Air-break switches	Intertek Inform
AS/NZS 4024 (series) Safety of Machinery	Intertek Inform
AS/NZS 4029.2 Stationary Batteries – Lead Acid – Valve Regulated Type	Intertek Inform
AS/NZS 4086.1 Secondary batteries for use with stand-alone power systems - General requirements	Intertek Inform
AS/NZS 4086.2 Secondary batteries for use with stand-alone power systems - Installation and maintenance	Intertek Inform
AS/NZS 4761 Competencies for working with electrical equipment for hazardous areas (EEHA)	Intertek Inform
AS/NZS 4836 Safe working on or near low-voltage and extra-low voltage electrical installations and equipment	Intertek Inform
AS/NZS 5000.1 Electric cables - Polymeric insulated - For working voltages up to and including 0.6/1 (1.2) kV	Intertek Inform
AS/NZS 5000.3 Electric cables - Polymeric insulated - Multicore control cables	Intertek Inform
AS/NZS 5139 Electrical installations - Safety of battery systems for use with power conversion equipment	Intertek Inform

Description	Location
AS/NZS 60034 (series) Rotating electrical machines	Intertek Inform
AS/NZS 60079 (series) Explosive atmospheres	Intertek Inform
AS/NZS 60255 (series) Measuring relays and protection equipment	Intertek Inform
AS/NZS 60947 (series) Low-voltage switchgear and controlgear	Intertek Inform
AS/NZS 61000 (series) Electromagnetic compatibility (EMC)	Intertek Inform
AS/NZS 61439 (series) Low-voltage switchgear and controlgear assemblies	Intertek Inform
AS/NZS IEC 60331 (series) Tests for electric cables under fire conditions – Circuit integrity	Intertek Inform
AS/NZS ISO 9001 Quality management systems - Requirements	Intertek Inform
IEC 60073 Basic and safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators	Intertek Inform
IEC 60269 (series) Low-voltage fuses	Intertek Inform
IEC 60445 Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors	Intertek Inform
IEC 60617 Graphical symbols for diagrams	Intertek Inform
IEC 60715 Dimensions of low-voltage switchgear and controlgear – Standardised mounting on rails for mechanical support of switchgear, controlgear and accessories	Intertek Inform
IEC 62444 Cable glands for electrical installations	Intertek Inform
IEEE 519 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems	IEEE
ISO/IEC 80000 (series) Quantities and units	Intertek Inform
MIR National Metering installation Requirements	masterelectricians.com.au
NCC National Construction Code	ncc.abcb.gov.au
QECM Queensland Electricity Connection Manual	energex.com.au
Relevant Australian Federal Legislation including, but not be limited to, the latest editions of the following: a. Security of Critical Infrastructure Act	legislation.gov.au
Relevant Queensland Legislation including but not limited to the following: a. Electricity Act and Regulation b. Electrical Safety Act and Regulation c. Environmental Protection Act, Regulation, Air Policy, Noise Policy and Water Policy d. Work Health and Safety Act, Regulation and Codes of Practice e. Professional Engineers Act	legislation.qld.gov.au

17. Changes from previous version

This Standard Specification will be regularly reviewed in accordance with the requirements of the Seqwater Controlled Document Management Procedure. Reviews will include consideration of suggestions for alteration or improvement made in accordance with Seqwater Procedure X-PRO-STD-004 Development and Review of Asset Standards. Changes made from the previous version are summarised in Table 24 below.

Table 24 Changes from previous version

Section Number	Change
All	**General** Reformatted document to fit new controlled document template. Restructured and edited document to align content with headings and remove duplicated information. Updated references to superseded standards and products. Miscellaneous minor corrections throughout document.
2	**Scope** Updated details on where to access Seqwater Engineering Standards. Included detail from “General Design Requirements” in previous version.
3.3	**Electrical Design Criteria - Hazardous Areas** New section.
3.4	**High Voltage Equipment and Installation** New section. Added prohibition of SF6 switchgear.
3.6	**Electrical Equipment Selection** Added guidance on equipment standardisation.
3.8.2	**Spare Short Circuit Withstand Capacity** Simplified requirements for switchboard short circuit withstand.
3.8.3	**Spare Space** Added MCC spare space requirement
3.9	**Voltage Levels** Removed obsolete 5.5kV voltage level. Added 33kV voltage level. Added 48 VDC for HV switchboard trip & control.
3.10	**Site Climatic Conditions** Removed “typical maximum” ambient temperature specification and retained maximum ambient temperature. Increased altitude specification to cover all Seqwater sites

Section Number	Change
3.11	**Electrical Equipment Location** New section.
3.12	**Ingress Protection** Revised Installation Conditions in IP Rating table.
3.14.1	**Lighting and Small Power – Equipment General Requirements** New section.
3.14.3	**Special Purpose Outlets (SPO)** Amended SPO requirements to align with AS/NZS 3000 and RCD requirements in section 6. Moved requirement for submersible pump/mixer SPO to the SPO section.
3.15	**Motor Control Circuit Design** Rewritten to align with I-SPE-STD-013 Control System Design and Construction, E-SPE-STD-010 Low Voltage Variable Speeds and Soft Starters, and motor starter schematic template drawings.
3.17.1	**Instrument Earthing** Revised requirements for single point of connection between instrument earth and power earth.
3.18	**Lightning Protection System** Added explicit non-recognition of ESE air termination systems
4	**Detailed Design Documentation** Removed OT design documentation. Now covered in I-SPE-STD-013.
4.6	**Cable Schedules** Removed list of cable schedule fields. Added reference to Cable Schedule Template.
4.11.1	**Drawings Standards** Replaced AS 1100 and AS 1101 with IEC 60617.
5.5.1	**Solar Photovoltaic Systems** - Removed Solar PV requirements removed from this document. Added reference to Seqwater Solar PV Standard Specification.
5.6	**Uninterruptible Power Supply** Removed detailed LV UPS equipment requirements from this standard. Added reference to E-SPE-STD-004 AC Uninterruptible Power Supply (UPS) Standard Specification. Removed prohibition of UPSs in switchrooms.

Section Number	Change
6	**Low-voltage Switchgear and Controlgear Assemblies** Merged LV Switchboard requirements from (now superseded) specification E-SPE-STD-009 into this document. Removed duplicated or conflicting requirements. Updated to align with AS/NZS 61439 and AS/NZS 3000. Removed detailed LV VSD and Soft Starter equipment requirements from this standard. Added reference to E-SPE-STD-010 Low Voltage Variable Speed Drives and Soft Starters Standard Specification.
6.4.2	**Arc Containment Performance** Updated Arc Containment requirements to align with E-SPE-STD-007 and AS/NZS 61439.
6.4.3	**Remote Operation** Added criteria and specifications for CB remote operation
6.5.21	**Latches, Handles and Locks** Revised to rectify gaps, overlaps and conflicting requirements
6.6.3	**Separation from Electrical Hazards** New specifications for separating control system equipment from LV power
6.7.27	**Residual Current Devices and Residual Current Breakers** Added guidance on exceptions to RCD protection. Added option for RCD test facility at DB.
6.9	**Local Control Panels** Rewritten to align with new document structure. Added allowance for polymer LCP.
7	**Junction Boxes** Rewritten with new requirements.
8.3	**Electrical Switchrooms – Doors** Rewritten to align with AS/NZS 3000 and allow for future equipment.
8.5	**Electrical Switchrooms – Signage** Added requirement for switchroom equipment number.
9.1	**Cables** Added specifications for instrument cables. Added specifications for ELV digital I/O cables. Added exception for intrinsically safe circuit cables.
9.3	**Segregation of Conductors** Rewritten with new requirements.

Section Number	Change
9.4	**Cable Ladder and Tray** Removed mandatory NEMA 20C cable ladder rating. Updated requirements to match the cable loading. Added requirements for cable tray. Aligned fastener requirements to corrosivity category.
9.5	**Above Ground Conduit Systems** Added prohibition of half saddles. Added WSX3 classification.
9.6.2	**Cable Glands** Removed obsolete product names. Added minimum technical specifications. Added nylon cable glands and conditions.
9.6.5	**Termination of Control and Instrument Cables and Wiring** Added conditions for use of double level terminals
9.8	**Cable Number Tags** Added tag material details. Clarified cable tag location requirements.
10.1	**Underground Conduits** Added technical specifications required for conduits. Added prohibition of sandwich conduit.
10.2	**Cable Pits** Increased maximum pit spacing and added requirements for pit locations. Added drainage requirements. Added segregation requirements. Added AS 3996 references.
10.3	**Conflict with other buried services** Added reference to D-SPE-STD-001.
10.5	**Road Crossings** Added requirements.
12	**Inspection, Testing and Commissioning** Removed requirements for fibre optic cabling, communication networks, PLC & SCADA; now covered in I-SPE-STD-011 and I-SPE-STD-013. Removed requirements for Electromagnetic flow meters; now covered in M-SPE-STD-006 and M-SPE-STD-009. Added CB and auxiliary functional testing.

Section Number	Change
13	**Documentation** Removed requirement for hard copy drawings and documentation. Aligned to X-PRO-STD-009 requirements.
14	**Definitions and Abbreviations** New section.
0	**Roles and Responsibilities** New section.
16	**References and Related Materials** Updated to align with controlled document template and to reference current relevant documents.