Solomon Islands Renewable Energy Development Project:

Section 6 Employer Requirements

Attachment A – General and Electrical Requirements

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1 GENERAL

1.1 Introduction

This appendix to the bidding documents for the supply and installation of renewable energy projects describes the general and electrical requirements of these projects. This appendix must be read in conjunction with the full set of bidding documents.

1.2 Glossary of terms

The following terms and their abbreviations are used in this document:

1.2.1 Project Terms

1.2.1.1 ADB – Asian Development Bank

1.2.1.2 SP – Solomon Power

1.2.1.3 IA – Implementing Agency

1.2.1.4 OEM – Original Equipment Manufacturer

1.2.2 Control System Terms

1.2.2.1 PLC – Programmable Logic Controller

1.2.2.2 PSC – Power Station Controller

1.2.2.3 SCADA – Supervisory Control and Data Acquisition

1.2.2.4 HMI – Human Machine Interface

1.2.3 Electrical Terms

1.2.3.1 BESS – Battery Energy Storage System

1.2.3.2 MCC – Motor Control Centre

1.2.3.3 AC – Alternating Current

1.2.3.4 DC – Direct Current

1.2.3.5 ACDB – AC Distribution Board

1.2.3.6 DCDB – DC Distribution Board

1.2.3.7 ITP – Inspection Test Plan

1.3 General requirements

1.3.1 Businesses operating in Solomon Islands

Contractors shall comply with all local laws and regulations. Any fees associated with meeting the requirements of operating in Solomon Islands are to be covered by the Contractor.

1.3.2 Project information board

Contractors are to supply and install a permanent project information board at a prominent location (to be agreed with the Employer) at the project site. This shall be of a material and construction suitable to last at least ten (10) years in site conditions. The information board shall be approximately 2.4 m wide by 1 m high. Graphics will be provided by the Employer in a readily exchangeable electronic format.

1.3.3 Software

Software included in this Contract shall:

- Not require an annual license fee or any other ongoing costs (any software licenses must be perpetual and in the client's name)
- Not require software upgrades or
- Be supported by the Vendor / OEM for a minimum of five (5) years (if this condition is not met, Contractor must provide a replacement system within the five (5) year period). If an existing software system is no longer supported, inadequate or superseded then replacement software would be required to be given so that the system remains repairable/supported for at least the 5 year period. The contractor shall demonstrate that the software performs the required functions for it to be deemed acceptable, and functional testing of the system prior to in-service operation would be required.
- Be readily accessible (generally freely available to the client, non-proprietary in nature).
- The system software shall run on latest Microsoft Windows Platform.
- Must be configured with security suitable for utility electricity operations, allowing authorized use only.

1.4 Training and capacity building

For all training described below, the Contractor shall submit a training plan to the satisfaction of the Employer.

1.4.1 Operator training

The utility (SP) will be responsible for ongoing operations and maintenance of the projects after Practical Completion and for the projects life. Operations and maintenance will be carried out by utility staff. The Contractor will be required to

undertake necessary training and capacity building, to ensure that nominated operations and maintenance providers have the necessary capabilities.

It is important to note that, in order to satisfy this part of the specification, the Employer expects that training and capacity building will be an integrated process. It must involve utility staff through the design, factory acceptance testing, and installation phases. It must demonstrate an approach that can deliver long term sustainability of the system.

The Employer will nominate up to ten (10) utility staff as the operations and maintenance staff. These staff will have existing skills and experience relevant to the operation of the power supply systems. Where recognized qualifications are reasonably required to be held by these staff, these should be specified by the Contractor during the design stage and the Employer will make arrangements to meet these requirements.

The Contractor shall:

- Nominate minimum pre-qualifications (to recognized Qualifications Frameworks) to be held by these staff.
- Develop training plans, to be approved by the Employer, to ensure that these staff can effectively operate and maintain the system.
- Provide all tools or equipment necessary to operate and maintain the system. Tools are to be of a suitable quality for site conditions.
- Provide all necessary training and support in accordance with manufacturer or equipment supplier requirements (i.e. to ensure any manufacturer warranty conditions are adhered to).
- Provide sufficient stock of consumables, as well as minor parts, for the period specified in the Contract.
- Provide phone and video conferencing support to staff as needed, for a minimum period of two (2) years of operation.
- Include BESS OEM service, warranty and monitoring support for a minimum of three (3) years, with option for Employer to continue such support on standard terms with the OEM (or its representative).

SP will also act as asset manager for the equipment and will have overall responsibility for the long-term planning and operations and maintenance of the project's assets. The Contractor is required to provide SP with the necessary training and information to enable this function. The Contractor Shall:

- Provide training to the Asset Manager personnel in use of data accessible via the utility SCADA to assess the projects assets' operational performance, diagnose faults, and identify unscheduled maintenance actions.
- Provide for a suitably skilled engineer to assist the Asset Manager to set up the utility SCADA for managing performance data from the systems, and to assist in configuration / reconfiguration of any network protection, switches and recloser

settings arising from this work. This shall include establishing automated alarms and notifications (and recommended responses for typical scenarios), tools to analyse and report on system performance, including reporting on consumed life of batteries, and archival of system performance data (hardware and software to be provided by the Employer).

- Provide details of scheduled maintenance activities to the Asset Manager.
- Prepare an asset hierarchy, categorizing all assets for each system. Use this hierarchy and create a data structure for the asset, such that it may be readily ported into the Employer's asset management database.
- Handover all documentation, including operations and maintenance manuals and as-built designs, as per the documentation requirements in Section 9, Appendix 7.

1.4.2 Emergency services training

The Contractor shall provide the local community with comprehensive training in emergency response for the power system. This shall include actions for first responders following at least the following contingency events:

- Fire or explosion at the power plant, including specific measures for battery fire or explosion
- Electrocution of worker or community member
- Spill hazardous substance or person contacting hazardous substance.

The Contractor is required to provide all emergency response equipment to allow the community to respond to new hazards introduced by the Plant, as required for first responders to carry out actions as per the training if required.

1.4.3 Electrical safety training (solar schools projects only)

The Contractor shall provide the local community with electrical safety training, targeted for consumers who may have little or no experience with electrical installations, including domestic distribution boards, power points, lights, and other appliances. Training shall also cover identifying underground services before digging. Training shall be provided on site, in local language and shall be conducted over a minimum of three (3) sessions at least one (1) month apart to improve retention and participation.

Contractor shall provide permanent signage, in addition to mandatory electrical warning signage, that reinforces general principles of electrical safety for the community, to be installed at prominent locations such as community halls (as agreed with local representatives).

1.5 Studies

The Contractor shall carry out all necessary studies to ensure that the equipment meets the Employer specifications and relevant standards. This includes, but is not limited to the following:
The design process will produce the following, minimum set, of detail design reports to support the electrical connection design:

1. Power system studies including but not limited to the following:
    a. Short-circuit analysis, minim and maximum fault levels and locations;
    b. Load flow;
    c. System stability (Voltage & Frequency transients);
    d. Ramping on/off requirements; and

   e. Insulation coordination and lightning mitigation
   f. Arc fault levels;
   g. Harmonic response – injection levels to 50th order
   h. Flicker levels
2. Protection study that documents:
   a. All protection devices and schemes;
   b. Overcurrent Protection (50/51)
   c. Differential Protection (87)
   d. Ground fault protection (50G/51G or 64)
   e. Reverse Power Protection (32)
   f. Under/Over Voltage Protection (27/59)
   g. Under/Over Frequency Protection (81U/810)
   h. Synchronism Check (25)
   i. Protection coordination with upstream devices;
   j. CT and VT sizing calculations.
3. Earthing study documenting:
   a. Reporting site resistivity levels
   b. Expected EPR contours at each site
   c. Earthing system design methodology
   d. Recommend mitigation / grid design
4. Cable sizing report documenting:
   a. Soil thermal resistivity reports
   b. MV and LV AC cable Sizing calculations (capacity, volt drop/rise, fault capacity, design assumptions, losses etc.)
   c. DC Cable Sizing calculations (capacity, volt drop/rise, fault capacity, design assumptions, losses etc.)
   d. MV, LV, DC Cable trench design parameters
5. Arc flash study:
   a. AC and DC panels and cabinets shall be subject to arc flash safety assessment and nomination of appropriate PPE
   b. IEEE 1584 is used to establish the incident energy and arc flash boundary for electrical equipment installed.
   c. The design shall be such that the arc flash study shows that for operation or any maintenance activities no higher than arc flash PPE category 1 is required for DC circuits as defined in “NFPA70E Table 130.7(C)(15)(b) Arc-Flash PPE Categories for Direct Current (dc) Systems”, and for AC circuits as defined in “NFPA70E Table 130.7(C)(15)(a) Arc-Flash PPE Categories for Alternating Current (ac) Systems”.

Additionally, the design process shall include civil and structural design analysis as required to substantiate the design, comply with local building regulations, and support application for building permits. This must include:

1. Applicable standards and evidence of compliance with such standards
2. Static, wind, earthquake, and any other design loading considerations
3. Corrosion protection, rates of degradation
4. Application of above to determine main civil and structural design elements
5. Application of above to determine material and equipment specifications
6. Hydrological study

Where applicable, studies shall be conducted for each subproject.

The Contractor must also provide power systems models of the facilities (except solar schools sub-project) to the Employer for its use. Power systems models shall be in PowerFactory format.

2 TECHNICAL REQUIREMENTS

2.1 Language and Units

2.1.1 Units of measurement

Systeme International d'Unites (SI) units shall be used.

2.2 Reference Documents and Standards

All equipment shall be installed and all work shall be carried out in accordance with AS/NZS 3000, Solomon Power regulations, relevant Solomon Islands Government statutory requirements (including amendments), and all applicable international standards.

Recognising that OEM products in the international market may not be certified against local Standards, such products will not necessarily be excluded. However, bidders must demonstrate product compliance with AS/NZS, IEC or ISO standards providing coverage of the same requirements (in particular, including earthing, substation design for access and safety, fire detection, lightning protection, switchgear, signage, and protection). Non-OEM products and custom installations should be built to the specified standards.

If a requirement included in the Employer Requirements exceeds the applicable standard, then the requirement within the Employer Requirements shall be adhered to.

Standard(s) referred to shall mean the current Edition / Revision together with Amendments issued. The following standards, in particular, should be satisfied:

- Those listed in Attachment A – General and Electrical where appropriate:

Mechanical (equivalent IEC standards shall be accepted also)

- AS/NZS 1170 Structural Design Actions
- AS 1345 Identification of the contents of piping, conduits and ducts
- AS/NZS 1554 Structural Steel Welding
- AS/NZS 4680 Hot-dipped galvanized (zinc) coatings on fabricated ferrous articles
- AS 1657 Fixed platforms, walkways, stairways and ladders
- AS 1796 Certification of welders and welding supervisors
- AS/NZS 2312 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings.
- AS 2700 Colour standards for general purposes
- AS 4100 Steel structures
- AS 3600 Concrete Structures

Electrical

- IEC 60688 Electrical measuring transducers for converting AC and DC electrical quantities to analogue or digital signals
- AS 1931 High voltage testing techniques
- AS 60529 Degrees of protection provided by enclosures (IP Code)

- AS/NZS CISPR 11 Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement
- AS 2373 Electric Cables – Twisted pair for control and protection circuits
- Electricity (Safety) Regulations 2010
- AS/NZS 3000 Electrical Installations Known as the Australia / New Zealand Wiring Rules
- NZECP 34 New Zealand Code of Practice for Electrical Safe Distances
- AS/NZS 3008 Electrical installations - Selection of cables
- AS/NZS 61439 Low voltage switchgear and control gear assemblies
- AS/NZS 60947 Low voltage switchgear and control gear – Multiple function equipment
- AS 2067 Substations and High Voltage Installations Exceeding 1 kV AC
- AS/NZS 3835.1 Earth Potential Rise – Protection of Telecommunications Network Users, Personnel and Plant. Part 1: Code of Practice
- AS/NZS 4853 Electrical Hazards on Metallic Pipelines
- AS/NZS 60479.1 Effects of Current on Human Beings and Livestock – Part 1: General Aspects
- AS 62271 High-voltage switchgear and control gear
- AS 4777.2 Grid connection of energy systems via inverters – Inverter requirements.
- AS/NZS 5033 Installation and safety requirements of photovoltaic (PV) arrays
- AS 5000 Electric Cables – Polymeric insulated Part 1: For working voltages up to and including 0.6/1 (1.2) kV
- AS 1429.1 Electric Cables – Polymeric insulated Part 1: For working voltages 1.9/3.3 (3.6) kV up to and including 19/33 (36) kV
- AS 1768 Lightning protection
- AS 1391 Safety signs for the occupation environment
- IEC 60071 Insulation co-ordination

ENA Guides

- ENA DOC 025:2022 Power System Earthing Guide (EG-0)
- NA DOC 045:2022 Substation Earthing Guide (EG-1)

IEEE Standards

- IEEE Standard 80 (2013): Guide for Safety in AC Substation Grounding
- IEEE Standard 837 (2014): Qualifying Permanent Connection Used in Substation Grounding

Drafting and Design Standards

- AS/NZS 1100.101-501 Technical Drawings
- IEC 60027.4 Letter symbols. for use in. electric technology
- AS 1101(series) Graphic symbols for general engineering
- AS/NZS 1102(series) Graphical symbols for electrotechnical documentation

- IEC 60848 Specification language for sequential function charts
- AS/NZS 4383 Preparation of documents used in electro-technology

Solomon Power Standards

- Standard Electricity Network Design Parameters and Service Conditions (Rev E)
- SIEA Safety Manual v3
- SP HSE SOP01 – Manual Handling Processes
- SP HSE SOP02 – Hearing Conservation Procedures
- SP HSE SOP03 – LOTO Procedure
- SP HSE SOP04 – Incident & Accident Reporting Procedure
- SP OHS Management Plan

2.3 Work Practices

The Contractor will submit a set of work practices applicable to this project along with the general Health and Safety plan before site mobilization. The procedures will be subject to acceptance by the Employer. The procedures shall meet the following requirements, along with general contractual requirements (such as working hours) as specified in Section 7, 8 and 9 of the bidding documents).

2.3.1 Site Facilities and Temporary Services

Contractors must assume they will provide all facilities undertaking work on site.

2.3.2 Site Access and Vehicle Parking

The Contractor shall utilise only existing site access and vehicle parking areas, unless by prior approval by the Employer. The Contractor shall liaise with the Employer to ensure that access to the site and the daily business operations of the Employer, community members, and other contractors are not adversely affected.

Bidders should note that access to the site and parking facilities are restricted, and will require coordination and agreement with SP.

2.3.3 Laydown and Security

The Contractor is permitted to use the specified sites for laydown or equipment storage as may be required. Use of any other areas for laydown, storage, parking, or other such activities is generally not permitted, except by express consent of the Employer.

The Contractor shall be responsible for the security within the Site of Works. The Contractor shall be responsible for inspection of the existing security fencing at the site and determining its fitness for purpose. The Contractor shall be responsible for

any additional measures, or upgrades and maintenance to the security fencing for the duration of the Contract.

2.3.4 Site Clean Up

The Contractor shall make every effort to keep the Site of Works in a clean and tidy condition for the duration of the Works. The Contractor shall, from time to time, and on completion of any area of the works, or where directed by the Employer, remove rubbish, surplus materials or any other construction debris from such areas as may be attributable to the Work under the Contract and generally leave them in a satisfactory condition and to the approval of the Employer.

Upon completion of the Works, the Contractor shall remove all rubbish, debris, temporary earthworks or surplus materials from the site of the Works. The site shall be left in a neat and tidy condition to the satisfaction of the Employer.

2.3.5 Site Control Measures

The Contractor shall provide for appropriate measures to manage and/or control traffic, water, dust and weeds in and around the Site of Works. Such measures shall be implemented during the entire duration of the Contract, and as specified in these Specifications, shown on the Drawings and/or as deemed necessary by the Contractor for performance of the Contract to the Employer's satisfaction.

In the event of the Contractor failing to comply with its responsibilities under this Clause, the Employer may, without further notice, take such steps as it considers necessary, to provide for the safe passage and safety of traffic or to remove any obstruction or to repair damage, including, if it considers it necessary, the employment of workmen and watchmen to complete work and the cost thereof may be deducted from any monies due to the Contractor under the Contact.

2.3.6 Traffic and Exclusion Zones

The Contractor shall provide for continuous operation of normal traffic along all roads, pedestrian and vehicular access ways in and around the Site of Works or that are otherwise affected by the Works. The Contractor shall, where necessary, provide side tracks which shall be constructed, sign posted, and maintained to the satisfaction of the road owner and the Employer.

The Contractor shall erect and maintain exclusion zones beneath and adjacent to all work at heights and shall be responsible for the safety of all pedestrian and vehicular traffic within the Site of Works and any adjacent areas affected by them. The Contractor shall provide for all necessary watchmen, lights, barriers, notices and signs, and shall provide and maintain the same to the satisfaction of the road owner and the Employer.

The Contractor shall not cause obstruction to any road, drain and/or watercourse and shall not break down or remove any gates or fences without prior approval of the Employer. Where such obstructions or breakages cannot be avoided, the Contractor shall remove such obstruction or repair such breakages, to the satisfaction of the Employer, as soon as possible.

2.3.7 Site Meetings

The Contractor shall provide for its relevant staff to attend required meetings with the Employer at the project site or the Employer's offices for the duration of the Contract. Consideration will be given to remote meetings (teleconference / videoconference) for instances where it can be shown that these will not affect the satisfactory outcomes of the meeting.

2.4 Manuals

2.4.1 General

The Contractor shall provide the following manuals (manuals subject to review and approval of the Employer, along with all other documentation):

- Quality Assurance Manual
- Health/Safety Manual
- Operation and Maintenance Manuals

2.4.2 Quality Assurance Manual

The Contractor shall operate and maintain a quality management system conforming to AS/NZS ISO 9001 or approved equivalent. The Contractor shall take and keep records of quality inspections and tests as evidence that the requirements of the Contract have been met.

The Quality Assurance Manual shall include but not be limited to the following:

- Design plan
- Quality plan
- Qualifications and experience of key personnel
- Sub-contractor quality assurance plans
- Inspection and test plans
- Field installation check lists
- Instrument test certificates
- Statutory certificates
- Reports on non-conforming work and corrective action

- Results of all inspections and tests undertaken prior to delivery.

During the course of the Contract, the Contractor shall register and maintain all quality documentation in an up-to-date centralised file and make this available for inspection by the Employer or their representative at all reasonable times.

The Contractor shall complete Field Installation Checklists as certification that installation activities have been completed in accordance with the appropriate specification. Field Installation Checklists shall be prepared by the Contractor and forwarded to the Employer on a progressive basis. All Field Installation Checklists shall be completed by the Contractor as a pre-commissioning activity.

2.4.3 Safety Manual

The Contractor shall operate and maintain a Safety Management System that conforming to ISO 45001, OHSAS 18001 or an equivalent national standard or accreditation. The Contractor shall provide a Safety Manual that clearly explains all credible safety risks for operation of the facilities, and the required level of operator training and accreditation, as well as necessary precautions and personal protection equipment in response to these risks. The Safety Manual shall be aligned with, and cross referenced to tasks described in the Operations and Maintenance Manual(s).

The format of the safety manual shall be such that it does not rely on written material and uses standard drawings and symbols to establish risks and required mitigation (such that it is accessible for people with low literacy).

The Safety Manual shall not mitigate any requirements for safety signage and mandatory equipment protection as set out elsewhere in this document, and as per relevant standards and regulations.

2.4.4 Operating and Maintenance Manuals

The Contractor shall provide Operating and Maintenance Manuals for all equipment supplied under this Contract. The information required from the Contractor shall conform to the Employer's standard requirements detailed below:

General

The format of the Operating and Maintenance Manuals or information contained therein, shall be provided in electronic and paper format and comprise instructions, diagrams and drawings which shall be sufficiently comprehensive to facilitate the training of the staff and to enable the operation and maintenance of the equipment to be performed in a safe and efficient manner.

The Contractor shall supply a comprehensive operation and maintenance instruction manuals for the equipment supplied, written in the English language, as part of the

contract. Three (3) hard copies and a compiled, text searchable PDF copy transmitted electronically shall be supplied.

Format

The format of manuals shall contain the following as a minimum requirement:

1. Comprehensive index.
2. Installation: Plain English description of the installation, its siting, layout and function, supported by general arrangement drawings.
3. Operating instructions: operating procedures for the overall system and each discrete equipment component are required. Must cover standard operations, in addition to the emergency and abnormal conditions procedures. Each set of instructions must include:
    a. Pre-start check lists covering all the individual plant systems.
    b. Starting procedures.
    c. In service checks and limits including routine test procedures.
    d. Shutting down procedures.
    e. Response to warnings and alarms.
    f. Documentation and logbook, data logging and back-up requirements.
4. Drawings:
    a. All as-built drawings for the system, including schematics, logic diagrams, data maps, including drawings index.
    b. Parts list, including all necessary information for replacement.
5. Specifications:
    a. Design and material limits for loadings such as pressure, temperatures, voltage, current, operating limits, settings, etc.
    b. Grades of lubricant and recommended frequency of lubrication.
    c. Test and performance data.
    d. Details of electrical circuitry, accompanied by schematic and logic diagrams, indicating the physical location of the equipment parts.
    e. A list of alarms detailing alarm initiator location and setting for alarm operation and re-set.
    f. A comprehensive list of parts for each item of installed plant.
6. Maintenance:
    a. Routine maintenance schedule.
    b. Step-by-step instructions for all routine maintenance events, including inspection, adjustment, replacement of parts and consumables.
    c. Check lists to be completed prior to and during routine maintenance.

   d. Trouble shooting and fault finding sufficient to allow rapid diagnosis of common faults.
   e. List of special tools and equipment required.
   f. Recommended Spares List.
7. Temporary and permanent decommissioning procedures.
8. Factory Acceptance Test or Commissioning test results for reference.
9. Manufacturer certificates where applicable.
10. Copies of all Manufacturer component operating and maintenance manuals.

2.5 Drawings

All design drawings must be in accordance with Section 12 (IA Drawing Specifications).

2.6 Design Review and Approvals

All review and approval by the Employer is conducted for its own purposes, to satisfy itself as to the adequacy of the designs, reduce risk to the Employer of design deviations and delays, and address any differences in understanding of the Employer Requirements. Such reviews do not in any way affect any right of the Employer or diminish in any way the Contractor's responsibilities or alter the scope or responsibilities under the Contract.

The Employer will promptly (typically within (10) ten working days), conduct its review and / or approval of design submissions. Contractor shall then respond to any comments raised by the Employer showing deviations from the Employer Requirements, by correcting such deviations or demonstrating that the Employer Requirements are satisfied (typically within (5) five working days).

If permits are issued subject to conditions affecting the Works, the Contractor shall refer such conditions to the Employer to enable consultation with the Authorities regarding such conditions.

Documents for review should be submitted electronically to the Project Manager.

Documents will only be accepted for review if they are properly version controlled, including maintenance of document version numbering, version description, and clouding of revisions.

Critically, key milestones including Factory Acceptance Testing, Site Acceptance Testing, Commissioning, and Functional Guarantee tests, as well as covered works that cannot subsequently be inspected, should not proceed until relevant Employer comments arising from the design review / approval process have been addressed.

2.6.1 Documentation Formats

All documentation shall be supplied by the Contractor as PDF and native formats as

detailed below:

- Documents – MS Word
- Specifications – MS Word
- Schedules, data maps, cause and effect matrices, etc. – MS Excel
- Drawings – AutoCAD

2.6.2 Document Storage

Backup copies of all documents onsite shall be stored in a safe offsite location. This shall include hardcopies and electronic file backups.

Where hardcopies of documents are required to be retained onsite (e.g. QA documentation) then the offsite backup shall consist of a 'pdf' scanned copy of those documents.

2.7 Workmanship and Materials

Workmanship shall be of first-class commercial quality and in accordance with the best shop practice. Like parts shall be interchangeable. Machining of fits on renewable parts shall be accurate and shall be to specified dimensions, so that replacement parts may be readily installed.

Unless otherwise specified, materials and components used for the Works specified shall be new and unused. Materials and components shall conform to the standards current at the time of execution of the Agreement.

2.8 Quality Assurance

The Contractor shall be responsible for the implementation, maintenance and monitoring of the Quality Assurance system to satisfy ISO 9001. All aspects of the Contractor's Quality Assurance shall be documented.

2.9 Preferred Equipment

Minor items and equipment, and all consumables should be confirmed with Employer prior to ordering to ensure compatibility with existing systems, training and spares.

2.10 Packing and Shipping

2.10.1 Packing

All items of Plant supplied by the Contractor shall be adequately packed and protected for shipment and outdoor storage at Site.

The Contractor shall ensure that the Plant shall be protected against corrosion,

weather damage, condensation, distortion, and damage by vermin and the ingress of foreign matter.

Packing of any Plant shall comply with the approved shipping preparation and packing procedures and shall include but not be limited to the following:

a) Plant shall be properly packed.
b) Plant shall be shipped in weatherproof and watertight containers unless otherwise agreed with the Employer.
c) Containers, crates or packages shall be checked for defects internally and externally prior to packing.
d) Weights and lifting points shall be clearly visible on each package.
e) Plant shall be not wrapped in plastic unless it is coupled with adequate moisture absorbent material, such as silica gel and the like.
f) Bright metal parts shall be greased coated or similar rust inhibitor applied commensurate with the type of machinery.
g) Machined surfaces shall be protected with wood blocks or similar approved means and reinforced externally with metal bands or plates.
h) Exposed threaded joints shall be encased or plugged as required.
i) Packaging shall be designed to minimize waste and be fully recyclable or biodegradable (e.g. cardboard) where possible.

For imported components, packing material shall comply with import and export regulations. All wood packing in each consignment shall be free from bark and all visible signs of insect and fungal attack at the time of shipment. Furthermore, the importation of packing materials such as second-hand sacking, hays, straw, chaff, rice husks and peat shall be prohibited. The Contractor shall be responsible for obtaining approval of the packing timber and materials before delivery. Packing lists shall state the type of packing used and certify that none of the prohibited material has been included.

The Employer may require to inspect and approve the packing before the items are dispatched but the Contractor shall be entirely responsible for ensuring the packing is suitable for transit and such inspection shall not exonerate the Contractor from any loss or damage to faulty packing.

2.10.2 Unloading and Storage at Site

The Contractor shall at Site place the equipment in the Contractor's storage area in the following manner:

a) Place any containers or any packages in locations as directed by the Employer.
b) Certify that the contents of any container or any package agree with the said packing lists.

c) Remove from Site any unwanted packing debris and any empty containers immediately after completion of unloading at Site.

2.11 Existing Works and Underground Services

The Contractor shall note that the drawings of existing services are incomplete and not accurate. The Contractor shall ascertain the location of any buried services in the vicinity of the Facilities before commencing construction. If services are identified, then the Contractor shall give notice of this to the Employer at least five (5) working days prior to the commencement of any construction activity that may affect those services(s).

The Contractor shall take all reasonable actions and provide all things reasonably necessary to protect and maintain existing services to the satisfaction of the Employer. In the case of damage occurring to existing services, the Contractor shall immediately report the damage to the Employer. The cost of the necessary repairs or renewals shall be borne entirely by the Contractor.

If it is found to be necessary to alter the location or level of any existing services to conform with the Facilities, the Contractor shall relocate, redirect or alter any existing services as required to execute the Works and to the satisfaction of the Employer. This will include altering finished surface levels of existing services.

If uncharted services are encountered during excavation, the Employer shall be notified before proceeding.

Any connections to live equipment will only be permitted with the consent and under the supervision of the Employer. The Contractor shall notify the Employer prior to carrying out any such work, detailing the method to be employed.

Any connection requiring statutory or other approvals shall be the Contractor's responsibility.

2.11.1 Services Shutdown

Where it is a requirement to temporarily shut down or disconnect services (such as electricity or water) for the completion of the works the Contractor shall notify the Employer at least five (5) days prior.

Generally, the Contractor will be required to undertake shutdowns outside of normal business hours unless by prior approval by the Employer.

The Contractor will have been deemed to have included all costs associated with any shutdowns in the agreed Contract Sum.

2.11.2 HV Switching and Isolations

The Employer will provide/organise for all HV switching and isolations for equipment connections. The Contractor shall provide a minimum of five (5) working days' notice for HV equipment isolation requirements.

2.12 Structural Integrity

The Contractor shall be responsible for ensuring the structural integrity of any existing or new works that impinges on the existing works.

2.13 Hazardous Areas

No sections of the installation are within hazardous areas or require hazardous equipment ratings.

2.14 Site Clearance and Demolition

The Contractor shall be responsible for obtaining all site permits or approvals and equipment isolations before commencing clearance of the Works. All existing equipment isolations will be completed by SP Power Station staff in conjunction with the Contractor.

The Contractor shall carry out all demolition necessary to complete the Works and shall be responsible for the removal and disposal as directed by the Employer of all demolished and decommissioned equipment.

2.15 Building Permits

The Employer will provide the building permits and local council authorisation for the new civil structures designed by the Contractor.

2.16 Site Induction Requirements

The Contractor shall be required to comply with all of the site requirements including compliance to all isolation, induction, site safety, first aid, and emergency procedures. The Contractor shall ensure that all site personnel have all of the requisite certification for site.

2.17 Local Environment

The Contractor shall only supply materials and fittings that are suitable for the local environment and ambient conditions. Indicative service conditions are included in Section 6, Supplementary Information, however, bidders should satisfy themselves as to the actual service conditions and ensure suitability of equipment.

All cut galvanized ends shall be painted with and approved sealant or 'paint on' galvanizing.

2.18 Site Control

The Contractor will be expected to formally request hand-over of site ahead of any site works, including laydown of materials. The Contractor will then have full control of the site within the fenced boundary. Where required, the Contractor shall cooperate with other construction activities on the broader lease.

3 ELECTRICAL WORKS

3.1 General

This section covers the general requirements for all electrical works to be provided by the Contractor and shall be read in conjunction with the other Appendices to Section 6 (Employer Requirements).

3.2 Equipment

3.2.1 Framework and Fixings

All framework required to support equipment and materials shall be provided. All metal work shall be fabricated hot dip galvanised, unless specified otherwise and bonded to earth system.

3.2.2 Installation of Floor Mounted Cubicles

All floor mounted cubicles shall be securely mounted to floors by the use of tapped holding down bolts, chemically held concrete inserts, through bolts, Unistrut fasteners, rawl plugs or the like. No fibre compression plugs shall be used.

The Contractor shall allow for all necessary fixings, including fishplates as necessary. No equipment shall be welded to cast in metal ground supports.

Where necessary packing plates, shims and the like shall be provided to align the cubicles.

3.2.3 Installation of Wall Mounted Cubicles

All wall mounted panels shall be securely back fastened to walls by the use of tapped holding down bolts, chemically held concrete inserts, Unistrut fasteners, rawl plugs or the like. No fibre compression plugs shall be used.

Where panels are to be mounted to unfinished concrete or block walls Unistrut or similar rails shall be provided and installed to provide an air gap between the panels and the walls.

3.2.4 Installation of Field Mounted Cubicles

All field mounted cubicles, junction boxes, operator interfaces, and the like shall be mounted to unistrut rails or similar, provided for fixing to metal work and the like if specific mounting locations have not been provided by the plant vendor.

The Contractor shall allow for welding or bolting of the Unistrut supports rails to the support structures, as well as clean up, paint and galvanising touch up around welds.

3.2.5 Installation of Transformers / Ring Main Units

The Contractor shall place and mount the transformers and secure to the concrete work with chemset bolts or the like.

Bunds shall be provided as part of the Contractor design to contain 110% of all liquids associated with the Transformers / Ring Main Units. Each of the bunds will have, valve drainage, removable fences for security purposes, complete with a man access gate for maintenance. All fences and gated shall be earthed.

3.2.6 Equipment Labels

Signage and labelling of all cables and equipment shall be to the requirements of AS/NZS 3000 or equivalent IEC .

Switchgear (33kV, 11kV and 415V), Transformers, PLC Equipment, Control Panels, Junction Boxes, and equipment within panels shall be labelled with a non-ambiguous name, code, or tag numbered as appropriate, and as used in the drawings prepared by the Contractor. Panels shall be clearly labelled front and rear. The English language shall be used throughout.

Equipment labels shall be engraved with black lettering on a white background on UV stabilised acrylic or similar material. All labels shall be fixed by small screws or studs. Self- adhesive labels shall not be used.

Unless otherwise specified, letter height shall typically be;

- Instrumentation, Miscellaneous items – 3 mm
- Main titles, for tag number and service description – 6 mm
- Control Panel, Junction Boxes, Main Equipment nameplate designation – 10 mm

3.2.7 Cables – General

The contractor shall produce a written specification and calculations for the HV cable to ensure that the supplied HV cable shall be of the highest quality and meets all Australian standards. The specification shall be submitted to the Employer for acceptance prior to ordering the cable.

The Contractor is to ensure that the cable installation is in accordance with IEC 61936 and AS/NZS 3000 as well as any requirement of the Network Authority (where this requirement exceeds those in the standards).

The contractor is responsible for all cable specification and design to suit installation and environmental conditions. Cable sizing shall be the most cost effective over the lifetime of the system. Cable size calculations shall be provided as part of the Contractors system design.

3.2.8 Cable installation and Termination

Above ground cables

All above-ground cables shall be installed using a cable support system. The system shall be either the primary cable ladder route under switch-rooms, and within cable trenches or as secondary cable support systems using localised tray or conduit.

In general, all cabling above ground shall be by secondary support structures.

The cable shall be secured to the cable ladder / cable tray with cable ties. At no time shall the bending radius of the cables be less than the manufacturer's recommendations or the requirements of AS/NZS 3000 or IEC equivalent whichever is the greater. All other installations shall lay in the trenches or ladders installed.

All power cables (33kV, 11kV and 415V), control and data cables shall be segregated from each other.

Underground cables

All underground cables shall include termite protection and water blocking. Underground cables shall be installed in trenches in accordance with the requirements of the relevant Standards.

Cable Segregation

All Power and control/instrumentation cables shall be segregated by installation in separate conduits or, where run on a common cable ladder or tray, a metal segregation barrier shall be provided between power and control/instrumentation cables.

Cable Termination

The Contractor shall terminate all cables. Termination is defined as the complete installation of the cable into its termination point. This consists of:

All cables shall be terminated using proprietary termination kits approved by the Employer and installed by an experienced cable jointer. These shall be complete with brass glands, earthing materials, and lugs for interconnection to the termination points on the switchgear, or transformer termination box.

All terminals shall be crimped using hydraulic crimpers with dies sized to the cable/lug size with a crimp pressure as specified by the crimp manufacturer.

The contractor shall drill all gland plates for the appropriately cable gland size.

Control Cables

Termination shall include provision of all plastic glands. Numbered ferrules on each core shall be installed as detailed on the cable connection drawings. All cables shall

have identification labels to an approved standard.

All control cables shall be neatly installed and secured to prevent vibration within the termination cubicle.

All outdoor control cable terminations shall be fitted with waterproof boots: All crimp lugs and terminal lugs shall be provided where necessary.

Instrumentation and Data Cables

Termination shall include provision of all glands and provision of earthing as required to the supplied gland plates. Numbered ferrules on each core shall be installed as detailed as well as cable identification labels.

All cores of instrument cables shall have bootlace crimp lugs or round terminal lug crimped by proprietary crimpers.

The screen earths shall be terminated at the primary source end only on the earth bars provided with the screen at the other end insulated by the use of a heat shrinking tube.

Fibre Cables

Termination shall include provision of all glands splice / pig tails and fibre termination connectors as required.

All multimode fibres are to be terminated and shall be terminated with an approved ST connector.

All fibre termination connectors shall be labelled.

Cable Labels and Core Numbers

Each cable shall be identified at each end with the cable reference using stamped metal tags fastened to the cable sheath with characters of not less than 5 mm high.

An approved proprietary core identification system shall be used. All cores shall be fitted with bootlace ferrules. Snap on ferrules / core labels shall not be used.

Cable Glands

Glands of an approved make and construction shall be supplied for the termination of the cables. Glands shall be of the following types:

- Un-armoured cables Compression
- Armoured cables Cone grip armour clamp

All gland plates will be un-drilled. The Contractor shall drill to the appropriate sizes and secure the gland with lock nut and star type lock washer. Where necessary separate earth washers may be used to affect an earth.

All outdoor cable glands will be covered with strapped or heat shrink PVC conical boots.

Laying and Tying

With the exception of HV cables the following applies:

Cables may be laid to a maximum of two (2) deep using a maximum of 75% of the cable support width. No cable shall be completely surrounded by other cables.

All cables shall be secured to prevent movement during normal service life and under fault conditions.

All vertical cables shall be fully supported at 500 mm centers. No terminals or glands shall be used to provide support for vertical run cables.

Control and power cables shall be fastened to ladder, bracket and trunking systems by nylon ties, spaced at approximately 300 mm and at each side of changes in direction.

Earth conductors shall be secured with nylon ties to cable support system. All cables shall be labelled at each end with approved markers.

Joints

No cable shall be jointed unless specifically approved by the Employer.

Spare Cores

All spare cores shall be terminated on spare terminals where possible. If this is not possible then the spare cores of each cable shall be tied together, marked with the cable number, and secured in a neat and orderly manner.

Support

All cables shall be supported to ensure no mechanical stress on the cable at the gland or termination point.

3.2.9 Cable Laying

Cable routes are to be determined by the Contractor in consultation with the Employer.

All cable pulling and laying shall be provided by proprietary or approved drum laying equipment. The pulling tensions shall not exceed the supplier’s recommendations. Cable being drawn into place shall be kept clear of abrasive surfaces and other cables by the use of rollers, cable tiles of the like to prevent damage to the cable sheathing. Cables in trenches must be laid without abrasion and without allowing rocks or the like to fall into the trench.

Trafficable cable pulling pits shall be designed and installed with adequate drainage

to prevent water damage to cables.

3.2.10 Bare Copper Conductors and Screens

All bare copper conductors and copper screens on VFD cables shall be terminated with heat shrink that is shrunk over and around the connecting lug. All finished terminations of this type, following the completion of testing, shall be securely wrapped in annealing insulation tape.

3.2.11 Cable Support Systems

General

All cables shall be mechanically supported and protected to the point of final termination. It is the responsibility of the Contractor to design to this route. All secondary and tertiary routes as defined below are to be site fitted.

Routes

Primary routes will generally be underground or on cable ladder racks.

Secondary routes are defined as routes that take cables from the primary route to within 1m of the final destination. Ladder, tray or conduit shall be used where appropriate.

Tertiary route is between the secondary route and the final destination of the cable. Typically this is metallic flexible hose with appropriate end fittings to ensure permanent fixing of the hose to the conduit, junction box or field device.

Cable Ladder

Construction

The cable ladder shall be constructed of substantial steel sections and be hot dip galvanised or of heavy-duty aluminium cross-section. Rungs shall be welded or bolted in place at spacing between centres of not more than 300mm. Generally separate ladder rack systems shall be used for separate pieces of plant unless this is patently uneconomical.

Bends

Horizontal bends and tees shall be fitted where cable ladders change direction in the horizontal plane. Where cables having a bending radius exceeding 400mm are to be laid on cable ladder, vertical bends shall be fitted at horizontal to vertical transitions.

Supports

The span between ladder support brackets is not to exceed 3m. Ladder lengths and supports are to be arranged, so that the distance from any connection point between two ladder sections and the nearest support bracket does not exceed 1m.

Earthing

Earth equipotential straps shall be connected across each cable ladder join. The earth straps shall comprise 16mm^2 copper conductor with compression lugs, terminating on either side of the splice plate on each side of the joint.

Cable Tray

No tray wider than 150mm shall be used. Where a wider tray is required, cable ladder shall be used in preference. Cable trays may not be installed other than vertically except where space so dictates. Where the latter conditions apply the tray shall be installed with a minimum vertical spacing of 300mm between rows.

Cable tray brackets are to be of substantial construction and they are to be firmly fixed to their support structure so that the tray does not warp or sag when fully loaded. Bracket spacing is not to exceed 500mm.

All vertical risers from the in-trench cable ladder system to the equipment shall be fitted with lids or covers to secure internal cabling from physical damage.

Conduits

Conduit may consist of steel pipe, Unistrut channel with mild steel capping or grey PVC Conduit.

Not more than three circuits shall be run in any one conduit except where approved. Circuits having different voltages shall always be run in separate conduits.

Where cables leave or enter conduit they shall be suitably protected from sharp edges and sealed.

The minimum size of conduit permitted throughout the installation shall be 19mm Metal, 20mm PVC. Thin wall, non-welded conduit shall not be used.

Maximum spacing of conduit hangers and brackets shall be 1.5m.

All PVC conduits shall be rigid high impact PVC colour orange and shall be used inside and for building services only.

Where conduit installation is specified for hazardous location, all wiring shall be continuously enclosed in screwed steel conduit. The conduit shall be solidly drawn galvanised tubing. All fittings shall be approved and certified for use in the hazardous locations specified.

3.2.12 HV Trenching

The trench and material construction shall comply with AS/NZS 3000 and IEC 61936. All HV cables are to be installed in HDuPVC conduits.

The Contractor shall:

- Excavate all trenches and remove soil
- Supply new filling soil or compound mix, with a thermal resistivity of less than 1.2 km/W in a dried out state
- Bed the cables in the filling along with any control cables and PVC ducts for fibre cables
- Compact in layers, no more than 200mm at a time, to the same density of the existing ground,
- Mechanically protect the cables with concrete covers or a weak concrete pour (no polymer-based covers)
- Provide and install warning tape
- Reinstall grassed areas
- Provide a compacted gap 40 layer and tarseal or concrete to existing levels those areas already tar sealed or concreted.
- Provide cable warning signs at each building entry and exit
- Plot location and provide drawings showing actual lay locations Underground ducts / conduits installed for cable installation shall be:
    - Rated heavy duty and UV stabilised
    - Suitable diameter for the cable and the cable operating conditions
    - Suitable for use with high voltage cable (HV cable installation)
    - Provide suitable mechanical protection for the cable and be buried at the depth required for the correct installation of the high voltage cables
    - Enclose the cable for the entire length of the cable run, except for pulling pits

3.3 Buildings / HV Substation

3.3.1 General

The Contractor shall provide a substation, with HV Switchgear / HV RMU, transformer, earthing, LV switchboard, control cabinets and panels, if and as required by the scope of work.

The substations may be either outdoor pad mount type, or constructed in a purpose-built enclosure, provided that the installation complies with all stated standards.

The design shall be submitted to the Employer for acceptance.

The Contractor shall produce a written specification for the substation equipment for acceptance by the Employer prior to ordering any equipment.

3.3.2 Substation Enclosures

Each substation enclosure shall;

- Be suitable for installation in public access areas
- Prevent the ingress of moisture from rain and storms

- Prevent intrusion by vermin
- Maintain suitable environmental conditions (temperature and humidity) to comply with manufacturer's requirements
- Be designed, manufactured and tested to relevant standards
- Provide HV, LV and communications cable entry as required
- Include a sump or catchment device for containment of the total volume of transformer oil (if transformer contains oil)
- Provide protection for the operator in the event of abnormal equipment operation such as electrical faults

3.4 Local Service

3.4.1 General

Local services for new buildings, substations, structures, equipment rooms and the like shall comply as required with appropriate standards, at a minimum.

3.4.2 Circuit Labels

Every light fitting, power outlet, and ancillary plant supplied from this system shall be clearly labelled with the distribution board and circuit number.

The labels shall be made of traffolyte with black writing on a white background and attached by screws or plastic rivets. Labels for lighting circuits shall be located adjacent to the light switches.

3.4.3 Cabling

All external cable shall be circular PVC/PVC multicore installed on the cable trays or in conduits. Flat TPS shall only be used within partitions or in concealed spaces.

Where cables penetrate outside walls, watertight seals shall be provided at the penetration points. Cables shall enter enclosures from underneath. Plastic bushes or other protection against abrasion from metal surfaces shall be provided for metal enclosures.

The Contractor shall provide covers for bunched cables entering switchboards where these are exposed.

The following minimum cable sizes shall be used:

a) Lighting sub-circuits - 2C+E 1.5 mm^2

b) General purpose power outlets 2C+E 2.5 mm^2

Local Service Surface mounted Conduit

All surface mounted cabling shall be installed in rigid grey PVC conduit, of the cold setting light duty type complying with AS/NZS 2053.1. Through joints together with

connections to fittings shall be glued with solvent cement. All conduits shall be fixed at no greater than 600 mm intervals.

3.5 Equipment Locations

The Contractor shall allow for reasonable relocation of equipment if conflicts arise with mechanical plant or building structure, or to enhance the lighting once the mechanical plant is fully installed.

All electrical equipment shall be located to permit easy access for, connection of external cables and maintenance and replacement without dismantling or removing other facilities, and without the use of portable ladders.

3.6 Earthing

3.6.1 General

The earthing design is predominately for the high voltage earthing systems. The earthing systems for the Facilities also requires special design consideration with regards to corrosion, DC faults within the Facilities, transients and harmonics of the BESS. These items are to be addressed in the Contractor design to ensure the safety of the installation during normal operations and under fault conditions and also to protect the life of the assets that can be significantly reduced due to the corrosion of support structures due to stray DC and AC currents.

The earthing system is defined as all in-ground conductors (grid, electrodes and connections) combined with all above earthing conductors and metallic components and structures that form the AC and DC earthing systems. The Contractor earthing system shall include all cable racks, accessible structural steelwork, the metallic enclosures, frames and other non-current carrying metal parts of equipment such as transformers, switchboards, motor control centres, control panels etc. and other metal parts.

The earthing system shall be designed to ensure electrical safety of personnel as well as equipment in and around the site in case of a fault. The Contractor shall conduct soil resistivity tests as may be required.

3.6.2 Earthing systems for Battery Energy Storage Systems (BESS)

Some BESS utilise “IT” style earthing systems rather than the standard “TN” style earthing system under AS/NZS 3000. IT earthing systems may not necessarily be allowed. If an IT earthing system is proposed, this should be raised with the Employer for consideration at the earliest opportunity, and the Contractor should ensure they are able to revert to a TN earthing system if required.

3.6.3 Standards

Earthing, equipotential bonding and testing shall be carried out throughout the Works to the requirements of the following standards, ENA EG1, ENA EG0, AS 2067 and AS/NZS 3000 Section 5 or equivalent IEC standards.

3.6.4 Earthing System Design

The following shall be included in the earthing system design:

- Calculation of the safety voltage limits for touch, step and hand to hand voltages in accordance with ENA EG0 and AS 2067 or IEC equivalent.
- Detailed design of the earthing system to ensure that the safety criteria are satisfied in the CDEGS® model
- Conductor sizing calculations
- Determination of corrosion protection requirements
- Determination of the earth conductor jointing requirements
- Determination of the earth connection redundancy requirements
- Detailed earthing drawings including:
    - Earth grid layout drawings
    - Typical equipment earth connection drawings
    - Typical foundation earthing drawings showing connection and welding requirements
    - Earthing notes drawing

3.6.5 Earthing Installation

The complete installation of all new metallic items shall be earthed.

Earth Conductors

All separate earth conductors shall be yellow/green PVC insulated single core and shall be run from the new earth bars to cable ladder and cable tray runs, steel platforms, switchboards and plant operating at high voltage.

Except where larger conductors are required continuity conductors not contained in a composite cable shall be in accordance with Table 5.1 of AS/NZS 3000.

Steel Wire Armouring

Steel wire armouring of cables shall not be used as earth continuity conductors.

Termination

All earth continuity and bonding conductors are to be terminated on studs not used for equipment or panel mounting, enclosure construction or any other fastening function. All paint, scale, enamel or rust shall be removed from points or contact on metal surfaces, before the earthing connections are made. After this connection has been inspected and passed an approved coat of paint shall be applied.

Joints

Joints in earthing conductors shall be made by using the “CADWELD” system and compression lugs.

Earth Bars and driven Rods

A least two separate star earth connections shall be made from central earth bars to the driven rod system for any plant that is not connected to the site wide earth system.

The tops of driven earth bar connections shall be just below the ground surface level and covered with a suitably labelled ‘toby’ box or similar, to allow for later inspection of the connection points.

Equipment Earthing

An earthing boss shall be fitted to the frame of skid mounted equipment to allow equipotential bonding to other structures and earthing systems.

Instrument Earthing

Instrument earthing shall be isolated from the power earth system. All instrument earth terminals shall be connected to a panel instrument earth bar separate and electrically isolated from the main panel earth bar.

4 MAJOR EQUIPMENT TECHNICAL SPECIFICATIONS

4.1 General

Major equipment specifications are detailed in the following sections, these specifications set out the minimum requirements for the Contractor designs;

- Section 5 - Switchgear / Ring Main Units
- Section 6 - Transformers
- Section 7 - Switchboards / MCCs
- Section 8 - PLCs, Control Cabinets, Junction Boxes
- Section 9 – LVdc Tripping / Battery Charger

5 SWITCHGEAR / RING MAIN UNITS

5.1 General

If HV switchgear or ring main units are installed, as part of the Contractor design, then the Contractor shall implement the following design requirements.

5.1.1 Breaker Sizing

Breakers on the main switchboard and ring main units must be sized to match existing stocked breakers to minimize spares.

5.1.2 Remote Operation

Irrespective of indoor switchgear arrangements or ring-main unit construction IA require remote operation of all breakers and isolators. This may be accomplished by solenoid control or motorised operation. Earth switches do not require to be remotely operated.

5.2 HV Switchgear Standards

The switchgear and component pieces supplied to this specification shall comply with the Australian/New Zealand standards (General Technical Requirements – Metal Clad Switchgear) or equivalent IEC standards.

5.2.1 Type of Switchgear

The switchgear shall be indoor mounted, IP3x, metal clad, front access, fully withdrawable, type tested, vacuum or SF6 breakers, internal Arc Fault Protection, with integral circuit and bus earth, and complete with current and voltage transformers, controls and protection as specified.

5.2.2 Bus Bars

All busbars shall be of the tinned copper arrangement, supported as required to maintain the fault rating, and heat shrink shrouded. Bus bar chambers shall be totally enclosed, and extendable at each end of the switchboard layout. Where construction or transport joints are provided the Contractor shall detail the connections and provide all shroud and filling compounds. The Contractor shall note the environmental conditions.

5.2.3 Current Transformers

All current transformers shall be wired to combination shorting/insulating terminals within the circuit breaker control area. The current transformers shall be totally insulated in epoxy resin and preferably be mounted singularly and supported over the appropriate insulated busbar or cable connection.

The following table lists the current transformer requirements:

Type	Ratio	Accuracy and Burden
OC+EF Protection - Incomers	Contractor Design	5P20, 25VA
OC+EF Protection - Feeders	Contractor Design	5P20, 10VA
Bus Zone Protection	Contractor Design	5P20, 25VA
Metering	Contractor Design	Class 0.2, 15VA

Class and Accuracy may alter on final Contractor design if agreed by the Employer.

5.2.4 Voltage Transformers

All voltage transformers shall be wired to insulating terminals within the circuit breaker control area.

The voltage transformers shall be connected star /star/delta (vector group Yyd) and shall have a rated voltage factor of 1.5 and a highest rated equipment voltage. The rated insulation level is 28/75 kV and continuous insulation class B. The tertiary winding shall be fitted with an appropriately sized resistor to eliminate ferro-resonance effects in the transformer if required.

If removable the voltage transformers shall be complete with all necessary carriage mechanisms, automatic safety shutters, isolating plugs and sockets, primary and secondary isolation fuses and links. Any special tools required for withdrawing the voltage transformers shall be provided. When padlocked the shutters shall prevent access to the fixed isolating contacts.

All fuses and links are to be clearly labelled. The voltage transformer particulars as specified shall be given on a readily visible name plate mounted externally on the carriage.

Secondary winding from busbar voltage transformers shall be cabled and terminated in each switchgear cubicle.

5.2.5 Revenue kWh Meters

Each of the circuit breakers shall be supplied and fitted with revenue class kWh meters to the following specifications.

Item	Type
Accuracy	Class 0.5
Voltage	57 to 240V
Current	5A
Communications	Contractor to Advise
Auxiliary Power	110Vac from VT
Aux inputs	Standard set 220V AC max.
Test Block	Yes

Class and Accuracy may alter on final Contractor design if agreed by the Employer.

5.2.6 **HV Cable Connections**

The Contractor shall supply cable terminal boxes or cable connection assemblies (bar connections and the like) sufficiently sized to accommodate, gland and terminate these cable sizes at each location. Where necessary extension boxes or separate cable entry boxes shall be provided. All cables will be lug connected to the switchgear.

5.2.7 Protection Equipment

The following indications and controls shall be designed and wired into the protection relays:

Item	Type	Remote Interface (Note 4)
CB Open and Close	2 x Digital Inputs	2 x Volt Free Change Over Contacts
Isolator Open and Close	2 x Digital Inputs	2 x Volt Free Change Over Contacts
Spring Charge Failed	1 x Digital Input	2 x Volt Free Change Over Contacts
Earth switch Open and Close	2 x Digital Inputs	2 x Volt Free Change Over Contacts
CB in Test Position	1 x Digital Input	2 x Volt Free Change Over Contacts
CB in Service Position	1 x Digital Input	2 x Volt Free Change Over Contacts
CB in Earthed Position	1 x Digital Input	2 x Volt Free Change Over Contacts
CB Close Command (Note 1)	1 x Digital Input	2 x Volt Free Change Over Contacts
CB Open Command(Note 2)	1 x Digital Input	2 x Volt Free Change Over Contacts
Isolator Close Command (Note 1)	1 x Digital Input	2 x Volt Free Change Over Contacts
Isolator Open Command(Note 2)	1 x Digital Input	2 x Volt Free Change Over Contacts
Protection Reset (Note 3)	1 x Digital Input	2 x Volt Free Change Over Contacts
Close Command	1 x Digital Output	-
Open Command	1 x Digital Output	-
Trip circuit supervision	2 x Digital Output	-

1. *Provide 120Vdc aux relay for this remote operation*
2. *Provide 120Vdc aux relay for this remote operation*
3. *Provide a Protection Reset Button.*
4. *Provide 120Vdc aux relay with volt free changeover contact(s) for remote interface*

The Contractor shall mount and support the protection relays within the low voltage enclosures and provide all interface wiring from the protection relays, remote interface relays, trip and close controls on the breakers. External trip signals will be provided to these relays by others via terminals provided by under this contract.

5.2.8 Protection Relay Ratings

Item	Type
Auxiliary Supply	120Vdc

Current Transformer Input	Contractor Design
Voltage Transformer Input	110Vac
Digital Inputs	24Vdc
Digital Outputs	24Vdc
Comms Protocol – Rear connection for SCADA connection	Ethernet / Modbus TCP communications

5.2.9 Protection Test Blocks

Each protection relay shall have a corresponding test block for testing purposes. The test blocks shall be mounted alongside the protection relays. One matching plug shall be provided loose.

5.2.10 Internal Arc Fault Protection

The Contactor shall offer as an optional item an arc fault detection system on each switchboard complete with all detectors, sensing relays, and connections to the tripping, alarm and DC connections. Where necessary additional current transformers shall be installed for connection to the arch fault protection unit, complete with isolation and enabling switches and contacts. The arc fault protection shall be of a recognised proprietary brand.

5.2.11 Circuit Breaker Operation and Ancillaries

Operation

The circuit breakers shall be closed by means of a stored energy mechanism which is normally charged by a motor and shall also have provision for manual closing, tripping and spring charging for maintenance purposes. A maintenance handle shall be provided for this.

The motor spring charging supply shall be 120Vdc, and all trip, anti-pump, close and auxiliary relays shall be a nominal 120Vdc. A motor charged contact shall be available to the control system.

It must be possible to close the circuit breakers with the voltage of the operating system 20% below normal. Tripping and closing of the circuit breakers shall be initiated electrically from the circuit breaker panel or remotely from the generator control system supplied by others.

Mechanical operation counters are required for each circuit breaker. The closing sequence shall be to IEC standards for trip free operation.

Locking and Interlocking

All interlock mechanisms shall be mechanical and shall be clearly labelled. Interlocks shall be provided to prevent the following operations:

1. The circuit breaker being withdrawn from or inserted into the isolating contacts when the circuit breaker is closed. Attempted isolation shall not trip a closed-circuit breaker.
2. The closing of the circuit breaker, unless correctly located in the service, earth or isolated positions, or unless the circuit breaker is withdrawn from the fixed position of the equipment.
3. The moving portion being withdrawn or replaced unless the circuit breaker is isolated and is in the appropriate position for withdrawal or replacement.
4. The circuit breaker being plugged in while in an incomplete state.
5. The circuit breaker being closed in the service position without completing the auxiliary circuits between the fixed and moving portions.

The interlock to meet the requirements of paragraphs (1) and (2) above shall be manually operated by means of a handle having two positions clearly labelled "Service", "Busbar/Circuit Earthed", "Racked down".

It must be possible to "safety" lock the circuit breaker in the earthed position when the circuit breaker is closed. The hole which accepts the padlock shank shall be a minimum of 5mm diameter.

Safety Shutter Devices

A set of shutters shall be provided to cover each three-phase group of stationary isolating contacts. Each set shall be capable of being individually operated and padlocked closed or secured with an approved alternative. The shutters shall open automatically by a positive drive. The closing operation shall also be automatic either by positive drive or by two independent means, each capable of closing the shutter alone.

When padlocked the shutters shall prevent access to the stationary isolating contacts. The hole which accepts the padlock shank shall be a minimum of 5mm diameter.

To facilitate testing, a device shall preferably be provided for fixing (but not padlocking) the shutters in the open position and subsequently for releasing them to the closed position and this device shall be designed so as to be cancelled by the moving portion, to ensure restoration of the automatic features of the shutters.

5.2.12 Auxiliary Wiring

Breaker Wiring

The wiring connections from the breaker assembly to the fixed section of the breaker cubicle shall be via an approved plug and socket and preferably by an 'umbilical' cord type connection. The length of the umbilical shall be such that the breaker assembly can be fully withdrawn from the switchgear fixed cubicle and the breaker control systems fully checked.

The umbilical cord will terminate within the low voltage control cubicle on a set of terminals to an agreed arrangement.

Terminals

All breaker and field terminals shall be mounted inside the switchgear low voltage control panel area on DIN rails. Terminals shall be segregated as to function and to an agreed arrangement.

The following terminal types shall be approved by the Employer prior to ordering:

- Current and Voltage Isolatable/Test links
- Rail Mounted terminals

All terminals having a circuit voltage of 120V or higher shall be shielded with an insulated cover marked with a warning notice "Danger [xxx] Volts".

Only one (1) conductor shall be terminated in each side of the terminal block.

Shorting straps shall be used between terminal blocks to bridge identical conductor terminals. Cubicles shall have extra space on mounting bars for another 20% terminals.

Secondary Wiring

All wiring shall be multi-stranded tinned copper conductor and shall be carried out in a neat and systematic manner.

In all cases, the sequence of the wiring terminals shall be such that the junction between multi-core cables and the terminals is affected with a minimum of crossovers. Claw washers or crimped connectors of approved type shall be used to terminate all small wiring. Insulating bushings shall be provided where necessary to prevent the chafing of wiring. All wiring to be terminated with an approved proprietary bootlace ferrules.

Inter-Panel Wiring

Inter-panel wiring between the circuit breaker cubicles and existing switchgear circuits shall be supplied by the Contractor. Wiring shall be supplied as pre-made looms of sufficient length, pre- crimped, complete with ferrule labelling; ready for connection on site by others.

5.2.13 Auxiliary Control Components

Fuses and Links

Fuse and links shall be grouped together on each panel, adequately labelled to show the function of the circuit, the voltage and the fuse rating.

Indication of Status

All indicating lamps shall have high intensity LEDs in bayonet style holders (BA9 or equivalent).

The following indication lamps shall be provided:

- CB Open Green
- CB Closed Red
- CB Fault Amber
- Earth Switch On White

Synchroscope

Each circuit breaker that is has provision for local synchronising and shall be provided with a Carrel & Carrel SQ0214 synchroscope (phase to phase measurement, continuous output at synchronism); the synchronizing contact of which shall be wired into the breaker close control circuits.

Local Auto/Override Switches/Control Switches

The circuit breaker shall have a Local/Auto switch (remote closing in Auto). Local Close (Green) and Open (Red) push buttons will only be active in Local mode and interlocked with the Synchroscope contacts. A keyed Dead Bus override switch shall be wired in parallel with the Synchroscope contacts.

Emergency Stop

All circuit breakers shall have an Emergency Stop push button. The button shall be of the 40 mm Diameter mushroom style, shall be coloured Red, and shall include a shroud to prevent accidental damage. The emergency stop button shall trip the breaker in any closed condition by direct mechanical connection (not electrical trip).

Auxiliary Switches

At least two (2) sets of Normally Open / Normally Closed changeover switches shall be available for use by others by wiring out to terminals.

All auxiliary switches shall be positively driven in both directions. They shall be mounted so as to be readily accessible for maintenance, and shall be designed to facilitate inspection, cleaning and adjustment.

5.2.14 Communications

Connection between the protection relays and other main equipment serial devices is to be advised by the Contractor. The communications to all main equipment serial

devices shall be on the same communications network and protocol for seamless integration with the SP Power Station SCADA.

5.2.15 Earthing and Earth Trolleys

The earthing arrangement shall be integral with the circuit breaker equipment so that the outgoing cables can be earthed through the circuit breaker. An earth on the busbar shall also be provided.

It shall not be possible to trip the earth breaker electrically whilst in the earth position

A test earthing trolley may be offered that provides the user with the voltage status indication on both sets of circuits.

5.2.16 Earth Bar

The main earth bar should be located adjacent to the cable box glands in order to reduce to a minimum the flow of external fault current within the switchboard framework. The short time rating of each earth bar should be not less than that of the switchgear with which they are associated.

5.2.17 Labels – General

All separate items shall be labelled using a permanent marking system. One label shall be provided on each breaker indicating the circuit name and number. One label shall be provided on each switchboard section to indicate the busbar name.

5.2.18 Labels – Rating

Each circuit breaker panel shall have an etched rating label installed on the cubical in a visible location. The labels shall include the following information fields:

- Rated Normal Current: ....A
- Rated Main Busbar Current: ....A
- Rated Short-Time Withstand Current: ....A, ...s
- Rated Peak Withstand Current: ....A
- Rated Voltage: ....kV
- System Voltage: ....kV
- Rated Insulation Level: ..../....kV
- Rated Frequency: ....Hz
    - Made in: .....
    - Standard: .....

5.2.19 Colours and Paint Finishes

The paint application method and finish on the switchgear shall be to an approved application process. The preferred finish is an epoxy coating to an overall thickness of 75 micron with a minimum of 50 micron and oven cured.

The colour shall be ‘Storm Grey’ colour N42 to AS2700. Internal gear plates shall be white.

5.2.20 Panel Heater and Cubicle Lighting

Each circuit breaker panel shall be provided with an anti-condensation heater. An external heater isolation switch shall be provided.

Each circuit breaker panel LV compartment shall be provided with a light, with door switch controller. The Contractor shall allow for inter-panel wiring to distribute this supply between circuit breaker panels.

5.2.21 Cable Voltage Indicators

Each circuit breaker shall be provided with a neon “phase voltage present” indication unit. The units shall indicate the presence of voltage on each phase. The sensing connection shall be on the cable side of the circuit breakers.

5.2.22 Control and Tripping Supply

The protection, control and indication, and circuit breaker spring charge motor shall be rated 120Vdc. One only 120Vdc incoming power supply is required for each switchboard. The Contractor shall allow for inter-panel wiring to distribute this supply between circuit breaker panels.

5.2.23 Expansion Capability

The completed switchboards shall be capable of being extended at each end (or, where an extension of an existing switchboard, at one end only).

5.3 General Technical Requirements – Ring Main Units

5.3.1 Type of Switchgear

The ring main units shall be indoor mounted, IP3x, metal clad, front access, fixed breaker, type tested, HV vacuum or SF6 breakers, internal Arc Fault Protection, with integral circuit earth, and complete with the necessary current transformers, controls and protection as specified.

5.3.2 Bus Bars

All busbars shall be of the tinned copper arrangement, supported as required to maintain the fault rating, and heat shrink shrouded. Bus bar chambers shall be totally enclosed, and extendable at each end of the switchboard layout. Where construction

or transport joints are provided the Contractor shall detail the connections and provide all shroud and filling compounds. The Contractor shall note the environmental conditions.

5.3.3 Current Transformers

All current transformers shall be sized to provide the quiescent current to the protection relay if self-power relays are provided.

5.3.4 HV Cable Connections

The major cable connection sizes to each isolator are by Contractor design, with special attention required for ambient conditions and soil thermal resistivity in this environment at the nominal current rating. The Contractor shall supply cable terminal boxes sufficiently large to accommodate, gland and terminate these cables. Where necessary extension boxes or separate cable entry boxes shall be provided.

The preferred arrangement is that all cables shall be lug connected to the switchgear terminals, however plug/socket arrangements may be offered if they can provide the connection to the cables shown. All sockets will be provided with the correctly sized plugs for the cable size specified for use by others in termination of cables.

5.3.5 Protection Relays

Every breaker shall contain a standard three phase over current and earth fault relay that can be set for timed and instantaneous protection functions. The relay may be self-powered, with the current transformers fitted with a separate power winding, or operated at 120Vdc from the local battery supply. The relay shall have at least one clean alarm contact wired to terminals for the indication of a trip condition. The Contractor shall mount and support the protection relays within the low voltage enclosures and provide all interface wiring from these relays to the trip and close controls on the breakers.

5.3.6 Operation

All isolators shall be motorised (120Vdc) and allow for remote open and close commands. Provision shall be made to open and close the isolators manually and dis-engage and re-engage motor drive mechanism.

All earth switches shall be manually operated, and mechanically interlocked with their associated isolator or breaker.

The circuit breakers may be closed by means of a stored energy mechanism which is normally charged by a motor or via a close coil and shall also have provision for manual closing, tripping and spring charging for maintenance purposes. A maintenance handle shall be provided for this.

The motor spring charging supply shall be 120Vdc, and all trip, anti-pump, close and auxiliary relays shall be a nominal 120Vdc.

It must be possible to close the circuit breakers with the voltage of the operating system 20% below normal.

Mechanical operation counters are required for each circuit breaker. The closing sequence shall be to AS standards for trip free operation.

5.3.7 Locking, Interlocking and Earthing

All interlock mechanisms shall be mechanical and shall be clearly labelled. Interlocks shall be provided to prevent the following operations:

- The closing of the circuit breaker or isolator unless the associated earth is removed
- The closing of the earth switch unless the associated circuit breaker or isolator is open

It must be possible to “safety” lock the circuit breaker or the isolator in the earthed position.

The circuit breaker shall not be required to be closed to earth the outgoing cable. No bus earth is required. The hole which accepts the padlock shank shall be a minimum of 5mm diameter.

5.3.8 Auxiliary Wiring

Terminals

All breaker and field terminals shall be mounted inside the switchgear low voltage control panel area on DIN rails. Terminals shall be segregated as to function and to an agreed arrangement.

All terminals having a circuit voltage of 120V or higher shall be shielded with an insulated cover marked with a warning notice "Danger [XXX] Volts".

Only (1) one conductor shall be terminated in each side of the terminal block.

Shorting straps shall be used between terminal blocks to bridge identical conductor terminals. Cubicles shall have extra space on mounting bars for another 20% terminals.

Secondary Wiring

All wiring shall be multi-stranded tinned copper conductor and shall be carried out in a neat and systematic manner.

In all cases, the sequence of the wiring terminals shall be such that the junction between multi-core cables and the terminals is affected with a minimum of

crossovers. Claw washers or crimped connectors of approved type shall be used to terminate all small wiring. Insulating bushings shall be provided where necessary to prevent the chafing of wiring. All wiring to be terminated with approved proprietary bootlace ferrules.

Inter-Panel Wiring

Inter-panel wiring shall be supplied by the Contractor. Wiring shall be supplied as pre-made looms of sufficient length, pre-crimped, complete with ferrule labelling; ready for connection on site by others.

5.3.9 Auxiliary Control Components

Fuses and Links

Fuse and links carriers and bases shall comply with BS 88: Parts 1 and 2

The fuse carriers shall be suitable for fitting 'GEC HRC type NS', fuse links up to 32 A rating. The fuse links fitted shall be class Q1 'GEC HRC type NS' or an equivalent.

Fuse and links shall be grouped together on each panel, adequately labelled to show the function of the circuit, the voltage and the fuse rating.

Position Indication

All indicating lamps shall be of the 22 mm Diameter style and have high intensity LED’s in bayonet style holders (BA9 or equivalent) if provided. The following indication lamps shall be provided:

- CB Open — Green
- CB Closed — Red
- CB Fault — Amber
- Earth Switch On — White
- Cubical Heater Supply Healthy — White

Clear and unambiguous mechanical indicators shall be provided to indicate the open/closed and earth status of all isolators and circuit breakers.

Auxiliary Switches

A minimum of two (2) adjustable and clean contact Normally Open / Normally Closed auxiliary switches shall be supplied on each breaker or isolator assembly for remote indication use by others.

All auxiliary switches shall be positively driven in both directions. They shall be mounted to be readily accessible for maintenance, and shall be designed to facilitate

inspection, cleaning and adjustment.

5.3.10 Earth Bar

The main earth bar should be located adjacent to the cable box glands in order to reduce to a minimum the flow of external fault current within the switchboard framework. The short time rating of each earth bar should be not less than that of the switchgear with which they are associated.

5.3.11 Labels – General

All separate items shall be labelled using BWB traffolyte or some other agreed form of permanent marking system. One label shall be provided on each breaker/isolator or earth switch indicating the circuit name and number. One label shall be provided on each switchboard section to indicate the busbar name.

5.3.12 Colours and Paint Finishes

The paint application method and finish on the ring main units shall be to an approved application process suitable for the environment.

5.3.13 Cable Voltage Indicators

Each cable connection shall be provided with a neon “phase voltage present” indication unit. The units shall indicate the presence of voltage on each phase.

5.3.14 Control and Tripping Supply

The protection, control and indication, and circuit breaker spring charge motor shall be rated 120Vdc. One only 120Vdc incoming power supply is required for each switchboard. The Contractor shall allow for inter-panel wiring to distribute this supply between circuit breaker panels.

5.3.15 Expansion Capability

The ring main units shall be capable of being extended from at least one end.

5.4 Design and Drawings

The Employer and the Contractor will agree the typical schematic drawings of each type of circuit breakers, inclusive of feeders and incomers.

The Contractor shall provide breaker (not system) schematic diagrams, wiring diagrams, layout and component schedules for all new circuit breakers in AutoCAD format. The drawings shall include all internal wiring and panel to panel wiring details.

5.5 Commissioning Assistance

The Contractor shall supply test personnel to assist with the final inspections and

first livening of the switchboards as well as breaker protection setup and commissioning.

5.6 Testing and Inspection

5.6.1 General Tests

Tests shall be carried out at the Contractor's works. The Contractor shall submit a proposed test procedure for approval at least one month prior to commencement of the tests. The Contractor shall provide notification to the Employer before the commencement of each test.

Where the supply is to ‘standard’ designs with certification available, only ‘routine’ tests shall be required. Full function tests on the operation of each breaker inclusive of forced tripping, earthing, manual closing and the like shall be included.

5.6.2 Inspection

The Employer shall be entitled to inspect the works and materials both during and after construction, and to witness testing. The Employer shall have the power to reject any equipment, etc., not in accordance with the specification.

5.6.3 Production Schedule

The Contractor shall provide a production schedule of the equipment relating significant stages of production to the proposed delivery date. The schedule shall specify the stages at which the equipment will be available for inspection and test. A preliminary schedule shall be provided with the tender and updated copies supplied to the Employer during the progress of the manufacture.

The guaranteed delivery dates shall not alter without the express written consent of the Employer.

5.6.4 Test Certificates and Reports

Reports detailing test methods and recording test results shall be supplied for:

- Type tests
- Factory Routine tests
- Pre-Commissioning tests.

Two (2) copies of all test reports shall be supplied to the Employer. Original prints and oscillogram photographs of such quality that all lines and inscriptions are clearly legible shall be included in each test report.

6 TRANSFORMERS

6.1 General

Transformers are part of the Contractor design, and the Contractor shall implement the following design requirements.

6.2 Transformer Power Rating

The Contractor shall offer options for the transformer power rating in order for the Employer to standardise on spare transformers for the network.

6.3 Transformer Standards

The new equipment in this Specification shall be designed, manufactured and tested to meet the requirements of international standards specified. Where any provision of this Specification differs from those standards listed hereafter, the provision of this Specification shall take precedence.

6.4 Statutory Regulations

The works and all plant, equipment, and materials associated with this Specification are to comply in all respects with all relevant Solomon Islands regulations, approvals, licenses and permits.

6.5 Technical Requirements

6.5.1 General

This Specification covers the design, manufacture, testing, supply to site, warranty and performance guarantees of three-phase power transformer(s) with off load tap changer and accessories.

6.5.2 Service Life

The life of this equipment shall not be less than (40) forty years.

6.5.3 Applicable Standards

Standards IEC	Standards AS/NZS	Title
IEC 60076*	AS/NZS 60076	Power Transformers
	AS 2374	Power Transformers – Minimum Energy Performance Standard requirements for distribution transformers.
IEC 60137*	AS/NZS 60137	Bushings for alternative voltages above 1000 V

	AS 1554	Structural steel welding
IEC 60071*		Insulation co-ordination
	AS 1767	Insulating oil for transformers and switchgear electrical equipment
	AS 62271.301	Dimension standardisation of terminals
	AS/NZS 3000	Electrical Installations (known as the Australian New Zealand Wiring Rules)

*- Or the equivalent AS standard

6.5.4 Equipment Parameters

The following table summarises Solomon Power's Standard Electricity Network Design Parameters and Service Conditions (Rev E, 27/07/2023)

Parameter	**33 kV system**	**11 kV system**	**0.415 kV system**
Nom. Voltage (Un)	33 kV	11 kV	0.415 kV (240V P-N)
Max. Voltage (Umax)	36 kV	12 kV	-
Design. Voltage (Um)	36 kV	12 kV	1 kV (600V P-N)
Voltage Variation	±7 % (normal) ±10 % (emergency)	±7 % (normal) ±10 % (emergency)	±6 % (normal) ±10 % (emergency)
Frequency Variation	50 Hz ±2 % (normal) 50 Hz ±4%, and not ±3% limits for more than 0.5 s (emergency)		
Rated short time current (2 secs)	25 kA	25 kA	50 kA
Earthing	Solidly Earthed		
Rated impulse withstand (peak)	170 kV	95 kV	-
Rated 1 mn power frequency withstand (peak)	70 kV	28 kV	-
Min. air clearance (P-E)	900 mm	300 mm	-
Creepage distance (outdoor)	25mm/kV	25mm/kV	

Transformers	**Step-up (Generation)**		**Step-down (Distribution)**	
Phases	3			
Type	0.415/11 kV	11/33 kV	33/11 kV	11/0.415 kV
Vector group	Dyn11 or YNd11	YNd11	Dyn11	Dyn11

Rated Power	<2 MVa	2 – 12.5 MVa	5 – 10 MVa	<2 MVa
Impedance	6 %	5 – 12.5 %	7 – 8 %	4 – 6 %
Tap Changer	Off load, ± 5%, 5 positions	On load, ± 10%, 17 positions	On load, ± 10%, 17 positions	Off load, ± 5%, 5 positions
Altitude	0 – 1000 m ASL			
Max. Ambient Temp	40ºC			
Avg. Ambient Temp	22 – 32ºC			
Air Humidity	>99 %			
Soil Thermal Resistivity	Average		Maximum	
	2.3 C m/W		3.0 C m/W	

Notes:

a) *Transformer size suitable for the plant and BESS maximum kVA output as a minimum taking into account harmonic content and overload capacity.*
b) *The standards and guidelines will apply, in order of priority, where the Solomon Power network standards do not provide standards or recommendations: Australian standards, the IEC standards, and the IEEE guidelines.*

6.6 Design Requirements

6.6.1 General

The power transformer shall be capable of delivering the rated kVA through the complete tapping range. Special attention is required for the Contractor design and sizing of transformers due to harmonic content of the PV System and ambient temperatures in the tropical environment.

6.6.2 Transformer Construction Style

The power transformer shall be of the “industrial” type, with separate HV and LV lockable cable boxes/cubicles with hinged doors. All cable entries shall be from the bottom.

6.6.3 Transformer HV and LV Cubicle Design

The transformer HV and LV cable box/cubicle shall be fitted with suitably rated bus bars sized sufficiently for the connection of all HV and LV cables. The cable box/cubicle shall be sized sufficiently to comfortably allow the installation of cables.

6.6.4 Transformer Core

The core shall be constructed of high quality, non-aging, high permeability silicon steel - M4 High B Grade or superior grade Cold Rolled Grain Oriented (CRGO) steel.

The steel shall be in thin laminations of 0.27 mm or less, annealed after cutting and rolled to ensure smooth surfaces at the edges. Both sides of each sheet shall be insulated with a durable, heat- resistant baked enamel or varnish.

The core shall be rigidly clamped with a positive locking device to ensure adequate mechanical strength to support the windings and prevent shifting of laminations during shipment, and also to reduce vibration to a minimum during operation.

The core shall be grounded at one point and means shall be provided for possible measuring of core insulation from the top of the tank.

Adequate lifting lugs shall be provided to enable the core and winding to be lifted from the tank.

6.6.5 Transformer Windings

The design, construction, and treatment of windings shall give proper consideration to all service factors, such as high dielectric and mechanical strength of insulation, coil characteristics, uniform electrostatic flux distribution, prevention of corona formation, and minimum restriction to free oil circulation.

Windings shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service.

Materials used in the insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise be affected under the operating conditions.

Windings shall contain no sharp bends which might damage the insulation or produce high dielectric stresses. The strip conductor wound on edge shall not have a width exceeding six (6) times its thickness.

All windings after being wound and all fibrous hygroscopic materials used in the construction of the transformer shall be dried under vacuum and impregnated with hot oil.

The windings shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to windings can be made readily without special equipment. The coils shall have high dielectric strength.

The windings, their insulation and connections shall be braced to withstand the mechanical and electrical stresses which may occur during transportation and erection, during lightning, switching surges, system faults or seismic disturbances.

An earth shield shall be installed between the HV and LV windings to reduce surge transfer and protect from inter-winding faults.

6.6.6 Transformer Tank

The transformer shall be enclosed in a suitable stiffened welded steel tank such that it can be lifted and transported without permanent deformation or oil leakage. The construction shall employ weldable mild steel and shall be of sufficient strength and rigidity to withstand moving, shipping and handling without deformation.

Lifting lugs shall be provided, suitable for the weight of the transformer, including core and windings, fittings, and with the tank filled with oil. Four (4) jacking points must be provided in an accessible position to enable the transformer to be raised or lowered.

The base of each tank shall be so designed that it is possible to move the complete transformer unit in any direction without damage when using rollers, plates, or rails.

The transformer tank shall have a flat rectangular base with supporting rails allowing minimum possible contact with the foundations (so eliminating water build-up under base). Skids or wheels are not required.

All joints other than those which may have to be opened, shall be welded. Caulking of defective welded joints will not be allowed. Defective welded joints may be re-welded subject to the written approval of the Employer's representative.

The tank and cover shall be designed in such a manner as to leave no external pockets in which water can lodge, no internal pockets in which oil can remain when draining the tank or in which air can be trapped when filling the tank, and to provide easy access to all external surfaces for painting.

Integrally mounted radiators shall be provided and all mounting equipment for the radiators and connections between the radiator and the transformer tank shall be provided.

Four (4) holding down/fixing points shall be provided, complete with 20 mm holes.

6.6.7 Transformer Valves and Location

All valves up to and including 75 mm bore shall be made of gunmetal. They shall be of full way type with screwed ends and shall be opened by turning 'counter clockwise' when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.

The transformer shall be fitted with the following valves as a minimum requirement:

- One 25 mm filter valve located near to the bottom of the tank and the top of the tank for online filtering
- One 25 mm drain valve with such arrangements as may be necessary inside the tank to ensure that the tank can be completely drained of oil as

far as practicable. This valve shall also be provided with an approved oil sampling device,

6.6.8 Transformer Joints and Gaskets

All joint faces shall be arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of oil or air.

Oil resisting synthetic rubber is not permissible except where metal inserts are provided to limit compression.

Gaskets shall be as thin as is possible consistent with the provision of a good seal. Full details of all gasket sealing arrangements shall be shown on the Plant drawings.

Gaskets shall be designed for a life of not less than thirty (30) years.

6.6.9 Transformer Oil Temperature Indicator

The transformer shall be provided with an agreed oil temperature instrument with a dial type indicator and a manually resettable pointer to register the highest temperature reached. The instrument shall have two sets of contacts, one for alarm and one for trip. The tripping contacts are to be adjustable to close between 60°C and 120°C and re-open when the temperature has fallen by not more than 10°C. The alarm contacts shall be adjustable to close between 50°C and 100°C and to re-open when the temperature has fallen by not more than 10°F. The contacts shall be wired to a junction box attached to the transformer and clearly labelled for connection by others.

6.6.10 Transformer Oil Level Sight Glass

The transformer shall be provided with an oil level sight glass.

6.6.11 Transformer Pressure Relief Device

A suitable pressure relief device shall be provided for the rapid release of any pressure that may be generated in the tank which may endanger the equipment. If the relief device is to be mounted on the tank cover, it shall be fitted with a skirt to project at least 25 mm into the tank and of such construction as to prevent gas accumulation.

The device shall be capable of maintaining the oil tightness of the transformer under all conditions of normal service.

The instrument shall have two sets of contacts, one for alarm and one for trip. The contacts shall be wired to a junction box attached to the transformer and clearly labelled for connection by others.

6.6.12 Transformer Earthing Terminals

Two (2) bare stainless steel 12 mm diameter studs shall be located at positions close to the two diagonally opposite bottom corners of the transformer tank to facilitate connection to the local earthing system. These grounding terminals shall be suitable for a bolted connection.

Earthing terminals should be suitable for carrying full short circuit current for four (4) seconds.

6.6.13 Transformer Insulating Oil

The transformer shall be transported to the site under oil to BS148.

Oil must be new, and de-gassed before filling of transformer takes place. The oil shall be pure hydrocarbon mineral oil of a naphthenic base refined especially for use in transformers. The oil shall be clean and free from matter likely to impair its properties.

Each transformer must have a sample of its oil analysed at a NATA approved facility. Tests are to include Karl Fischer water content, acidity, interfacial tension, colour, dielectric strength, resistivity at 90 $^{\circ}$C, dissolved gas analysis, and total PCB content.

The total PCB content must be not detectable (assume detection limit is 0.1 PPM).

Results of these tests must meet requirements of IEC 61125, except as follows:

a) Colour shall be determined according to ISO 2049. The colour number of the oil shall be less than 1.5
b) Interfacial tension shall be determined according to ISO 6295. The oil shall have an IFT not less than 40 mN/m, nor greater than 50 mN/m
c) Gassing tendency shall be determined according to IEC publication 628 (A). The oil shall have a gassing tendency less than 5 mm^3/min
d) Resistivity at 194°F shall be greater than 80 G ohm
e) Water content of transformer oil sample shall be less than 15 PPM

Results of the above listed tests for each transformer oil sample must be supplied to The Employer and results cleared as acceptable by The Employer before the transformers can be handed over.

6.6.14 Transformer Bushings

Bushings shall conform to the requirements of IEC 60137.

Primary and secondary bushings shall be provided in two separate cubicles sealed to no less than IP21 rating.

The insulation level of bushings shall be equal to or greater than the insulation level

of the winding to which they are connected.

Stress due to expansion and contraction in any part of the bushing shall not lead to deterioration or loosening of cemented joint. In case of paper insulation, care shall be taken to prevent ingress of moisture and a final coat of non-hygroscopic varnish shall be applied.

Bushings of identical voltage rating shall be interchangeable.

Each bushing shall be so coordinated with the transformer insulation that all flashover will occur outside the tank.

6.6.15 Transformer External Finish

The external finish of the transformer, radiators, marshalling areas/kiosks etc. shall be treated to an agreed marine grade painting system providing long term withstand to the environment.

The proposed methods shall be stated in the tender.

6.6.16 Transformer Rating Diagram and Valve Plates

The following plates, or an approved combined plate, shall be fixed to the Transformer inside the low voltage cubicle:

a) A rating plate with the data specified in AS 60076.1. This plate shall also include a space for the Employer's serial number

b) A diagram plate, showing in an approved manner, the internal connections and the voltage vector relationship of the different windings, in accordance with AS 60076 Part 1 with the Transformer voltage ratio for the tap ranges and, if standard, a plan view of the Transformer giving the correct physical relationship of the terminals

Plates are to be stainless steel or another approved material capable for continuous outdoor service and withstanding the climatic conditions of the site.

6.6.17 Transformer Auxiliary Wiring

All wiring shall be multi-stranded copper conductor and shall be carried out in a neat and systematic manner.

In all cases, the sequence of the wiring terminals shall be such that the junction between multi-core cables and the terminals is affected with a minimum of crossovers. Claw washers or crimped connectors of approved type shall be used to terminate all small wiring. Insulating bushings shall be provided where necessary to prevent the chafing of wiring. All wiring to be terminated with approved proprietary bootlace ferrules.

All PVC insulated panel wiring shall comply with the requirements of BS 6231 Type BK. F Conductors. F Conductors shall generally have a minimum cross section equivalent to 2.5 mm^2 for current circuits and 1.5 mm^2 for any voltage circuits. Colours shall be to an agreed arrangement.

6.7 Commissioning Assistance

The Contractor shall supply test personnel to assist with the final inspections and first livening of the transformer as well as breaker protection setup and commissioning.

6.8 Testing and Inspection

6.8.1 Routine Tests

Routine tests shall be carried out on all transformers and the tests shall be conducted in accordance with the relevant Standards as outlined below.

The following routine measurements and tests shall be carried out in accordance with the applicable standard:

- Measurement of winding resistance on tap positions and phases;
- Measurement of voltage ratio and check of polarity and vector group;
- Measurement of impedance voltages;
- Insulation resistance before and after impulse tests (if provided);
- Oil dielectric test: conforming to AS 1767. The minimum acceptable oil dielectric level shall be 120kV/cm;
- Galvanising tests on transformer tanks prior to painting shall be in accordance with ISO 1460.

The report of all tests, curves and standard application data shall be furnished to the Employer after completion of the tests. The costs of all tests and reports shall be borne by the Contractor. The tests will be witnessed by the Employer or its representative if required, without any additional cost. Original prints and oscillogram photographs of such quality that all lines and inscriptions are clearly legible shall be included in each test report.

7 SWITCHBOARDS / MCCs

7.1 General

If LV switchgear or MCCs are installed as part of the Contractor design, then the Contractor shall implement the following design requirements.

7.2 Standards and Regulations

All switchboards shall comply with AS/NZS 61439.1 and any subsequent amendments and alterations, including all standards as listed in Clause 2 'Normative Reference' of AS/NZS 61439.1 or equivalent IEC standard. Where switchboards are manufactured to standards other than those above, it shall be the responsibility of the Contractor to list the applicable standards and to prove that the equipment is at least equal to the above standards.

Specific technical requirements in accordance with AS/NZS 61439.1 are included in the following table:

Item	**Value**	**Notes**
Service Conditions	Indoors where the switchboard is in a well-ventilated room	
Cable Entry (Incoming)	Contractor to specify	Bus Duct
Cable Entry (Outgoing Cables)	Contractor to specify	
Access	Contractor to specify	
Supply Voltage (V)	415V 3 phase	Classification in AS61439.1
Supply Frequency (Hz)	50 Hz	Classification in AS61439.1
Connected Load (A)	Contractor to specify	Classification in AS61439.1
Fault Level (kA)	Contractor to specify	Classification in AS61439.1
Fault Duration (sec)	Contractor to specify	Classification in AS61439.1
Diversity	0.9	Classification in AS61439.1
Ambient Temperature	+15°C to +45°C	
Relative Humidity	Up to 100%	Damp conditions
Pollution Degree	Degree 3	Classification in AS61439.1
Segregation	Form 3b OR 4	Separation of busbars from the functional units and separation

		of all functional units from one another. Separation of the terminals for external conductors from the functional units, but not from each other. Terminals for external conductors separated from busbars.
Degree of Protection	IP21 or better	Live parts, ingress of foreign bodies (dust)
Spare Space	20% minimum	
Incoming Cable Size	Contractor to specific	
Module Style	Semi demountable	
Main Circuit Breaker	Withdrawable ACB/MCB	
MCCBs – VFDs	Fixed	
Power Monitors	Separate Unit per incomer	Schneider PM810 with Ethernet or Modbus communications, Contractor to advise.
Motor Starters	All DOL Motor – three-phase Heaters – single phase	
Motor Starter Communication	Nil	
Soft-starters	Nil	
Soft-starter Communication	Nil	

7.3 Construction and Arrangement of Equipment

Switchgear assemblies shall be constructed in accordance with IEC61439 Clause 8 and shall be of metal-clad, totally enclosed construction. Unless noted otherwise in the drawings the switchboards and MCCs shall have the following characteristics:

1. Be constructed to give a minimum degree of protection of IP40 or better to AS 60529.
2. Be vermin proof.
3. Have a form of segregation Form 3b OR Form 4 to AS/NZS 61439.1
4. Manufactured to a design successfully tested to the standard requirements of internal arcing-fault tests to AS/NZS 61439.1 or equivalent IEC standard

5. Have an overall height not exceeding 2350 mm.
6. The starter module type to be semi-demountable.

7.4 Ratings of Switchgear

Switchboards, including all incoming connections, circuit breakers and associated busbars and terminals, shall be constructed to be capable of withstanding the thermal and dynamic stresses resulting from the short time short circuit withstand currents specified in the above table and in accordance with the requirements of AS/NZS 61439.1 or equivalent IEC standard.

7.5 Switchboard Construction

The switchboards and MCCs shall be designed to accommodate all incomers, starter modules, feeders etc. as required together with the required spare space. Special attention shall be made and allowed for the termination of cables to and from the switchboard.

Each cable compartment shall be fitted with a lift-off hinged door. Covers over the main horizontal and vertical busbar chambers shall be removable without disturbing cables to enable inspection of the busbar joints. It is to be noted that the inspection panels can only be removed by the use of a purpose built key or tool.

All tiers shall be equipped with un-drilled non-ferrous gland plates of minimum size 400mm x 400mm. Gland plates shall be of sufficient size to ensure that cable glands are readily accessible for removal when all cables are installed. Gland plates shall be designed to maintain the IP rating of the switchboard. All gland plates shall be connected to earth.

All removable panels covering normally live equipment shall be secured by screws or bolts and labelled accordingly.

7.6 Arrangement of Equipment

All switchboards shall be arranged for maximum safety to personnel and equipment. The degree of protection with the doors or covers of functional units or ducts open or removed shall not be less than IP21.

All isolators, selector switches, pushbuttons, over-load reset buttons and other manual control devices shall be positioned at convenient operating heights and shall all be operable from the front of the switchboard without the opening of doors or the removal of covers.

Control gear, devices or terminations shall not be mounted higher than 1800mm or lower than 250mm above floor level. All equipment shall be arranged for simplified servicing and shall be readily accessible for routine maintenance, inspection, testing

and parts replacement without the need for major dismantling.

All access doors to normally live equipment shall be arranged such that they cannot be opened unless the particular circuit isolator is in the ‘Off’ position. Each final circuit shall be arranged and segregated such that after the removal of fuses, or ‘locking off’ of the isolator for that circuit, all associated equipment, contactors, indicator lights, meters, control equipment and outgoing cable terminations, can be safely worked on without isolating supplies to adjacent equipment.

Equipment mounted on doors shall be limited to manual control devices, indicator lights and protective relays. Fuses shall be spaced to allow for finger grip of fuse carriers.

7.7 Layout and Spare Space

Spare space shall be available for the installation of future motor starter modules, which shall not be less than 20 %. The spaces available for additional modules shall be fitted with vertical busbars, hinged doors, vertical cable ducts and other accessories or fittings necessary to permit the safe installation of future modules cables while the switchboard is live.

All tiers and modules shall be numbered from the left to right when viewed from the front of the switchboard unless noted otherwise.

7.8 Starter / Feeder Module Design

Each module shall be capable of housing all components required for the electrical function of a particular starter or feeder. It shall be complete with a lockable door and all fastenings for these doors (as well as for vertical cable ways) shall remain captive when the door is open or the cover removed.

Modules shall be constructed of an interchangeable combination of modular heights, and shall be of standard depth and width. Modules shall be arranged to allow adequate space for the installation and termination of all internal and external wiring. All door (or cover) mounted operating equipment, in particular pushbuttons, switch handles, mechanical interlocks and overload reset actuators shall be correctly aligned. Where extension rods are necessary, separate guides shall be provided allowing the operating button (or handle) to be independent of the rod.

7.9 Lifting Facilities

The switchboard shall include a fully welded steel plinth either galvanized or painted steel plinth for secure mounting. The steel plinth shall be of suitable size and rigid so as to avoid twisting on the MCC panels when the MCC is bolted in place. The plinth shall be drilled to allow lifting of transport units by means of lifting bars and slings

and drilled for holding down.

7.10 Future Extension

Removable access covers shall be provided to enable the main busbars to be extended for future tiers for at least end of the switchboard.

7.11 Temperature Rise

The temperature rises of all current carrying parts shall not exceed the limits stated in AS/NZS 61439.1.

7.12 Ventilation

Where Form 4 separation is provided each starter cubicle shall be vented to atmosphere via a separate channel (flue) section such that any gases caused by arcing or explosion within a module are vented directly to atmosphere. The path of such gases shall not be via another functional unit, shall not be to the front of the switchboard and shall not pass through any area which contains wiring or other electrical combustible equipment.

7.13 Site Assembly

Where it is necessary to split the switchboards into transport units, the Contractor shall clearly identify all mating parts and supply all fish plates, sealing gaskets, bolts, interconnecting wiring etc., for on-site erection and assembly. Interconnecting wiring shall be of ample length and supplied complete with identification ferrules and termination lugs.

7.14 Earthing

Switchgear assemblies shall be designed and constructed for a direct earthed system as defined in AS/NZS 3000 or equivalent IEC standard.

The main earth bar shall be copper and shall run the full length of the switchboard. The main earth bar shall be capable of carrying the short-time withstand current specified for a period of three seconds. Full height earth bars in cable compartments shall be provided. The earth bars shall be drilled at regular spacing’s for the connection of external cabling earth conductors.

All metal parts of the switchgear assembly including equipment panels, doors, switch fuse unit frames, circuit breaker frames, terminal strip mounting channels, gland plates, shall be fitted with an earthing bolt or stud and be connected to the earth bar with copper earth conductors sized in accordance with AS/NZS 3000 or equivalent IEC standard.

The secondary circuit of each current transformer shall be earthed at a single point.

The neutral point of each three-phase voltage transformer and one side of each single-phase voltage or control transformer secondary winding shall be earthed. Means shall be provided for these earth connections to be disconnected for testing at a readily accessible position. All connections to the earth bar shall be readily accessible without disturbing or disconnecting other internal or external wiring.

7.15 Busbars and Busbar Construction

All busbars and connections shall be of high conductivity tinned copper. Busbars and their insulated supports shall be mechanically strong to withstand all the stresses which may be imposed upon them in ordinary working, due to fixing, vibration, fluctuating temperature, short circuits or other causes. If necessary, provision shall be made for expansion and contraction of busbars and connections with variations in temperature.

Main busbars shall have the same current rating for the full length of the switchgear. The temperature rise of busbars and busbar connections shall not exceed 50 °C when carrying rated current continuously.

The switchboard shall be capable of extension at either end (unless noted otherwise) and busbars shall be pre-drilled to permit extension. Blank cover plates to permit extension to busbar and inter panel wiring shall be provided at the ends. As-manufactured drawings shall show details of the extension arrangement of the bars. Cover plates with WARNING signs shall be provided to prevent access to otherwise exposed equipment. All joints, take-off points and other connections on the busbars shall be adequately prepared to avoid high contact resistance.

All busbars shall be identified with paint or heat shrink sleeving at regular intervals (not exceeding 600mm) in phase, neutral and earth colours. Main busbars shall be completely enclosed except for power take-offs and shall be completely segregated from all other equipment and wiring, including extra-low voltage busbars and wiring. All wiring passing through busbar chambers shall be double insulated or enclosed in supported conduit and shall not touch the busbars.

The busbar assembly shall be a Type Tested Assembly.

Busbar drilling details and bolting torques shall be as in AS/NZS 62271-301 or equivalent IEC standard. Neutral and earth busbars shall be completely isolated from each other. Neutral and earth terminals shall be arranged for easy cable termination. The current carrying capacity of the Main Neutral bar shall be not less than 33.3% of that of the current carrying capacity of the associated active busbars.

All busbar assemblies, including main horizontal and vertical runs and connections to incomer and bus tie ACBs shall be fully accessible for inspection and available

(with the necessary safeguards) for thermal imaging.

7.16 Bus Duct Connections

The switchboard shall include all fittings and connections to the bus ducts specified.

7.17 Commissioning Assistance

The Contractor shall supply test personnel to assist with the final inspections and first livening of the switchboards as well as breaker protection setup and commissioning.

7.18 Approved Equipment Selection

All Minor items and equipment should be confirmed with Employer prior to ordering to ensure compatibility with existing systems, training and spares.

7.19 MCCB Units

MCCB's shall be mechanically interlocked to ensure that access can only be accessed to and normally live parts when the units are in the 'OFF' position. In the 'OFF' position all normally live parts shall be shielded to prevent accidental contact. The operating mechanism shall be arranged such that when the door is open the switch can be turned to the 'ON' position. Where special tools are required for this purpose the Contractor shall supply one set of tools for each MCC. Provision shall be made for padlocking all operating handles in the 'OFF' position.

The operating handle shall still be interlocked with the door to prevent opening the MCC cell with live components. MCCB shall be of the double break type, ensuring that links are isolated from supply voltages when the device is in the 'OFF' position. This requirement allows the links to be changed without a switchboard shutdown. MCCB units in motor circuits shall interrupt the control active conductors when in the 'OFF' position. MCCB units shall be provided with clear, easily read ON/OFF indication.

7.20 Incomer Circuit breakers (ACB / MCBs)

All incomer circuit breakers shall be assembled on withdrawable carriages and arranged to automatically align within the switchgear cubicle without joggling. Interlocking mechanisms shall be provided for selection of SERVICE, TEST, and ISOLATED positions ACB / MCBs shall have the following features:

1. Automatic shutters to protect both line and load side fixed portion of plug-in contacts
2. The shutters shall be pad lockable
3. Be of the 'trip free' type

4. Be interchangeable for units of the same rating within the same switchgear assembly
5. Have a motorised spring charged, stored energy spring closing mechanism, with manually operated release.
6. Have suitable protection relays integrally fitted complete with over current protection in each phase and earth fault protection with very inverse (or inverse cubed) IDMT and short time plus instantaneous protection. The current and time settings shall be independently adjustable for each IDMT and instantaneous relay, and with each element capable of being set to OFF.
7. Have suitable protection relays integrally fitted to provide restricted earth fault protection to the HV cable and LV winding of the step-up transformer. A single multifunction protection relay forming part of the ACB / MCB is preferred.
8. Have a metering capability. A separate multifunction power meter complete (Schneider PM810 series or equivalent complete with Ethernet / Modbus TCP communications module), with the necessary interposing VTs and CTs shall be provided.
9. Have tripped indication for each relay, and preferably for each element, and a manual reset facility.
10. Have test terminals to facilitate secondary injection tests of protection relays.
11. Have a MANUAL direct trip push button.
12. Have provision for REMOTE tripping from the clean contacts on the transformer (over temperature, over pressure)
13. Have mechanical indication devices for ON, OFF, TRIPPED, SPRING CHARGED, and SPRING NOT CHARGED
14. Have interlocks for the prevention of insertion or withdrawal of the circuit breaker truck when the circuit breaker is in the ON position
15. Be possible to discharge the closing spring without closing the circuit breaker contacts, either manually, with the circuit breaker racked in and the main contacts in the OFF position or automatically when the breaker is being racked out from the Service to Test position
16. Have a minimum of two (2) type ‘a’ and two type ‘b’ auxiliary contacts wired to terminals for use by others
17. Have a ‘a’ auxiliary contact for the remote tripping of the incoming HV breaker to the main transformer
18. The auxiliary supply for incomer circuit breakers shall be provided from the incomer cables or from an ancillary

Where incomer circuit breakers are specified as having a spring charged closing mechanism, the following shall apply:

1. It shall not be possible for the circuit breaker to close while the spring is being charged.
2. It shall be necessary for the spring to be fully charged before it can be released to close the circuit breaker.
3. It shall be possible to charge the spring when the circuit breaker is open or closed.
4. The closing mechanism shall not be dependent upon one spring only.
5. A limit switch shall be provided for remote spring charged indication.

The following operator controls and indications shall be provided:

1. Open and Closed indication via LEDs.
2. Trip / Off / Close spring return-to-centre operator switch.

7.21 Motor Starter Units

Each module shall be equipped with the following equipment as a minimum or alternately as shown in the standard schematic drawings.

1. Motor isolating fault/load make/break MCCB unit.
2. Motor contactor 120Vac.
3. Protection current transformer (if required) and motor protection relay complete with manual reset.
4. Three-position selector switch (Remote / Off / Local)
5. Local stop and start push buttons.
6. Indicator LEDs - 2 of, Red and Amber (120Vac).

7.22 Heater Units

Each module shall be equipped with the following equipment as a minimum or alternately as shown in the standard schematic drawings.

1. Heater isolating fault/load make/break MCCB unit.
2. Heater contactor 120Vac.
3. Protection current transformer (if required) and motor protection relay complete with manual reset.
4. Three position selector switch (Remote / Off / Local).
5. Local stop and start push buttons.
6. Indicator LEDs - 2 of, Red and Amber (120Vac).

7.23 Contactors

Contactors shall provide Type 2 co-ordination with their respective fuses or MCBs under short conditions. Contactors shall have a utilization category of AC4 in accordance with AS/NZS 60947.4.1 or equivalent IEC standard and a mechanical life of 10×10^6 operations and be suitable for uninterrupted duty. Contactors shall be fitted with a minimum of two spare ‘normally open’ auxiliary switches wired to

terminals. These are in addition to those shown on the schematics. Reversing starters and change-over contactors shall be electrically and mechanically interlocked.

7.24 Control Relays

All control relays shall be of the plug-in type with screw or clip retainers. Relays of different voltages shall not be interchangeable. All relays shall be supplied with integral push-to-test buttons and LED indicators. Shunt diodes shall be connected across the relay coils of all DC control relays.

7.25 Motor Protection

Appropriately rated ambient compensated thermal overload relays shall be fitted in all three phases and all contactors shall have an inherent under-voltage release. Thermal relays shall be of the 'trip- free' design. Where required thermal overload relays for motors shall be operated via current transformers supplied under this contract.

Protective devices shall be supplied complete with electrical reset features initialised from the auxiliary contacts on the STOP push button. Thermal overload relays shall provide single phasing protection.

7.26 Indicator Lights

All indicators shall have LED type replaceable globes. LED colours shall be as follows:

Motor Starters / Heaters;

Green:	Off, Open OR Stopped
Red:	On, Closed OR Running
Amber / Orange:	Fault AND Trip
White and Blue:	For other Conditions, 'plant ready' etc.

Main Circuit Breakers / Bus Couplers:

Circuit Breaker Open:	Green
Circuit Breaker Closed:	Red
Trip Circuit Healthy:	White
Incoming Supply Available:	Red, Yellow, Blue (one for each phase)

7.27 Current Transformers

All current transformers shall be Class 1, Class 5P10, 5/10/15VA according to requirement and have a rated secondary current of 1A.

7.28 Cables and Wiring

Switchgear assemblies shall be completely factory wired. All wiring shall comply with the requirements of AS/NZS 3000 or equivalent IEC standard. All wiring shall be carried out in a neat and secure manner, and shall be either loomed or enclosed within wiring ducts. Wiring ducts shall be plastic and shall have positive continuous clipping (or clamping) edges on both the wiring channel and cover. Wiring ducts shall have at least 30 % spare space.

Equipment shall be arranged to allow adequate space for the installation and termination of all internal and external wiring. Flexible wiring shall be used to door or hinged panel mounted equipment. Wiring shall be arranged in a manner that prevents any strain or chafing of the wiring over the full travel of the door or panel. Suitable protection such as spiral wrap shall be used on door looms. Self-adhesive wiring supports shall not be used.

The neutral termination for each compartment shall be connected directly to the Main Neutral bar. Each wire connected to the main neutral bar and earth bar shall be identified with its own particular wire number. Stranded conductors shall be terminated with insulated crimping lugs, with separate lugs used for each conductor.

All wiring shall be colour coded. All control wires (including neutrals) internal and external to compartments and power wires external to compartments, shall be identified at each termination with numbered ferrules. Ferrules shall be of white insulating material with black numbers.

All outgoing power wiring shall be arranged to allow the use of a clip-on ammeter for testing purposes. Wiring shall be arranged so that not more than (2) two wires are connected to any particular equipment terminal screw or stud. All control wiring shall be terminated at equipment and terminals using pre-insulated, crimp type lugs or pins. Where an assembly is split for transport, each wire shall be legibly identified.

7.29 Incoming Supply

Non-ferrous gland plates, suitable for the specified cable, shall be supplied as part of the switchboard. Drilled termination flanges shall be provided for the cable with adequate clearance for the installation of lugs. A clear plastic barrier shall be provided behind the incomer access covers to prevent inadvertent contact with normally live items when the access covers are removed.

7.30 Extra-Low Voltage Circuits and Equipment

Extra-low voltage equipment, control wiring and busbars shall be grouped and separated from low voltage equipment. Extra-low voltage transformers shall have an earthed screen between the primary and secondary windings. These screens shall be connected directly to the earth busbar.

7.31 Terminal Strips

All field cables, except main power cables, shall terminate on fully identified terminals or terminal strips of adequate size and current rating. For fixed and demountable functional units, power cables for circuits rated above 60 Amp shall be connected directly to equipment terminals or lugs. Space shall be provided to enable the installation and termination of such cables.

Terminals shall be clip-in tunnel type equivalent to Weidmuller SAK6N as a minimum. Where terminal strips are mounted in the cable compartments they shall be mounted vertically and at an angle to the point of access, e.g., front, to facilitate both installation and termination of cabling. Extra-low voltage terminals shall be grouped and separated from terminals of other voltages by means of approved barriers. Each terminal strip shall have at least 30 % spare terminal space. Terminals for power cables shall be sized for termination of cables. Terminals shall be sized and arranged so that one wire only is terminated in each side of each terminal block. Extra terminals with bridging connection links shall be provided where multi-terminations occur. Each connection and terminal shall be numbered in accordance with the respective circuit diagram. Terminal strips shall be identified in accordance with schematic and/or termination diagrams. All spare ancillary controls shall be wired to terminals on terminal strips. Barriers shall be installed on each side of groups terminals associated with spare controls.

7.32 Tinned Copper Cabling

All conductors, bus bars, neutral and earth bars, flexible cables or bus ways, small panel wiring and the like shall be tinned copper.

7.33 Identification Labelling

A switchboard identification nameplate in accordance with AS/NZS 61439.1 shall be provided or equivalent IEC standard.

All equipment shall have engraved Traffolyte labels, fastened with screws or plastic rivets. The following labelling shall be provided:

1. Each MCC shall have an equipment label engraved in 12mm high lettering with the designated name of the switchboard.

2. Each incomer shall have an equipment label engraved in 12mm high lettering with the incomer name and designation number and the source of supply, e.g.

INCOMER XXX SUPPLIED FROM TRANSFORMER TX

3. Each cubicle or tier of an MCC shall have a tier number label engraved in 10mm high lettering with the tier number.
4. Each MCC module shall have a label engraved in 7 mm lettering with the motor or feeder name. Each module will have a small label indicating the module position in the tier (i.e. F3) and a duplicate label shall be installed inside the frame of the demountable cell to allow easy identification during assembly
5. Each item of equipment within MCCs, e.g. fuses, contactors, timers and relays, and door mounted items such as pushbuttons, indicator lights, control switches and meters shall have a label engraved in 4mm high lettering with the designation shown on the schematic diagrams. The labels shall be fixed adjacent to the item and may be mounted using adhesive fastenings.
6. Warning labels shall be engraved in white lettering on red background. All other labels shall be engraved in black lettering on a white background.
7. All identification and labels shall be in the English language.

7.34 Warning Nameplates

Nameplates reading ‘DANGER LIVE BUSBARS’ shall be affixed on each removable cover of busbar chambers or incoming supply connections. Each shroud over terminals or normally live bare metal shall be labelled ‘DANGER - LIVE TERMINALS’.

7.35 Painting

Unless specified otherwise, MCCs shall be painted as follows:

1. All metal shall be de-scaled and rust removed prior to applying a metal primer. At least two finish coats of enamel shall be applied both to the inside and outside of the panels
2. All internal gear trays shall be painted ‘white’
3. Contractors standard paint system may be used subject to prior approval

7.36 Inspection

The Employer reserves the right to inspect the work and progress at any reasonable time during manufacture. Inspections may be carried out at the following stages:

1. Completion of panel fabrication
2. Commencement of panel wiring

3. Completion of panel wiring
4. Immediately prior to dispatch for factory acceptance testing
5. At any other time mutually acceptable to the Contractor and the Employer

7.37 Testing

All equipment shall be tested in accordance with AS/NZS 3080:2007. Type test certificates as specified in AS/NZS 61439.1 Clause 10 shall be supplied with the Tender. Routine Tests, in accordance with AS/NZS 61439.1 Clause 11 shall be carried out at the Contractor's works with opportunity for witnessing by the Employer and/or Client's Engineer, and shall be signed off by the Employer before shipping.

The contractor shall prepare FAT documentation outlining tests and procedures. These test sheets will be approved by the Employer before commencing FAT.

All test results shall be provided to the Engineer for final approval prior to equipment dispatch to site.

These tests shall include:

1. Micro ohm meter, the test shall be complete with a detailed footprint diagram
2. Dielectric tests
3. Contact resistance on circuit breakers
4. Functional tests on all circuit breakers
5. Ratio and impedance tests on current transformers
6. Insulation resistance
7. Earth continuity
8. Functional sequence testing, interlocking testing and operational testing
9. Primary injection testing of all protective relays and devices

8 PLCs, CONTROLS CABINETS, JUNCTION BOXES

8.1 General

If PLCs, Control Cabinets are installed as part of the Contractor design, then the Contractor shall implement the following design requirements.

8.2 PLCs / Control Systems

PLCs and Control Systems for the PV System local and remote monitoring and control shall be provided to monitor, control, display, alarm, and record operation of the PV Systems. The PLCs and Control Systems shall fully integrate with the Employers remote control system and incorporate comprehensive system diagnostics to assist in maintenance and troubleshooting.

PLCs and Control Systems shall include processor modules, power supplies, input/output cards, communication cards or any other specialty cards to provide a fully functioning system. The Processor and I/O bus shall have minimum of 25% spare capacity at the end of the commissioning for future works at the PV site.

8.3 Cabinet General Requirements

There are two types of cabinets to be used in the Contactor designs;

- PLC / Control Cabinets Indoor Installation - Based on a Rittal standard cabinet designs
- PLC / Control Cabinets Outdoor Installation - Purpose built stainless steel cabinets

These PLC cabinets shall contain PLC components, and their standard I/O connections, as well as the fibre, small wiring, AC and DC distribution systems and all of the PLC / control system components.

The PLC / Control Cabinets scope shall include the following:

a) Supply of the PLC cabinets for the installation in accordance with the following specific and common drawings, completely wired with all terminals, and ancillary equipment
b) Supply and installation of all PLC components, backplanes, connectors, terminators, power supplies and the like
c) Supply and installation of the associated 120Vdc charger, battery, and DC distribution systems
d) Supply and installation of the associated fibre terminations and connection systems, fibre patch lead, and fibre to copper converters, copper patch leads, network switches and the like
e) Provision of any workshop drawings where the designs are altered from the arrangements provided herein

f) Inspection and testing plans and testing documentation
g) Assembly at the manufacturer's works and first livening
h) Allowance for a hardware Factory Acceptance Test (FAT) at the manufacturer's works by the Employer and their representatives
i) Delivery to site following acceptance by the Employer of the manufactured panels
j) As-built documentation

8.4 Indoor PLC Cabinets

The PLC cabinets are to be Rittal cabinets. Summary of key component specifications below:

- Rittal Cabinets – Baying System TS8
- Dimensions – As required by Contractor Design
- Colour – RAL 7035 (light grey)
- Cabinet Rating - IP55
- All equipment mounted on a removable painted gear plate
- Full width two-piece undrilled aluminum gland plate
- Plinth for floor mounted cubicles
- Strengthened backplate or superstructure for wall mounted units
- Three point securing location lockable doors with lockable operating handles
- Earth bar and copper earth straps to all doors
- External panel label (traffolyte or similar)
- All internal wiring tinned copper
- All instrument earth bars, phase, neutral and earth bars to be tinned copper
- No nickel fittings, nor exposed copper
- Internal wiring secured in slotted cable PVC trunking
- Plinths;
    - PLC Cabinets – 100mm x 50mm steel channel (minimum)
- Gland Plates – Aluminium
- PLC Cabinets to be complete with;
    - Internal lights (one per cubicle) operated from door switches
    - RCD GPO
    - Thermostat and Heater
- Equipment Labels;

- All internal equipment to be labelled (PLC, PLC cards, communications equipment, IO termination blocks, monitoring equipment, power supplies etc.) – engraved traffolyte
- Exterior labels – engraved stainless steel

8.5 Outdoor PLC Cabinets

The PLC cabinets are to be purpose-built stainless steel cabinets. Summary of key component specifications below:

- Cabinets – Purpose built, stainless steel
- Dimensions – As required by Contractor Design
- Cabinet Rating - IP56
- All equipment mounted on a removable painted gear plate
- Full width two-piece undrilled aluminium gland plate
- Plinth for floor mounted cubicles
- Strengthened backplate or superstructure for wall mounted units
- Three point securing location lockable doors with lockable operating handles
- Earth bar and copper earth straps to all doors
- External panel label (traffolyte or similar)
- All internal wiring tinned copper
- All instrument earth bars, phase, neutral and earth bars to be tinned copper
- No nickel fittings, nor exposed copper
- Internal wiring secured in slotted cable PVC trunking
- Plinths – Integral to cabinet
- Gland Plates – Aluminium
- PLC Cabinets to be complete with:
  - Internal lights (one per cubicle) operated from door switches
  - RCD GPO
  - Thermostat and Heater
- Equipment Labels;
  - All internal equipment to be labelled (PLC, PLC cards, communications equipment, IO termination blocks, monitoring equipment, power supplies etc.) – engraved traffolyte
  - Exterior labels – engraved stainless steel

Factory Acceptance Testing and Client witness testing of all PLC cabinets, Control Cabinets, and the like is to be completed before equipment is sent to site.

8.6 Junction Boxes

All Junction Boxes shall be manufactured from standard cubicle designs (Rittal or similar) complete with:

- Original supplier's surface finish
- IP65 rating minimum for all floor mounted cubicles
- IP65 rating minimum for all wall mounted cubicles
- All equipment mounted on a removable painted gear plate
- Full width single piece undrilled aluminium gland plate
- Plinth for floor mounted cubicles
- Strengthened backplate or superstructure for wall mounted units
- Three point securing location lockable doors with lockable operating handles
- Earth bar and copper earth straps to all doors
- External panel label (traffolyte or similar)
- All equipment labelled with schematic item designation (traffolyte or similar)
- All internal wiring tinned copper
- All instrument earth bars, phase, neutral and earth bars to be tinned copper
- No nickel fittings, nor exposed copper
- Internal wiring secured in slotted cable PVC trunking

9 120Vdc TRIPPING / BATTERY CHARGER

9.1 General

If 120Vdc Tripping / Battery Chargers are installed as part of the Contractor design, then the Contractor shall implement the following design requirements.

9.2 Control and Tripping Battery and Charger

The protection and control, and circuit breaker spring charge motor shall be rated 120Vdc, with PLC and control system interface rated at 120Vdc.

A self-contained nominal 120Vdc tripping battery/charger systems shall be supplied if required under this contract, along with 120Vdc supply system for PLC and control system interface.

This unit shall operate from a 120Vac single phase or three phase supply, and be complete with a comprehensive float and boost battery management system.

The batteries shall be of the sealed lead acid type and sized to operate each switchboard for a nominal twenty-four (24) hours without AC power.

The charger and batteries shall be housed in a free-standing cubicle complete with ventilation grills and lockable doors and supplied completely wired and operational suitable for the environmental conditions.

Monitoring of the 120Vdc systems for alarms and status shall be via digital IO and serial communications. Contractor to confirm serial communications during the design, however all major equipment shall be on the same communications platform for remote monitoring.

10 TESTING AND COMMISSIONING

10.1 General

The Contractor shall prepare an Inspection and Test Plans (ITPs) covering all aspects of the works; these shall be submitted to the Employer for review and approval prior to any Inspection and Testing of the works. The Contractor shall carry out inspection and testing in accordance with the best industry practice and manufacturers recommendations.

The Employer reserves the right to inspect the Works to the extent necessary to satisfy himself that the work conforms to the drawings and specifications and to verify that all the required testing and inspections have been completed to the satisfaction of the Employer and Client Engineers.

The Employer may appoint an Inspection Agency to carry out inspection services and to witness and verify tests. The Contractor shall liaise and co-ordinate fully with the Inspector and take all necessary measures to facilitate testing and verification.

The ITPs shall clearly define the objectives, any pre-requisites and pass / fail criteria. The pass criteria shall be correct operation. Any failed test shall be rectified by the Contractor. On the identification of a failed test the Employer reserves the right to halt all further testing until satisfactory remedies have been implemented and recorded. The resumption or continuation of testing shall be on the approval of the Employer and noted on the Corrective Action Request (CAR) sheet.

The ITP shall be marked up during testing and each test signed as completed by the Contractor and witnessed by the Employer. A copy of the signed off ITP and related test certificates shall be delivered to the Employer in electronic form at the successful completion of the tests.

The ITPs shall include but not be limited to:

- Methodology
- Checklists
- Manufacturer factory test certificates
- Employer involvement including Witness and Hold points
- Acceptance criteria
- Sign-off sheets

No testing shall commence before the ITP has been approved by the Employer.

10.2 Mechanical Tests

10.2.1 General

The Contractor shall carry out Pre-Commissioning Tests immediately following completion of installation of the Works and prior to completion, in accordance with the Contract. The purpose of the Pre-CommissioningTests are to confirm that the installation of the Plant is complete and correct, and in a safe condition for livening and operation.

10.2.2 Electrical Pre-Commissioning Tests

The Contractor shall pre-commission all of the electrical works.

The Electrical Pre-Commissioning Tests shall include all requisite cold checks, high potential testing, meggering, phasing, insulation resistance, continuity, point to point termination checks, polarity, phase rotation, protection testing and functional operation of all devices and controls.

The Contractor shall provide all suitably calibrated test equipment to perform all pre-commissioning and post livening tests and suitably qualified and experienced personnel to provide the testing.

The Contractor shall provide detailed test sheets for the commissioning of each protection and metering type. The Employer test sheets shall be limited to an overall check sheet encompassing all checks suitable for sign off before livening.

No item of plant shall be livened until clearance is obtained from the Employer, at which time the necessary warning notice in accordance with safety procedures shall be attached to the relevant circuit switch or isolator, and where appropriate, to the plant item itself.

The Electrical Pre-Commissioning Tests shall include but not be limited to the following:

10.2.3 Visual Inspections

Visual inspections shall include:

- Checking plant for conformity with specifications
- Removal of packing or protective materials from instruments, equipment and devices
- Systems complete “component count”
- Switches, fuses and ancillary equipment correctly labelled and set to appropriate

current ratings

- Checking all fasteners, fittings, supports, alignments and clearances
- Checking rotation direction of all drives
- Checking of all earthing
- Electrical systems certified for compliance with the relevant standards

10.2.4 Switchgear

Tests to be carried out on the switchgear shall include, but not be limited to the following:

- High potential tests on busbars, including metal enclosed bus, and switchgear.
- Contact resistance measurements of joints in bus and cable connections.
- Mechanical tests.
- Point-to-point wiring continuity checks on all low voltage circuits to confirm that the final connections agree with the panel wiring diagrams.
- Meggering at the appropriate voltage of all high voltage circuits.
- Energizing of all low voltage circuits.
- Functional testing of all equipment including interlocks

10.2.5 Motors:

Motor tests shall include:

- Insulation resistance measurement
- Phase rotation check
- Vibration
- Shaft Alignment

10.2.6 High Voltage Cables

All high voltage cables shall be tested for:

- Continuity

- Ductor testing of terminations
- Pressure tests (high voltage AC only)
- Correct phasing
- Labelling
- High voltage terminations shall be included in the test circuit.

10.2.7 Control and Instrument Cables

Control and instrument cables shall be tested for:

- Continuity
- Labelling
- Terminations against schematics
- Removal against schematics

10.2.8 Low Voltage Cables

Low Voltage cables shall be tested for:

- Continuity
- Insulation resistance
- Labelling
- Terminations against schematics

10.2.9 Earthing

Conductivity tests of the system and earthing resistance tests shall be performed at points throughout the system before any electrical equipment is energised from the permanent source of power.

The commissioning testing of the earthing system will include performance testing, continuity testing and visual inspection for design compliance. The objectives of the testing will be to:

1. Verify the safety performance installed earthing system in accordance with AS 2067-2016, ENA EG1, ENA EG0 and other relevant standards codes, guides and

legal requirements.

2. Establish benchmarks for the earthing system performance for future audits by simulated earth fault current injection tests to determine earth grid voltage rise, step and touch voltages and earthing system impedances.
3. Report on the condition of the earthing systems in terms of compliance with the design, standards and to provide a statement of compliance or non-compliance. The intent of the report is to provide a comprehensive assessment of the condition and performance of the earthing systems and provide sufficient information such that remedial action can be arranged based on the recommendations provided in the report.

The performance testing shall use the off-frequency test methodology described in ENA-EG1 to perform the following testing:

- Earth grid voltage rise (EGVR)
- Fault current distribution
- Earthing system and earth grid impedances
- Earth potential rise (EPR) voltage profiles (1000 V and 430 V as applicable)
- Prospective touch and step potentials at relevant locations inside and outside the substation
- Transfer potentials around the substation

Physical inspection of the earthing system shall include inspection of the earthing system to determine condition and compliance to design (conductor size, material, connections).

The Contractor shall carry out electrical continuity measurements on the earthing system, to a specific reference point(s), to determine whether plant equipment is adequately earthed in compliance with design and relevant standards.

10.2.10 Fibre Cables

Fibre cables shall be tested for:

- Optical Time Domain Reflectometer (OTDR) Tests, all cores in both directions:
    - Single Mode Fibres: 1310nm and 1550nm

- Multimode Fibres: 850nm and 1300nm

- Insertion loss tests
- Labelling
- Terminations against schematics

10.2.11 Protection Equipment

All protection items shall be checked for the necessary protections associated with the protection of cables/ transformers/ and motor generator sets.

10.2.12 Instrumentation

All instrument items shall be field-calibrated and a calibration certificate shall be provided for each instrument.

Instrumentation shall be tested where applicable for:

- Full loop test using primary signal injection, i.e. temperature, pressure, flow etc.
- Check of the complete measurement/display from instrument to HMI for correct display including value and unit of measure and alarm points

The Contractor shall liaise with the Employer to carry out the above and provide comprehensive calibration reports and testing check lists for each instrument.

10.3 Livening

The Contractor shall provide:

1. Undertaking ‘first livening’ (with assistance from the Employer):
    a. HV
    b. UPS and Battery Systems
    c. Local Service
    d. Transceivers
2. Function checking of all motors / pumps, solenoid valves and switches, and motorised valves and switches
3. Range checking of all instrumentation back to the SCADA
4. SCADA to field checking for operational items

All checks shall be accompanied by the necessary check sheets. Documentation shall be provided in accordance with the Contract Appendices.

10.4 Hand Over

The Contractor shall provide to the Employer signed and dated reproducible copies of Reports, Red Lined ‘As-Built’ Drawings / Schedules and Inspection Test Sheets / Plans clearly showing the extent to which Inspections and Tests have been

completed and the result of such inspection and testing.

The Contractor, in the presence of the Employer will sign off the Employer supplied check lists supplied specifically for that equipment.

The Inspections and Tests shall be deemed to have been completed when the Contractor has obtained from the Employer written verification that the said Inspections and Tests have been completed and passed in accordance with the Contract and that the Plant is ready for the commencement of the commissioning and livening.

Handover documentation to include all operator and maintenance training, and higher-level site engineer training on the equipment supplied.

For the purposes of Practical Completion, hand over shall be deemed to have occurred when the Contractor has received from the Employer the said written verifications.

11 Metal Work Specifications

The following specifications are to be adhered to for fabrication of metal work for Solomon Power. All Dimensions are in millimetres and are to be correct after galvanising.

- All metal work is to be sandblasted prior to galvanising.
- Tolerance on dimensions shall be +/- 0.5mm for hole diameters and hole spacing and +/- 1 for general dimensions unless otherwise stated.
- All steel work to be fabricated to NZS 3404:1997 sections 14 & 15.
- All steel work to be hot dip galvanized to as 4680.1999 after fabrication. Minimum average zinc coating mass to be 600 g/m2 for steel work.
- Steel work shall be grade 250 or above.
- All holes shall be drilled through steel section in a single pass.
- Members shall be punch stamped with the member name (drawing number) prior to galvanising. Identification marks shall be at least 15 mm high and clearly visible after galvanising.
- These specifications are to be read in conjunction with specifications on individual drawings. Paragraph 2 of this specification is to be adhered to in addition to all other requirements for metal work.
- All metal work may be subject to QA inspection prior to acceptance of a delivery. Any metal work not meeting the standards identified will be rejected.

12 Solomon Power Drawing Standards

As-built drawings can be red line mark ups of colour prints provided from plans of road maps. Such Drawings can also be provided in CAD in colour by electronic mail or other electronic form as approved by IAs Engineer.

All drawings shall be provided in A3 CAD (e-transmit) and PDF format in English, clearly labelled and legible. The drawings shall be in accordance with AS 1100 and shall use IEC electrical symbols.

12.1 Reticulation, Distribution System and Customer Mains and Service Drawings

12.1.1 Construction Drawings

- A plan clearly defining the locality (may be an existing distribution plan)
- For changes affecting the operation of the Network a mark-up of the Single Line Schematic
- Length of spans / lengths of UG cable runs in metres
- Pole numbers of existing poles
- Any bearings to be magnetic North
- Road names (if local knowledge can provide these on location)
- Reference to existing drawings
- Dimensions to locate ground mounted equipment, (e.g. transformers, UG cable)
- Sizes and types of cable and equipment
- Earthing details
- Fuse ratings
- Schedule of changes to equipment labels

12.2 As Built Drawings and Forms

12.2.1 The Following require ‘As Built’ details

- All Network owned OH lines, UG cables and equipment on road reserve and private property
- Point of connection to the Network detail form for customer connections
- All other low voltage UG cables and OH lines (including service mains, street light circuits) on road reserve
- Street light locations on road reserve and public access ways
- For service mains on private property. “As Built” information and numbering

are required for Network and private owned equipment, poles, cables and connection points. A selection of forms are provided for the purposes of capturing information as necessary. The IAs engineer shall approve forms for purpose on site.

12.2.2 'As Built' drawings shall provide the following information:

- Length of spans / lengths of UG cable runs in metres
- Position of plant must be clearly shown and dimensioned from existing features in Utilities GIS system
- Measurement shall be to the following standards:
    - Overhead lines
        - Rural +/- 5.0 m
        - Urban +/- 1.0 m
    - Underground reticulation
        - Rural +/- 5.0 m
        - Urban +/- 0.3 m
    - Private poles
        - Rural +/- 5.0 m
        - Urban +/- 2.0 m
    - Pole Numbers
    - Any bearings to be Magnetic North
    - Road Names
    - References to existing drawings
    - Equipment locations and specifications
    - Reference to construction drawing number
    - Sizes and types of cable and equipment
    - Earthing details

12.2.3 Drawing Scale

12.2.3.1 Utilities staff will enter each drawing into the GIS and this will be drawn full size, except where details are to be shown larger for clarity. Drawings will be scaled into the GIS system when details are confirmed.

12.2.3.2 The Contractor to provide marked up plans chosen as appropriate for the situation as agreed with the IAs Engineer to either one or more of the following standard plotting scales of:

- 1:1 1:2 1:5
- 1:10 1:20 1:25
- 1:50 1:75 1:100

- 1:200 1:300 1:400
- 1:500 1:1,000 1:1,250
- 1:2,500 1:5,000 1:10,000

12.2.4 Drawing Units

- Solomon Power drawing units are to in Metric
- Definition to 0.1 m for construction 'As Builts'
- Definition to 0.001m for construction structure and equipment detail drawings

12.2.5 Drawing Format

- All drawings presented are to show all text legible at the Scale given when printed
- Plans to be presented on plain paper 80g on sheet size A3 (or A4 if the IA's Engineer agrees) with IA title block and logo, using scale standard symbols and line weights
- The IAs Engineer will provide symbols and lines file to the Contractor

12.2.6 Consultants / Contractors Logos

- No Consultants or Contractors Logos are to be placed on the drawings. These can be listed as appropriate in the issue section of the title block

12.2.7 Drawing Numbers

- Drawing Numbers will be issued by the IAs Engineer
- These numbers will be inserted into the drawing number section of the title block and will be used as the basis for all referencing between drawings and details.
- The consultants or Contractor may include their own number system in the notes area.

12.2.8 Drawing Revisions

- The issue status will be shown in the issue box of the Title Block.
- For each amendment after that use a alphabetic character e.g. "A" through to "Z"

12.2.9 Drawing Statues

A drawing can be in one of three states:

- Concept Prior to detailed design
- Design Prepared prior to work being carried out
- As Built Showing actual details at the completion of works

12.2.10 Amendments

- For each amendment or issue of a drawing, the current status must be shown first on the amendment line followed by a brief description of the changes and who carried them out.
- For each amendment a cloud is to be drawn on the plan (or 'amend' layer) around affected parts and label with the amendment letter.

Use a different colour for each amendment shown on the same plan submitted.

12.2.11 Drawing Approvals

- Two hard copies must be provided to IAs Engineer for concept approval purposes.
- All maps and drawings on plain paper 80g on sheet size A3 (or A4 if IA engineer agrees) with IAs Engineer title block and logo, using scale standard symbols and line weights.
- Further documentation is required as follows, two (2) hard copies must be provided of each.
- All Concept, Design, As Built drawings submitted shall be signed by the draughts person, checked by another suitably experienced / qualified person and approved by the Contractor.
- Acceptance by the IAs Engineer shall appear on all drawings prior to release for construction
- Acceptance by the IAs Engineer shall appear on all drawings prior to release for As Built by Solomon Power's GIS staff

13 Switching Request Standards

Switching is to be planned fully before any approach is made to SP to arrange for planned Electricity Network Shutdowns.

A marked-up drawing/s showing the area concerned shall be provided and can be red line mark ups of colour prints provided from plans of road maps.

These will have proposed construction works imposed upon them to show the affected area.

A marked-up drawing/s showing the area concerned shall be provided and can be red line mark ups of colour prints provided from plans of SP Electricity Network Single Line Diagram.

Such drawings can also be provided in CAD in colour by electronic mail or other electronic form as approved by SP's Engineer.

13.1 Network Shutdown Release

13.1.1 Arranging Shutdowns

13.1.1.1 SP Staff or Contractors Arranging Shutdowns shall provide the following information:

- Switching is to be planned fully before any approach is made to Utilities to arrange for planned Electricity Network Shutdowns
- A marked up drawing/s showing the area concerned shall be provided and can be red line mark ups of colour prints provided from plans of road maps.
- These will have proposed construction works imposed upon them to show the affected area.
- A marked up drawing/s showing the area concerned shall be provided and can be red line mark ups of colour prints provided from plans of SP Electricity Network Single Line Diagram.

13.1.2 Drawings

13.1.2.1 Positions Shown Clearly

- Position of plant must be clearly shown and relative to existing features in SP GIS system and Utilities Electricity Network Single Line Diagram.
- Pole Numbers
- Any bearings to be Magnetic North
- Road Names
- References to existing drawings
- Equipment locations and specifications
- Reference to construction drawing number
- Sizes and types of cable and equipment

13.1.3 Shutdown Request Notice

13.1.3.1 All switching shall require prior notification to the Utilities in every case:

- High Voltage
- Low Voltage
- Low Voltage Mains
- Low Voltage Services

13.1.3.2 All switching involving work in Any Urban areas shall require prior notification to SP's Engineer in all cases, who will consider offering assistance to advise customers or otherwise advertise the plan prior to the event.

- Up to 30 customers 1 working day
- Over 30 customers 4 working days

13.1.4 Network Switching to be done by IA

13.1.4.1 Unless otherwise agreed by the Utilitiies:

- All High Voltage switching is required to be carried out only by SP staff
- All Low Voltage switching at the Transformer is required to be carried out only by SP staff

13.1.5 Network Switching to be done by The Contractor

13.1.5.1 Unless otherwise notified by the SP's Engineer, all Low Voltage switching at a position other than the Transformer is able to be carried out by the Contractor

13.1.5.2 Otherwise SP staff shall complete switching as necessary.