LETHABO SOLAR PV FACILITY EMPLOYER'S REQUIREMENTS

ESKOM HOLDINGS SOC LTD

Document Reference Number: 375-172742

Alternative Document Reference Number: R00000014-LET-SOLPV-ERS

13 September 2023

"It always seems impossible, until it is done."

Nelson Mandela

MPAMOT (Pty) Ltd
Subsidiary: MPAMOT Africa (Pty) Ltd

Head office: Gauteng Region
147 Bram Fischer Drive
Ferndale
Randburg
South Africa
☽+2711 052 1000

KwaZulu Natal Region:
Liberty Building
21 Aurora Drive
Umhlanga
Durban
South Africa
☽+27 31 8241000

Western Cape Region:
The Towers Building
Cnr Heerengracht and Hertzog Boulevard
Cape Town
South Africa
☽+27 21 820 5900

Contents

FIGURES

TABLES

ANNEXURES

ANNEXURE A. ACRONYMS AND DEFINITIONS

ANNEXURE B. TECHNICAL STANDARDS AND REGULATIONS

ANNEXURE C. LETHABO PV SWITCHING STATION AND OVERHEAD LINE TO RWB LETHABO POWER STATION

ANNEXURE D. LETHABO SOLAR ENERGY FACILITY NETWORK DIAGRAM

1 INTRODUCTION

1.1 DOCUMENT PURPOSE

Eskom Holdings SOC Ltd (the "Employer") desires to engage the services of an Engineering, Procurement and Construction (EPC) Contractor (the "Contractor") to undertake, on a lump-sum basis under an EPC Contract (the "Contract"), all studies, permitting, design, engineering, procurement, manufacturing, deliveries to Site, execution, erection, commissioning, testing, completion, operation and maintenance (O&M) until the end of the Defects Liability Period, making good defects and warranty cover during the Defects Liability Period, and other works (altogether defined as the "Works") necessary to construct a solar photovoltaic (PV) power Plant (the "Plant"), the access road, the Site facilities and any additional infrastructure (the "Project").

This document represents the Employer's Requirements and specifies the minimum technical requirements that must be fulfilled by the Contractor to undertake the Works, with a minimum design lifetime of all components and structures of at least 25 years starting from the Date of Completion.

The Employer's Requirements will be part of the Contract and all capitalized terms shall have the meanings given to them in the Contract, except as otherwise defined herein.

Any acceptance, approval, response, or comment given by the Employer under or in connection with the Employer's Requirements shall not relieve the Contractor of any responsibility under the Contract, except to the extent expressly provided otherwise.

1.2 GENERAL DESCRIPTION OF THE PROJECT

The Project shall be composed of a single PV power Plant, using PV modules mounted on a single axis (north-south) tracking system or fixed tilt (single tilt and azimuth) structure. The maximum AC capacity is indicated in Table 1, defined as the sum of the AC power of the inverters at the inverter level with a power factor of 1 and 50 ºC of operational temperature. It is to be noted that the maximum export capacity for the Project is 75 MWac.

A minimum DC/AC ratio of 1.15 is to be used and applied to the Plant's maximum rated AC capacity at the inverter level with a power factor of 1 and 50 ºC. Thus, if the Project has a maximum rated AC capacity of 75 MWac at the inverter level with a power factor of 1 and 50 ºC, the minimum installed DC capacity (front + rear side in case of bifacial) will be 86.25 MWp at Standard Test Conditions (STC).

The Plant shall be designed for efficient and long-term operation, optimising LCOE, and Performance Ratio.

Table 1: Plant total installed and maximum AC capacity

Plant	Minimum DC/AC Ratio	Maximum AC capacity (MWac) at the inverter level with a power factor of 1 and 50 ºC of operational temperature.
Lethabo	1.15	75

The Project is located within the borders of South Africa in the Metsimahalo municipality, located in the Free State Province, and near to the Lethabo power station and close to the RWB Lethabo Substation. The city Vanderbijlpark is located about 27 km from the Site. Table 2 shows the location of the Plant through the respective coordinates of the centre point for the site.

Table 2: Plant location and total area

Plant	Number of plots/areas	Total area (Ha)	Coordinates of the central point
Lethabo	1	162	26°44'47.544" S, 27°57'17.312" E

The Project grid connection includes a new switching station and overhead line (OHL), connecting to the existing RWB Lethabo Substation as shown in Figure 1 and Annexure C. The Project design layout shall be done considering the possibility of the future installation of a Battery Energy Storage System (BESS) for the Plant. The battery limits for the Project are defined in Section 3.2, noting that the Contractor is expected to coordinate and liaise with the HV Contractor in relation to the interfaces, design inputs, commissioning, energisation, and Grid Code compliance for the Project.

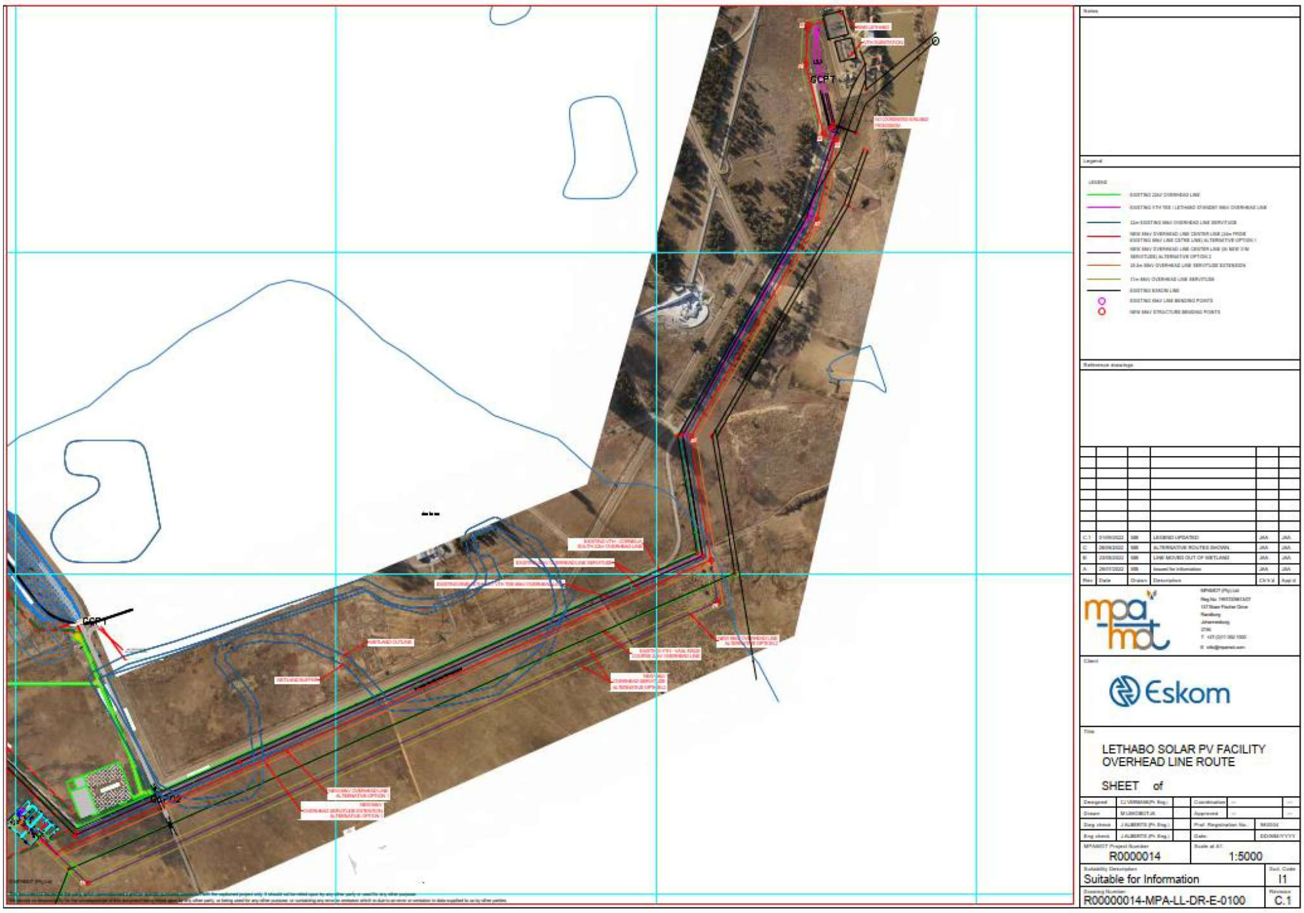

Figure 1: Lethabo PV switching station and overhead line to RWB

1.3 Statement of Compliance

It is the responsibility and scope of the Contractor to include the whole of the Works which are described in, or implied by, these Employer's Requirements. All items which are omitted from the Employer's Requirements, but which can be inferred to be necessary for the safe, efficient, and reliable operation of the Project during its lifetime, requiring minimum maintenance with minimum staffing consistent with prudent industry practice, shall be deemed to be part of the Works and the responsibility of the Contractor. No additional cost payable to the Contractor shall be allowed for any item which the Contractor has not considered but that is needed for the proper completion of the Works in every respect.

The Contractor shall carry out the Works in accordance with and taking into consideration any requirement imposed by all necessary Permits, Licenses, Authorisations, national laws, local (by-)laws, regulations, and environmental and social assessments needed to obtain the necessary construction permits from local, regional, and national authorities as applicable.

The Contractor shall be responsible for all necessary studies, government approvals, and permits required for performing the Works, even for those for which the authorisation process is still ongoing and final design requirement changes may take place.

The Contractor shall comply with all the requirements included in the already available and future applicable Permits, Licenses and Authorisations, which will prevail in case of conflict with the Employer’s Requirements.

The Contractor shall comply in all instances with the requirements of these Employer’s Requirements, unless compliance would (for any reason) risk their safety, reliability, or conflict with any Applicable Laws, Permits, Codes and Standards. No defect, error, or omission in this document in relation to any design, specification or method set out herein shall relieve the Contractor from their responsibility to provide a fully operational Project, capable of delivering the defined capacities and meet the expected performance over the full range of expected operating conditions, and for the expected lifetime of the Project.

The Contractor shall be responsible for the full design of the Project and shall submit the design to the Employer for the Employer’s review, as per a Master Document List (MDL) to be agreed between the Employer and the Contractor. Review and comments by the Employer to the Contractor´s design documents shall in no way diminish the Contractor's contractual obligation and ultimate design responsibility for the correctness and adequacy of the design.

Any omissions, deviations, and/or conflicts in requirements between the Employer’s Requirements, the referenced standards, Applicable Laws, Permits, Codes and Standards, and other associated Project Documents noted by the Contractor, shall be notified as soon as identified to the Employer for clarification. The Contractor shall be responsible for any work and cost associated with any omissions, deviations and/or conflicts not notified by the Contractor to the Employer.

2 CONTRACTOR SCOPE OF WORK (SUPPLY AND SERVICES)

2.1 General

The Contactor scope of work shall cover, among any other activities indicated in this Employer's Requirements, the following (but not limited to) in relation to the Works:

- The procurement and delivery of the studies, designs, engineering, licensing and permitting, manufacturing, factory testing, deliveries to Site (including customs duties and importation), project management, project cost control, supervision, documentation, labour, execution, erection, progress reporting, commissioning, testing, completion, training, and other works necessary to construct and safely operate the Project;
- All security, fire protection, health, safety, environmental, and socio-economic requirements as included in any relevant environmental and social assessments, Applicable Laws, Permits and Codes and any other Project Documents;
- All plant, equipment, materials, and work required to complete the Works; and,
- Making good defects and warranty cover during the Defects Lability Period.

The Contractor shall follow the Good Industry Practice, Prudent Industry Standards and comply with all requirements included in the Project Documents and the Applicable Laws, Codes and Standards.

The references in these Employer's Requirements to the Employer shall be interpreted as a reference to the Employer or its representatives, according to the Contract or any other Project Documentation.

Further details of the Contractor's scope of works are defined in the section below which sets out the minimum Project's requirements. It is not intended to provide a complete list of activities to be performed but rather functional specifications, which are intended to be used as a guideline and does not detail interfaces between Subcontractors.

The words "including" and "includes", or any variants of those words, will be read as if followed by the words "without limitation".

2.2 Project management

The Contractor shall provide the overall project management services to manage the Contract and the execution of the Works, including (but not limited to) the following:

2.2.1 Project management

- Conduct and attend meetings as indicated in section 6.1.4 and as required by the Employer or its representative(s) during the execution of the Works, including the engineering, procurement, construction, commissioning, and Defects Liability Period phases of the Project.
- Timely submission as required by the Employer for its review (as applicable), and implementation of all the relevant management plans as further discussed in section 6.1.3.
- Any plan relevant to construction activities shall be submitted prior to the commencement of the Works.
- Timely submission of detailed monthly progress reports, according to templates to be agreed with the Employer.
- Procurement of all permits, licenses and authorisations required to be granted to the Contractor to execute the Works, including (but not limited to):

  –heritage matters;

  –occupational health and safety;

  –construction permits;

  –licenses and authorisations related to building regulations standards;

–permits and consents related to roads;

–labour and personnel;

–taxes and customs;

–land;

–permits relating to electrical works;

–environmental permits; and,

–other permits, such as civil aviation authority consent, Water Supply, etc.

- Provide inputs, documentation, and draft notices as required by the Employer in relation to the permits, licenses and authorisations granted to the Employer.
- Provide and maintain a document register which shows the status of all Contractor's documents to be delivered. It should indicate the title, number, revision, planned issue date for Employer's review, actual issue date for Employer's review, and review status.
- Liaise, in collaboration with the Employer, with other parties involved in the development of the Project, if required.
- Provide and maintain required insurances and bonds during construction, according to the Contract.
- Provide a Project organogram, including qualifications of management and supervisor team. Proof of individual's experience for key positions (such as Project Manager, Site Manager, Health, Safety, and the Environment (HSE) Manager, etc.) and competence (a curriculum vitae (CV)) must be submitted to the Employer for review. The Project organogram shall be reviewed by the Employer.
- Nominate one responsible person who should act as a single point of contact to the Employer and its representatives on all matters pertaining to the Contract, who will be available at Site during all working hours.
- Ensure adequate number of HSE and quality supervisors to ensure safe, proper, and timely completion of the Works.

2.2.2 Quality management

- Implement a quality assurance system following ISO 9001 or equivalent as a guideline. The Contractor shall be responsible for the submission and execution of the Quality Management Plan in compliance with section 7.2, including the monitoring of all Subcontractors' works and the quality control of the manufacturing process of the main equipment of the Project.
- Provide the Inspection Test Plan (ITP) and checklists for all the construction activities a minimum of 2 (two) weeks prior to the commencement of the associated works. The Employer will then indicate those items that it wishes to witness, for which the Contractor needs to notify the Employer sufficiently in advance.
- Provide the ITP/Quality Plan for the manufacturing of Main Equipment prior to the commencement of the manufacturing. The Employer will then indicate those items that it wishes to witness, for which the Contractor needs to notify the Employer sufficiently in advance. Hold points need to align with the standards and good practice.
- Complete the relevant Factory Acceptance Tests (FAT), Site Acceptance Tests (SAT), and any other tests in external laboratories, as per the Contractor's Quality Management Plan, Good Industry Practice, and the requirements included in the Employer's Requirements. Inform the Employer in advance for the items the Employer has indicated it would like to witness.
- Undertake regular site inspection (following pre-defined ITP items or ad-hoc inspections) with the Employer and/or its representatives, providing sufficient notice in advance.

- Undertake inspections with the Employer and/or its representatives when systems are transferred from construction to commissioning.
- Undertake inspection with the Employer and/or its representatives in the context of a development of a punch list.
- Respond in a timely manner to any query and non-conformity raised by the Employer or its representatives.

2.2.3 HSE management

The Contractor shall carry out the Works giving the highest priority to ensure the health and safety of all persons involved in the Works and be responsible for compliance to South African Legislation (Occupational Health and Safety Act, Act No. 85 of 1993 and Regulations), Employer HSE specification, Baseline and Project Risk Assessment, and Applicable Plant Permits and implementation of the Contractor's HSE Plan, including, but not limited to:

- Submission for the Employer's review, comment, and acceptance of the HSE File before commencing the Works;
- Design the Project HSE Specification and Baseline Risk Assessment;
- Compile HSE component for tenders to include HSE Specification and HSE costs for the tenderer to price;
- Stipulate and audit pre-start up requirements from the Contractor;
- Review the successful Contractor's HSE Plan for the Project including all legal appointment, Safe Work Procedures, and training requirements;
- Provide all authorizations and accreditations of the Contractor's personnel, including vehicles and machinery, and ensure that only accredited personnel shall intervene on the construction Sites by means of a suitable access control and access platform that must be implemented on Site;
- Provide a list of envisaged Subcontractors including previous related experience and achievements. The Subcontractors and Suppliers must be accepted by the Employer;
- Require Subcontractors to previously accept, in writing, the HSE Plan's terms and requirements, and forward relevant supporting evidence to the Employer. The contract between Contractor and Subcontractors shall have same HSE contractual conditions included in the Contract between the Employer and the Contractor;
- Submission of HSE monthly project reports and statistics to the Employer providing manhours, incidents and accidents on Site;
- The Contractor's minimum HSE team responsible for the HSE Plan during construction shall be composed as per section 5.3 and Table 4;
- Produce signage and traffic plans, provide the correct task-specific personal protective equipment (PPE), safety training, and environmental information for all the Site staff;
- Specific event reports will be provided since occurrence for near miss/incidents and accidents as described in section 5.3;
- Promptly inform the Employer of any violation of the current HSE Manual or any other safety rule, plan, policy or procedure;
- Report all lost time incidents to the Department of Labour by completion of Annexure 1 form in the construction regulations;
- Give access and necessary assistance to external/independent HSE audits required by the Employer as well as the Department of Labour;
- Integrate the HSE Plan into their decision-making and managing activities;
- Adopt practices to produce a continuous improvement of HSE conditions at the workplace;
- Take all the necessary actions to eliminate HSE risks and to avoid or reduce pollution by preventing HSE events, controlling the used materials and generated waste, and generating and observing the established HSE operating practices;
- Develop, through adequate information and training programs, the skills of employees;

- Under normal conditions, and in situations of danger or emergency, raise the awareness concerning their role and their potential regarding the prevention of risks and the achievement of HSE objectives and results;
- Promote and support an open dialogue with local communities, organisations, and government departments to protect and enhance activities aimed at improving internal and external HSE protection; and,
- Define yearly specific and measurable objectives and assess their actual achievement by continuously monitoring of the results obtained.

2.3 Engineering and Documentation

The Contractor shall prepare the necessary engineering, construction and installation drawings, specifications, quality control, inspection protocols, and commissioning documents, consistent with Good Industry Practice and in compliance with the Applicable Laws, Codes and Standards for the Works.

The Contractor shall, for all Works to be performed under the Contract, establish, and maintain a comprehensive computer-based Document Management System (DMS). The DMS is covered in greater detail in section 6.4.

The Contractor shall include transmittals when submitting documentation.

The Contractor shall design the Works with due consideration to the Site's environmental conditions, particularly in relation to potential seismic conditions, wind, dust, humidity, rain, salt, and other corrosive substances in the atmosphere and in the Site ground conditions.

The design and equipment selection shall consider the prevailing and extreme environmental and ground conditions on Site. The selection shall reasonably ensure that equipment is protected from conditions outside of their rated design operating conditions, as these are stipulated within the respective manufacturers' operating manuals and other associated literature, such as IEC 60721-1: Classification of environmental conditions - Part 1: Environmental parameters and their severities.

The Contractor will provide a proposed MDL for the Employer's acceptance, which will cover all planning, scheduling, HSE, quality control, design, manufacture, shipping, construction, installation, commissioning, and testing documentation to a level of detail satisfactory to the Employer, and consistent with the design documentation requirements, agreed document naming procedure, and expected submission timelines.

2.3.1 Surveys, studies, and reports

The Contractor shall carry out all topographical, geotechnical, hydrological and/or other surveys and studies that might be necessary in addition to the studies provided by the Employer to carry out the Works with Good Industry Practice and in compliance with all Applicable Laws, Permits, Codes and Standards. Any surveys and studies provided by the Employer are strictly on a non-reliance basis unless otherwise communicated by the Employer. The Contractor needs to satisfy themselves with such documentation and carry out any further studies and investigations as deemed necessary (at their own cost within the Contract price) in order to accept ground risk.

The Contractor shall, as a minimum, prepare and complete the following surveys, studies, and reports:

- Structural (including, but not limited to, foundation, pile load, and pull-out testing) analyses, including mounting structure's length-pile foundations calculations and length-pile model;
- Pull-Out tests;
- Flooding and drainage studies where required to complete the flood risk assessment, storm water management plan, and erosion management plan for the Site;
- Seismic study;
- Ecological regeneration plan for the re-vegetation, regeneration and restoration plan of the Site's ecosystem;

- Ground resistivity test;
- Lightning risk assessment;
- Access route assessment, access management plan, and Traffic Management Plan;
- Waste management plan;
- Electrical calculations, cable sizing, earthing, protection studies, load flow study including loss calculations and voltage profiles, short circuit calculations, and any other studies that are required for the Design Lifetime;
- Any information or studies that might be necessary for the connection of the Plant to the Grid or as requested by the Grid Operator, including Grid Code compliance studies such as network compliance study, and which have not been provided as part of the Tender Information Pack;
- Any other meteorological study to carry out the Plant design (i.e., extreme meteorological conditions on Site);
- Energy Yield Assessment (EYA), as described in section 9.4; and,
- Transportation study/logistics and expediting plan for the Plant's equipment, including the necessary information related to BoM, purchase orders submission dates, origin, manufacturing date, pre-shipment FAT dates, shipment, and ETA.

The Contractor shall also prepare any other survey, study, and/or report not listed above but which is necessary for the proper execution of the Project in accordance with the Employer's Requirements, the Contract, Good Industry Practice and all Applicable Laws, Codes and Standards.

2.3.2 Engineering and design

The Contractor shall be responsible for all engineering and design activities related to the Project, including (but not limited to):

- Design basis statements and Project design report;
- Design drawings, design reports, execution drawings, and equipment drawings;
- Lists, datasheets and specifications of main components, equipment, materials and accessories;
- Confirmation that materials and components fabricated off-site comply to the relevant specification and standards;
- Quality testing reports of the Main Equipment, materials, and all other equipment;
- Electrical layout diagrams;
- Plant detailed layouts;
- Plant control and protection schemes;
- Design and calculation reports of all roads, stormwater network, structures, inverters, overhead line foundations, and buildings' foundations;
- Routine test certificates according to SANS standards for step-up transformers to adapt the inverter's output voltage;
- Routine test certificates for MV breakers in accordance with SANS standards;
- Design of the telecommunication system of the Plant and connection to the public telecommunications network, and any other documentation related to the instrumentation and Plant control engineering;
- Operation and maintenance manual for the Plant, including manuals for the Main Equipment; and,
- Any other documentation for the correct operation and maintenance of the Plant.

Appropriately trained, qualified, and experienced design teams shall be available to attend technical discussions with the Employer's representatives.

The detailed engineering and design shall comply with the requirements of the Contract, including Applicable Laws and Regulations, Codes and Standards, and with the technical requirements contained in the Employer's Requirements, and shall achieve:

- An optimised LCOE and Performance Ratio;
- Optimised operation and maintenance of the Works;
- Installed capacity, measured at the respective Point of Connection (POC), shall not exceed the maximum AC capacity;
- Maximise performance of the Project over its 25-year design life; and,
- Ensuring the provision of a high quality installation with maximum availability, as defined within section 9.1.

2.3.3 Procurement and construction documents

The Contractor shall be responsible to develop all procurement and construction documents related to the Project, including (but not limited to) the following:

- The data sheets, technical specifications, installation manuals, user manuals, operation and maintenance manual, logistic and traceability monitoring, and quality monitoring of every equipment of the Plant as established by the manufacturers;
- Detailed construction/erection method statement and processes;
- Quality Management Plan;
- Materials and equipment delivery plan;
- Detailed ITP and associated inspection procedures and checklists for each construction activity;
- Two (2) weeks look ahead schedule of Site activities from Notice to Proceed;
- Work schedule detailing the major milestones aligned with the Project's payment milestones from the Notice to Proceed. Linked to the work schedule, the Contractor shall provide personnel and machinery curves and respective key performance indicators to confirm the resources and times;
- Main Equipment product warranties as per Table 12, section 15.3;
- Contractor's licenses and permits for the Works;
- Completion certificates defined in the Contract;
- Main Equipment conformity certificates;
- PV modules test reports, as per section 14;
- Calibration certificates of all measuring instruments; and,
- Any other document required under the Applicable Laws and Regulations, Permits, Codes and Standards directly related to the Project.

2.3.4 Commissioning documentation

The Contractor shall prepare all required documentation and manuals whilst ensuring that it conforms to IEC 62446-1 and any Applicable Laws, Codes and Standards, including (but not limited to):

- As-built documents;
- Field Inspection Checklists (FIC);
- Commissioning tests results for the following Plant equipment where applicable:
  - PV Modules
  - Tracker system
  - String combiner boxes
  - Inverters
  - All electrical circuits (LV DC, LV AC, MV AC, auxiliary services circuits, communication system circuits, earthing system, etc.)
  - HV circuits/substation/reactive power compensation system commissioning testing
- Mechanical Completion Tests results and commercial operation start-up/commissioning report;
- FATs;
- SATs and performance tests results; and,
- Other commissioning tests results as required by the Contract.

2.4 Procurement

The Contractor shall be responsible for all the costs related to international and domestic transportation of equipment and goods to Site, including custom duties and insurances.

The Contractor shall supply all equipment as new, unused, complete, free, and clear from liens and encumbrances in accordance with the final drawings and specifications. All components supplied shall be designed, manufactured, and tested in accordance with the latest applicable SANS, IEC and/or any other relevant Standards and shall have the CE marking as applicable.

The Contractor should select components and equipment to ensure ease of maintenance using, to the extent possible, local facilities and after-sales technical services.

The Contractor shall supply the equipment and components listed in the Employer´s Requirements along with any other equipment or component that, although not listed here, is necessary for the construction and proper, safe, and efficient operation of the Project with due consideration of the Project's 25-year Design Lifetime counted from the Date of Completion.

The Contractor shall procure the equipment and components informing the Employer about timely ordering, tracking, unloading, staging, managing, and the secure storage of all equipment and supplies required for the successful completion of the Works. The Contractor shall ensure that the packing, shipping, handling, and logistics during transportation and on Site of all components shall comply with the manufacturer's requirements and Applicable Laws and Regulations, Permits, and Codes and Standards.

The Contractor shall perform an inspection in factory before releasing the transport of the Main Equipment. The consequent report with the result of the inspection, confirming the compliance with the ITP/Quality Plan, and applicable standards for the manufacturing of such equipment must be shared with the Employer before releasing the transport.

2.5 Construction, Installation, and Commissioning

The Contractor shall be responsible for: delivering the Works in accordance with the proposed Work Schedule; ensuring that the Works are fully complete and in accordance with the Contract, Employer's Requirements, Good Industry Practice, and in compliance with the Applicable Laws and Regulations, and Codes and Standards. The Contractor shall include all resources, tools, equipment, and workmanship in order to perform the correct construction, installation, commissioning, and testing of the Project as per Project requirements.

All of the Works shall be individually and collectively certified by an appropriately qualified Engineer as compliant with Applicable Laws, and Codes and Standards (i.e., certificates of compliance).

The Contractor shall be responsible for the supply of all the materials, consumables, machinery, human resources, and mechanical equipment (e.g., tools, PPE), service vehicles, fork-lifts, cranes, lifting equipment, workshop, store, and office equipment) necessary for the Works.

2.5.1 General infrastructure and utilities

The Contractor shall be responsible for, but not limited to, the following:

- Provide and install all necessary signalisation on the Site and for access of the Site;
- Maintain security on Site 24/7 from when granted access to Site until Date of Completion, including the installation of security system(s), video surveillance and guards' posts, if necessary;
- Installation of temporary lighting posts, if necessary;
- Provision of first aid facility and medical facilities on Site in accordance with legislation and local regulations;
- Provision of changing facilities for both sexes;

- Supply of electricity, water, and any other required supplies during construction and commissioning;
- Sheltered areas for eating, trainings, and meetings, properly sized for the respective number of workers;
- Communal kitchen and canteen services;
- Supply of shaded areas with fresh water;
- Site temporary firefighting supplies and systems;
- Erosion and sedimentation control;
- Site industrial effluent handling (i.e., concrete mixer cleaning water) and removal;
- Maintenance and operation of clean Site conditions facilities, including change areas, ablutions, and common areas in line with the regulations. The Employer's authorised personnel shall have access as and when required;
- Housekeeping and Site establishment;
- Emergency lighting and signage to enable its personnel to evacuate Site in the event of an emergency;
- At laydown areas and temporary areas external to the Site, any temporary fencing, lighting, guarding, and all other materials and services necessary for the safety and security of persons and property;
- A temporary car park and its maintenance for use by the Contractor's and its Subcontractors' personnel, as well as the Employer's personnel;
- Temporary roads, hardstanding, and parking areas;
- Provision of temporary telephone and uncapped high-speed internet connections to any Site offices and other such places it considers necessary for the efficient performance of its operations;
- Site offices for the Contractor;
- Dedicated, fully furnished, equipped (including air conditioning, heating, printer, fridge, microwave, drinking water, washing facilities and toilets), functional, and ready to use Site offices for the Employer and its representatives, including main offices which shall have a capacity for at least four (4) people. Offices shall be made available at the earliest after Notice to Proceed and shall be regularly and systematically maintained and cleaned by the Contractor at the Contractor's own cost;
- Solid waste disposal facilities;
- Sanitary facilities and sewage disposal;
- Catering services during construction, considering the necessary hygienic measures with regard to all processes involving food: manufacture, processing, packaging, storage, transport, distribution, preparation, handling, sale, and deliver;
- Temporary storage facilities for spares until the warehouse is operational; and,
- Backup diesel generators and one stand-alone PV system to supply, as much as practically possible, the energy needs of the temporary facilities.

Those facilities must be in place prior to the start of the construction activity, equipped with internet connection, lights, air conditioning, heating, and with proper housekeeping from the start of the construction period. The Contractor must ensure lights and air conditioning from the onset by using the temporary generators if necessary.

2.5.2 Preparatory works

Prior to the start of construction, preparatory works shall be performed by the Contractor, including (but not limited to) the following:

- Create, modify, extend, or upgrade the access routes needed for the construction and operation of the Plant. Access roads shall be protected, maintained, and repaired if damaged during construction. A condition assessment prior to use is recommended;
- Install fencing;

- Install access control and security;
- Install Site offices; and,
- Install infrastructure for the provision of utilities (such as electricity, water, uncapped high-speed internet, solid and other waste removal, and sewage).

2.5.3 Civil works

The scope of the civil works shall include, but is not limited to, the following:

- Infrastructure works. Rerouting/relocation and dismantling of existing facilities such as foundations, piping, cabling, and ducts, where necessary;
- Cut and fill, ground levelling, removal of roots, rocks, and other material and vegetation clearing as per Project requirements, environmental authorisations and Applicable Laws and Regulations, and Codes and Standards;
- Ground investigations;
- Soil improvement (e.g., bearing capacity, piling, compaction), as required;
- Procurement of all materials, construction plant, tools, accessories, and secondary equipment required for the correct execution of the civil works;
- Drainage system;
- Adapting and upgrading existing water courses and/or crossings;
- Foundation works for trackers, string combiner boxes, inverters, power transformers, buildings, weather stations[1], security system, fences, and any other structures or equipment requiring foundations, where applicable;
- Ancillary and temporary buildings, including (but not limited to) transformer and MV installations;
- Site fencing and gates for construction and operation;
- Access roads;
- Internal roads for construction and operation. The road material shall minimise dust during the Design Lifetime. The road material used shall be low on the dustiness index;
- Trenches for electrical works, earthing, and telecommunications system;
- Environmental Site management;
- Dust control management;
- Construction of permanent buildings;
- Security fence and gate(s) including one motorised main access door connected to the O&M building for remote operation;
- Firefighting and fire protection system (supporting) structures, where required; and
- Waste management, including, but not limited to, disposal of off-Site waste as required.

2.5.4 Mechanical works

The scope of the mechanical works shall include, but is not limited to, the following:

- Mounting structure foundations (piling, pre-drilling, with concrete pads if required, etc.), galvanized with sufficient thickness for the conditions of the Site (corrosive soil conditions, salty air, dust, and chemical aggressiveness etc.) for the expected lifetime of the Plant;
- Complete support structure installation, including motors, controllers, and any other components of the structure (drives, bearings, track controller, etc.);
- Accessories to mount the structures, cables, and PV modules (including nuts, bolts, washers, lock washers, claws, clamps, etc.);
- Application of corrosion protection (cold galvanizing paint) on damaged structures, in accordance with manufacturer's guidance and design specifications;
- String combiner boxes installation and cabling mounting arrangements, where applicable;

[1] Weather stations and meteorological stations shall have the same interchangeable meaning in this document.

- PV modules installation, to be optimised based on short-circuit current sorting by the manufacturer and compliant with the manufacturer's recommendation and installation manual. Module installation must be performed according to Good Industry Practice, Manufacturer's guidelines, and the module installation manual, to minimise any module breakage (module breakage being at the Contractor's expense);
- Inverter stations and necessary cable connection arrangements;
- Equipment and services for buildings;
- Structures needed for the electrical and control and instrumentation (C&I) systems;
- Meteorological stations (applicable mechanical elements);
- Heating, ventilation, and air conditioning (HVAC) to all buildings, as applicable;
- Auxiliary systems, as far as applicable;
- Equipment for workshop, stores, and other facilities, including storage racking;
- Firefighting and fire protection system devices and equipment (in accordance with Laws, Consents, and Codes and Standards);

2.5.5 Electrical works

The scope of the electrical works shall include, but is not limited to, the following:

- Installation of electrical equipment;
- Cable laying in trenches;
- Installation of cables in cable trays;
- Connection of PV modules strings and string combiner boxes (if applicable);
- Installation of earthing and lightning protection systems;
- Installation of inverter stations, operational meters at LV AC side of inverter (one meter per inverter station), MV/LV transformer, MV switchgears, and auxiliary transformers;
- Cable connections at inverters, string combiner boxes (if applicable), MV/LV transformer, auxiliary transformers, and MV switchgears;
- Installation of power supply for trackers (if applicable);
- Meteorological stations (applicable electrical components);
- Electrical building services to all buildings and LV auxiliary distribution board for power, lighting, emergency lighting, ventilation, etc.;
- Security and surveillance systems and equipment;
- Installation of the auxiliary supply system;
- Site lighting compliant with all Applicable Laws, and Codes and Standards;
- Emergency power facilities;
- Underground evacuation line for the Plant to its respective substation, according to the respective Project Documentation and Applicable Laws, Permits, and national Regulations and Codes; and,
- Any additional equipment required to meet the Grid Code requirements at the POC, such as reactive compensation equipment or harmonic filters.

2.5.6 Control and Instrumentation works

The scope of the C&I works shall include, but is not limited to, the following:

- Installation of all C&I equipment;
- Supervisory Control and Data Acquisition (SCADA) system[2], including licenses;
- Power Plant Controller (PPC);
- Telecommunications;
- Protection systems;
- Meteorological stations;

[2] Please note that where the term "SCADA system" is used in a generic sense, as in this case, it applies to both the Plant SCADA system and the security SCADA system.

- Communication cabling and fibre optics;
- Monitoring equipment;
- CCTV and surveillance system; and,
- Intruder detection system.

2.5.7 Buildings

All buildings should be erected in line with SANS 10400, all (other) applicable building regulations, respective building permits, preliminary and existing Project Documentation (in terms of surfaces, distribution, materials, and design concepts), unless the existence of a more restrictive indication under this section and section 10.12, which shall prevail.

The Contractor shall install the following buildings for each PV Plant:

- Control and Operation building, including security room, operations room, server room, office space, meeting rooms, sanitary room, changing rooms, storage room/space, and others according to HSE requirements and local regulations. The Control and Operation building shall include a nearby parking area with a minimum of five (5) parking spaces; and,
- Storage/warehouse building, with a minimum area of 130 m^2, including racks and adequately sized gates.

All building platforms must be waterproof and be suitable for the ground conditions for the Project's Design Lifetime (considering a minimum elevation of 0.25 m higher than the 1:100-year return period maximum water level), especially the cable entrance, door, etc.

Sufficient clearance around the buildings must be provided for future maintenance (equipment replacement, transformer access, etc.).

The buildings must be equipped with power, telecommunications (uncapped high-speed internet connection), water, fire-fighting system, offices, restrooms, and refectory required for the O&M team and security team.

Thermal insulation materials shall be incorporated into the fabric of the buildings to minimise heat gain and the load on the HVAC systems. A proper waterproofing system shall be used for all buildings.

2.5.8 Commissioning and testing

It is the obligation of the Contractor to produce a Testing and Commissioning Plan which must be provided for the Employer's acceptance at least two (2) months prior to the commencement of the commissioning activities. Tests may not commence until such Testing and Commissioning Plan has been accepted by the Employer.

The Contractor shall undertake, at its responsibility and cost, all pre-commissioning, commissioning, and any other tests necessary to demonstrate the quality and reliability of the Project conforming to the Contract, the applicable norms (including IEC 62446-1), and any applicable Laws, Consents, and Standards.

The lack of an acceptance criteria will not relieve the Contractor from its contractual obligations, such as compliance with the applicable Standards and Employer's requirements, or the proper design and installation of the Project. The Testing and Commissioning Plan for the Project shall include the points during commissioning at which the verification activities are to occur, the personnel involved, and the records to be kept.

The Contractor will provide detailed reporting of the test results to the Employer.

The Employer will have the right to be present or to redo any inspection, control, test, or verification, which shall be for the Employer's account, unless such test result indicates additional defects, in which case such cost shall be borne by the Contractor.

The Contractor will carry out the commissioning/start-up process, electrical, and mechanical tests as per section 14. A non-exhaustive list of the testing criteria required for implementation must be included in the Testing and Commissioning Plan.

The Contractor must ensure that the Testing and Commissioning Plan is according to the relevant requirements in the Grid Code, as well as the testing requirements of the Contract, if applicable.

The Contractor shall carry full responsibility for: the testing of the Eskom Connection Works to the full satisfaction of Eskom; the handing-over of the Eskom Connection Works to Eskom; and for the rectification of any defects in the applicable warranty period, as set out in the Eskom Self Build Agreement and in accordance with Eskom procedures.

The Contractor shall, in consultation with NERSA's Renewable Energy Technical Evaluation Committee (RETEC), propose a full test programme to demonstrate compliance with all applicable Laws, Consents, and Codes and Standards. The Contractor shall satisfy the requirements of the Grid Code compliance assessment conducted by NERSA in order to achieve issuance of the Time for Completion Certificate by the Time for Completion.

The Contractor shall provide the final Codes compliance testing programme no later than three (3) months prior to the planned grid connection date as defined in the Programme, with reference to the Eskom Budget Quote, if applicable. This must be in addition to a provisional South African Grid Code compliance testing programme provided to the Employer within 30 days of the Signature Date. For the avoidance of doubt, Grid Code compliance is a requirement for the Early Operating Period and Taking Over.

The Contractor must supply all consumables and power required for testing and commissioning.

All testing and commissioning activities must comply with the following:

- In-country Laws and Regulations;
- Project Documents;
- Project Agreements;
- Applicable Laws, Permits, and Codes;
- Employer's Requirements;
- Manufacturer's specifications, and in a manner so as not to void any product warranties;
- Standards;
- Contract's Quality Management Plan; and,
- Contractor's Testing and Commissioning Plan.

Testing and commissioning activities shall include:

- FATs;
- Material tests;
- SATs;
- Installation checks;
- Functional tests;
- Commissioning Tests;
- Provisional Acceptance Tests; and,
- Final Acceptance Tests (Tests after Date of Completion).

Inspection and testing shall be carried out at all stages of manufacture and installation. This must ensure that the Works and the Project conform in all respects with the requirements of the Contract and Project Agreements.

If needed due to delays in the grid interconnection works, the Contractor shall provide provisional energisation by means of a temporary generator not affecting the progress of the commissioning activities.

The Contractor shall ensure that Provisional Acceptance Tests and Final Acceptance Tests demonstrate the operation capabilities of the Plant are within the requirements, and the Guaranteed Performance Ratio and Guaranteed Availability Tests are fulfilled.

2.5.9 Connection works

The Contractor is expected to coordinate and liaise with the HV Contractor in relation to the interfaces, battery limits, design inputs, commissioning, energisation, and Grid Code compliance for the Project.

The Contractor shall ensure Grid Code compliance of the Project. The Contractor shall obtain the relevant certifications as required by the latest version of the Grid Connection Code for Renewable Power Plants (RPPs) connected to the electricity Transmission System (TS) or the Distribution System (DS) in South Africa, and the Eskom Standard for the Interconnection of Embedded Generation (240-61268576).

2.5.10 Equipment

The Contractor shall provide all equipment, tools, and spares necessary for discharging his responsibilities in carrying out the Works, including commissioning, being responsible for loading, transportation, unloading, on-Site storage of all supplied equipment including modules, mounting racks, inverters, and all the other equipment.

2.5.11 Labour

The Contractor shall provide appropriately trained and experienced, equipped, and protected competent labour resources for the correct execution of the Works.

The Contractor shall develop a mobilisation and training plan in accordance with the schedule and sequence of the various construction and commissioning activities.

The Contractor shall promote local economic development as described in section 8.4.

2.5.12 Cleaning and waste management

The Contractor shall, until Date of Completion, provide the necessary resources, equipment, and services to ensure proper housekeeping and waste management on Site, including (but not limited to) the following:

- The Contractor shall provide a Waste Management Plan according to the Applicable Laws and Regulations, and Codes and Standards;
- The Contractor shall keep the Site and work areas clean and neat during the execution of the Works and will remove rubbish diligently. A general cleaning of the facilities shall be done twice a week, and a legal waste management company must certify the removal of the segregated waste on Site;
- The Contractor shall ensure environmentally friendly measures such as reduce, reuse, recycle and second life waste management;
- The Contractor must ensure that rubbish present on the Site is not a risk of causing, and does not actually cause, any safety concerns or hazards;
- Equipment such as switchboards, panel boards, cabinets, enclosures, and MV/LV power stations must be cleaned prior to energising equipment and Final Acceptance;
- The Contractor shall make sure all installed PV modules are clean for the anticipated Date of Completion; and,
- The Contractor is responsible for disposal of rubbish and debris unless otherwise instructed by the Employer.

2.5.13 Maintenance before Provisional Acceptance

Until the Date of Completion, the Contractor shall maintain the Plant at its best capacity and performance, shall provide the necessary O&M services, and shall ensure the security of the Site.

2.5.14 Removal of temporary facilities

Unless otherwise agreed with the Employer, on completion of the Works the Contractor shall remove from the Site, and other temporarily used areas, all materials, construction plant and equipment, as well as temporary facilities not incorporated in the permanent Works. These include all temporary services, screens, fences, buildings, rubbish, unused materials, storage tanks, temporary power distribution lines, wooden crates, planks, plyboards/plywood used as packaging of equipment, and all other temporary facilities.

Burning or burying the rubbish on or close to the Site is not permitted.

The Contractor shall fill and dress all holes and cavities made for its convenience. The Contractor shall leave the Site in a safe and tidy condition and in good order to the satisfaction of the Employer.

The Contractor shall furthermore ensure that all areas of the Plant that have been disturbed during the project, shall be rehabilitated with grass or other flora that naturally occur in the area.

2.6 DIGITALISATION

The Contractor shall maximise the use of digital tools for the delivery of the Works, including among other things:

1. The provision of a PV module register, including: module serial number, the module geolocation in the Plant, location in the module string, module string number, combiner box number (if applicable), inverter number, transformer number, and subfield number for each PV module. The register shall be stored in a cloud-based software platform and be able to be interrogated by office and Site personnel using standard devices. Site personnel should be able to use mobile applications to direct themselves to a specific module easily from the cloud-based software platform.
2. The development and provision of a single cloud-based software platform to store serial numbers, inspection data, test results, and any other relevant metadata covering design and construction aspects for all components, to the Employer. All components and equipment will be represented in a digital geolocation map aiming to represent a digital twin of the Plant.

3 DESIGN DATA

3.1 INTRODUCTION

This section sets out the design data for the Plant and shall be read in conjunction with all other parts of the Employer's Requirements.

The design data is provided solely for the purpose of assisting the Contractor in making its own assessment of the Works. It does not purport to be all-inclusive, to be perfect or contain all information that may be required. The Contractor shall make its own investigations, projections, and conclusions and consult its own advisers to verify independently the information provided. Neither the Employer, nor any of its representatives or advisers, shall have any liability as to the completeness or correctness of the information contained in, or omitted from, the Employer's Requirements.

3.2 BATTERY LIMITS

All terminal limit point connections shall be performed by the Contractor, except as otherwise indicated. The design of the connection shall be approved by the relevant parties which are responsible for the supply of services up to the relevant terminal point.

The Contractor is responsible for liaising with the relevant parties to determine the location and details for all the terminal points.

The anticipated terminal points for the connections between the Plant and the external services are as follows:

- Access road: the access road to the site is on Dihlabakela road, connecting from the R716;
- POC shall be agreed with the relevant authority and the Employer by the Contractor, who shall also obtain all relevant permits. The POC is defined as the point in the grid connection where the Solar PV Energy Facility is connected and where any energy consumed by the PV Facility is measured[3];
- Water: to be defined at a later stage;
- Electrical infrastructure: as described in section 3.3; and,
- C&I interfaces (including telecommunications): see section 13.10.

Other battery limits required for the completeness of the Plant may arise as the detailed design progresses and shall be provided by the Contractor within the Contract price.

3.3 BATTERY LIMITS WITH THE HV CONTRACTOR

The battery limit is located at the MV voltage level in the Project's substation.

Supply, installation, termination, and testing of the respective MV circuits from the Plant to its respective substation (respective MV switchgear located at the electrical room) shall be carried out under the Contractor's scope of works. The Contractor will be responsible for the respective HV and MV tests as per the section 14.3.4 on the MV circuits. The HV Contractor will be responsible for the underground routing, including the construction of troughs and electrical raceways, of the incoming MV power cables from the Plant inside the substation's boundary fences only.

Supply and installation of the respective Plant's PPC system shall be carried out under the Contractor's scope of works. The Contractor shall liaise with the HV Contractor to define the space requirements for the installation of these cabinets during the detailed engineering phase.

Any patch cords or communication cables required for connecting the substation control room to the Plant SCADA system (via the patch panel cabinet), for connecting the power quality and metering equipment with the PPC, and for the connection of the PPC with the patch panel cabinet shall be

[3] See R00000014 | GS01 | B for more details on the Plant's Grid Connection

supplied and installed by the Contractor. The make and model of the power quality and metering equipment shall be provided by the Contractor to the HV Contractor at due time.

The necessary supply, installation, termination, and testing of the fibre optic communication cables between the substation(s) and the Plant shall be the responsibility of the Contractor. The HV Contractor shall be responsible for the underground routing, including the construction of troughs and electrical raceways, of the incoming communication cables from the Plant inside the substation's boundary fences only.

3.4 General design considerations

The Plant shall be capable of operating within the technical limits specified below and according to all Applicable Laws and Regulations, Permits, and Codes and Standards:

- The Plant and its components shall be designed to optimise LCOE;
- Minimum design lifetime of 25 years from Date of Completion, without necessity for major repairs/substitution works;
- Designed to withstand the most extreme climatic conditions on Site as further discussed in this section;
- Designed taking into account the specific characteristics of the Site as further discussed in this section;
- Materials shall be proven to be suitable and sufficient for the minimum Plant design lifetime (25 years);
- The manufacturer and, to the extent possible, type of equipment shall be the same for the Plant for the main equipment, such as the PV modules, trackers, DC string combiner boxes (if applicable), inverters, main DC and AC power cables, transformers, MV switchgear, MV/LV power stations, meteorological stations and respective components, CCTV systems and respective components, monitoring system equipment, etc.;
- All electrical components must be contained in component-specific enclosures, following the original equipment manufacturer's (OEM) recommended IP enclosure rating, and taking into account the most extreme climatic and environmental conditions on Site;
- The Plant shall achieve a high level of reliability through quality control and assurance during procurement, construction, and Plant maintainability/operability;
- Equipment shall have the minimum warranty periods stated in section 15;
- The Plant shall be designed to achieve the guaranteed level of performance as stated in the Contract;
- The Plant shall be designed for 1,500V_{DC} configuration;
- The mounting structure shall be suitable for adaption to the topography of the Plant, in order to optimise the solar irradiance on the plane of the array;
- The PV array shall be designed with either central inverters or string inverters;
- If using trackers, both rows/tables of a tracker shall be connected to the same inverter;
- All equipment needs to comply with SANS or equivalent international (IEC/EN/ISO) standards;
- Any changes in technology or equipment supplier, as per the provision of the Contract, need to be accepted by the Employer;
- Design must be optimised taking into consideration replacement works necessary for components that are designed to be replaced or overhauled at intervals of less than the minimum Plant design lifetime (25 years);
- The Plant design shall ensure the protection of native animal and plant species;
- Equipment location and arrangement shall ensure that not less than two (2) escape routes are available for personnel in case of fire or other hazards during normal O&M procedures;
- Designed access systems to electrical equipment shall comply in full with the requirements and recommendations of the relevant Standards. Specific attention shall be given to meeting the appropriate safety legislation and approved codes of practice; and,

- A lightning risk assessment shall be carried out as per SANS 62305-2 and a suitable lightning protection system must be designed and installed as per the relevant Standards (such as SANS 62305).

3.5 PLANT LOCATION

The Site is located approximately 550 km north-west from Durban's port, the largest seaport in South Africa and approximately 90 km south of OR Tambo, the largest airport. The Employer owns the Site and will grant access to the Contractor. The Site access road is on Dihlabakela road, connecting from the R716.

The Plant and any temporary facility used during the construction of the Plant (such as Site offices, workshops, and equipment lay down area) shall be located within the land plots shown in the respective general layouts provided in the Project Documents. The Contractor shall optimise the Plant layout within the Site.

The Contractor shall ascertain the nature and location and all conditions which may affect both the design and layout of the Plant. The Contractor shall be responsible for its own investigations to establish sufficient and accurate information to support its proposal in relation to the Site conditions. The Contractor shall perform additional surveys to re-evaluate the Site's conditions that may affect both the design and layout of the Plant at its own costs. No claims will be accepted by the Employer based on the accuracy or sufficiency of the assessment already carried out and to be provided.

The Contractor shall ensure a minimum clearance distance between the perimetral fence and the respective public roads axles of 5 m, and 3 m to the land registry limits of each Project area, unless a more restrictive indication by national or local regulations exists at a later stage.

The Contractor shall ensure a minimum clearance distance between the perimetral fence and the land registry limits of each Project area of 3 m, unless a more restrictive indication by national or local regulations exists at a later stage.

3.6 CLIMATIC CONDITIONS

The Contractor shall analyse the meteorological and environmental conditions on the Site including the wind conditions (maximum wind speed and direction), extreme temperatures, and rainfall. The Contractor shall guarantee that the Plant is designed for safe operation and maximum performance for the entire range of meteorological and environmental conditions.

The mechanical and electrical designs of all equipment and systems shall consider operation under the most severe climatic conditions, adding a 2 ºC safety margin for temperature (-2 ºC for the minimum temperature and +2 ºC for the maximum temperature) and +5 km/h safety for wind speed.

The Contractor shall undertake all necessary investigations and studies to identify the most severe climatic condition expected on Site and define the design criteria accordingly. The design conditions shall, as a minimum, comply with the following requirements:

- Minimum ambient temperature: -5 ºC
- Maximum ambient temperature: 55 ºC
- Maximum wind speed: 70 km/h

The Contractor can propose different design conditions to the Employer, providing the necessary evidence and supporting documentation for the Employer´s consideration.

Table 3 below shows the meteorological conditions of the Site provided by the Employer for reference purposes only.

Table 3: Project meteorological conditions

Parameters	Value	Units	Source
Elevation:	1475	m	SolarGIS
Extreme maximum temperature:	40,0	°C	Visual Crossing
Extreme minimum temperature:	-10.0	°C	Visual Crossing
Maximum daily precipitation:	57	mm	Visual Crossing
Maximum wind speed:	60	km/h	Visual Crossing

3.7 SITE TERRAIN

The Project Site comprises several available plots with hardly any shadows and, in principle, suitable topographical features. A detailed topographical survey must be conducted by the Contractor to confirm the Site topography and assess far or near shadows in the energy yield calculations.

Earthworks across the Site may be necessary to level and prepare the terrain.

The Contractor shall undertake a topographic survey (if using drone(s), it should allow a minimum level of accuracy as expected for its intended use) and submit the associated report and results to the Employer.

The Contractor shall undertake a utility services scan/survey of the Project Site to confirm the existence of any utility services such as water, sewage, telecommunications etc., prior to any construction works taking place.

3.8 SOIL AND GEOTECHNICAL DATA

The Project Site geotechnical data and conditions are described within the respective Plant's geotechnical assessment report[4], provided on a non-reliance basis as part of the Project Documentation.

The Contractor shall undertake a detailed geotechnical assessment at own cost and submit the associated report and results to the Employer.

3.9 HYDROLOGY

The Plant will be designed for minimum water consumption.

The Contractor shall ensure a minimum clearance distance between the perimetral fence and the respective streams margins of 5.0 m.

The Project Site hydrological data and conditions are described within the respective Plant's hydrological impact assessment report provided on a non-reliance basis as part of the Project Documentation.

The Contractor shall undertake a detailed hydrological impact assessment and geohydrological survey and submit the associated report(s) and result(s) to the Employer.

The hydrological impact assessment shall be developed considering two different scenarios ((1) prior to PV plant construction, and (2) post PV plant execution, including the proposed drainage system). It shall focus on the development of a flood risk assessment, storm water management plan, and erosion management plan to address potential issues of flooding and soil erosion.

[4] Report Reference No: RN-0723-03

3.10 Lightning

The Contractor shall make its own investigation of the lightning activity in the Project Site and surrounding areas. The Contractor shall undertake a lightning risk assessment following applicable Standards (such as SANS 62305-2) to inform the design of a suitable lightning protection system as per the relevant Standards (such as SANS 62305). Every element that can cause a severe unavailability event shall be protected by the lightning protection system, as well as any area where there may exist personal risk.

The Contractor shall submit a lightning risk assessment report to the Employer.

3.11 Seismic conditions

The Contractor shall make its own investigation of the seismic activity in the area of the Site and shall design the Plant accordingly.

3.12 Archaeological data

Archaeological and heritage surveys were conducted by the Employer as part of the Environmental Impact Assessment (EIA) process to confirm the incidence of items of cultural heritage significance and potential impacts of the construction and operation of the Project. These studies will be shared as part of the Project Documentation through the Final EIA report (FEIAr) and Environmental Management Programme (EMPr).

The assessments undertaken did not identify any graves on the site, although there are known graves in the area. Although no palaeontological artifacts were identified on the surface of the site, the area is underlain by potentially fossiliferous sedimentary rock of the Early Permian Vryheid Formation. It contains highly scientifically and culturally significant fossils (particularly the plant macrofossils of the *Glossopteris* flora).

Based on the assessments, it is not anticipated that the Project will have direct or indirect significant impact on items of cultural heritage significance in the area. The Contactor shall, however, develop a chance finds procedure as per the requirements of the EMPr and recommendations of the specialist reports in case of any chance finds.

The Contractor shall comply with the requirements of the EMPr, the Environmental Authorisation (EA), and Applicable Law (including, but not limited to, the National Heritage Resources Act No. 25 of 1999).

3.13 Biophysical Environment

Environmental assessments have been carried out by the Employer, concluding that the Project Site is compatible with the construction and operation of the Project and with the conditions established in the studies.

The study area falls within the original extent of the Central Free State Grassland and consists of gently to moderately undulating landscapes. The area receives about 650 – 750 mm of rain on average per year, mostly occurring from late October to March, peaking between December and January. The average daily temperature is 26 ºC during summer months and 17 ºC in winter months. Winter temperatures are on average -1 ºC with frost occurrence being common.

The past land use of the area is open cast mining (which was rehabilitated), a landfill site (on a portion of the site), open rangeland, small portions of sand mining, and excessive grazing (now resolved). The site is currently covered by semi-natural grassland.

At the time of the site assessment, only 115 of the 1432 known plant species in the area (as per SANBI database) were recorded, and an additional 22 alien invasive species.

It is not anticipated that the Project will have a significant impact on flora and terrestrial vertebrate species. However, the Contractor must comply with the recommendations of the specialist reports, and the requirements of the EMPr (and associated management plans including, but not limited to, the Alien Plant and Open Space Management Plan; Revegetation and Rehabilitation Plan; and Plant Rescue and Protection Plan), the EA, and Applicable Provincial and National Legislation.

3.14 RAW WATER SUPPLY

The Contractor shall design and install a water storage tank system, of no less than 7 500 liters capacity, and associated pumping and infrastructure facilities to provide water for the O&M phase.

The Contractor shall be responsible to conduct all the investigations which are necessary to design the infrastructure needed to supply the water to the Plant. The water supply system infrastructure shall be designed and constructed by the Contractor in compliance with the Applicable Laws, Permits, Authorisations, and Codes and Standards.

Consideration of the utilisation of a raw water supply from the Lethabo Power Station fire and floor cleaning water supply should be made by the Contractor.

The Contractor shall install any temporary infrastructure needed to source water during construction, subject to compliance with Applicable Laws, Permits, Authorisations, and Codes and Standards.

4 SITE ARRANGEMENTS

4.1 Transportation of Goods and Materials

4.1.1 General

The Contractor shall be responsible for the safe transport of all goods and materials to the Site and for obtaining any necessary approvals and permits from the relevant authorities for such transport.

The Contractor shall assess the transport routes in terms of the lengths and weights of loads required to be transported. Approvals from the responsible authorities must be obtained by the Contractor where necessary. The assessment and suitability of public roads for the transport of all equipment between the port of arrival or manufacture facility and the Site remains the full responsibility of the Contractor.

The Contractor shall develop a Traffic Management Plan as per section 5.7.

The Contractor is to bear all expenses in connection with the import and transport to the Site of all Plant, equipment, materials, and other items needed for the Works, including warehouse rent, handling, other charges, and customs charges and duties where applicable.

Each item shall be properly packed and protected for shipment, transport, and storage, according to the respective OEM manuals and guidelines.

The Contractor shall take safety precautions to be considered during the transport and storage of hazardous substances or dangerous materials, which shall comply with the requirements of the safety legislation and minimise their potential impact on the environment.

4.1.2 Offloading and Handling

The Contractor shall establish and maintain a system for the preservation, segregation, and handling of all materials from receipt, through the manufacturing process and subsequent storage and installation, according to the manufacturer’s requirements, at the Site until over the Date of Completion. This is to prevent abuse, misuse, damage, deterioration through exposure to air, moisture or any other elements and theft. The Contractor shall be responsible for the offloading and handling of all goods and materials on Site and for the provision of all cranes and equipment necessary for the erection, manufacture, installation, testing, and commissioning of the Works.

The provision of any covered construction stores or preparation of hard standing storage areas shall be the Contractor's responsibility.

Each item shall be properly offloaded and handled, according to the respective OEM manuals and guidelines.

4.2 Roads

The Contractor shall be responsible for ensuring the adequacy of the public and private roads to the Site and for obtaining any necessary approvals relating to the transportation of equipment and materials to and from the Site.

The Contractor shall be responsible for investigating any height, width, weight, or other restrictions in respect of the means of transportation. The Contractor shall be responsible for upgrades or modifications to existing roads, railways or quays which may be necessary. In this regard, the Contractor shall undertake a transportation study and provide it to the Employer for information purposes.

For the access roads to Site, and all private roads used for transport of personnel and equipment to Site, the Contractor shall ensure that the conditions of these roads are reinstated to their condition prior to the Commencement Date. In order to do so, the Contractor shall complete surveys for the public roads and record the pre-construction condition of these roads, including photos and aerial footage, and provide it to the Employer for information purposes.

The Contractor shall comply with all regulations and/or permits regarding traffic, transit or access of labour, Plant and materials to and from the Site, and with all regulatory or other obligations applicable to the use of existing public and private roads.

Existing public and private roads and all Site roads, including the access roads to the Site, constructed by the Contractor shall always be kept free from spillage and debris. All costs in this activity shall be borne by the Contractor. Furthermore, during the entirety of the Contract, the Contractor shall implement dust mitigation measures on the roads.

Contractors shall ensure that all vehicles used on Site are in a roadworthy condition and are insured for third party risks. All mobile vehicles or machinery shall only be operated and/or driven by trained and certified operators.

4.3 Site Establishment

The Contractor's representative(s) on the Project Site shall be appointed prior to commencement of any Site activities and shall be given full responsibility to enter into negotiations regarding points arising out of erection and setting to work so that the Works may be expedited.

The Contractor shall confine its labour, material, Plant, and equipment within the designated areas to which it has been given possession. No lands or other places which are the property of the Employer or third parties shall be entered into except in accordance with the instructions and permission of the Employer.

If permission is given to enter the Employer's or third party area, the Contractor shall comply with all instructions and procedures in place. The Contractor shall be responsible for the acts and omissions of the Contractor's and/or Subcontractor's personnel in such areas. Any damage or injury, howsoever caused, to the property or person, caused by the Contractor's and/or Subcontractor's personnel whilst in such areas shall be the liability of the Contractor. The Contractor shall indemnify the Employer against all actions, suits, claims, demands, costs, charges, and expenses arising in connection therewith.

The Contractor shall inform its personnel that any persons found within such areas shall be removed from the Site.

If the Employer's access is restricted, the Contractor shall move any vehicle, temporary work, plant, or other obstruction within its control promptly on the instruction given by the Employer, and at the Contractor's cost.

The Contractor shall maintain access for the inspection, operation, and maintenance of any of the Employer's premises, plant or works that are within the Site. Before entering the Site for the first time, the Employer's Personnel may be required to obtain the permission of the Contractor who shall not unreasonably withhold or delay such permission. Once permission is obtained, the Employer's Personnel shall be able to enter the Site following the standard access procedures established for the Site.

The Contractor shall maintain the whole of its operations in a clean, tidy, and safe condition and shall arrange its materials in an orderly manner. All rubbish, waste materials, debris and the like shall be regularly and systematically cleaned off the working areas as it accumulates and deposited in collecting points from which the Contractor shall regularly dispose the waste materials at the Contractor's expense.

The Contractor shall ensure that the Site and adjoining lands belonging to third parties are kept free from construction materials of any kind arising from the Works, and that no damage occurs to third party property. Special attention shall be given to the parking areas for workers during construction in order to avoid third parties' land areas/plots.

5 ENVIRONMENT, HEALTH AND SAFETY

5.1 HEALTH AND SAFETY AT WORK

The Plant shall be constructed, installed, commissioned, and be operable and maintainable in full compliance with relevant health and safety at work requirements and all statutory Laws, such as (but not limited to):

- Occupational Health and Safety Act No. 85 of 1993 and Regulations.

Based on the above; the Contractor shall submit a comprehensive HSE File including HSE Policy, HSE Plan, HSE Safe Work Procedures and Emergency Evacuation Plan, Traffic Management Plan, Environmental Impact Plan to the Employer for review and acceptance as per the Contract. The HSE File will be project specific for the Works (and not generic), the Site, and all places where the Contractor intends to execute the Works. The HSE File will always apply during the construction and operation of the Plant. The HSE procedures and HSE Plan shall be to the highest international standards, and particularly in compliance with:

- Quality Management Systems (ISO 9001) and Occupational Health & Safety Management Systems (ISO 45001).

In this regard, a Site-specific safety induction training will be required for all persons working on the Project, including visitors. Workplaces shall be properly secured and fenced to control Site access and risk of third parties entering the work area. Access to the Works will be prohibited to personnel outside of the Construction.

The Contractor shall be responsible for implementing and controlling safety procedures during all phases of the Work. The Contractor shall ensure that all requirements of the HSE File and all Applicable Laws are complied with by its employees and Subcontractors.

The Contractor shall appoint in writing a full-time, competent HSE Responsible manager. They shall have a proven record of managing the safety on a project of comparable type and size. In addition, the Contractor shall appoint a safety committee as required by the General Administration Regulations combined with all Subcontractors on Site.

The Contractor shall implement an HSE team, composed according to Table 4, responsible for the implementation of the HSE Plan during execution of the Project. The number of workers considered in Table 4 includes not only the Contractor's workers but also all workers from Subcontractors.

Table 4: Contractor HSE Team

<table>
<tr><th rowspan="2">Team's role</th><th colspan="4">Number of workers on Site</th></tr>
<tr><th>1-50</th><th>51-80</th><th>81-150</th><th>151-250</th></tr>
<tr><td>Principal HSE Manager</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Contractor HS Officer</td><td>1</td><td>3</td><td>4-5</td><td rowspan="4">Increase the number by one (1) professional for each additional 100 workers.</td></tr>
<tr><td>Environmental Officer</td><td>1</td><td>1</td><td>2</td></tr>
<tr><td>Contractor HS Officer for complex activities (additional)</td><td>0</td><td>1</td><td>2</td></tr>
<tr><td>Environmental Officer for complex activities (additional)</td><td>0</td><td>1</td><td>2</td></tr>
</table>

As part of the HSE Plan, the Contractor shall perform a baseline risk and issue-based risk assessment on all activities and shall submit these assessments to the Employer for the Employer's review and acceptance. Prior to the commencement of any task on Site, the Contractor shall update the issue-based risk assessments as necessary.

The Contractor shall ensure that all requirements of the HSE Plan, and all Applicable Laws, are complied with by all its employees and contractors.

The Contractor shall identify a single person (Construction Supervisor) of the team to manage human-machine interactions during activities.

The Employer, its representatives or any delegated authority from the Employer who notices a failure to comply with the necessary safety rules or who identifies a potential safety risk, may stop the Works. The Work stoppage must be notified to the Contractor and any relevant third parties such as the Owner's Engineer and the H&S Responsible person. In all cases, all costs and expenses caused by the suspension of Works, part of the Works, and any corrective measures taken shall be borne by the Contractor party in breach of its obligations.

All employees should have their medical examinations conducted by a registered Occupational Health Practitioner. All records should be kept inclusive of pre-employment, annual medical examinations, and exit-medical examinations. For consistency, all medicals should be done by the same Occupational Health Practitioner(s) for any period or examinations completed.

The Contractor shall ensure that procedures for maintaining hygienic conditions and appropriate shelter or shading at eating, resting, drinking, and washing facilities are established and adhered to in compliance with the Facilities Regulations.

Proper signage shall be implemented, maintained, and managed by the Contractor on Site during the execution of the Works as well as when (part of the) Works is to be carried out outside of the Project's Site and invading public roadways.

All HSE-related activities and plans for the Plant shall adhere to the OHS requirements for Lethabo 75MW Solar PV project (375-172744).

5.2 Records and Reporting

The Contractor will be responsible for investigating and keeping a record of all safety incidents, accidents, damage to property, near misses, and positive interventions and provide details of these incidents or accidents in the monthly project progress reports. The Contractor and its Subcontractors shall diligently inform the Employer and declare any reportable safety incidents, and the Employer shall be actively involved in the investigation. The timeframe for reporting events is by the end of the same shift. The investigation will be conducted after any treatment that may be required. The incident site must not be tampered with and must be barricaded until the investigation has been completed. No works in this area will commence until the incident has been completed and deemed safe for return by the Employer.

Information related to the number of workers and total hours worked (including Subcontractors) shall be included within the monthly report.

5.3 Health, Safety, and Environment File

The Contractor shall provide a detailed HSE File prior to the commencement of the Works to indicate how HSE will be managed on the Project. In addition, all Subcontractors will be required to provide separate job specific HSE Files for approval by the appointed Contractor. This HSE File shall demonstrate the Contractor's commitment to the Standards of health and occupational hygiene of the construction workforce during the construction of the Plant.

The HSE File shall be in line with the following procedures, but not be limited to:

- Company Health, Safety and Environmental Policy;
- Company HIV and AIDS Policy;
- Company COVID-19 Policy and plan;
- Company Profile;
- Proof of company registration;
- Letter of Good Standing with COID;
- Public Liability (insurance cover);
- Company organogram (showing company reporting structure);
- Site Team organogram with the names and cell numbers of the specific team working on the specific site;
- Scope of Work;
- List of employees working on this project (with their ID numbers and positions listed);
- List of tools and equipment to be used on this project;
- Subcontractor's internal Employee induction (focusing on specialist work, specific tasks, risk assessments related to these tasks, methods to be used, and general site safety);
- Letter of appointment from Contractor or Employer;
- Agreement with the Mandatory HSE signed by Contractor and Subcontractor(s);
- Statutory Legal Appointments – (application to all contractors);
  - CEO's delegation of duties – attach ID, CV & certificates;
  - Supervisor of construction work – attach ID, CV & certificates;
  - Subordinate supervisor of construction work – attach ID, CV & certificates;
  - Fall protection plan developer – attach ID, CV & certificates;
  - Risk assessor – attach ID, CV & certificates;
  - Portable electrical tools inspector;
  - Accident/Incident Investigator – attach ID, CV & certificates;
  - Safety committee member;
  - Stacking and storage inspecting; and,
  - Hand Tools inspector.
- Other appointments (if required);
  - Safety officer – attach ID, CV & certificates;
  - First aider (must be certified and certificate attached);
  - HSE representative (must be certified and certificate attached); and,
  - Emergency Evacuation Planner.
- Company's Health and Safety Plan (must be site specific and related to your scope of work and signed by the CEO/owner);
- Environmental Management Plan (include waste management which must be signed by the CEO/owner);
- Method statement (how you are going to do your work);
- Hazard identification and risk assessments – based on method statement;
- Registers and checklists – general (if required as per scope of work);
  - Material Safety Data Sheet register and supporting documentation if hazardous substances will be used.
- Accident/Incident Procedure;
  - Appointment of accident/incident investigator;
  - Proof of competency of investigator (certificate and CV); and,
  - Accident/Incident Register.
- Certificate of competency;
  - Proof of Registration SACPCMP (Safety Officer);
  - First aider (training record); and,
  - HSE representative (training record).
- Medical Certificates for persons working above 2 m on edges, on scaffolding, painting, rooftops, and any person operating any machinery, etc.;
- Certificates of competency of operators;
  - Medical Certificates for drivers and operators (to include lung function, hearing, and eye tests);
  - Vehicle maintenance records;
  - Operator appointments;

  - Inspector appointments;
  - Explosive power tools; and,
  - Portable electrical tools.
- Toolbox talks;
- Awareness training records (how to use equipment correctly/waste management/site safety rules);
- Accident/Incident Investigation;
  - Accident/Incident Register;
  - Accident/Incident Reporting Procedure;
  - Recording of the accident/incident;
  - Employers report of the accident (WCL1 and WCL2); and,
  - Emergency contact list.

The HSE File shall be revised as necessary by the Contractor, the Contractor's safety officer, or at the reasonable request of the Employer. Each revision of the HSE File shall be submitted promptly to the Employer.

The permit to work (PTW) system put in place by the Contractor shall be designed to prevent work on any Plant item or system, without notice and without authorisation, and in any event in accordance with the recommendations of the issue-based Risk Assessments. The PTW system shall have multiple levels of safeguards (e.g., documentary and physical) to guarantee the safety of personnel and equipment. The Plant design shall allow for the easy integration and compliance of the PTW system with the Eskom Standard for Generation Plant Safety Regulations (240-150642762) and the Eskom Standard for Operating Regulations for High Voltage Systems (240-114967625). The Employer shall have the right to review all PTW systems.

A dedicated manager shall be appointed to manage the permits. All HSE-related permits shall be recorded in a dedicated permits register.

Where work is carried out either on or off the Site at any interfaces for which such interface is not the responsibility of the Contractor or the Employer, the Contractor shall comply with the PTW system of the relevant organisation.

In general, the Plant's design shall include all adequate interlocks to prevent unsafe operation of the Plant while personnel are working on any equipment. Electrical switchboards shall incorporate safety interlocking systems (consigned and signalled by means of a padlock and prohibited signage) to ensure correct system operation, avoiding unsafe switching conditions, and to ensure safe isolation for maintenance work.

The Contractor shall ensure a fully functional system of communication within the Site, according to the HSE Plan. No dead zone shall be present on the Site, including road access. In case of a working area with no mobile phone coverage, a satellite mobile phone, a Wi-Fi network, and/or a radio communication system must be implemented. The Contractor shall ensure the equipment maintains a direct line of communication between the respective safety officers, supervisors, first aid, and fire fighter personnel.

5.4 PPE

Any authorised person entering the Site shall use the full range of PPE including, as applicable, general PPE, fall protection devices, overalls when dealing with hazardous materials, and complete respiratory protection for tools in confined spaces.

The Contractor shall ensure that its employees, Subcontractors' employees, and any authorised person entering the Site wear PPE as required by the specific task being performed and the potential of the exposed hazards. Any person entering the Site shall always wear a shirt with long sleeves and long pants. Tank tops, sleeveless shirts, and short pants or cut-offs are not permitted. Loose or floppy clothing is prohibited around rotating or moving equipment. Rings, neck chains or loose jewellery shall be removed.

Provision of PPE for visitors must be kept on Site (minimum 10 pieces per each PPE). PPE must be kept in good condition.

5.4.1 Head protection

An approved hard hat shall always be worn by all visitors and employees working at the Site, except while in vehicles, living quarters, offices, and control rooms.

5.4.2 High visibility jacket

An approved high visibility jacket shall always be provided by all visitors and employees working at the Site.

5.4.3 Eye protection

Safety glasses with side shields shall always be worn on Site, except while in vehicles, offices, and control rooms (after construction in control room is complete). When safety glasses do not provide adequate protection, safety goggles or face shields shall be the means of protection (i.e., splash hazards when working with chemicals, high-pressure washers, chipping, buffing, or grinding operations). Welding hoods shall be used during all arc-welding operations. Goggles or other suitable eye protection with appropriate filter lenses shall be used during all gas welding, gas cutting or brazing operations.

5.4.4 Hand protection

Appropriate gloves shall be worn on Site when hands are exposed to hazards such as cuts, punctures, or abrasions (such as cloth, leather, leather palmed); when handling chemicals or hazardous materials where absorption is a concern (rubber gloves); and when performing electrical work. Flameproof gauntlet gloves shall be used during all arc welding, gas welding, or gas cutting operations, except when engaged in light work such as test fitting pieces.

5.4.5 Foot Protection

Safety boots with ankle support and steel toe caps shall always be worn on Site.

5.4.6 Hearing Protection

Hearing protection shall be worn on Site in all high noise areas or wherever a high-noise warning sign is posted. High noise areas will be demarcated in areas exceeding 85 dbs.

5.5 WARNING SIGNS

The Contractor must ensure the placement and maintenance of sufficient signage on Site with the proper material, so that it can be clearly visible and comply to the following minimum requirements.

Work Site Project information panel at the entrance:

- Use of PPE;
- Speed limit;
- Speed bump;
- Emergency assembly point;
- No smoking area; and,
- Danger signal.

Signage must be understandable to all the workers on Site.

The Contractor shall provide and install on Site an emergency sound alarm system with multiple sources if necessary, according to Site extension.

5.6 SITE ACCESS

The Contractor shall implement a system to control access to the Site of people and vehicles. Each access gate will be equipped with an “access control system” guarded 24/7 by a security guard. Only authorized people and vehicles are allowed to enter the Site. As part of the access control, the

Contractor shall verify possession of any weapons, illegal drugs, input and output of equipment and material, and an alcohol test to all persons entering Site.

It is expected that authorised people entering the Site will include:

- Project workers with all the necessary documentation already checked, verified, and available on Site, trained in conformity with their responsibilities;
- Employer's representatives and its advisors;
- Visitors, cleared by the Contractor and/or Employer; and,
- Public authorities as required by Law.

All authorized persons must wear an identity card/badge and their presence shall be recorded daily on an electronic attendance record system recording access and exit time. Attendance records must be submitted weekly to the Employer and available to be audited on Site.

Similar daily electronic attendance record procedures shall be followed for authorised vehicles identified.

5.7 Traffic Management Plan

The Contractor shall develop a construction Traffic Management Plan, in accordance with the Applicable Laws, Permits, and Codes and Standards for best practice traffic management procedures during construction, including a traffic incident response plan. The Traffic Management Plan shall set a procedure to describe the rules and preventive measures for traffic movement, including approaching and parking near mobile equipment, key responsibilities, the processes to operate on Site, and speed limits. The Traffic Management Plan shall include detailed information on proposed transport routes, have identified proper information related to procedures for trucks (single-unit trucks and trailer units), waiting areas, access to Site, estimated amount of heavy and light vehicles in the areas, definition of parking areas for workers, impact on nearby towns, etc. Additionally, copies of approvals must be provided and included within the respective Traffic Management Plan.

Sufficient visible traffic management signage shall be installed on Site, including internal roads, open trenches and excavations, road restrictions, pedestrian areas (offices, parking, etc), speed limits, and speed bumps. The speed limit on Site shall be 30 km/h under normal conditions, with a reduced speed limit of 20km/h around laydown areas and offices, and under poor weather conditions, such as fog, rain, hail, thunderstorm, high wind speeds and low visibility due to dust or other factors.

The presence of activities must be highlighted with adequate signage. Flagmen can be required to manage the traffic on Site.

The Contractor shall take all reasonable measures to manage and reduce the interferences with the local/municipal/provincial/national roads, and, in case traffic in these roads needs to be temporarily interrupted, the Contractor shall consider requirements imposed by the Applicable Laws, Consents, Permits, and Codes and Standards, and consider the use of mobile traffic lights.

Special attention shall be given to the communication between vehicles and machinery. Drivers must follow communication procedures and shall be trained in the correct use of two-way radios, where applicable. Hand signals (waving arms) shall be used to draw attention of the operators.

The parking on Site and internal roads (either permanent or temporary) shall be well defined, with a clear separation of heavy machinery, trucks, personal vehicles, and pedestrian areas such as offices, paths, pedestrian crossing areas, etc. Temporary parking on Site shall be well recognised using reflective cones, intermittent lights, or other signals (visible also during the night).

In case of cable crossing in internal roads, cable protection ramp or other protection mechanisms shall be used.

5.8 Waste Management Plan

The Contractor shall submit a Waste Management Plan as part of the HSE File. It shall establish the classification, handling, storage, transportation, and disposal of waste generated as a result of the construction activities, in accordance with all Applicable Laws, Permits, Codes, Standards, and requirements of the local Authorities, taking into account the following:

- Minimise the negative effects of the generation and management of waste on human health and the environment;
- Reduce the use of resources and favour the practical application of the waste hierarchy: prevention, preparation for re-use, recycling, other recovery (e.g., energy recovery, recyclable materials in catering services, etc.) and disposal;
- The Contractor shall prefer bio-based content materials, recyclable or reusable components and recycled-content materials, and, in general, use resources at their highest potential throughout the lifecycle to improve efficiency (in product manufacture, design, construction, operation, refurbishment, and at end of life);
- Identification of designated place(s) to store different types of waste such as not recycled and hazardous waste materials. Before placing an order or a contract with a waste carrier, the carrier shall be asked to provide a copy of his waste carrier license or proof of registration as a waste carrier by the local authority. A copy of this approval must be kept on Site in the HSE file;
- Segregate the waste at source with removal by a licensed waste removal contractor;
- Waste shall be removed on a regular basis in order to respect waste storage limits in compliance with the Applicable Laws and Regulations, and Codes and Standards. At a minimum, the Contractor must guarantee and respect the following limits:
  - no more than 100 m^3 of not hazardous waste;
  - no more than 20 m^3 of hazardous waste; and,
  - if not exceeding this quantity, no more than 3 months for hazardous waste and 6 months for non-hazardous waste.
- Waste storage on Site out of the designated areas is prohibited;
- The temporary waste storage must be done in the proper containers and shall be limited to the time of activities execution;
- Broken PV modules must be segregated and collected, paying particular attention to avoid dispersion in the environment of any fragments;
- Needed interventions to delimitate eventual polluted area ensuring environmental protection and Safety condition;
- Chemical analysis of polluted soil and water; and,
- Remove all sewage and wastewater from the site in compliance with all environmental approvals and the Applicable Laws and Regulations, and Codes and Standards.

5.9 Emergency Plan

The Contractor shall submit an Emergency Plan as part of the HSE File. It shall establish a system of procedures to organise and supervise the safe and orderly movement of people in case of evacuation from a danger zone. In this regard, the Emergency Plan must consider the Site as an “open system” that can generate an event inside that can also have an impact outside, and vice versa.

The Emergency Plan shall be an organisational tool developed to mitigate the damage of events, expected or not, that could endanger an organisation’s ability to function. It must include measures that provide for the safety of personnel and, if possible, property and facilities. It should also include provisions to assess the severity of an incident and implement steps to eliminate any incident, determining potential emergency situations and appropriate responses to each.

The Emergency Plan shall contain, or be a collection of, all the information required by the Occupational Health and Safety Act and regulations.

The Emergency Plan must be reviewed periodically as the Works progress, especially if the Site conditions change. The Contractor shall conduct at least one emergency drill per year on each Site to check the suitability and correct application of the Emergency Plan. Shortly after any emergency drill, the Contractor shall analyse the results and send a report to the Employer including the results of the emergency drill and the action plan to solve any issues identified.

5.10 First aid and injured management

First aid, Emergency Plan, and equipment on Site shall comply with the General Safety Regulations. The Contractor shall be responsible to provide first aid and provide a dedicated survey to locate the nearest and specialised hospitals available, considering the most possible critical situations, such as heart attack, internal haemorrhage, fracture, and snake bites.

Emergency drills must be performed before the start of the activity, including the path between the Site and the nearest hospital. The nearest hospital must be informed, prior to start the Works, of the presence of the construction or main activities.

The Contractor shall provide:

- Emergency/first aid room with paramedics always present on Site during the whole execution of the Works;
- First aid personnel and first aid kits at every work area. Work areas shall be identified and communicated to the HSE Manager;
- In case the time to reach medical assistance from the nearest hospital identified will take more than 30 minutes from Site, one permanent 4 x 4 emergency vehicle/ambulance for each Contractor with the proper equipment and medical tools to assist and stabilise any injured person shall be maintained on Site, with a radio communication system to guarantee communication with emergency services;
- An automated external defibrillator on Site and the necessary trained personnel to use it;
- Each Contractor’s vehicle shall contain, as a minimum, a first aid kit.

The Site Paramedic shall decide the transport of injured personnel to the nearest hospital identified, assessing all the respective conditions, such as injured conditions, distance, number of workers injured and the time from a hospital ambulance arrival. Depending on that assessment, the First Aid team might be requested to use the ambulance if present, to call for an external ambulance, or to request the helicopter emergency service.

5.11 Firefighting

The Contractor shall carry out a fire risk study in the Emergency Plan and implement all the reasonable measures, as required by the Applicable Laws, Permits, and Codes and Standards, as well as guarantee the supply of firefighting equipment.

The Contractor shall:

- Identify local fire stations available (considering distance and equipment), inform them of the construction activities, and have regular communications with them as the Works progress;
- Provide firefighting vehicle(s) to be present full-time on Site (the number and type of vehicle(s) must be defined based on the fire risk for the ongoing activities on Site);
- Provide fire extinguishers at buildings, MV/LV power stations, transformers, and any other areas with fire risk across Site;
- Provide means of emergency notification at every work area. An emergency trial must be performed before the start of any construction activities;
- Provide staff trained in firefighting activities and appoint the necessary firefighting personnel in relation to the number of workers present on Site, and as required by Applicable Laws, Permits, and Codes and Standards; and ,
- Provide on Site the measures aimed to avoid fire risks.

5.12 Water management

The Contractor shall ensure that the source of water to be used for the construction activities must come from legal sources, according to the Permits, Licenses, and Authorisations. All the withdrawals shall be used only for the purpose of the authorisation and continuous monitoring shall be carried out for all the permits for water discharges and water withdrawals.

Erosion control measures and treatment device shall be taken into consideration and installed where necessary before starting the construction activities. This is to minimise the threat of flooding and loss of rich nutrient soil, maintain the flow regimes of any water courses, and prevent any deterioration in water and soil quality.

Drainage trough and from areas of disturbance shall be designed to minimise surface flow velocities.

Cleaning of equipment and flushing of mixers must occur in designated wash bays (the location to be agreed with the environmental officer and with contaminated water collected or stored/contained) to ensure that contaminated wash water does not enter the environment.

Water quality sampling shall be ensured by the Contractor in order to check conditions on Site. At least every two months the sample shall be reported.

5.13 Storage of Hazardous Material

The Contractor shall be responsible to adequately store any hazardous materials according to the Construction Regulations and the General safety regulations, the recommendations of the suppliers/manufacturers, and standard industry practices. The hazardous storage area shall include measures for proper containment such as bund walls, access control, ventilation, fire extinguisher, and material safety datasheets on hand.

In addition, the Contractor shall be responsible for ensuring that all hazardous waste, including contaminated or hazardous soil or sub soil arising from the Works, is deposited, treated, stored, and disposed of in accordance with the provisions of all Applicable Laws and Regulations, Permits, and Codes and Standards. The Contractor shall be responsible for the provision of the approved disposal facilities, including obtaining all necessary permissions.

5.14 Excavation and trenching

The Contractor shall ensure that all excavation and trenching operations shall be performed under the adequate supervision of the construction management team and in compliance with all requirements, including the excavation plan and the material disposal authorisations.

The Contractor shall ensure that, in addition to the Statutory requirements, the following minimum requirements are met during every excavation and trenching operation:

- Protected measures aimed to avoid falls, dislodgment of materials, person buried or trapped-in, as well as fenced measures shall be taken into consideration;
- Sides of excavations must be clean and neat;
- Drilling holes must be covered, signalised, and fenced;
- Locations of cables, communication wires, and other underground hazards such as pipelines shall be established and marked prior to beginning excavation or trenching operations;
- In case of excavation at the edge of a track/road that has an impact on the movement of the vehicles, the traffic must be managed with two flagmen or with traffic lights;
- If an excavation or trench is greater than 1.5 m in depth, shoring, bracing, or under-pinning will be provided;
- Access and egress must be provided adequately dependant on the size of the trench;
- All excavations must be on register and inspected daily before Work commences and after inclement weather by the Contractor, be declared safe, and have any findings noted in the daily register; and,

- No work shall commence in an excavation unless the excavation has been declared safe by the Contractor.

5.15 Environmental and Social Requirements

The Contractor shall comply with and include in the design, construction, and operation all requirements stated in the EIA report, the EA(s) from the relevant competent authority, the EMPr(s) (and all associated management plans), applicable licences and permits, and all applicable National and Provincial Legislation. This includes the environmental requirements for the OHL route as contained in the separate documents provided (project reference 14/12/16/3/3/1/2805) as part the Request for Proposal (RfP) documentation package.

The Contractor shall include in the HSE File, before Work commences on Site, an Environmental and Social Management Plan, including environmental policy, procedures, and certification.

The Contractor shall submit the environmental requirements to the Employer for review and acceptance as part of the HSE documentation submission. The Contractor shall ensure that the environmental requirements include as minimum, but not be limited to:

- Identification and understanding of the applicable environmental legislation;
- Provide upon request any documentation to certify proper compliance with Applicable Laws and Regulations, Permits, and Codes and Standards;
- Identify the procedures for continuous compliance;
- Environmental risk assessment in order to identify all the processes and activities that may involve potential risks and ensure adequate measures to prevent these risks; and,
- These environmental requirements must be considered as minimum requirements. In case the local environmental authorities' requirements and Applicable Laws and Regulations, Permits, and Codes and Standards are more restrictive, these shall prevail over the Contractor's environmental requirements.

The environmental risk assessment shall be performed by competent personnel (risk assessor) appointed in writing by the Contractor. It shall consider the following non-exhaustive aspects according to the construction and operation activities to be carried out:

- Vulnerability of the Site to climate change effects (extreme changes such as floods, heat/cold-waves, hailstorm, heavy snowfall, and storms; and chronic changes such as water bodies/water-level rise, temperature change, and average change in precipitations);
- Considerations during development, construction, and operation:
  - interaction with the atmosphere (emissions from combustion, machinery, execution of different activities, geothermal fluids, and other emissions, such as SF6);
  - interaction with soil (for soil structural vulnerability, soil erosion vulnerability, rainwater/stormwater management, fuel or chemicals, or hazardous substances storage);
  - interaction with existing infrastructures (such as houses and roads);
  - sedimentation impacts;
  - interaction with water (interaction with rivers/lakes/sea, risk of floods inside and outside the Site, wastewater management, etc.);
  - physical impacts (risk of fire, heat, noise, vibrations, electromagnetic fields, odours, light, etc.);
  - consumption depletion of scarce resources (water use intensity, soil use, materials, energy, wastes, waste recovery, hazardousness, end of life impact, etc.);
  - chemicals/hazardous materials;
  - biodiversity and visual impacts (land, wetland losses, natural habitat degradation/ clearing, flora, fauna and sensitive species and Site, such as threatened and range-restricted species, near protected areas, and species or Sites of stakeholder concern, fauna and

sensitive species and Site, presence of historical/archaeological importance/heritage, etc.);

- Governance for internal monitoring and reporting adequacy, and workforce and competence adequacy; and,
- Compliance with Applicable Laws and Regulations, Permits, Authorisations, Codes and Standards, mandatory prescriptions, purchasing, supply robustness, and reputation.

Breaches of the environmental requirements are not permitted. In case any such breach would nevertheless occur, the Contractor shall immediately report said breach to the Employer, and if applicable, to relevant authorities, and shall rectify the same in due course.

The Contractor shall be responsible to obtain any additional environmental related permits required for the execution of the Work prior to the commencement of the relevant activity.

5.15.1 Environmental and Social Management Plan

An Environmental and Social Management Plan (and all associated management plans) shall be submitted to the Employer by the Contractor for review, comments, and acceptance and shall adhere to the Applicable Laws and Codes and Standards. As part of the monthly progress report, the Contractor shall provide a summary on any environmental and social actions undertaken with respect to the Environmental and Social Management Plan.

The Environmental Officer(s) shall monitor and control the implementation of actions plan. The Environmental Officer(s) can, at any time, request the Contractor and Subcontractors to transmit relevant documentation for the realisation of the Environmental and Social Management Plan.

The Contractor shall be responsible for the preventive measures to preserve biodiversity and for the protection of native animal species on the Site, which have to be taken in compliance with the Applicable Laws, Permits, Authorisations, and Codes and Standards, as well as the provisions of the approved Environmental and Social Management Plan.

An independent environmental specialist shall be engaged by the Contractor to intervene at the start of construction to ensure the respect of the Environmental and Social Management Plan and to assess immediate ecological threats. The Contractor must ensure the protection of native animal species during construction.

The Contractor shall appoint a Community Liaison Officer (CLO) to inform the local community of employment and sub-contracting opportunities prior to the start of construction. The CLO shall be responsible for developing specific programs benefiting the local community. The discussions with local authorities and community should not involve any form of intimidation or unethical behaviour.

The CLO shall keep on file a complaints and grievances register during the Project. The register shall be available to the Employer at all times.

The Contractor shall ensure working practices respectful of human rights and promoting human development, especially by prioritising Suppliers and Subcontractors with human rights or supply chain certifications, with an Environmental, Social, and Governance policy in place.

The Contractor and all Subcontractors shall demonstrate compliance with all South African and international legislation that applies to their business operations from modern slavery, anti-bribery, and Health & Safety laws to product-specific regulations. The Contractor and all Subcontractors and Suppliers commit to conform to the following international rules:

- Universal Declaration of Human Rights;
- The key conventions of the International Labour Organisation; and,
- United Nations Guiding Principles on Business and Human Rights.

The Contractor shall provide to the Employer a social and ethics report specifying efforts to ensure compliance with the Employer code of conduct for the Contractor and the level one Suppliers and Subcontractors.

6 PROJECT MANAGEMENT

6.1 Project Administration

6.1.1 Introduction

The Contractor will be responsible for the management of the Project, the coordination, interface management with HV contractor and any third parties (if applicable), scheduling, supervision, and execution of the Works, either directly by the Contractor or by any Subcontractor in accordance with the terms of the Contract.

The Contractor shall bring to the attention of the Employer immediately as they occur any important issue impacting HSE, schedule or equipment integrity, along with the proposed corrective actions.

6.1.2 The Role of the Employer

The Employer will set up a management team to review, monitor, and audit the Contractor's activities. Access to Site, the Contractor's works, and premises (and those of his Subcontractors and Suppliers), shall be granted at any reasonable time for the purpose of auditing and monitoring the quality and progress of the Works.

The Employer shall have the opportunity to review, audit, and comment on all of the Contractor's Documents, including design documentation, equipment specifications, and construction documents in accordance with the agreed MDL and contractual review timelines. Any review and comment by the Employer do not relieve the Contractor of their design responsibilities under the Contract. The Contractor shall be responsible for any discrepancies, errors, or omissions in the documents supplied, whether such documents have been reviewed by the Employer or not.

The Contractor shall make allowance in its price and programme for the Employer's review process as well as revisions of the documents that may be needed as a result of the Employer's review. The Contractor shall plan for any additional documents it may need to produce during the course of the Works, in addition to those included in the MDL, and which the Employer may require for acceptance, review, audit, or comment.

6.1.3 Contractor's Documents

The Contractor's Documents shall comprise at the minimum of the following documents:

- Monthly progress reports as per section 6.2.5;
- Project programme as per section 6.2.1;
- HSE File as per section 5.2 (to be submitted within 21 days from Notice to Proceed and in any case prior to any Site mobilisation) including:
  - Emergency plan;
  - Access management plan;
  - Traffic management plan;
  - Waste management plan;
  - Stormwater management plan;
  - Erosion management plan;
  - Excavation management plan;
  - Lifting plan;
  - Environmental and Social management plan;
  - Ecological regeneration plan; and,
  - Stakeholders' management plan.
- Project Plans (noting that the Contractor can propose that some of these plans be combined as long as they are all developed for the Project):
  - Project execution plan (to be submitted within 21 days from Notice to Proceed);

  - Document and communication management plan (to be submitted within 21 days from Notice to Proceed);
  - Equipment identification plan (to be submitted within 28 days from Notice to Proceed);
  - Programme management plan (to be submitted within 21 days from Notice to Proceed);
  - Mobilisation and training plan (to be submitted within 21 days from Notice to Proceed and in any case prior to any Site mobilisation);
  - Quality management plan (to be submitted within 21 days from Notice to Proceed and in any case prior to any Site mobilisation);
  - Risk management plan (to be submitted within 21 days from Notice to Proceed);
  - Engineering and design management plan (to be submitted within 21 days from Notice to Proceed);
  - Interface (battery limit) management plan (to be submitted within 21 days from Notice to Proceed);
  - Procurement and subcontracting management plan (to be submitted within 21 days from Notice to Proceed);
  - Logistics management plan (to be submitted within 21 days from Notice to Proceed);
  - Construction management plan (to be submitted within 21 days from Notice to Proceed and in any case prior to any Site mobilisation);
  - Stormwater management plan (to be submitted within 28 days from Notice to Proceed);
  - Erosion management plan (to be submitted within 28 days from Notice to Proceed); and,
  - Testing and commissioning plan (to be provided at least 2 months prior to the commencement of commissioning activities).
- Contractor organisation chart, including CVs for key positions;
- Permit register;
- Suppliers list;
- Engineering documentation:
  - Technical specifications;
  - Datasheets;
  - Contractor's Sites studies;
  - Layouts;
  - Single Line Diagrams (SLDs);
  - Network line diagrams;
  - Wiring and termination drawings;
  - Cable calculations;
  - Cable schedules;
  - Foundation calculations;
  - General design criteria, Standards, and design basis (civil, electrical, and C&I);
  - Battery limits;
  - Equipment lists;
  - Control philosophy;
  - Earthing and bonding studies;
  - Fire detection and protection design;
  - Building design and drawings;
  - Fence design and drawings;
  - Drainage design and drawings;
  - Access roads design and drawings;
  - Internal road design and drawings;
  - Trenches layout;
  - Cable schedules;
  - General arrangement drawings of enclosures, cabinets, etc.;
  - List of licenses;

  - List of passwords;
  - Hardwired Signal Lists;
  - Virtual Signal Lists;
  - SCADA system historian Input/Output (I/O) tag list; and,
  - Any other engineering documents, lists, calculations and drawings (civil, electrical, and C&I).
- Construction documents
  - Method statements for all the construction activities;
  - ITP for all construction activities;
  - Test results; and,
  - Site delivery documentation.
- Commissioning documents
  - Testing and commissioning plan;
  - TOP documents for all systems; and,
  - Test results.
- Spare parts lists;
- Special tools lists;
- Training manuals;
- As-built drawings;
- O&M manuals; and,
- Any other documents requested in the Employer's Requirements.

6.1.4 Meetings and Coordination

The Contractor shall make provision for the following meetings, from Contract signature to the Date of Completion:

- Kick-off meeting to be held shortly after Contract signature and preferably prior to the Notice to Proceed. It is expected that an agenda is circulated by the Employer prior to the meeting, requesting the Contractor to prepare a presentation for the meeting. The Contractor shall take detailed minutes of the meeting and submit them to the Employer within one week after the meeting;
- Risk Assessment workshop prior to commencement of the construction works. This is for the Contractor to present the risk management plan and to discuss the initial Risk register developed by the Contractor, and to allow the Employer to comment and note potential additional risks for the Contractor's consideration;
- Weekly design review meetings. This meeting is intended to allow for an open discussion between the Employer or its representatives and the Contractor, to discuss technical and design aspects either prior to or after the Contractor's submission of the relevant design document. It is expected that any key items for discussion are shared by the Employer and the Contractor ahead of the meeting. The Contractor shall develop, maintain, and share documents with the Employer to track the key discussion and outcome of the design review meetings;
- Monthly progress and management meetings. It is expected that these meetings are chaired by the Employer or its representatives and that an agenda is circulated by the Employer prior to the meeting. The Contractor shall take detailed minutes of meetings and submit them to the Employer within one (1) week after the meeting. Recording of these meetings may be required by the Employer in which case the Contractor shall provide the necessary equipment to that regard; and,
- Weekly Site construction meetings covering construction and commissioning activities, planning, quality, Health and Safety, Site deliveries, and any other relevant aspects for the execution of the Works. It is expected that these meetings are chaired by the Contractor. The

Contractor shall take simplified minutes/actions of meetings and submit these to the Employer within two (2) days after the meeting.

The Contractor shall be properly represented at all these meetings and ensure adequate facilities are available for these meetings when held on site or at the Contractor's premises. Additional meetings may be held (at no extra cost) as required by the Employer as and when necessary to address specific technical, operational, HSE, and commercial aspects.

6.1.5 Contractor's Project Management

The Contractor shall execute the Works in accordance with its project execution plan, any other project procedures, project organisation, and Applicable Laws and Regulations, Permits, and Codes and Standards, subject to on-going review and agreement by the Employer.

The Contractor shall appoint a dedicated Project Manager to manage the overall execution of the Works and be the key point of contact with the Employer.

The Contractor shall appoint a dedicated Contacts Manager to support the Project Manager in the management of the Contract and contracts with the Suppliers and Subcontractors

6.2 Project Control, Programme, and Reporting

6.2.1 Initial Programme

The Contractor shall submit to the Employer for acceptance the initial programme that shall consist of a Level III bar chart type schedule that will be included as a schedule of the Contract. The initial programme shall be broken down into major elements showing key project milestones (including those relating to the terms of payment), shall include the critical path and all activities and floats (i.e., shall indicate the early and late finish project curves), and shall clearly show the key dates relating to the following:

- Notice to Proceed;
- Site investigations, studies, and assessments;
- Design activities as per MDL documents;
- Exchange of information with other parties concerning terminal points;
- Contractor mobilisation;
- Availability of temporary facilities;
- Availability of services (water, fuel, and electricity);
- Civil works activities:
  - Site preparation;
  - Earth movement;
  - Fencing;
  - Mounting structure foundations;
  - Inverter foundations;
  - MV/LV power station foundations;
  - Trenches;
  - Roads; and,
  - Buildings.
- Procurement and manufacturing;
- FATs;
- Equipment delivery;
- Electrical works;
- Equipment installation;
- Cold commissioning;
- Hot commissioning;
- Mechanical completion tests;

- Provisional Acceptance Tests;
- Date of Completion; and,
- Payment milestones.

6.2.2 Baseline Programme

The Contractor shall, within 28 days from Notice to Proceed, submit to the Employer for acceptance the baseline programme. It shall consist of a Level III bar chart type schedule and be developed based on the initial programme included as a schedule of the Contract whilst keeping the same completion and key milestone dates.

The Contractor shall submit the native file (Primavera or Microsoft Project).

6.2.3 Revised programme

The Contractor shall submit to the Employer for acceptance a revised programme that shall consist of a Level III bar chart type schedule. The revised programme shall accurately reflect the true progress of the Works whenever the baseline programme or any subsequent revised programme ceases to reflect actual progress, or is otherwise inconsistent with the Contractor's obligations.

The Contractor shall submit the native file (Primavera or Microsoft Project).

6.2.4 Programme control

The Contractor shall monitor and control the programme by use of an integrated tiered planning system whereby all activities can be uniquely identified and directly related to activities at all other levels.

All programme levels shall include the critical path and all activities and floats, i.e., shall indicate the early and late finish project curves.

There shall be at least five (5) levels of planning, as detailed below:

- **Level I** – Overall programme showing the Contract milestones and containing all major key dates and activities;
- **Level II** – Initial programme containing all interface terminal points clearly identified as individual activities, related to both documentation and physical tie-ins. A more detailed network from which overall project reports are produced and on which risk analysis is performed. It is anticipated that this Programme will have been agreed to at Contract award and will be incorporated into the Contract;
- **Level III** – The Contractor's detailed level of programming with a record for each activity. Each major Subcontractor is expected to maintain and update his own section and pass all update information to the Contractor, who will update and maintain an overall programme. The Level III planning network shall be structured so that progress reporting and field progress correspond directly with planning activities identified in the Programme. The level of detail and the work breakdown structure(s) shall be subjected to on-going review and agreement by the Employer. The planning shall be resource-loaded so that all key Contractor and subcontractor activities can be monitored for resource adequacy and appropriate levelling by discipline. This shall include construction progress by discipline;
- **Level IV** – The Contractor's working programme produced and maintained by the Contractor. The Contractor shall also ensure that each main subcontractor provides a detailed network programme that relates to activities in the Level III network; and,
- **Level V** – The Contractor's and Subcontractors' work definition and progress measurement level, document issue schedule (engineering), and work item database (deliveries, construction through to commissioning).

The Contractor shall submit to the Employer for acceptance a programme management plan describing the process to measure progress of the Works, the weighting factors for the various activities that comprise the programme, and the frequency for measuring progress.

The Contractor shall follow the programme management plan during the execution of the Works.

The Contractor is expected to measure the progress at least on a weekly basis in preparation for the Site's weekly meeting.

6.2.5 Progress Reporting

The Contractor shall submit a detailed monthly progress report for each calendar month up to the agreed measurement cut-off date (last day of the month unless otherwise agreed). The monthly report shall contain but not be limited to:

- Executive summary;
- Overall progress;
- Engineering:
  - Progress;
  - MDL status summary;
  - Activities on the critical path;
  - Late or delayed activities and expediting measures proposed to bring late activities back on schedule;
  - Activities performed in the past month;
  - Activities planned for the next month; and,
  - Areas of concern
- Procurement:
  - Progress;
  - Procurement status, including separate tables for Suppliers and Subcontractors as per below:

Equipment	Supplier	Status	Purchase Order execution date	Manufacturing / Design progress	Transport progress	Delivery to site progress

Services	Subcontractor	Status	Contract start date

  - Activities on the critical path;
  - Late or delayed activities and expediting measures proposed to bring late activities back on schedule;
  - Activities performed in the past month;
  - Activities planned for the next month; and,
  - Areas of concern.
- Construction:
  - Progress;
  - Construction status summary including the table below:

Task	Total Quantity (Ha, m or #))	Quantity completed	Progress (%)

  - Activities on the critical path;
  - Late or delayed activities and expediting measures proposed to bring late activities back on schedule;
  - Activities performed in the past month;
  - Activities planned for the next month; and,
  - Areas of concern
- Commissioning and Testing:
  - Progress;
  - Commissioning status summary;
  - Activities on the critical path;
  - Late or delayed activities and expediting measures proposed to bring late activities back on schedule;
  - Activities performed in the past month;
  - Activities planned for the next month; and,
  - Areas of concern.
- Quality;
- Payment milestones;
- Personnel:
  - Site staffing;
  - Changes to key personnel; and,
  - Hours worked (including Subcontractors) in the month and cumulative.
- Contractual matters:
  - Claims; and,
  - Change Orders
- Health and Safety;
- Environmental factors, including incidents, interventions, utility consumption, and waste management;
- Risk register summary;
- Annexes:
  - Photos;
  - Updated MDL;
  - Updated Programme including native file (Primavera or Microsoft Project);
  - Progress S-curves, including planned and actual progress status;
  - Updated Risk register; and,
  - Plant machinery list.

6.2.6 Project Risk Register

The Contractor shall develop and maintain a Project risk register through the execution of the Works, covering all risks to the Project, such as quality, schedule, cost, social, environmental, and financial. The initial risk register shall be provided to the Employer no later than 2 weeks after the Risk Assessment Workshop.

6.3 PROJECT EXECUTION PLAN

The Contractor shall submit to the Employer for review a comprehensive project execution plan, describing the Contractor's project management organisation, management procedures for the various phases of the Works, coordination and communication with the Employer, and management of the battery limits. The project execution plan shall cover at least the items below, either as part other document or referring to other Project Plans:

- Project description;
- Project objectives;
- Contractor's project management organisation, including Subcontractors;

- Reporting obligations;
- Procurement methodology;
- Equipment identification system;
- Construction management;
- Value improvement practices;
- Scope of services;
- Time management;
- Project responsibilities;
- Cost management;
- Quality management;
- Project risk management;
- Contracting plan;
- Planning and work control;
- Project communication;
- HSE procedures;
- Project document requirements;
- Document naming procedure;
- Interface (battery limit) management;
- Stakeholder management; and,
- Other topics needed to describe the project management and co-ordination.

6.4 Project Documentation Requirements

6.4.1 Document Language

All the Contractor's Documents shall be in well-worded written English. Should any documentation, in the Employer's sole discretion, be deemed not to comply with this requirement, the Employer shall have the right to request a translation of the document from a professional translation service provider from the Contractor.

6.4.2 Document Management System

The Contractor shall, for all Works to be performed under the Contract, establish and maintain a comprehensive computer-based DMS software at no cost to the Employer for the Employer to use, control, issue, store, and manage reviews of all Contractor's Documents generated during all phases of the Works. It shall follow the agreed document naming procedure and allow accessing of current and past revisions of the documents. The Contractor shall propose DMS software options for the Employer´s acceptance. The Contractor shall provide the necessary training to the Employer in the use of the agreed DMS software.

The DMS shall have the following features:

- Documents and drawings can be viewed over the Internet without requiring specialist software;
- Fully integrated with Windows software;
- Ability to send notification emails;
- Ability to categorise and file documents, including drawings;
- Ability to attach key words to documents for easier searching;
- Flexible search capability;
- Ability to make documents and categories with restricted access;
- Full audit trail on all documents and comments/communications;
- Revision control; and,
- Ability and ease of downloading documents individually or in bulk.

The layout, format, and information on the Contractor's drawings and reports shall be agreed and reviewed upfront by the Employer.

6.4.3 File Formats

All the Contractor´s Documents shall be submitted in a latest version of Microsoft Office formats, non-password protected and searchable.

The Employer may request the Contractor to submit the Contractor´s Documents in native/editable format as follows:

- Text documents (MS Word 2013/2016) .docx format;
- Presentation (PowerPoint 2013/2016) .ppt format;
- Programme (Microsoft Project 2013/2016) .mpp format;
- View formats (Adobe Acrobat) .pdf format;
- Drawings .dgn format;
- Photos .jpg format;
- Video .mpg (.avi) format;
- Sound .wav (.mp3) format; and,
- Compressed files .zip format.

The Contractor needs to comply with the requirements in the Eskom Engineering Drawing Standard - Common Requirements (240-86973501).

6.4.4 Document and communication management plan

The Contractor shall submit to the Employer for acceptance a document and communication management plan defining the document naming procedure and communication procedure to be used for the Project.

6.4.5 Master Document List

The Contractor shall submit an initial MDL for the Employer’s review and acceptance before the signature of the Contract, including all Contractor´s Documents and indicative submission timelines. The Employer will indicate those documents in the initial MDL that shall be submitted to the Employer for review and acceptance and those that shall be submitted for information.

Within one month of signature of the Contract, the Contractor shall submit the final MDL for the Employer’s review and acceptance, which shall be developed on the basis of the initial MDL included in the Contract. The Employer will indicate those documents in the final MDL that shall be submitted to the Employer for review and acceptance and those that shall be submitted for information.

The MDL is expected to be a live document that is updated regularly by the Contractor and that is included as an annex to the Contractor´s monthly progress reports.

All documents forming part of the MDL shall be uploaded to the DMS with one (1) week after acceptance/approval.

The Employer reserves the right to request any and all documents in the MDL for review.

6.4.6 Document Review

The Employer shall have a 10 working day review period, unless otherwise stated in the Contract, for the review of any Contractor’s Documents that are subject to the Employer’s review. The Contractor shall avoid submitting Contractor’s Documents in a large lot/package, in which case the review period may be extended based on the number of Contractor’s Documents submitted. For those Documents requiring review and/or approval by third parties, i.e., local authorities, the Contractor shall allow for a longer review period.

Prior to submitting any Contractor’s Documents, the Contractor shall review and ensure that the Contractor’s Documents are complete, legible, and comply with the Contract, the Employer’s Requirements, and all Applicable Laws, Permits, and Codes and Standards. Any document which is apparent that it has not been checked properly by the Contractor before submitting it for the Employer’s review can be rejected by the Employer.

The review and acceptance of the Contractor’s Document(s) by the Employer is intended to assist the Contractor in implementing the requirements defined in the Contract, the Employer’s Requirements, as well as Applicable Laws and Codes and Standards. The Employer’s review of the Contractor’s Documents shall not relieve the Contractor of any of their obligations to meet all the requirements defined in the Contract, the Employer’s Requirements, Applicable Laws, and Codes and Standards, or relieve the Contractor of the overall design responsibility for the correctness of the Contractor’s Documents.

Any review by the Employer does not constitute any limitation of the Contractor’s warranty obligations and does not establish a liability on the part of the Employer. The Contractor cannot derive any claims from requests of the Employer for modification or supplementation which, in keeping with the state of the art by the time of the Contract award, ought to have been included, and are necessary for the Works.

When submitting the Contractor’s Documents for review by the Employer, including any documents prepared by Subcontractors, the Contractor shall include a transmittal following a sequential numbering. The transmittal shall mark whether a Contractor’s Document is submitted “for review” or “for information”. After review of a Contractor’s Document submitted “for review”, the Employer will issue a Design Review Comment Sheet (DRCS) or similar per Contractor’s Document, including the Employer´s comments to the Contractor’s Document and the review status as follows:

- NO-OBJECTION: authorises the Contractor to continue the Works covered by the Contractor’s Document;
- NO-OBJECTION WITH COMMENTS: authorises the Contractor to continue the Works covered by the Contractor’s Document, with the exception of the areas that are subject to comments noted by the Employer in the DRCS. The Contractor shall address the Employer´s comments and reissue the Contractor’s Document for the Employer´s review, including the DRCS with the Contractor´s responses to each of the Employer´s comments; and,
- REJECTED: prevent the Contractor to continue with the Works covered by the Contractor’s Document. The Contractor shall address the Employer´s comments and reissue the Contractor’s Document for the Employer´s review, including the DRCS with the Contractor´s responses to each of the Employer´s comments.

For those Contractor’s Documents submitted “for information”, the Employer is not required to provide comments but may elect to do so if it considers that it does not comply with the Contract, the Employer’s Requirements, Applicable Laws, Permits, and Codes and Standards.

The Contractor shall not undertake any Works prior to receiving the NO-OBJECTION status for such Works by the Employer. The Employer reserves the right to instruct the Contractor to make necessary design modifications in order to execute the Works in compliance with the Contract, the Employer’s Requirements, Applicable Laws, and Codes and Standards without additional cost to the Employer.

6.4.7 Construction Records

The Contractor shall generate, maintain, and store (electronically and physically on site as required) records of construction activities as per the quality plan.

All records, including those generated by Subcontractors or suppliers, shall be concisely compiled, indexed, and uniquely identified with the contract reference number and, where relevant, subcontract or order numbers. They shall be clearly identifiable to the individual parts and assemblies to which they refer by using the agreed equipment identification system.

For items of the Plant or equipment that are being delivered to Site, the Contractor shall ensure that all records required by the Employer pertaining to such equipment arrive on Site with the Plant or equipment.

Copies of all records generated during the course of the Contract by the Contractor, including its Subcontractors and Suppliers, shall be retained by the Contractor for a period of twenty-five (25) years from the date of contract completion. These records shall be made available to the Employer on request.

6.4.8 Transfer of Package Documentation

The Contractor shall develop Transfer of Package (TOP) documentation for each equipment/system and submit it to the Employer at least two weeks prior to commencement of commissioning of the system/equipment that it relates to. The TOP documentation shall include the relevant design, quality (manufacturing and construction) and commissioning documentation applicable for the system/equipment. The Contractor shall propose a list of systems/equipment to divide the whole Works and submit a separate TOP for each system/equipment, including as a minimum the following:

- The Contractor´s confirmation that system/equipment is ready for commissioning;
- Data sheets;
- Manufacturers' installation manuals (where applicable);
- FATs (i.e., where applicable);
- Equipment test certificates (i.e., Type approval certificates);
- Signed ITPs and associated installation checklists and reports;
- SATs (where applicable);
- Instrument and measurement tools calibration certificates;
- Setting sheets (i.e., protection and control settings where applicable);
- As Built drawings;
- Commissioning procedures, associated protocols, and checklists to be completed during commissioning;
- Test procedures; and,
- Construction punch lists at the moment of transferring the system/equipment from construction to commissioning.

6.4.9 Commissioning Procedures

The Contractor shall prepare detailed "stand-alone" commissioning procedures necessary to cover construction completion, testing, and commissioning of equipment and systems to a state of readiness for start-up and operation in accordance with the procedures, test details, and criteria contained in the Contract. The Contractor shall provide for specialist vendor personnel to assist as required.

The Contractor is responsible to manage, co-ordinate, and control the pre-commissioning and commissioning activities of each system. The Contractor is responsible to ensure that the systems which will be energised are operated safely and according to the relevant South African legislation, Grid Code, and operating instructions. In this regard, the Contractor will be required to place locks on doors and switchgear to prevent inadvertent energisation of these systems and/or electrocution of personnel.

The Contactor is also expected to appoint a designated official to perform all switching operations on the project. Proof of this individual's experience and competence (a CV) must be submitted to the Employer for review and acceptance at least two (2) months before commencement of the commissioning activities for the Contractor's Project Manager and Site Manager roles. Pre-commissioning and commissioning will be carried out on a system-by-system basis. The Contractor shall, in accordance with the procedures, test details, and criteria referred to above, prepare a separate procedure for each system to be commissioned. It is important that where vendor packages/equipment commissioning procedures are written, all relevant vendor drawings and documentation are included in the relevant procedure file. Each system commissioning procedure shall contain:

- Title and system number to which the procedure refers;

- Index;
- Status/approval signature sheet; and,
- Equipment test record sheets, including pre-commissioning and commissioning test records.

The Contractor shall submit copies of its proposed commissioning procedures, including associated checklists, to the Employer for review at least sixty (60) days prior to the start of commissioning of the Plant or any equipment.

The Employer shall be present at all the commission activities and shall sign off on the commissioning file.

Within two (2) weeks of the completion of commissioning the Contractor shall submit a comprehensive commissioning report with bound sets of completed and signed check sheets.

6.4.10 Submission of Final Documentation

The Contractor shall submit to the Employer all Contractor´s Documents in a virus free memory stick. Three (3) physical hard copies will be issued to the Employer.

6.4.11 Operation & Maintenance Manuals

The O&M manuals shall include all operating procedures and instructions, equipment supplier's operating instructions, and all other information related to the Works that is necessary for safe and successful operation of the Project.

The O&M manuals shall include instructions to safely start, efficiently operate, properly control, and shut down the equipment and systems under normal conditions, during maintenance of the system, and under emergency situations.

The O&M manuals shall describe and explain in detail the Plant's systems and processes so that new O&M personnel can study and understand the function and controls of the various systems.

The O&M manuals shall contain, but not be limited to, the following:

- Detailed system description of the Plant's systems, including the design operating conditions and system control philosophy;
- Detailed functional description of the control systems, including, but not limited to, string monitoring, inverters, MV transformers, and Plant's Substation;
- Operating procedures for start-up, normal operation, and shutdown;
- A detailed explanation of equipment safety interlocks and emergency shutdown systems, including recommended operating procedures for each alarm and shutdown;
- Emergency procedures and any procedures recommended to prevent deterioration during prolonged non-operation;
- Maintenance procedure explaining the steps required to prepare and perform all maintenance activities, including details of the spares and special tools required;
- Fault diagnosis guidelines;
- A comprehensive preventive maintenance schedule outlining each maintenance operation and the frequency with which each operation shall be repeated;
- Detailed instruction manuals covering all instruments and other hardware, together with copies of all software, to enable the Employer to maintain the C&I systems and, in particular, to:
  - Identify faults;
  - Make adjustments;
  - Reconfigure;
  - Reprogram;
  - Alter control programming, logic, algorithms, or settings; and,
  - Retrieve historical data from system storage media.

- Detailed information about the spare parts required for the Plant, including details of their dimensions, manufacturing Standards and materials, as well as ordering details and contact details of the supplier;
- Original equipment manufacturers' warranties;
- Copies of all test results; and,
- List of licenses and list of passwords required for the Plant's O&M.

7 QUALITY ASSURANCE AND CONTROL

7.1 INTRODUCTION

The Contractor shall develop, establish, and implement a Quality Assurance System (QA System) covering all the Works as a minimum to meet the requirements set out in the relevant parts of ISO 9001. The QA System shall be a means of ensuring that the Works conform to specified requirements as per the Contract, the Employer´s Requirements, the Applicable Laws and Regulations, and Codes and Standards.

The QA system, and all other quality-related aspects of the Plant shall adhere to the Lethabo Solar PV Plant Quality Specification (375-172743).

The QA System shall address design, construction, manufacture, installation, testing and commissioning, and O&M aspects of the Plant. The QA System shall detail the specific activities and checks to be performed, operations, control procedures, inspections, testing, approvals, and certificates applicable. It shall contain specific technical compliance metrics and shall be subject to acceptance by the Employer. The QA System shall also clearly demonstrate how deviations are recorded, followed up, and closed out.

The QA System shall define and document the Contractor's policy for quality and its commitment to quality. The Contractor shall ensure that its policy is understood, implemented, and maintained at all levels in its organisation, including all subcontractors.

A fundamental principle of the QA System is that the Contractor shall monitor and approve its own work. The Employer will monitor the Contractor's ability to follow approved plans and procedures throughout the entire project, from design phase to the Defects Liability Period.

The Contractor shall employ the necessary resources and tools to develop, document, implement, and maintain the QA System.

The QA System shall, as a minimum, cover the following aspects:

- Permanent works;
- Temporary works;
- Construction activities;
- Laboratory test reports;
- On-Site test reports;
- FATs;
- Transfer from construction to commissioning;
- Cold commissioning;
- Hot commissioning;
- Mechanical completion;
- Provisional Acceptance;
- Operation & Maintenance;
- Environmental and social elements; and,
- Health and Safety.

The QA System shall be based on its internal quality control processes, manufacturer's recommendations, Subcontractor's quality processes, well-established principles, and proven performance, and be adapted for the Project as required. The QA System shall identify reasonable hold, witness, and review points linked to particular activities during the manufacturing or execution of the Works on Site, which need to be implemented and documented by all Suppliers and Subcontractors. The QA System should follow a tiered approach where construction activities are signed off following the applicable ITP and only upon the signing-off of all activities that form part of a system, is the system reviewed for compliance and sign-off.

For the duration of the Contract the Employer may require that the Contractor's QA System be audited either by the Employer or external parties to ensure that activities are being performed in accordance with the contracted standards. The audits will be carried out against the requirements of ISO 9001 quality assurance system requirements.

The Contractor shall keep the Employer informed in advance of the time of starting, and of the progress, of the Works in its various stages so that arrangements can be made for inspection and testing which require the Employer's acceptance/witnessing.

The Employer may visit the Contractor's or Subcontractor's works or audit the Contractor's records at any time after prior announcement, with a reasonable lead time to verify that the QA System is being followed and sufficient reviews, checks, and tests are being performed during the execution of the Works.

Any inspection and tests done by Employer of any components, equipment, or installations, shall not relieve the Contractor of any responsibility in relation to defects or other failures which may be found before the end of the Defects Liability Period.

7.2 Quality Management Plan

Based on the QA System, the Contractor shall develop and implement a Quality Management Plan describing all the tests, inspections, and controls (including any work done by Subcontractors) that must be carried out during the execution of the Works covering manufacturing and construction activities.

The Contractor shall appoint a designated Quality Assurance and Quality Control (QA/QC) team for the whole execution of the Works, including a full-time dedicated QA/QC Manager with the relevant experience in QA/QC for projects of similar complexity and technology to the Project. The Contractor shall present the CV of the QA/QC Manager to the Employer for acceptance. The QA/QC Manager shall be responsible for all tasks related to the QA/QC of the Project and the overall implementation of the QA System.

7.2.1 Engineering

The Contractor shall establish and implement systems and procedures to control engineering activities in order to ensure achievement of a satisfactory level of quality and compliance with the Contract, Employer´s Requirements, and all Applicable Laws, Codes and Standards.

The Contractor's engineering control activities shall include, as a minimum, the following:

- Implementing an agreed system for (internal) discipline checking, including the use of checklists where appropriate, to substantiate compliance with statutory requirements, industrial Standards, the Employer and Contractor applicable specifications, and standards and contractual requirements. Discipline checks shall be documented and traceable;
- Implementing an agreed system for inter-discipline checking for all types of Contractor design documents and supplier design documents. Inter-discipline checking shall be documented and traceable;
- Systematically recording, for each revision of all documents, the originator, checker and approval signatures, and incorporating comments made during the checking and approval processes into the various documents, as required;
- Regularly and systematically review the technical content, as well as the suitability of the design at dedicated, multi-disciplinary meetings, and report potential problems. Such internal design review meetings are to be fully documented;
- Ensure that all documentation and data are accurate, correct, complete, consistent, clear, and unambiguous;

- Ensure that all documents and data meet the Employer's Requirements for storage, presentation, format, and quality;
- Ensure that all aspects of the design (including supplier information) are systematically verified; and,
- Ensure that there is no conflict between documents.

The Contractor shall make allowance for the Employer to observe key inspections/tests and to receive copies of data and reports.

7.2.2 Manufacturing

The Contractor shall submit to the Employer within two (2) weeks of signing the Purchase Order or Supply Contract for each equipment the manufacturing quality plan/ITP for such equipment, including associated test procedures and inspection checklists to be used during the implementation of the Quality Plan/ITP. The manufacturing quality plan/ITPs shall cover:

- Pre-production factory audits;
- Material inspection;
- Production process inspections;
- FATs;
- Pre-shipment inspections in the factory; and,
- Pre-shipment inspections in an external accredited laboratory (when applicable).

After receipt of the manufacturing Quality plan/ITP, the Employer will inform the Contractor of the items that it wishes to witness, and the Contractor shall notify the Employer with at least 21 days' notice the date for each of those items.

Witnessing of Quality plan/ITP items by the Employer does not relieve the Contractor of any responsibility whatsoever regarding defects or other failures which may be found during the lifetime of the Project.

The Employer has the right to inspect all manufacturing facilities and workshops for equipment related to the Project. The Contractor shall arrange all access and visits with the respective Supplier/Subcontractor.

7.2.3 Construction

7.2.3.1 Inspection Test Plan

The Contractor shall submit to the Employer, at least two (2) weeks prior to the commencement of each construction activity, the ITP for such activity, including associated ITP test procedures and inspection checklists to be used during the implementation of the ITP. After receipt of the ITP, the Employer will inform the Contractor of the ITP items that it wishes to witness, and the Contractor shall notify the Employer with at least five (5) days' notice the date for each of those ITP items.

The ITP shall make provision with each of its items for the sign-off by the Contractor and Subcontractor (when applicable), and for the witnessing confirmation by the Employer (when applicable).

The Contractor shall witness and sign off 100 % of the ITP items Quality Plans and inspection checklists for all construction activities with its Subcontractors.

The Contractor shall develop, at a minimum, an ITP for the following activities:

- Levelling and grading;
- Module mounting structure installation;
- PV module installation;
- String combiner box installation (if applicable);
- Trenches;
- Cable laying;

- Inverter station foundation;
- Inverter transformer foundation;
- Ring Main Unit (RMU) and LV panel foundation;
- Buildings;
- Site fence and gate;
- Roads;
- CCTV installation;
- Inverter installation and terminations;
- Inverter transformer installation and terminations;
- RMU installation and terminations;
- LV/Auxiliary panel installation and terminations;
- MV switchgear installation and terminations;
- SCADA system installation;
- Meteorological stations installation;
- Earth mat installation;
- Battery and Uninterruptible Power Supply (UPS) installation;
- Diesel Generator;
- HV transformer;
- HV switchgear; and,
- OHL/UGL, if applicable.

Additional ITP may be requested by the Employer depending on the specificity of the Project and method statements.

Witnessing of ITP items by the Employer does not relieve the Contractor of any responsibility whatever regarding defects or other failures which may be found during the warranty period of any components, equipment, etc., of the Project.

7.2.3.2 ITP test procedures

The Contractor shall submit, together with the ITP, all test procedures needed to undertake any check, test, or measurement related to ITP items.

7.2.3.3 Inspection checklists

The inspection checklist is a set of documentation prepared by the Contractor that will be submitted to the Employer for review, and used by the Contractor, its Subcontractors, the Employer, the Employer’s Representatives, etc., to control the main inspection points of the activities. The inspection checklists shall describe the specific activities related with the inspections defined on the field Quality Plan.

The minimum typical lists of inspection checklists can be found below. Additional inspection checklists may be requested by the Employer depending on the specificity of the Project and methodologies of erection.

- Checklist for material inspection;
- Civil clearing and grubbing checklist;
- Civil checklist for perimeter and internal fence installation;
- Civil checklist for Site levelling and grading;
- Civil checklist for pre and post concrete pouring (per element);
- Civil checklist for concrete curing;
- Civil checklist for backfilling works;
- Civil checklist for buildings (per building);
- Civil checklist brick masonry works;
- Civil checklist for plastering works;
- Civil checklist for painting;

- Civil checklist for fencing;
- Civil checklist for form works;
- Civil checklist re-bar works;
- Civil checklist for roads;
- Civil checklist for stormwater;
- Civil checklist for traffic and other signage;
- Civil checklist for cable trenching;
- Civil checklist for ramming post and pre-drilling posts, when required;
- Checklist for module mounting structure installation;
- Checklist for PV module installation;
- Checklist for setting out;
- Checklist for excavation;
- Checklist for DC Cable installation and termination works;
- Checklist for MV & LV cable installation and termination works;
- Checklist for DCB installation and termination works;
- Checklist for inverter installation and termination works;
- Checklist for transformer installation and termination works;
- Checklist for MV panel installation and termination works;
- Checklist for LV panel installation and termination works;
- GIS Installation and termination works;
- Weather station installation works;
- Checklist for plumbing works;
- Checklist for sanitary works;
- Checklist for building electrical works;
- Checklist for false ceiling works;
- Checklist for doors and windows fitment works;
- Checklist for flooring and tile fixing works;
- Checklist for gate fitment work;
- Checklist for DC cable IR and continuity test;
- Checklist for LV cable IR test;
- Checklist for MV cable IR test;
- Checklist for SCADA system installation;
- Checklist for earthing system works – internal;
- Checklist for CCTV installation;
- Checklist for earthing system works – external;
- Checklist for Sites levelling and grading; and,
- Additional inspection checklists may be requested by the Employer depending on the specificity of the Project and method statements.

7.2.3.4 Method statement

The Contractor shall submit to the Employer a method statement for each construction activity at least one (1) week prior to the commencement of such activity, describing the construction procedures, tools, machinery, QA/QC, and HSE considerations.

The Contractor shall not proceed with any construction activity until the corresponding method statement is submitted to the Employer.

7.2.4 QA/QC audits

7.2.4.1 QA/QC audits to Contractor QA System

Except otherwise agreed with the Employer, the Contractor shall be requested to perform a complete internal audit of the QA System within the Works every six (6) months from Notice to Proceed in order to verify the correct implementation of the Quality Management Plan by the Contractor´s personnel and its Subcontractors.

A detailed scope of each audit along with a schedule shall be communicated to the Employer at least two (2) weeks prior to the audit scheduled date.

An audit report after completion of each audit shall be submitted to the Employer within the following two (2) weeks after completion of the relevant audit.

7.2.4.2 QA/QC audits to Subcontractor

The Contractor shall audit the QA/QC systems of its Subcontractors within three (3) months of having appointed a Subcontractor. The Contractor shall notify the Employer of the time of these audits and that Employer shall have the right to participate in the audits. The Employer reserves the right to request the Contractor to replace a Subcontractor if the results achieved on the quality audits are not acceptable.

7.3 Employer´s inspections

The Employer reserves the right to attend any test or inspection at Sites or at any Subcontractor's premises or manufacturer's premises.

The Contractor shall keep all QA/QC files updated with a complete set in his Site office. The Employer has the right to review and check documentation without prior notice.

7.4 Control of Subcontractors

To ensure conformance and consistency within the QA System, the Contractor shall ensure that all quality management requirements are fully implemented by each Subcontractor.

The Contractor shall, prior to award of any Subcontractor, assess the Subcontractor's quality plans to determine compliance with the QA System. The Contractor shall include the Subcontractor´s quality plans in the QA System.

The Contractor shall remain responsible for the quality of all the Subcontractor's work.

A maximum of three (3) levels of Subcontractors are allowed.

7.5 Third party/Notified Body Certification

The Contractor shall, at their expense, arrange for either a notified body or independent third party organisation to certify that the design, materials, and construction of the relevant equipment and components part of the Works comply with regulatory requirements. These certifications shall cover both fabrication at the manufacturer's works.

The Contractor shall also be responsible for obtaining design or other approval of all such equipment from any relevant national or local organisations, including any signatures required in terms of the Applicable Laws and Regulations, Permits, and Codes and Standards.

8 GENERAL TECHNICAL REQUIREMENTS

8.1 STANDARDS AND CODES

The design, materials, engineering, fabrication, inspection, testing, certification, stamping, cleaning, painting, and erection, including all auxiliary facilities and systems, to be supplied under the Contract (for the Contractor works and Subcontractor works) shall be in accordance with the applicable provisions of the Standards and Codes specified herein. In addition, the Contractor shall conform to all applicable requirements of the national and local regulations, including those of the System Operator and Eskom.

All Standards and Codes referenced here shall be the latest edition with applicable addenda and code cases in effect on the date of the Contract, unless specially stated otherwise. Application of subsequent addenda and code cases published both before and after that date are subject to agreement between the Employer and the Contractor.

The Contractor is responsible for the procurement of all Applicable Standards. Applicable Eskom standards shall form part of this tender package and are referenced throughout the text and in Annexure B.7.

National standards shall be preceded from equivalent international standards such as EN, IEC, or ISO. Without prejudice to the Contractor's responsibility to ensure that the Works comply with the Applicable Laws and Regulations and Codes and Standards, the standards referred herein shall be read in the following order of precedence:

- National Standards;
- International Electrotechnical Commission (IEC);
- International Organisation for Standardisation (ISO);
- European Standards (EN); and,
- International Standards such as American Society for Testing and Materials (ASTM), Energy Network Association (ENA), and Institute of Electrical and Electronics Engineers (IEEE).

National Standards:

- SANS (South African National Standards);
- Roads Codes and Standards:
    - T.R.H Series (Technical Recommendation for Highways);
    - T.H.M series (Technical Methods for Highways);
    - UTG series (Urban Transport guidelines); and,
    - Committee of Transport Officials (COTO) Standard Specifications for Road and Bridge Works for South African Road Authorities.
- Eskom Standards; and,
- Any Applicable Laws and Regulations, Permits, Codes and Standards, and requirements of the local Authorities having jurisdiction, such as local codes of the Metsimahalo municipality, which shall be followed with respect to civil works and building.

International Standards:

- ISO International Organisation for Standardisation;
- IEC International Electrotechnical Commission;
- ASCE American Society of Civil Engineers;
- EN European Standards;
- ANSI American National Standards Institute;
- DIN Deutsches Institut fuer Normung (German Institute for Standardisation); and,
- NFPA National Fire Protection Association.

Other Standards and instructions:

- All manufacturers' instructions and warranties;
- Quality Assurance documentation;
- Health and Safety national regulation, Security Plan;
- Labour and unions national regulation and requirements, among others;
- IFC standards, if required by financial entities;
- Permits and Authorisations;
- Environmental and Social assessments;
- Site Layout;
- Requirements of applicable policies of insurance required by the Contract; and,
- All other standards, obligations, and requirements of the Contract.

Recommendations:

- AASHTO American Association of State Highway and Transportation Officials;
- CMA Concrete Manufacturers Association;
- AGMA American Gear Manufacturers Association;
- ASME American Society of Mechanical Engineers;
- AISI American Iron and Steel Institute;
- ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers;
- ASTM American Society for Testing Materials;
- AWS American Welding Society;
- AWWA American Water Works Association;
- CIRIA Construction Industry Research and Information Association;
- HIS Hydraulic Institute Standards;
- ICE Institution of Civil Engineers;
- IEEE Institute of Electrical and Electronics Engineers;
- IPCEA Insulated Power Cable Engineers Association;
- ISA Instrument Society of America;
- NACE National Association of Corrosion Engineers;
- SAICE South African Institution for Civil Engineering;
- VDE Verband Deutscher Elektrotechniker (German Society of Electrical Engineers);
- VDI Verband Deutscher Ingenieure (German Society of Engineers);
- ITU-T International Telecommunication Recommendations;
- VGB Technische Vereinigung der Grosskraftwerksbetreiber E.V. (Society of big power plants operator); and,
- Other national standards and codes which are acceptable internationally.

Other recognised Codes and Standards may be proposed by the Contractor by means of a report detailing the differences between the proposed alternative(s) and the specified Code and Standard and shall be subject to the Employer's acceptance.

A Bidder will not be disadvantaged by proposing a piece of equipment, technology, or (part of) a system or subsystem as part of their Bid Response which claims compliance to a more recent internationally equivalent version of a national standard, provided that the differences between the standards do not adversely affect the quality or performance of the Project in a material manner.

To prevent undue repetition, where equivalent national and international standards exist, only the national standard has been listed in Annexure B. This does not mean that the equivalent international standard will not be accepted if a given technology claims compliance to the equivalent international standard and not the national standard on its accompanying documentation (datasheets etc.).

In the event of a significant conflict between a national and international standard which is likely to have a material impact on the Project, it shall be brought to the Employer's attention. While the national standard shall take precedence by default, the Employer reserves the right to consider requiring adherence to the international standard instead.

In the event that any applicable regulation or industry standard does not govern specific features of any item of the Works, Contractor or equipment manufacturer standards will be applied, subject to the Employer's review and acceptance.

The Contractor shall be responsible for ensuring that its Subcontractors comply with all Applicable Codes and Standards.

8.2 Software

Only industry recognised software shall be used.

Licences for the software systems will be purchased by the Contractor and made available with step-in rights for the future purchasers and operators of the Plant.

The Contractor shall provide all project specific software, firmware, and operating system developed for, and applicable to, the control and monitoring systems being provided. The SCADA system shall include novel modelling approaches and techno-financial indicators allowing the operators to predict failures, detect root causes of errors, and optimise the Plant operation in a cost-effective manner.

The software shall be completely documented by the Contractor and be provided on a non-proprietary basis. The Contractor shall provide a remote monitoring system and software with a supervisory role and access to historic values.

Custom software required to adapt or customise the control and monitoring systems shall be provided by the Contractor.

8.3 Staffing

The Plant shall be designed for O&M with minimum staffing consistent with safe, efficient, and reliable O&M of the Plant and good industry practice. The Plant shall have a sufficient level of automation to ensure that all operations, including Plant start-up and shutdown functions, are performed from the central control room[5]/O&M building without the need for local (field) operations.

8.4 Local Economic Development

In order to ensure that local economic development is promoted throughout the execution of the Project, the employment of local employees shall be maximised for the execution of the Works based on a minimum obligation of employing unskilled and semi-skilled workers from the local municipality, local district, Free State Province, and Gauteng Province.

A complete set of supplier development and localisation (SD&L) requirements shall be addressed in a separate document.

8.5 Making Good Defects

Defects shall be made good in accordance with the conditions of the Contract.

8.6 Factor of Significance

The Contractor shall take notice of the following factors (listed in no particular order), which are considered to be of particular importance:

- Plant technology selection and its configuration based on proven performance;
- Operational aspects: simplicity, minimum manning, safety;

[5] The central control room in the O&M building is the primary location from which the Plant is controlled though the Plant SCADA system and PPC system.

- Maintenance aspects: ease of access, simplicity, minimum manning, safety, long service intervals, standard tools;
- High reliability and high availability;
- Design optimised for efficient and flexible operation;
- Construction: practicality, maximum factory fabrication and testing, minimum Site work;
- Compliance with the environmental requirements; and,
- High level of automation

8.7 Contractor's Support

The Contractor shall support the Employer in all dealings with third parties relating to the Works and Applicable Laws and Regulations, Permits, Authorisations, and Codes and Standards, including the provision of information, drafting notices and/or technical notes, and attendance of suitably qualified personnel at meetings in South Africa or overseas at no extra cost.

8.8 Units of Measurements

All units of measurement and symbols shall conform to the "Système International d'Unités[6]" (1000 SI units) for basic and derived units or names of units. SI units shall be used in all correspondence, documentation, calculations, drawings, and measurements. If reference has to be made to non-standard units, the SI units shall be quoted in brackets followed by the non-standard units. All time-stamped measurements shall be formatted using the correct UTM zone applicable to the Project Site location.

8.9 Nameplates and Labels

Each nameplate shall contain the year of manufacture, manufacturer's name, country of origin, type of equipment, serial number, and main design data, together with any other such information that will assist future maintenance and the purchase of spare parts.

Nameplates shall be attached securely on the equipment itself, or in the case of small equipment, on an adjacent pipe or structure. Securely fixed shall mean with stainless steel fixing screws or other approved means to facilitate replacement. The use of adhesives will not be permitted.

All instruction plates, nameplates, labels, and warning signs shall be in English and these will be suitable and sufficient for the minimum Design Lifetime (25 years).

Instruction plates, nameplates, and labels are to be installed for:

- Indoors installations shall generally be made from traffolyte materials unless the local environment dictates otherwise; and,
- Outdoors installation shall be manufactured from stainless steel or aluminium with a mat or satin finish.

Instruction plates, nameplates, and labels to be installed at the Plant shall be fitted after completion of construction Works and before commissioning on all equipment. Lettering shall be of a minimum of 5 mm high with upper case lettering.

Elements such as control and instrument panels, control centres, and junction boxes shall be fitted with labels in accordance with the equipment identification system. Instrument and control panels shall be fitted with labels at front and rear.

All label nomenclature shall match precisely the SLDs, network line diagrams, and general Plant (design) drawings. Any later revision to the Plant drawings shall be reflected on the respective physical equipment labels and on all their control and status indication panels.

[6] International System of Units.

Each MV circuit shall be provided with unique identifier ‘human error’ symbols on both front and rear of the switchboard.

8.10 Equipment identification system

The Contractor shall submit to the Employer for acceptance an equipment identification system based on the guideline RDS-PP (Reference Designation System for Power Plants – AKZ or KKS system, to be confirmed at a later stage) or similar, ensuring there is a unique identification for each Plant item.

The Contractor shall apply the equipment identification system in all Contractor’s documents.

8.11 Quality of Materials

All materials shall be new, unused and in the best condition. They shall be proven to be suitable and sufficient for the purpose of the Project. They shall withstand the variations of temperature arising under operation without distortion, deterioration, or the setting up of undue strains in any part, such as to affect the efficiency and reliability of the Plant, and also without affecting the strength and suitability of the various parts for the Works.

All equipment shall be of the class most suitable for working in the local conditions and in compliance with the design data.

The quality of all material shall not in any way be inferior to the requirements of the most recent National and International Standards applicable at the time of Contract signature.

8.12 Preservation

All Plant, equipment, and systems shall be preserved during all stages of the Works in accordance with the Employer’s Requirements and OEM requirements. This shall include, but not be limited to, manufacturing, packing, transport, storage, construction, commissioning, and start-up of equipment and systems, through to Provisional Acceptance.

The Contractor shall maintain preservation records for inspection by the Employer at all times.

8.13 Padlocks and Keys

For safety purposes, and where appropriate, all the Plant electrical isolation points and equipment, including switchgear cubicles and hand switches, shall be suitable for being padlocked in order to comply with the maintenance procedures and permits to work. Specifically, each device which has the capability of isolation, such as power supplies, circuit breakers, isolators, earthing switches, control selector switches, etc., shall be provided with means of locking out with a padlocking system. Therefore, no work on live equipment shall be undertaken without fully complying with the permits to work procedures.

The Contractor shall be responsible for the supply of all locking devices during the execution of the Works. All padlocks to be used on equipment (with two sets of keys) after commissioning shall be supplied by the Contractor.

Padlocks and keys shall be properly labelled.

For MV switchgear, a trapped key interlocking system is recommended.

8.14 Training

8.14.1 General

The Contractor shall provide training to the O&M Contractor and/or Employer’s O&M staff and the Employer in English. Training shall be applicable to all the equipment provided under the Contract and cover all O&M aspects as required to run the Plant in a safe and efficient manner.

Training shall take place early enough to allow the O&M Contractor to participate in the commissioning process undertaken by, and under the direction of, the Contractor.

Training shall include both theoretical and practical based components.

The Contractor shall submit to the Employer, within 90 days from Notice to Proceed, a complete training programme based on the guidelines and requirements specified in this section for review and acceptance. The Contractor shall subsequently liaise with the Employer to discuss and finalise the training programme and ensure that it can be integrated with the Employer's own training and development agenda. The training programme shall be agreed with the Employer at least two (2) months before the start of commissioning.

The Contractor shall arrange for representatives or approved personnel from the OEM and PV modules, inverters, module mounting structure, MV/LV power stations, Plant and security SCADA systems, and weather station suppliers to provide specific instruction and training as part of the overall Contractor's training programme. This instruction and training shall be sufficient to enable the Plant Operator to undertake corrective maintenance activities on behalf of the supplier without voiding the equipment warranties.

The training programme shall take place on the Site. The Contractor shall submit the training manuals one (1) month prior to commencement of the training.

The overall objectives of the Contractor's training programme shall be to:

- Deliver thorough training to achieve a high standard of awareness, knowledge, and understanding of the Plant, its systems, and operational, instrument, electrical, and mechanical devices;
- Provide an effective contribution to the overall training and development of the Plant operators;
- The Contractor shall ensure adequate training in all aspects of its codes of practice and safety rules;
- Ensure that each trainee is qualified to be competent to operate the Plant; and,
- Enable each Plant operator to undertake corrective maintenance activities on behalf of the various OEM suppliers without voiding equipment warranties.

The Contractor shall liaise with the Employer regarding all training issues. The Employer reserves the right to review and discuss in a meeting prior to start of training with the Contractor all training materials/aids, course outlines, training schedules, steps, procedures, guidelines, and other training matters.

The Contractor shall ensure that each person completing the training will understand the Plant's systems and their operational, instrument, electrical and mechanical devices, and equipment productively, independently, competently, and effectively once the training is complete.

Trainers shall be experienced commissioning engineers capable of teaching the respective subject matter. Trainers shall be also competent to properly utilise professional adult education classroom techniques, procedures, instruction methods, student evaluation and grading, and special assistance procedures to ensure the satisfactory attainment of the required level of training for each trainee.

Trainees will undergo a competency assessment which shall be provided by the Contractor at two (2) points within the training period. The Contractor will first conduct a competency assessment prior to the commencement of commissioning and secondly at the completion of training. The Contractor shall keep comprehensive records of all personnel who have been trained in a format agreed with the Employer and these records shall become the property of the Employer.

8.14.2 Training Programme

Personnel to be trained will include managers, engineers, team leaders, operations technicians, and maintenance technicians, totalling approximately 10-20 persons for the Plant.

Each element of the training programme shall include, for all listed components, instruction in system fundamentals review, start-up, normal operation, shutdown, and emergency procedures. In addition, the training programme shall include instruction in all necessary areas and disciplines:

- Operations;
- Maintenance;
- Electrical and C&I;
- Stock and spares control;
- Safety;
- Environmental; and,
- Emergencies

Each element of the training programme shall concentrate on specific systems and/or Plant areas, and shall include, but not be limited to, the following components:

- Task steps;
- Standard performance for each step;
- Tools and equipment;
- Safety requirements; and,
- Resources (i.e., manufacturer's manuals, O&M manuals, drawings, and Plant documents)

Initial training by the Contractor for the majority of the Operator personnel shall be delivered prior to the start of commissioning of the Plant. The objective of this training shall be to equip the operators to assist in the commissioning activities safely and effectively under the direction of the Contractor's commissioning team.

The requirements as specified above are the minimum requirements. Additional subjects shall be proposed by the Contractor if necessary for the proper and complete understanding of the O&M of the Plant.

8.14.3 Facilities and Training Materials/Aids

Suitable facilities and training accommodation to support training shall be provided by the Contractor on Site to meet the requirements of the training programme. If available, the Employer's facilities may be utilised.

The Contractor shall provide training materials, textbooks, manuals, and other materials required for the Contractor's training programme. Classroom equipment such as overhead projectors, white/blackboard, and monitor shall be provided by the Contractor.

Training aids, such as films, slides, interactive videos, software packages, materials, and supplies considered necessary by the Contractor to support, maintain, and successfully supplement the Contractor's training programme shall be provided for the training period.

8.15 Plant Operators

The Contractor shall at all times be responsible for the commissioning, operation and maintenance of the Plant up to Provisional Acceptance. The Contractor shall not rely upon the availability of the O&M Contractor personnel in order to carry out the Contractor 's duties during this period.

Any Contractor personnel involved in O&M activities shall have prior experience in PV generation plants.

8.16 Material Handling and Storage

8.16.1 General

Materials should be handled as little as possible and care should always be taken to ensure that the materials are being handled in a way that reduces any physical impacts or exposure to harmful environments and, notwithstanding, that it conforms with the manufacturers' recommendations.

Storage of materials should also be in conformance with manufacturers' recommendations. Care should be taken not to damage any materials and any damaged materials should be separated from the stock and brought into a quarantine area.

Plant materials, components, and equipment shall not incorporate:

- Asbestos or asbestos-containing materials;
- Lead-based paints;
- Isocyanides;
- Naturally occurring aggregates for use in reinforced concrete and/or naturally occurring aggregates for use in concrete which do not comply with the Standards;
- Polychlorinated biphenyls (PCBs);
- Chlorofluorocarbons (CFCs) or other ozone depleting substances, except (with proper notification in writing) in applications where their use cannot reasonably be avoided and is generally accepted for the specific application;
- Carcinogenic materials (including hydrazine);
- Toxic inhalation hazardous chemicals except (with notification in writing) in applications where their use cannot reasonably be avoided and is generally accepted for the specific application;
- Cadmium plated nuts and bolts; and,
- Any other materials generally known in the construction industry at the time of use to be deleterious to health if used or incorporated in such projects.

8.16.2 PV Module Handling and Storage

PV Module pallets should not be stacked more than two (2) pallets high unless otherwise stipulated in the manufacturer's guidelines. The foundation on which the pallets are stored should be levelled and compressed to prevent any subsidence taking place while in storage. PV modules shall always be handled by no less than two (2) installers, carried from the box to the module mounting structure table while holding the module in four (4) places in total at all times. PV modules in the field should never be placed face down on the ground and should also never be stacked horizontally on top of each other, but rather resting against each other in a vertical fashion.

Storage of PV modules shall ensure preservation against the elements as per the manufacturer's recommendations.

The PV modules shall be packed on pallets according to the power nameplate and current sorting.

8.16.3 Substructure Handling and Storage

Substructure components must be identified upon arrival and grouped according to part numbers. All motors and gears, electronic components, and any other components which are sensitive to water should be covered with industrial-grade plastic no less than 50 microns thick for dryness and to protect against moisture. All torque tubes shall be stacked in a neat, flat manner, and shall not be balanced over any objects which would allow them to bow. The components should be handled by a telehandler or forklift, or alternatively by multiple Installers ensuring that the weight expected to be lifted by each installer is limited to a maximum of 20 kg.

8.16.4 Cable Handling and Storage

All cables shall be stored out of direct sunlight, covered either by plastic or inside a warehouse/ storeroom. Care must be taken not to damage the insulation on the cables when being handled. Cables should be stored on cable drums and installed with the use of forklifts or other machinery able to hold the cable drum up while the cable is unwound. This is to avoid any twisting of the cables during unwinding and installation.

8.16.5 Electrical Components Handling and Storage

All electrical components, specifically string combiner boxes (if applicable), shall be stored in an upright position and covered by plastic for dryness, or stored in a warehouse/storeroom. Care must be taken when moving materials into the field with regards to bumps in the road. Sensitive components should not be moved around Site on a vehicle without shock absorbers and dampers, such as a forklift.

8.16.6 Handling of Hazardous Materials

Manual handling of dangerous materials and chemicals shall be minimised, with the use of automatic or remotely controlled equipment preferred. Where this is not feasible, systems for safe manual handling shall be provided in accordance with the applicable local regulations.

For residual exposure risks, necessary organisational safety measures such as the use of personal protective equipment shall be mandatory. This shall be specified in the method statements and O&M manuals.

8.16.7 Spare parts

Spare parts are classified into two categories:

- Maintenance spares and consumables: These are items for which the Contractor anticipates that demands will arise in normal operation of the Plant; and,
- Strategic spares: These are items for which the Contractor anticipates that demand may arise through breakdowns which could jeopardise the performance, availability, or safety of the Plant.

The Contractor shall define and be responsible to procure and provide the minimum stock of spare parts required for the O&M of the Plant during the Defects Liability Period, taking into account the OEM's recommendations, Site location, and lead time. The minimum stock of spare parts shall include a minimum level of Strategic spares. The minimum level of spare parts shall be at least as per manufacturers' recommendations (the Contractor shall provide written confirmation from each manufacturer in relation to the recommended spare parts) and shall take into account the minimum specific requirements below:

- PV modules – Minimum of 0.5 % of the total installed PV modules;
- Inverter (including cooling mechanism):
  - Central inverters: the Contractor shall request the manufacturer to provide a recommended list of spares/bill of quantities that shall take into consideration the number of inverters and Project's location. This recommended spare part list by the manufacturer shall specify proper equipment information, such as manufacturer's unit code, name, description, and total quantity to be considered; and,
  - String inverter: Minimum 30, or as recommended by the manufacturer.
- Tracker (module) mounting structure:
  - Posts: Minimum 0.5 % of total quantity;
  - Module mounting rails: 0.5 % of total quantity;
  - Torque tube/beam: 0.5 % of total quantity;
  - Motors and associated complete drive-unit mechanisms: Minimum 0.5 % of total quantity;
  - Power supply source: 0.5 % of total quantity;
  - Power backup supply source: 0.5 % of total quantity;
  - Inclinometers: Minimum 0.5 % of total quantity;
  - Controllers/control-units: Minimum 0.5 % of total quantity;
  - Structural components, bolts, nuts, washers, flanges, bearings, mounting brackets, beam splices, etc.: Minimum 0.2 % of total quantity; and,
  - Complete table: Minimum 0.5 % of total quantity.
- Fixed tilt (module) mounting structure:
  - Posts: Minimum 0.5 % of total quantity;
  - Module mounting rails and cross beams: 0.5 % of total quantity;
  - Structural components, bolts, nuts, washers, flanges, mounting brackets, beam splices, etc.: Minimum 0.2 % of total quantity; and,

    - Complete table: Minimum 0.5 % of total quantity.
- DC Cable: Minimum 0.5 % of total quantity per size (mm^2)
    - LV connector MC4 (male and females): Minimum 0.5 % of total quantity.
- AC Cables: Minimum 0.5 % of total quantity per size (mm^2);
- Cable Trays (if applicable): Minimum 0.5 % of total quantity;
- Communication cables: Minimum 0.5 % of total quantity:
    - LV connector MC4 (male and females): Minimum 0.5 % of total quantity.
- PV String Combiner Box (if applicable): Minimum 0.5 % of total quantity;
- PV String Combiner Box communication card (if applicable): Minimum 5 % of total quantity;
- LV fuses: Minimum 4 % of total quantity;
- LV Switchgear: Minimum 0.5 % of total quantity;
- MV/LV transformers: Minimum three (3) units;
- MV switchgear/RMU: Minimum three (3) units;
- Auxiliary Transformer: Minimum one (1) unit;
- Meteorological station: Minimum one (1) unit;
- Soiling stations: Minimum one (1) unit;
- SCADA system: Minimum 0.5 % of total quantity of all components comprising the SCADA system (e.g., relays, server hard drives, network cables, etc.);
- PPC system: Minimum 0.5 % of total quantity of all components comprising the PPC system;
- UPS system and components: Minimum 3 % of total quantity;
- CCTV system (including all cameras, poles, fixtures, etc.) – The Contractor shall request to the manufacturer a recommended list of spares/bill of quantities that shall take into consideration the size of the CCTV system, the number of CCTV cameras, poles, fixtures, etc., and the Project's location. The manufacturer-recommended spare parts list will be the minimum level of spares that shall be held on Site; and,
- Lights – The Contractor shall request to the manufacturer a recommended list of spares/bill of quantities that shall take into consideration the type of light, the number of lights, and the Project's location. The manufacturer-recommended spare parts list will be the minimum level of spares that shall be held on Site.

A minimum level of maintenance spares and consumables shall be recommended by the Contractor to be held on Site for each component at all times based on the OEM requirements. It shall consider the different systems and equipment of the Plant, such as DC String Combiner Boxes (if applicable), AC Junction Boxes, LV cabinets, communication system, CCTV system, etc.

8.17 WELDING REQUIREMENTS

Welding on Site shall be minimised and all materials that need to be welded should be welded in a controlled factory environment. If any welding is required on Site, it shall be done in accordance with the appropriate international and local standards, such as:

- SANS 10238: Welding and thermal cutting processes – Health and safety;
- SANS 1400:;
- SANS 3834: Quality requirements for fusion welding of metallic materials Part 1 to 6;
- SANS 6520 Part 1 & 2: Welding and allied processes - Classification of geometric imperfections in metallic materials;
- SANS 15609: Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1 to 5;
- SANS 15614: Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1 to 13;
- SANS 17660: Welding-welding of reinforcing steel - Part 1 & 2;
- BS-EN 1011-1; and,
- BS-EN 1708-1.

All welders and operators shall be properly trained and qualified in accordance with the applicable design code and weld quality. The corresponding weld inspection shall comply with the Applicable Laws and Regulations and Codes and Standards.

8.18 ENVIRONMENTAL AGGRESSIVENESS

The Contractor shall take into account the conditions found at the Site and in the subsurface layers in order to avoid any corrosion problems aboveground and underground, especially with equipment installed outdoors. Additionally, respective environmental requirements shall be included and taken into consideration after the respective EIA submission.

The Contractor shall confirm the atmosphere and soil corrosivity category for further observation and proper design protection according to SANS 12944 Part 1 to 8 for steel structures. Additionally, corrosion protection shall be designed, as a minimum, for a design operational lifespan of 25 years and the specific location conditions, such as soil chemical testing results, humidity, wind loading, ambient temperature, soil aggressiveness and air corrosivity.

The Contractor shall ensure that precautions are taken in packing and crating to avoid damage to the equipment and protective treatments during transportation to the Site, after consultation and confirmation from the manufacturer. Any damage to paintwork and galvanising layers which occurs during transport shall be made good at Site. All surfaces shall be thoroughly cleaned prior to any painting in accordance with the requirements of the specific paint used.

Paint shall be stored in dry, covered conditions and shall not be used if it has been in storage for more than three (3) months or not used for more than six (6) months after the manufacture date.

Unless otherwise specified, galvanising shall be hot-dip galvanising in accordance with SANS 121 and SANS 14713-2. Bolts, nuts, and washers, together with all other threaded components used as fasteners, shall be finished with a centrifugal galvanised coating in accordance with this standard.

The thickness of zinc in every galvanised element shall be higher than the calculated minimum thickness required in all its sides and parts. Local mean thicknesses below the minimum calculated thickness shall be avoided.

All drilling, punching, stamping, cutting, and welding of parts together and removal of burrs shall be completed before articles are galvanised in accordance with SANS 121 and SANS 14713-2. Any Site modifications of galvanised steelwork shall be made good with an approved cold galvanising system as reviewed by the Employer.

Materials and coatings for all structures shall be based on the findings of the soil chemical testing and with a durability range of at least 25 years.

Details shall be provided of any special finishes, including those on components manufactured from sheet aluminium or steel.

All ferrous metals shall be protected from corrosion in accordance with SANS 121, SANS 14713-2, SANS 12944 or equivalent National Standards or International Standards. The exposure conditions to be used shall be entirely suitable for the type and intended purpose of each structure, taking full account of the components' and Plant's location.

Where the Contractor shall use a paint system for corrosion protection, the Contractor shall ensure that it shall be applied in full accordance with the manufacturer's recommendations and that each coat applied to any member shall be from the same manufacturer.

The Contractor shall submit full details of its proposals for corrosion protection for the Employer's consideration. Proper analysis for avoidance of galvanic corrosion due to contact between different metals shall be done and justified if required.

All external coating systems shall be designed to be UV resistant from the UV radiation spectrum expected for the Site.

Considerations must be given to fauna protection of all equipment and materials which may come into contact with rodents or other vermin. This includes cable sheaths, outdoor switchboards and DC Boxes, outdoor inverters, transformer centres and/or switchgear buildings, O&M buildings, substations, etc. Means of protection shall be valid under planning approval conditions and environmental management plan.

The Works shall be adequately protected against any kind of frost damage, if applicable to the location.

8.19 Carbon Tax Credits

All carbon tax credits for the Plant shall be owned by, and accrue to, the Employer.

8.20 Renewable Energy Certificates

All renewable energy certificates for the Plant shall be owned by, and accrue to, the Employer.

9 PV SYSTEM REQUIREMENTS

9.1 Proven Technology

Availability and reliability of the Plant are of equal importance to the Employer as the net electrical output. For this reason, prototypes or modified designs on proven equipment shall not be allowed.

The Contractor shall ensure that equipment and materials proposed have a proven track record in similar service.

These requirements above are applicable to the following main equipment:

- PV modules;
- Inverters;
- String combiner boxes (if applicable);
- Transformers; and,
- Module mounting structure.

The Contractor will only be allowed to use Tier 1 PV modules (according to Bloomberg New Energy Finance), with a proven track record and which have received DNV/TUV/Bureau Veritas/IEC certification. The respective PV module manufacturer is to be rated amongst the top ten OEMs. Similarly, module mounting structure and inverters will be sourced from experienced and competent OEMs who have adequate financial health (balance sheet strength), a proven track record, and the relevant experience. Suppliers with national presence and experience will be preferred.

Where equipment or components are subject to the approval of an independent certifying authority, the Contractor (directly or from the OEMs and/or Subcontractors) shall be responsible to procure and bear the cost of such independent certifying authority.

9.2 Plant Layout

The Plant layout shall consider the following:

- For tracking systems, a minimum motion range of ± 50 degrees; backtracking is to be implemented to limit the shading cast from one tracker row onto an adjacent or nearby row;
- The minimum inter-row spacing between the PV modules (PV modules in horizontal position) shall allow a tractor vehicle with mounted pulverised water cleaning brush to pass between rows, and in no case be less than 3 m free of obstacles;
- The layout shall consider sufficient space for the circulation of light all-road vehicles to reach any equipment where recurrent maintenance needs may be expected. At least 3 meters wide free of obstacles paths shall be considered for this purpose;
- Minimum distance of 3.5 m between perimeter fence and the end of the array PV modules to allow clearance for vehicles circulation for operation and maintenance. The Contractor shall note that more stringent requirements may be imposed by Applicable Laws and Regulations, Permits, Authorisations, and Codes and Standards;
- Minimum distance between the perimetral fence and any water streams of 5 m;
- Minimum distance between the perimetral fence and the land registry limits of the Project area of 3 m. The Contractor shall note that more stringent requirements may be imposed by Applicable Laws and Regulations, and Codes and Standards;
- Minimum distance between the perimetral fence and the centre line of public the roads of 5 m;
- Inverter location and cable runs shall be specifically optimised for lowest capital and operational cost, and for maximum production and system efficiency; and,
- The Plant layout design shall be in accordance with IEC TS 62738: Ground-mounted photovoltaic power plants – Design guidelines and recommendations.

The Plant layout shall be designed to ensure ease of maintenance and operation and shall be arranged to minimise the crossover of services, cables, piping, and access ways. The Contractor shall ensure that sufficient laydown spaces and lifting devices are arranged. Details of these arrangements shall be provided to the Employer.

The Plant layout shall facilitate the maintenance activities of redundant items or items not essential for maintaining continuous operation, without reducing the electrical output of the Plant.

Plant layout, access, and roads shall take into consideration the access routes for vehicles and major equipment for all foreseeable O&M activities, as well as for emergency responses and events.

The Plant layout shall take into account the space required for all substations, transformers, switching station, substation yard, Solar Plant control room, and other related Grid Connection facilities.

The Plant layout shall take into full consideration the environmental impact of the Plant in line with the HSE File and Environmental and Social Management Plan. Boundary features should include hedgerows, ditches, stone walls, hedge banks, and scrub, according to the EIA. The Plant design shall ensure the protection of native animal, plant, and tree species.

Suitably classified equipment shall be used in the designated hazardous area.

The entire Site shall be contained within perimeter security fencing with emergency exits, security gates, and security lighting.

9.3 Energy Yield Assessment

The Contractor is required to submit a detailed EYA for the Project including a PVSyst report (PVSyst version to be used shall be 7.2 or higher). The EYA shall be based on the SolarGIS Typical Meteorological Year (TMY) data file provided by the Employer and the near and far shading horizontal files defined by the Contractor based on the central coordinates of the Plant provided by the Employer. In case different meteorological data than the provided TMY is intended to be used, the Contractor shall provide justification and it shall be agreed beforehand with the Employer. The Contractor may then submit an additional EYA[7] using their own TMY and use this additional EYA for the development of their Bid's performance guarantees.

A description of the PV system modelled shall be provided, covering design aspects such as interrow pitch (meters), PV module tilt angle, azimuth angle, and number of PV modules per string.

The following losses shall be considered in the EYA:

- Incidence angle loss;
- Low irradiance loss;
- Temperature loss;
- Thermal loss;
- Shading loss (from both mutual and external objects, i.e., near and far shading);
- Soiling loss (it is noted that this is affected by the frequency of the module cleaning regime and site conditions, including expected rainfall patterns; Contractor is expected to evaluate the module cleaning cost against frequency of cleaning and soiling effect on energy generation with respect to Plant guaranteed performance ratio);
- Mismatch losses and power tolerance loss;
- Cabling loss (AC and DC);
- Transformer loss;
- Inverter loss;
- Transmission losses until the battery limit with the HV Contractor;

[7] Submission of the first EYA using SolarGIS TMY is compulsory.

- System technical unavailability (in accordance with the guaranteed technical availability in the Contract and section 15);
- Annual degradation (as per module datasheet);
- Structure rear shading factor (applicable only to bifacial modules);
- Auxiliary consumptions; and,
- Light Induced Degradation (LID) loss.

All losses up to the battery limit with the HV Contractor shall be considered.

The balance of plant components must be selected and designed such that the auxiliary losses due to self-consumption for the entire Plant should not exceed 1 %.

The Contractor shall state clearly the various technical assumptions applied in the EYA and provide supporting (third-party) documentation as applicable.

If bifacial modules form part of the PV system proposed, supporting documentation of the albedo factor used in the EYA is to be provided, as well as other factors specific to the bifacial module and mounting structure proposed, such as mismatch loss factor and structure shading factor.

The EYA shall also include probability of exceedance for the energy generated (P50 and P90 (1-year, 10-year and 25-year return periods)) over the minimum Plant design lifetime of 25 years (for each operational year), including uncertainty calculations and assumptions (uncertainty of resource data, modelling, assumed irradiance variability, etc.).

In case the East-West or North-South slopes are high enough to anticipate an impact over the EYA of more than 1 % in annual generation compared with a completely flat ground area, a simulation considering the actual elevation and slope of each tracker will be mandatory. The Contractor will have to justify properly that the expected affection is below that 1 % for avoiding slopes consideration.

The EYA shall include the expected performance ratio for the Plant based on the simulated yield, losses etc.

9.4 PV Array Design

The Contractor should undertake the PV array design in line with the following considerations:

- Array stringing design shall be compatible with the operational range of the inverter DC input limits, such as maximum and minimum input voltage for Maximum Power Point Tracking (MPPT) and maximum open circuit voltage (V_{oc}), considering only correction for the minimum expected module operating temperature. In the calculation of the maximum V_{oc} no correction for radiation will be made (neither for its possible influence on the cell temperature) and the minimum and maximum extreme temperatures on Site will be considered;
- PV Panels shall be securely fastened to the mounting structure frame as per the manufacturer's installation specifications with suitable protection against damage;
- Earthing of the array including the mounting structure frame must be in accordance with National Standards and International Standards with regards to DC, AC, and PV power systems. These include EN 50522, Eskom Standard 240-56356396, Eskom Standard 240-75880946, and SANS 10142-1;
- The junction/combiner boxes shall have gland secured cable entry and exit points;
- Cable terminals connecting to the junction/combiner-box shall have suitable crimping and the main DC cables must be torqued;
- All cables, inverters, buildings, etc. should be clearly marked with permanent labels durable for the minimum design life of the Plant (25 years);
- All string combiner boxes must have a layout indicating the location and number of the combiner box relative to the overall array;
- All array rows and tables must be labelled with engraved labels showing row and PV table number;

- All string combiner boxes must be labelled with permanent marking denoting the associated string/subarray number as the as-built drawings. All labelling must be in accordance with applicable Standards;
- A lightning risk assessment for the Plant shall be conducted as per SANS 62305-2 and a suitable lightning protection system must be designed and installed as per the relevant Standards, such as SANS 62305;
- In the case of a tracking system, the minimum height above ground to the lowest point of the PV Modules during the whole range of motion of the tracker system must be taken into consideration;
- In the case of string inverters, the height of the inverter and accompanying stand, canopy, and/or enclosure shall be designed not to provide shading on the PV modules. The minimum clearance between the inverters (structures) and the PV modules shall be at least 0.5 m;
- The number of PV modules per tracker or fixed tilt table will depend on the capacity of the structure used, but in no event will it be allowed to separate PV strings between each tracker or fixed tilt table. On the other hand, sufficient distance between PV modules must be allowed to assure an adequate gap for thermal dilatations; and,
- The PV array must be designed in with compliance to IEC 62548: Photovoltaic (PV) arrays – Design requirements.

9.5 PV Modules

The PV modules shall be crystalline silicon technology, monofacial or bifacial, and shall have been installed in at least three (3) commercial plants of similar size (75 MWac) that have been in successful operation for at least one (1) year.

As stated in section 9.1, it is mandatory that the PV modules are Tier 1 (according to Bloomberg New Energy Finance) with a proven track record and have received DNV/TUV/Bureau Veritas/IEC certification, and that the module manufacturer is rated amongst the top ten OEMs.

The PV module shall have valid certifications issued by reputable testing institutions according to the following standards:

- SANS 61730-1 (IEC 61730-1): Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction;
- SANS 61730-2 (IEC 61730-2): Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing;
- SANS 61215 (IEC 61215): Crystalline silicon terrestrial photovoltaic (PV) modules — Design qualification and type approval;
- IEC 61701: Photovoltaic (PV) modules – Salt mist corrosion testing;
- IEC 62716: Photovoltaic (PV) modules – Ammonia corrosion testing;
- IEC 60068-2-78: Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state;
- IEC 60068-2-68: Environmental testing — Part 2-68: Tests — Test L: Dust and sand;
- Module flash test data from manufacturer, measurement according to IEC 60904-1: Photovoltaic Devices – Part 1: Measurement of photovoltaic current-voltage characteristics;
- For bifacial modules, bifacial module flash test data from manufacturer, measurement according to IEC TS 60904-1-2: Photovoltaic devices - Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices;
- IEC TS 62804-1: Photovoltaic (PV) modules – Test methods for the detection of potential-induced degradation – Part 1: Crystalline silicon; and,
- CE Certification.

Frameless PV modules shall not be considered.

The PV modules' warranty requirements are defined in section 15 of the Employer's Requirements.

The PV modules shall comply with the following technical specifications:

- Positive Power Tolerance between 0 to +5 W or alternatively 0 to +3 %;
- Module efficiency, greater than or equal to 20 %;
- Minimum cell temperature of -40 °C;
- Operating temperature between -40 °C and 85 °C;
- Compatible with a system voltage greater than or equal to 1500 V_{DC};
- Module design lifetime greater than or equal to 25 years;
- Nominal Module Operation Temperature (NMOT) lower than or equal to 45 °C ± 2 °C (NMOT @800 W/m^2, 20 °C, AM 1.5, Wind speed 1 m/s);
- Pmax temperature coefficient greater than or equal to -0.37 %/°C;
- Module LID loss less than or equal to 2 %;
- If applicable, Bifaciality Factor where:
  - Minimum Bifaciality factor for p-type bifacial module greater or equal than 70%±5%;
  - Minimum Bifaciality factor for n-type bifacial module greater or equal than 85%±5%;
- The photovoltaic cells of the PV modules shall be activated in the solar spectrum as defined by STC within IEC 61215-1-1;
- PV modules shall comply with a minimal safety class II according to:
  - SANS 60364-7-712;
  - IEC 60364-4-41;
  - IEC 60364-4-42;
  - IEC 60364-4-43;
  - IEC 60364-4-44;
  - SANS 61140; and,
  - SANS 61204.
- PV modules rear junction box should include at least three (3) bypass diodes to protect against partial shading and module overheating as well as fly leads fitted with IP67 rated pin type "Multi-Contact" connectors or equivalent with a clear indication of polarity for the connections. Connectors must not be interchangeable and must have an ampacity rating not less than the maximum series fuse rating of the PV module;
- PV modules' independent potential induced degradation (PID) testing and verification tests should be performed and results provided in accordance with IEC 61215-2 and SANS 61730-2;
- PV modules shall be capable of operating in the most extreme climatic and environmental conditions on Site and will be designed to ensure the highest possible reliability in operation and to ensure minimum and efficient required maintenance over the minimum lifetime of the Plant (25 years);
- PV modules must be certified for resistance to a suction pressure of 2400 Pa, a static mechanical load greater than or equal to 2400 Pa, and an increased distributed mechanical load of 5400 Pa on the front glass surface (wind, snow, hail, and ice);
- The active electrical components within each PV module must be electrically insulated from the metal casing (frame), the rear cover, and the front glass surface. The insulation must withstand 1500 V DC between the short-circuited module output leads, the metal frame, and the rear and front covers. To avoid galvanic corrosion, any contact between the PV module frame and an incompatible material must be fully electrically isolated;
- Factory-fitted PV module cables shall be long enough to allow the PV modules to be interconnected electrically in series to form the desired strings inter-connection between the PV modules;
- The PV module cable connectors provided with the PV modules shall fulfil at least the requirements of a rating IP67 as defined in SANS 60529 and fulfil the safety requirements and tests of SANS 62852. The PV modules connectors must be protected against dust and water while waiting to be plugged with PV cable connectors;

- PV modules shall have a front surface protected with tempered glass and a manufacturer-applied anti-reflective coating;
- All PV modules (and module connectors) supplied for the Plant shall be of the same type and from a single manufacturer;
- The PV module manufacturer is to conform to the following requirements:
  - Manufactured PV modules for more than five (5) years;
  - The envisaged factory has been manufacturing PV modules for more than two (2) years;
  - Cumulative installed capacity of PV modules in excess of 1,000 MWp;
  - Production capacity capability in excess of 500 MWp per year;
  - Have supplied PV modules to at least three (3) different commercial[8] projects of a similar size (75 MWac) which have been in operation for at least one (1) year at Date of Tender Bid Submission; and,
  - The PV Module manufacturing facilities should be certified according to: ISO 9001, ISO 45001, and ISO 14001.

The PV manufacturer shall be able to accept material control procedures and a requirements tests plan for the production procedures. Inspection methods shall be required for any aspect related to the manufacturer format of records, raw material storage, solar cells, cell connectors and strings interconnectors, encapsulation material (EVA, PO, POE), rear cover (back sheet), adhesive sealant, front cover (glass), framing, junction box with diodes, flux, label, RFID, packing materials, etc.

The transport of PV modules shall be in accordance with IEC 62759-1 Photovoltaic (PV) modules – Transportation testing – Part 1: Transportation and shipping of module package units.

The PV manufacturer shall be able to accept Quality Controls and PV test plans by a third party based on IEC TS 62782 during the PV module selection process, ensuring the proper quality and performance assurance levels. The third party quality checker of the PV module manufacturer must hold SANS 17020 and SANS 17025 accreditation. Quality Control and PV test plans shall consist of, but not be limited to, the following implementation of additional test and surveillance programmes:

- Visual inspection, insulation test and wet leakage test conditions and duration to be defined by certified owner’s inspection company accepted by the Employer;
- Damp heat tests. Temperature and humidity conditions and duration to be defined by certified owner’s inspection company accepted by the Employer;
- Humidity freeze tests. Thermal and humidity conditions, duration, and number of cycles to be defined by certified owner’s inspection company accepted by the Employer;
- Thermal cycling tests. Thermal and humidity conditions, duration, and number of cycles to be defined by certified owner’s inspection company accepted by the Employer;
- PID tests. Temperature, humidity and voltage conditions and duration to be defined by certified owner’s inspection company accepted by the Employer;
- Mechanical load tests sequence. Combination of static and dynamic load stress levels, thermal and humidity conditions, duration, and number of cycles to be defined by certified owner’s inspection company accepted by the Employer; and,
- LID and Light and elevated temperature induced degradation (LeTID) tests. Temperature and current conditions and duration to be defined by certified owner’s inspection company accepted by the Employer.

Additionally, the PV modules manufacturer and the Contractor shall be able to accept a manufacturing and dispatch procedures test plan during the PV module selection process, ensuring the proper quality of all the stages of the production planning, production, quality control plans and dispatch.

[8] Not demonstration or pilot projects.

The Contractor shall provide results of extended damp heat testing for the selected PV module type with the minimum testing period of 2,000 hours to recognized standards by an independent third party. Other relevant extended durability testing results will be considered beneficial.

The Contractor shall provide results of testing for LID and LeTID for the selected PV module type to recognised Standards by an independent third party.

The PV modules manufacturer's documents and information shall be provided to the Employer, such as factory certificates, company (factory) business licence, Quality Control plan, list of testing equipment (including serial number information), list of appointed manufacturing workshop for each production Site, Bill of Materials (BoM), mandatory product certificates, packaging design, etc. The PV manufacturer shall be able to provide quality control records, such as IQC, IPQC, FQC, and OQC.

Upon delivery of the PV modules on Site, the Contractor shall submit the post-production flash test reports for each PV module batch at STC in electronic format (Excel files). As part of the As-Built documents, the Contractor shall provide a summary spreadsheet containing all the documentation on the PV modules, including the BoM and the full installed capacity.

The PV modules shall be installed according to the current sorting in order to minimise the mismatch losses.

Each PV module shall permanently display a technical characteristics nameplate carrying the following information as a minimum:

- Name of manufacturer;
- Type or model number;
- Serial number;
- Polarity of terminals or leads (colour coding is acceptable);
- Maximum system voltage which the module is suitable for;
- Safety class;
- Date and place of manufacture on label or traceable from serial number; and,
- The nameplate itself shall be designed for a minimum design lifetime of 25 years under high UV radiation and temperature.

Should bifacial PV modules be proposed by the Contractor for use in the Plant, the methodology for post-production performance testing (both in the factory and on-Site testing) for the back side of the module shall be submitted to the Employer prior to the start of the PV module production.

PV modules shall be installed in accordance with the applicable requirements of the PV module manufacturer and installation guidelines. Fixing arrangements that deviate from the PV module manufacturer and installation guidelines shall be agreed between the PV module manufacturer and the module mounting structure manufacturer. Confirmation must be provided from both PV module and module mounting structure manufacturers that they are satisfied with the installation and that the warranties will not be invalidated. The respective documents shall be reviewed and accepted by the Employer prior to PV module installation.

9.6 DC Interconnections and Cabling

Purpose-designed double-insulated PV cables and safety connectors shall be used for all DC connections. The DC cables shall be designed according to National Standards and International Standards, and shall have the following minimum technical requirements:

- All cables and connectors used in the PV array shall be of solar grade and rated for harsh climatic conditions, including high temperatures, UV radiation, rain, humidity, and dirt for the minimum design lifetime (25 years) of the Plant;
- Cables' insulation material and cable routing method should be in accordance with any applicable Site restrictions;

- If using bifacial PV modules, the maximum current that could be generated from the rear side shall be considered for defining the maximum current generated by the PV modules for the cable sizing calculation. In order to define the maximum current from the rear side, the worst-case scenario as a combination of the following needs to be accounted for:
  - Highest possible albedo on Site;
  - Highest bifaciality gain, considering the whole tracker motion range (if trackers are used), sun geometry, and irradiance;
- Wires with sufficient capacity shall be designed and used so that the maximum DC voltage-drop (including diode voltage drop) between the PV modules and the inverter at full power complies with all applicable SANS Standards and Codes;
- Cable terminations shall be made with suitable cable lugs and sockets, crimped properly and passed through brass compression-type cable glands at the entry and exit point of enclosures, or equivalent;
- When using lugs for cable termination, tinned copper lugs are required when terminating copper conductors and aluminium lugs are required when terminating aluminium conductors. When terminating aluminium conductors onto equipment with either copper or brass terminal fixing points, bimetallic lugs shall be used;
- All cable/wires shall be clearly marked with permanent and UV-resistant marking identifying its type, place of manufacture, and date of manufacture;
- Enhanced resistance to heat and fire, with low smoke emissions and halogen-free;
- DC voltage maximum rating of 1,500 V;
- Wiring located above ground and secured to the PV module mounting structure shall be secured utilising UV-resistant devices and secured in a manner such that no exposed wiring is in direct contact with unfinished metal edges or direct sunlight;
- DC cabling shall not be located above ground except when fastened along the PV module mounting structures. DC cable runs between structure rows shall be underground;
- String cables between PV modules and string combiner boxes/string inverters do not need to be armoured. However, if directly buried they shall be protected by corrugated HDPE conduit, including from the trench up to the electrical enclosure termination point or one (1) meter above ground, whichever is less;
- Conduits shall be sealed with a proper material to take environmental conditions into consideration, i.e., UV light, rain, etc., preventing water and animal ingress;
- Where applicable, cables between string combiner boxes and inverters need not be armoured; if directly buried, they shall comply with specifications of section 10.9. Both ends of the cable (from the trench up to the electrical enclosure termination point or one (1) meter above ground, whichever is less) shall be protected by corrugated HDPE conduit. Conduits shall be sealed with appropriate expanded foam spray or similar to avoid water and rodents entering into the conduit;
- All string and main cables must be permanently labelled at both ends. At a minimum, the label shall provide information about the corresponding (string) inverter, string combiner box (if applicable), and string number;
- All cables must be fixed. Under no circumstances shall any cables bear any mechanical load on their terminations (strain relief);
- Cables shall be tied or cleated to cableways using materials specifically designed for UV-resistant tie elements. Cables shall be arranged neatly in cableways and bundled, where and if appropriate. Conductive cable ties shall not be used on single-phase cables. Cables shall be properly supported and secured to avoid loose cables and avoid the risk of undue mechanical strain. Cableways shall be selected and erected so as to minimise the damage arising from mechanical stress, e.g., by impact, abrasion, penetration, tension, or compression during installation, use, and maintenance;
- Cables shall be arranged and securely fastened to the module mounting structure with suitable cable tie solutions, noting that:

  - Cables are to avoid direct contact with sharp edges of metallic components of the module mounting structure;
  - Cables are to be protected against direct sunlight, considering UV-ducting protections when this will not be possible (i.e., for the spaces between mounting structure table structures);
  - If using plastic ties, these shall be specifically designed for the purpose of sorting and fastening cables and shall be UV-protected and have a minimum design lifetime of 25 years;
  - If using metallic ties, these shall have proper edge protection to avoid damaging the cables; and,
- Cable joints shall not be allowed.

Where applicable, the requirements in the Eskom Field Instrument Installation Standard: Junction Boxes and Cable Termination (240-56355815) and Eskom Field Instrument Installation Standard (240-56355754) shall be adhered to.

9.7 DC Cabling

The solar cable to be used shall be unipolar electrolytic tinned copper, class 5 (flexible) and ZZ-F solar type cable according to IEC 60228 (conductors of insulated cables) and SANS 10142-1 / IEC/SANS 60364, and shall have the following minimum characteristics:

- Flame retardant, according to SANS 60332-1 and -3;
- Halogen-free, according to SANS 60754-1:/2 (gases involved during combustion of cables);
- Low smoke emission, according to SANS 61034-1/2. Luminous transmittance > 60 %;
- Low emission of corrosive gases, according to SANS 60754-2; and,
- Minimum lifetime 25 years, according to IEC 60216-2.

Alternatively, solar cable type H1Z2Z2-K 1.5/1.5 1 kV (1.8 kV) DC according to Standards SANS 62930/ TÜV 2Pfg 1169-08 / UTE C 32-502 can be used. This solar cable shall have the following minimum characteristics:

- Flame retardant, according to SANS 60332-1 and -3;
- Fire protection, according to EN 50305-9; DIN VDE 0482 part 266-2- 5;
- Halogen-free, according to SANS 60754-1;
- Low smoke emission, according to SANS 61034-1/2: Luminous transmittance > 60%;
- Low emission of corrosive gases, according to SANS 60754-2;
- Lifetime of 25 years, according to SANS 60754-2; and,
- Resistance to ultraviolet rays, according to SANS 62930: and TÜV 2Pfg 1169-08.

If central inverters are used, the cable to connect from the string combiner box to the central inverter shall be type AL XZ1 (S) 1.5/1.5 (1.8 kV):

- Insulation: Cross-linked polyethylene (XLPE);
- Outer sheath: Low smoke zero halogen (LSZH) polyolefin DMO1 type according to HD 603-1;
- Ambient temperature: -40 °C to +90 °C; and,
- Short circuit temperature 250 °C (five (5) second maximum).

All DC cables shall be ≥ 4 mm^2 cross sectional area.

Suitable derating factors for the current-carrying capacity of the cables shall be applied according to the applicable National Standards to prevent overheating under design conditions. LV cables shall be sized based on current ampacity, voltage drop, and let through passing energy.

As per SANS 1507, LV DC cables will be colour coded Red and Black (neutral).

Where applicable, the requirements in the Eskom Field Instrument Installation Standard: Junction Boxes and Cable Termination (240-56355815) and Eskom Field Instrument Installation Standard (240-56355754) shall be adhered to.

9.8 LV AC Cabling

LV AC cabling shall be copper or aluminium cables, type RV-K with XLPE or HEPR (Hard Grade Ethylene Propylene Rubber). The cables shall be suited for outside installation, ground burying and, where necessary, for protection against UV radiation. LV AC cables shall comply with the following minimum criteria:

- Conductor material: Aluminium/copper;
- Insulation material: XLPE or HEPR;
- Design and testing in compliance with SANS 6282, SANS 6283, SANS 6284, IEC 60502-2;
- Comply with the applicable Codes and Standards;
- Be flame retardant, according to SANS 60332-1 and -3;
- Shall be capable to withstand the expected maximum electrical voltages during the minimum design lifetime of the Plant (25 years);
- Be marked and properly identified;
- Be designed with a maximum operation temperature of:
  - ≥ 90 ºC under normal operation; and,
  - ≥ 250 ºC under short circuit circumstances (five second maximum).
- Capable to withstand all electric loads without overheating;
- Capable to withstand all electric through faults without insulation and screen damages;
- Suitable for the environmental conditions at the Project Site, including UV protection (provide certification from manufacturer); and,
- AC cables with sufficient capacity shall be designed and used so that maximum AC voltage-drop between the inverter and the MV/LV transformers at full power complies with a maximum of 1.5 %.

Suitable derating factors for the current-carrying capacity of the cables shall be applied according to the applicable Standards to prevent overheating under design conditions. LV cables shall be sized based on current ampacity, voltage drop, and let through passing energy.

All power cables shall be suitable for service at maximum design load and minimum voltage conditions for the Site conditions and shall be capable of sustaining maximum through fault current without damage for the short time rating of the associated switchgear. Power cables with fuse/ moulded case circuit breaker (MCCB)/miniature circuit breakers (MCB) protection shall be capable of sustaining maximum prospective fault let-through current/time.

The following maximum voltage drop limits shall apply:

- Between main switchboards (i.e., supplied by a transformer) and sub switchboards: 2 %;
- Between main switchboards (i.e., supplied by a transformer) and static load terminals: 5 %; and,
- Between sub switchboards and lighting loads: 3 %.

As per SANS 1507, LV AC cables will be colour coded Red, Yellow, Blue, and Black (neutral) depending on the number of phase cores. For earthing, Green and Yellow-coloured cables shall be used.

Where applicable, the requirements in the Eskom Field Instrument Installation Standard: Junction Boxes and Cable Termination (240-56355815) and Eskom Field Instrument Installation Standard (240-56355754) shall be adhered to.

9.9 PV String Combiner Box

Strings of PV modules may be combined in parallel in a string combiner box for central inverter applications and shall be sized according to the number of string inputs, power, and voltage. The string combiner box shall have the following minimum technical requirements:

- Metallic with appropriate environmental protection (plastic combiner boxes will not be accepted) with proper sunshade/sun protections;
- Protection class IP 65 or above;
- Suitably rated double pole load break switch disconnectors for utilisation category DC21B in compliance with SANS 60947-5-1;
- Door switch interlock;
- Over-current protection for each string (fuses with disconnect bases in each positive and negative string input) within the string combiner box in compliance with SANS 10142-1, SANS 60364-7-712, and PV module manufacturer recommendations;
- PV specific surge arrester type 2 with the appropriate nominal discharge current capacity, maximum surge current, and voltage protection rating;
- String monitoring device interface with the Plant SCADA system for single string current monitorisation and visual alarm in the central control room in case of abnormal string operation. The protocol used should be able to time-stamp the I/O signal of any alarms activated;
- Earthing bars connected to the Plant earthing system;
- Ventilation lugs to be used to prevent condensation forming inside;
- Fully labelled and colour-coded wiring;
- Conduit and cable entry into string combiner boxes shall be through the bottom or sides of the enclosure only; and,
- All cables in the string combiner boxes shall be labelled as per industry good practice.

All string combiner boxes shall be subject to sufficient visual and electrical testing prior to termination of the DC string cables into the combiner boxes.

Where applicable, the requirements in the Eskom Field Instrument Installation Standard: Junction Boxes and Cable Termination (240-56355815) and Eskom Field Instrument Installation Standard (240-56355754) shall be adhered to.

9.10 AC Distribution Panels

All AC distribution panels should be equipped with:

- Appropriate functionality, safety, and protection;
- The terminals shall be connected to a bus-bar arrangement of proper sizing. The panels/ boards shall have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables;
- Panels should contain adequate rating fuses and disconnectors, all of which shall consider the expected operating conditions (i.e., voltage level);
- The panels shall be rated with suitable ratings to the Site's environmental conditions as per the applicable national and international standards, including SANS 62208, IEC 60068-2-68 and IEC 60068-2-78;
- All metallic parts of the boards/panels must be earthed properly to ensure all safety-related measures for safe operation;
- Panels shall be mounted to prevent direct sun exposure; and,
- MCBs shall be monitored by a MCB status monitoring system comprising at minimum a local controller, controlling unit, remote alarms, and remote display unit.

All the distribution panels shall be manufactured with sufficient space for working and must have temperature suitability for the local Site conditions and maximum current rating with separate cable and bus bar alley.

Where applicable, the requirements in the Eskom Field Instrument Installation Standard: Junction Boxes and Cable Termination (240-56355815) and Eskom Field Instrument Installation Standard (240-56355754) shall be adhered to.

9.11 INVERTERS

The inverters shall comply with all necessary manufacturers' specifications in relation to interconnection with other Plant components. Attention is drawn to the following areas:

- Inverters can be central or string-type;
- The inverters shall be designed and constructed for continuous operation under the most extreme climatic and environmental conditions on Site;
- The inverters shall be designed to provide a Maximum Capacity of 75 MWac at the inverter level with a power factor of 1 and 50 ºC of operational temperature, as defined in Table 1;
- According to the PV module manufacturer's requirements, the earthing of the negative/positive pole shall be provided;
- The Contractor shall employ inverters capable of complying with Grid Code requirements (power factor, harmonic distortion, voltage ride through, ramp rate control) along with any proposed additional power conditioning equipment;
- The inverter shall include requisite filters such that any heating on the MV Inverter transformer and upstream equipment due to harmonics is mitigated;
- The total harmonic distortion (THD) shall be less than 3 %;
- The Inverter shall be capable of providing reactive power compensation at night;
- The inverter shall meet all relevant Laws, Consents, and Standards, including, but not limited to, the following requirements and international standards:
  - Protection type IP (SANS 60529);
  - Safety of power converters for use in photovoltaic power systems (SANS 62109-1, SANS 62109-2);
  - Equipment safety and protection class (SANS 62103 or EN 50178);
  - DC overvoltage protection;
  - Surge protection (SANS 61643-11/-12);
  - Anti-islanding protection;
  - National/regional requirement;
  - CE Declaration to conformity;
  - DIN VDE 0126-1-1;
  - EMC guideline (SANS 61000-6-1, SANS 61000-6-2, SANS 61000-6-3, SANS 61000-6-4);
  - Voltage guideline (SANS 62103 or EN 50178); and,
  - Electrical safety (SANS 61557).
- The protection system shall be selected and coordinated in line with the requirements of the Grid Operator;
- The inverters shall be capable of automatic synchronisation with the grid;
- A proven communication protocol compatible with the PPC system and Plant SCADA system at the substation shall be provided (the chosen protocol must be capable of timestamping I/O signals);
- Incorporate display which shows performance values and faults;
- Plant SCADA system to detect individual string loss (string inverters) or loss/reduction in output of string combiner boxes (central inverters) and alert the O&M staff accordingly;
- Each inverter shall be connected to the earthing protection system by an appropriate arrangement;
- Inverter shall have a minimum European efficiency of 98 %;
- Maximum system DC voltage should be 1,500 V;
- The inverter and transformer components, including all enclosures and fixings, shall be made of materials with an IP rating suitable for the Site-specific environmental conditions and the proposed enclosure;
- IP Protection shall be at least IP54 in case of central inverters and IP65 for string inverters;

- If outdoor-type inverters are considered, these shall be designed to withstand the most extreme climatic and environmental conditions on Site;
- If indoor-type inverters are considered, these shall be provided within an inverter station enclosure designed to withstand the most extreme climatic and environmental conditions on Site. The air flow and cooling design of the inverter station should be adequately calculated to avoid overheating of the inverters;
- Any conduit coming in and/or out of the inverter station shall be sealed with appropriate expanded foam spray or similar to avoid water and rodent ingress;
- The inverters shall be suitably mounted to prevent water or dust ingress and be shaded against direct sunlight. Temperature and moisture content control should be provided;
- If containerised inverter/transformer solutions are proposed, sufficient ventilation (or air-conditioning if necessary) to maintain optimum performance and to avoid any unnecessary equipment derating or damage must be ensured;
- If bifacial PV modules are used, the installation of inverters cannot be carried out under the trackers to avoid shadows, hot spots, or other potential issues; and,
- Inverters must have a shelter to reduce direct exposure to the sun.

The inverters and inverters' manufacturer shall have a proven track record in commercial international projects, and comply with the following requirements:

- All inverter types and models proposed shall have been in operation in at least three (3) commercial plants totalling 200 MWac or higher nominal power (not demonstration projects), which have been in operation for a period of at least twelve (12) months at Date of Tender Bid Submission, and have recorded a technical availability of at least 99 % for twelve (12) consecutive months of operation at Date of Tender Bid Submission;
- All inverters to be supplied for the Plant shall be of the same type and from a single manufacturer;
- Inverter manufacturers are to conform to the following requirements:
  - Manufactured inverters for more than 5 years;
  - Cumulative installed capacity in excess of 1,000 MWac;
  - Production capacity capability in excess of 500 MWac per year; and,
  - Have supplied inverters to at least three (3) different commercial projects of a similar size (75MWac) in the past one (1) year at Date of Tender Bid Submission, all of which have been financed non-recourse.

A letter of confirmation certifying that the above requirements are met, shall be issued by the inverter manufacturer and received by the Employer.

- The inverter manufacturing facilities should be certified according to:
  - ISO 9001 – Quality Management Systems; and,
  - ISO 14001 – Environmental Management Systems.

10 CIVIL ENGINEERING AND BUILDING WORKS REQUIREMENTS

10.1 General

10.1.1 Scope of works

Civil works shall include, but not be limited, to the design, procurement, construction, and installation of the following:

- Site investigations and surveys, including topographic survey, utility services survey, geotechnical study (field and lab tests), hydrological impact assessment, geohydrological survey, and Pull Out Tests (POT), as discussed further in section 10.6.1;
- Site preparation, including clearing and grubbing of land, excavation, backfilling, compaction, grading, levelling, earthworks, soil improvement, cable trenching routes, and rehabilitation of parts of the Site as affected by Works;
- Permanent fencing, gates, and access control;
- All necessary access roads (internal and external) to construct, operate, and maintain the Plant, including hard standings areas, as well as permanent access to all power stations/inverters and PV modules (if required);
- Drainage system;
- PV structure (piling), inverters, and MV/LV power stations/inverters foundations;
- Electrical, telecommunications, duct system, earthing, and cable trenches;
- Road crossings and directional drilling as required for underground cabling, utilities, and rivers/streams;
- Building's foundation;
- O&M and control building, as well as any other building, including furnishing and equipping;
- Parking lots;
- Storage areas;
- Sewers and sewage systems;
- Water supply and storage;
- Temporary facilities with offices for the Contractor's team and the Employer's representatives, including the Employer's Owner Engineer team, meeting room, and restrooms, including furnishing and equipping, as further discussed in section 2.5.1;
- Utilities for temporary facilities (power, water, telecom, waste);
- Temporary Roads and parking;
- Temporary fencing, lighting, and security for all materials; and,
- Site rehabilitation during construction works, and rectification of defects.

10.2 Existing Services

The Contractor is responsible for the identification and demarcation of all existing underground and overhead services and infrastructure within the Project Site. If encountered during the course of the Works, all live pipes, mains cables, transmission lines, and services of any kind are to be maintained in position or diverted to a location reviewed by the Employer and must be protected and kept in working order unless otherwise directed by the Employer.

No works in this regard shall commence without the prior acceptance in writing by the Employer of the Contractor's proposed method statement and programme.

10.3 Site preparation

Prior to the commencement of any construction works, the Contractor shall clear the Site of all rubbish, debris, building, vegetation, and unwanted materials of any description, and remove and dispose of such items in line with the local Environmental requirements through licensed contractors permitted by the local approving authorities.

The Contractor shall carry out a topographical survey and evaluate if the relevant slopes are observed within the minimum and maximum recommended slopes with respect to the module mounting structure, as well as access and internal roads.

The preparation of the Site and the levelling work shall also be done to ensure that the PV modules will, once installed and fastened onto the mounting structure, stand at their lowest level (at maximum tilt) at a height that enables ease of cleaning, free movement, and safe operation in case of flooding, for the minimum return period and storm duration specified in the Employer's Requirements. It shall comply at all times with the specifications of the mounting structure supplier. Furthermore, the distance from the bottom edge of the PV modules shall at all times be more than 0.5 m from the ground at all locations, in order to allow for unplanned movement of fauna below the PV modules.

No slope greater than 15 % shall exist on the Site. In cases of more restrictive slopes being required by the manufacturers, such as a tracker system or MV station manufacturers, these shall prevail. Special attention shall be given to the manufacturer's requirements of a tracker system regarding N-S and E-W slope tolerances.

10.4 Earthworks

Where excessive differences in the existing ground levels are identified in the topographical survey, the Contractor shall carry out the necessary earthworks within, and in the immediate vicinity of, the Site. This is to ensure that the slopes across the Site comply with the requirements of the PV module mounting structure manufacturer, the intended use of the access road and internal road, and to allow for an overall optimised layout. Earthworks shall be minimised and cut and fill amounts balanced to the extent possible to reduce the need to import or dispose of material.

Excavated materials not reused for the Works shall be disposed of in compliance with the Applicable Laws and Regulations and Codes and Standards.

Levelling and grading of the Site shall aim to match the existing surrounding ground levels to facilitate free drainage of the Site. Additional fill material required to achieve the falls necessary for free draining shall be a suitable imported fill material.

The filling for foundations purposes will be done in layers of no more than 250 mm each and compacted at 98 % of maximum density at optimum moisture content.

Adequate hard standings suitable for the equipment and/or vehicles using them shall be provided for the proper O&M of the Plant. Hard standings shall be provided to allow storage and handling of equipment as may be required during overhauls as well as areas for containers and car parking. These areas shall be included in the layout drawing.

Any platform required due to earthworks, as well as the slopes, will be designed according to the required bearing capacity in the top of the platform, either for a foundation or a road, and will depend on the geo-mechanical parameters obtained from the geotechnical study.

The minimum layer of topsoil specified in the geotechnical report shall be removed and used/spread over to other free areas and perimeter inside the Site for later environmental restoration activities. The use of topsoil as fill material or any other construction use shall not be permitted.

The finished Site shall be well compacted in layers according to SANS 1200 & SANS 2001.

The Contractor shall carry out its construction activities in such a manner as to avoid damage to, or deterioration of, the final surfaces of excavations. The Contractor shall not allow water to lie in any part of the Works unless required to do so under the Contract. Water arising from, or draining into, the Works shall be drained or pumped to an approved disposal container/area. Any contaminants whose presence would render water unsuitable for discharge into water courses or drains external to the Site shall be effectively removed prior to discharge and, where appropriate, such extracted contaminants shall be transported to a licensed facility. The stormwater management plan should include the aforementioned considerations and actions.

All excavated materials for reuse (especially all excavated topsoil) or for disposal off-Site shall be placed in stockpiles prior to processing and final classification in accordance with the Soil/Material Management Plan. Where required, unacceptable excavated material shall be processed by mechanical or chemical testing, or by other means, to render the material acceptable for use in the execution of the Works. Classification and disposal of any contaminated material shall be the responsibility of the Contractor, with the agreement of the Employer and in line with Environmental Legislation.

The Contractor shall provide to the Employer documentation to prove the source of materials brought onto the Site and that sufficient chemical testing has been performed to demonstrate beyond-reasonable doubt that these materials are free of pollutants.

The Contractor shall prepare and re-dress the Site as necessary with free-draining granular material to facilitate the efficient movement of personnel during the construction of the Works. The Contractor shall maintain the surfacing as required such that construction is not interrupted nor water allowed to collect on the surface.

The Contractor shall establish a temporary Site drainage system including settlement/attenuation ponds depending on the flooding risk during construction, which is to be evaluated by the Contractor. Oil interceptors and wheel washes shall be required, if applicable under the EA and EMPr. Any contaminants whose presence would render water unsuitable for discharge into water courses or drains external to the Site shall be effectively removed prior to discharge and, where appropriate, such extracted contaminants shall be transported to a licensed disposal Site.

Finished ground floor level of technical and non-technical buildings/enclosures shall be at least 250 mm higher than the 1:100 year return period maximum water level in order to ensure free drainage of the surrounding grounds away from the buildings. For any case where the flood risk assessment/hydrological impact assessment report specifies higher ground floor levels, these shall be prioritised. The Contractor shall also refer to the recommendations of the hydrological studies in terms of finished ground floor levels.

10.5 STRUCTURAL DESIGN PRINCIPLES

All structural calculations shall be in accordance with SANS 10160 and further codes shall be followed where the Structural Code needs to be complemented.

All structural design reports, calculations, and drawings prepared by the Contractor shall be signed by a registered structural engineer.

The module mounting structure structural calculation performed by the module mounting structure manufacturer shall be validated and approved by a registered engineer to validate the necessary local regulations.

The Contractor shall make use of finite element materials (FEM) analysis to calculate the loading conditions at any critical component, including bolts, joints, and welding, of the module mounting structure. This includes the fastening method of modules to the mounting structure.

If the Contractor proposes a solar PV solution using single axis trackers, the Contractor shall determine in detail the mean net pressure coefficients and the peak negative and peak positive net pressure coefficients for the tracker row at each stow/operational position for all wind directions, and take into consideration the reduction in sheltering effect of the interior trackers due to differences in the relative elevation of each row. Proper justification of this analysis will be required.

Mounting structure elements for tracking structures shall be verified in the respective calculation, including panel rails and joint elements.

For tracking structures, dynamic loads (including possible instability that might occur due to vortex shedding, wake buffeting, etc.) shall be considered when these might lead to higher stresses, and they shall be estimated using state-of-the-art tools and methodologies. A modal analysis shall be performed when necessary.

Fatigue verification shall be performed using state-of-the-art tools and methodologies for a tracking mounting structure, if proposed.

In the calculation reports and drawings notes to be provided to the Employer, the following information shall be present:

- Detailed supporting structure characteristics (type, dimensions, etc.);
- Detailed materials characteristics (concrete technical specifications, steel grade, protection against corrosion, etc.);
- Detailed design assumptions (environmental conditions, load combinations, modelling software, etc.); and,
- Detailed calculation results for all load combinations.

10.5.1 Load Assumptions

In designing the Project, the Contractor shall take into account all the loads that can be reasonably expected for the specific Site conditions, including, but not limited to, the following:

- Self-weight loads;
- Wind loads;
- Thermal loads;
- Seismic loads;
- Snow loads;
- Water (flooding) loads;
- Actions induced by cranes and machinery;
- Actions during execution; and,
- Basis for geotechnical design and actions.

The Contractor shall consider the loads and load combinations in accordance with SANS 10160. Uplift and downforce load at the tilt angle or entire operational range of the module mounting structure must be provided and must comply with the allowable loads of the PV module as confirmed by the PV module manufacturer.

The Contractor is responsible for system survivability over the design lifetime of the Project (25 years).

10.5.1.1 Dead loads

PV Structure and PV module dead loads must be considered in the design. Values must be provided in kN and shall be justified by the Contractor.

10.5.1.2 Wind Loads

Wind loads shall be defined according to SANS 10160-3.

The Contractor shall document the assumptions made using available wind data and any supporting material verifying the suitability of the structures proposed as part of the design and components for the Site conditions.

Each component forming part of the Project shall be designed or verified against the expected wind loads. This includes, but is not limited to, foundations, buildings, PV module support and mounting systems, tracking systems, structures, weather stations, fences, etc.

Wind loads shall be duly combined with other loads as prescribed in the Applicable Laws, Permits, and Codes and Standards by implementing adequate safety factors. Consideration of wind accelerations caused by near obstacles, hills, or escarpments shall be considered and properly justified.

The Contractor shall perform its own investigation as to the maximum expected wind conditions over a return period not less than 50 years.

In case of trackers, deformation and twisting of the tracker structures shall be considered whenever it leads to higher loads at the structure.

The Contractor shall seek to support their assumptions and calculations using wind load tests, such as wind tunnel tests or computational fluid dynamics (CFD) tests whenever necessary to demonstrate compliance with the aforementioned conditions, Applicable Laws, Permits, and Codes and Standards. The wind loads shall be obtained from a dedicated wind tunnel test for the proposed tracker. The wind tunnel test shall include several tracker rows to capture the influence of the trackers upstream in the wind pressure of the trackers downstream.

The aerodynamic coefficients and wind loads shall be obtained for several angles of attack including all the tracker movement and several wind directions to cover all the load scenarios.

The wind loads shall include the required Dynamic Amplification Factors (DAF) depending on the tracker natural frequency and damping factor.

A graph showing the limit between stability and instability at certain frequencies and wind speeds for different tracking angles shall be included, as well as Cp coefficients at different tracking angles.

10.5.1.3 Seismic load

The Contractor shall perform its own investigation as to the maximum expected seismic accelerations over a return period not less than 50 years according to SANS 10160-4.

Each component forming part of the Project shall be designed or verified against the expected seismic loads. This includes, but is not limited to, foundations, buildings, PV module support and mounting systems, tracking systems, structures, weather stations, fences, etc.

10.5.1.4 Snow load

Specific snow load (kN/m^2) for the Project location must be considered in the mounting structure design and justified by the Contractor if considered applicable.

10.5.2 Combined Loads Results and considerations

The Contractor must provide a table showing the Static moment and Static + Dynamic moment, in Nm, for the whole operational range of the tracker and each part of the different trackers, if any, such as exterior, edge, interior, etc.

The wind loads combinations shall cover all possible load scenarios (wind direction and angles of attack).

10.5.3 Aeroelastic stability

If proposed, the Contractor shall demonstrate the aeroelastic stability of the tracker mounting structure, showing that the critical wind speed is well above the design wind speed, including the aeroelastic wind tunnel if necessary, for instability mechanisms such as torsional divergence, flutter instability, etc.

The Contractor must provide a graph showing the critical wind speed before instability occurs for each type of tracker and for the whole operational range. There must be a 2 degrees tolerance to cover inaccurate installation or tracking. If this information is not available, a 10 % safety factor needs to be applied for this expected deviation on stow position angle.

The structural design of the tracker shall ensure that aerodynamic instabilities do not occur for the entire range of design wind velocities. It is furthermore recommended to assume an additional safety margin of 25 %, i.e., the onset velocity of aerodynamic instabilities should be at least 25 % above the design wind speed.

Wind induced vortex shedding shall be considered and checked against the frequencies of the structure. Wind-induced dynamic instability must be avoided.

10.5.4 Wind tunnel test

The Wind tunnel test (as conducted by a third party) shall cover at least the following with respect to tracking mounting structures:

- Static and dynamic coefficients based on wind load testing using a rigid model or similar;
- Aerodynamic stability of the tracker to assess the sensitivity to wind dynamic actions caused by aerodynamic instability such as flutter;
- Wind-inducted buffeting check to assess all combined effects of inertial wind load, mean wind loads, gust wind loads, and self-excited forces from own tracker;
- A wind load coefficient consistent with the Applicable Standards (SANS 10160-3) must be recommended;
- The wind impact on the PV module (front or back) at each wind direction and the whole operational range of the tracker shall be modelled;
- Twist of the torque tube must be not restricted by any obstacles or equipment along the tracker axis, limited only by the torsional stiffness of its closest torque tube;
- Time series of the wind load and the instability condition must be applied on each node according to the actual twist in the previous time step;
- The first torsional eigenfrequency used for the analysis and maximum damping ratio must be defined;
- It must include the mass moment of inertia used for the analysis;
- Terrain roughness used on the test must be in accordance with Site roughness;
- Slopes resulting in different elevation of trackers shall be assessed in order to quantify sheltering reduction of the interior rows;
- The results of the critical wind speed obtained in the sectional wind tunnel test depending on the tilt angle and other system properties must be provided; and,
- The static pressure coefficients C_{drag}, C_{lift}, and C_{moment} for the different tracker (row/table) locations in the Site and different tilt angles must be provided.

10.5.5 Corrosion protection

The Contractor shall demonstrate that all metal structures are adequately protected against corrosion, both due to the ground aggressiveness and atmospheric factors on Site. A third party corrosion ambient report shall be provided by the Contractor. Where metal surfaces are protected against corrosion through the application of galvanising, the galvanising shall be appropriate for all Site conditions (climate, soil conditions, agricultural practices, anodic and cathodic reactions, etc.) for the 25-year design lifetime of the Project in accordance with SANS 121 and SANS 14713-1/2, equivalent Standards, or ASTM. The Contractor shall obtain galvanisation certificates confirming such compliance. For underground steel, DIN 50929-3: Corrosion of metals – Part 3: Buried and underwater pipelines and structural components standard shall be followed.

The thickness of zinc in every galvanised element shall be higher than the calculated minimum thickness required in all its sides and parts. Local mean thicknesses below the minimum calculated thickness shall be avoided.

Pre-galvanisation or similar treatment as G90 is not allowed for any part of the structure in contact with the ground.

10.6 Foundations

Foundations shall be designed according to the relevant Standards.

The Contractor shall assume the ground risk as regulated within the Contract. Prior to construction, the Contractor shall carry out all necessary geological, hydrological, geotechnical investigations, and land surveys and studies to satisfy itself of the ground conditions.

In the Contractor's Documents, the following information, as a minimum, shall be made available to the Employer:

- Detailed foundations design documentation for all required foundations (type, dimensions etc.);
- Reinforcement characteristics (rebars diameter, rebars separation steel grade);
- For steel structural elements, protection against corrosion;
- Structural interface components (base plates, holding down bolts etc.);
- Concrete design mix (grade, composition);
- Design basis statements and supporting calculations;
- Specific construction methodology and testing criteria requirements; and,
- Specific bearing capacity requirements.

Foundations shall be designed to withstand the Site conditions for a minimum of the design lifetime of 25 years without being replaced.

10.6.1 Piling / Mounting structure foundations

The Contractor shall take full responsibility for the design, construction, and operability of the solar field foundations. The Contractor shall design the foundations according to the relevant Standards and module mounting structure manufacturer's specifications.

The mounting structure shall be designed to withstand the Site conditions (including the soil chemistry) for the entire design lifetime of the Project (25 years) without being replaced. In designing the foundations, the Contractor shall take into account all loads from the upper structures to determine the foundations' embedment depth and specifications. The foundations and substructures shall be able to transfer all actual load combinations including, but not limited to, horizontal and uplift forces safely to the foundation system.

The Contractor shall design a suitable foundation type, as far as practically possible, using pile foundations. However, the foundation type should consider other options including pre-drilled piled foundations (or similar) and concrete footing as required, based on the load testing and geotechnical studies.

The Contractor shall state in the foundation calculations the maximum permissible foundation movement that may be tolerated consistent with normal operation of the Project. The design of the mounting structure foundations shall account for settlement in accordance with the manufacturer's requirements.

All Pull-Out Tests (POT to be conducted in line with industry standards) conducted to confirm the design values and ultimate capability of the mounting structure foundations shall be done in line with industry standard practice, mounting structure supplier's site specific recommendations and applicable technical studies.

The following step process shall be followed by the Contractor; any deviations from it shall be accepted by the Employer.

a) Initial foundation pre-design based on geotechnical study;
b) Initial POT on Site at the earliest opportunity, following the definition of the initial foundation design, in order to verify the assumed loads and validity of the initial foundation design. The initial POT shall be done in accordance with the mounting structure manufacturer POT

procedures on certain number of test piles that shall use the same material, geometry/dimensions, and installation procedure as defined in the initial foundation design. The initial POT shall be done with a quantity commensurate with Good Industry Practice and the Site area, but, at a minimum, one POT for each foundation type in each area of varying ground conditions and geological makeup, as defined in the geotechnical study, with a minimum of 10 POTs for each foundation type. POTs shall include investigation and analysis of compression, tension, and horizontal load applications up to ultimate/survival loads;

c) Final foundation design shall be based on the initial foundation design and the information gathered from the design POT;
d) Design POTs on Site prior to commencement of the foundation works in order to verify the final foundation design. All the different foundation types shall undergo POTs at all the different types of terrain where such foundation type will be installed, if the terrain proves to have significant heterogeneities. POTs shall include investigation and analysis of compression, tension, and horizontal load applications up to ultimate/survival loads. Any variation on the design or execution procedure of the foundation for adapting to the actual terrain behaviour will be tested with dedicated POTs up to ultimate loads, in order to verify adequate safety margins before initiating execution of works;
e) Execution of the foundations;
f) Validation POTs on Site in order to validate the design executed. All the different foundation types shall undergo POTs at all the different types of terrain where such foundation type will be installed, if the terrain proves to have significant heterogeneities. POTs shall include investigation and analysis of compression, tension, and horizontal load applications up to maximum working loads, not ultimate/survival loads;
g) Pile rejection (not reaching the prescribed embedment depth) shall be treated following the manufacturer procedures; and,
h) Rejection POTs on Site, in order to verify the rejected piles following the manufacturer procedures but at least covering 20 % of the rejected piles.

The Contractor shall repair, in accordance with the designer and manufacturer's specifications, any metal surface damage caused accidentally during ramming, or that requires subsequent mechanical interventions such as cuts or drilled holes. During the ramming process, the top of the ramming profiles damages should be repaired by applying two layers of a zinc coat painting with 95 % of Zn content. Alternatively, it should be repaired according to the post head damage procedure of the structure manufacturer.

Verification of the possible damage of the Zinc cover in the underground part of the piles during the ramming is required. A sample of each type of pile will be rammed and extracted in different areas of the Plant for checking that there is no significant damage in the galvanised surface.

10.6.2 Other foundations

The Contractor shall perform all required geotechnical and other studies to the extent deemed necessary to assess the ground conditions of the Site, and to determine the type of foundations and any ground improvement techniques to be employed as necessary (soil improvement; compaction, etc.).

The Contractor shall provide a detailed structural analysis demonstrating that the design conforms with the Site wind speeds, seismic loads, snow loads (if applicable), and to the Standards, and shall clearly state in the design basis report(s) the load combinations, assumptions, and design specifications.

The foundations shall be able to transfer all actual load combinations, including horizontal and uplift forces, safely to the support soil material determined by the geotechnical assessment report. The Contractor shall, in the design calculations, state the maximum permissible foundation settlement that may be tolerated, consistent with normal operation of the Works.

The material used for the foundation shall be steel-reinforced concrete. Overall, the minimum strength of structural concrete for the foundation shall be strength class 35 MPa as per Eskom Standard 240-56364545 unless otherwise specified. The Contractor is to specify a higher grade of concrete where required and submit all designs for review by the Employer. All below-ground concrete structures shall be adequately waterproofed. Likewise, the concrete design mix will be specified according to the aggressiveness and the geomechanical properties of the ground conditions and groundwater shown in the geotechnical report and laboratory analyses of samples.

Should a risk of excessive soil erosion and/or dune formation be identified, suitable mitigation measures shall be implemented to manage any long- and short-term impact subject to Employer acceptance.

The Contractor´s Documents shall include, but not be limited to, the following:

- Detailed foundations characteristics (type, dimensions, material technical specifications, etc.);
- Geotechnical design assumptions and verifications;
- Specific construction requirements and testing criteria;
- Climatic condition assumptions and verifications (wind, snow, humidity, temperature, etc.);
- Concrete foundations:
  - Reinforcement characteristics (diameter, steel grade, protection against corrosion, etc.); and,
  - Design mix requirements (grade, composition, etc.).

The Contractor is responsible for the sealing of cable ducts that enter buildings, foundations, or other areas which will be suitable for the construction phase (temporary sealing) and for the Plant design lifetime of 25 years (permanent sealing).

10.6.3 Excavations and backfilling for foundations

Foundation excavations shall be designed and performed in order to ensure their stability and the Works in safe conditions, and to allow for concrete placing avoiding any mixing with soil in place. Excavated material shall be stored in a suitable place, preventing any disturbance. Topsoil shall be stripped to avoid contamination with excavated subsoil. Excavations dimensions shall comply with foundation design.

The final sub-formation (excavation bottom) shall be inspected by the Contractor to demonstrate compliance with the final detailed design specifications for bearing capacity. Excavation shall be backfilled with suitable material and properly compacted in layers not exceeding 0.25 m. This is to achieve the density required for supporting structure stability and resistance against erosion and light vehicles traffic.

In the event of water ingress (groundwater or surface water) into the foundation excavation area, the excavation will be drained before foundation construction works activities commence. The Contractor shall supply any temporary equipment and take such action as necessary to ensure all foundation excavations are kept free from water during the foundation construction works activities period. The Contractor shall consider environmental constraints for location of outfall for each location where pumping is required.

10.7 Roads

The Contractor shall be responsible to liaise with local authorities in other to ensure permanent access during construction and operation to the Plant.

The access road up to the boundary of the Site, internal roads, parking areas, and other surfaces within the Site shall be the responsibility of the Contractor.

The Contractor shall develop and carry out a construction Traffic Management Plan and best practice traffic management procedures, including a traffic incident response plan.

The California Bearing Ratio (CBR) shall be established from the geotechnical investigation in order to evaluate the mechanical strength of the road subgrades and basecourses.

Roads and surfaces shall be designed in conformity with a specialist geotechnical report to support the use of heavy vehicles needed for the transportation of Goods, Materials, and Plant (equipment) to and within the Site (area) during the construction period, and vehicles to be used for the O&M activities that will be required during the 25-year Plant lifetime. The wheel and/or axle loads shall be submitted for all road designs. Furthermore, the Contractor shall take into consideration the loading capacities and clearances of existing services and connecting roads when carrying out transportation studies. The road structural layers shall be defined taking into account the most restrictive scenario (construction phase: heavier loads, longer turning radius).

Suitable excavation materials, according to the SANS or COLTO soil classifications, from excavations may be re-used in road construction provided the material is uncontaminated and deemed appropriate for load-bearing capability.

Roads and parking areas shall be designed to suit Site conditions and compacted crushed rock shall be used as a construction material if periods of wet weather are anticipated. The maximum size of crushed rock shall be 40 mm. The compaction ratio for each layer of the roads shall be defined according to SANS or COLTO standard (using Modified Proctor test).

The road's widths (the usable surface) shall be at least 4 m or as per the component manufacturer(s) requirements. Road and turning radii shall allow access for maintenance and replacement of the largest (Plant) components and for emergency personnel, and these shall be at least 10 m from the axis of the respective road. The road's minimum height over the ground level shall be equal or higher than 0.1 m.

Roads (including road surfaces) shall be designed to allow proper drainage, both cross and longitudinal drainages. During the roads' construction, roads shall be backfilled with suitable material and properly compacted in layers not exceeding 0.25 m, in order to achieve the density required for supporting structure stability and resistance against erosion and light vehicles traffic.

Internal roads shall be carried out at the Plant, with as many interior roads as needed for providing access to string combiner boxes, inverters, transformers, substation, tracker drives, permanent buildings, and any other relevant equipment by its dimensions deployed within the Site.

In the areas of the solar field where no roads are included, the layout shall consider sufficient space for circulation of light all-road vehicles to reach any equipment where recurrent maintenance needs may be expected. At least 3 meters wide paths free of obstacles shall be considered for this purpose.

The Contractor shall be responsible for keeping the roads clean and usable during all weather conditions for the areas within its limit of supply.

Different in-situ and laboratory tests shall be developed by the Contractor, amongst which: compaction grades, bearing capacity or vertical deformation of foundation road, and topographic survey-road levels according to SANS or COLTO.

The Contractor shall implement the necessary maintenance and resurfacing of the roads during the execution of the Works to ensure the roads are in good condition by the Date of Completion.

10.8 Drainage Systems

The Contractor shall design and build a drainage system suitable for the 25-year Plant design lifetime. Site conditions (specifically climatic and rainfall data and the Site's configuration and topography) shall be taken into account to protect the Project against erosion and flash-flooding or other types of flooding. The drainage works shall be located within the area secured for the Site. No additional area outside of the Site shall be provided or utilised.

Based on the hydrological impact assessment and flooding risk assessment, the Contractor shall design a drainage system that handles the runoff from an extreme storm event, thereby preventing the Project from being flooded.

In this regard, the drainage philosophy will require two parts:

- External drainage: To protect the Plant against external water runoff though the watershed from the neighbouring areas of the Site; and,
- Internal drainage: To manage the runoff generated from rainfall within the Site.

The external drainage shall be designed for a 1:50 year return period. Conditions shall also be checked for the 1:100 and 500 year return periods to assess the risk of floor levels being inundated (buildings, inverters, and transformers) and a flood risk assessment presented to the Employer with the conclusions and potential mitigation measures.

The internal drainage system shall be designed for a 1:50 year return period. The internal drainage system shall be designed in a manner that water drains away from the permanent Site infrastructure, and that other infrastructure (such as trenches, ducts, or cable conduits) do not act as part of the drainage system.

Roads and trafficable areas shall be designed to guarantee a minimum transverse slope of at least 2 % to allow surface water runoff to drain away in accordance with formal flood risk assessments indicating acceptability.

Existing drainage courses shall be maintained as far as possible. Before any discharges off-Site, the discharge water shall be treated to retain or neutralise unacceptable pollutants. Provisions shall be required in respect of surface water and Plant drainage. All drains and liquids discharged from the Plant shall be disposed in accordance with the EIA, the EMPr, the EA, and the relevant permits.

Longitudinal or transversal elements of the drainage system shall not block circulation within the solar field which significantly increase the distance to reach Plant equipment for maintenance.

Surface drainage in areas which may be contaminated by oil shall be routed via an appropriate oily water drainage system with an oil separator.

Drain channels and ditches shall be covered in concrete in case it is needed due to the water speed, in order to avoid erosion at the bottom and walls of the drain channels and ditches.

The Contractor shall provide a Stormwater management plan, including the maintenance requirements for the drainage system proposed.

No water-induced erosion is allowed within the Site. The drainage system shall be designed to prevent erosion.

10.9 Trenches, Ducts and Manholes

Underground cable runs, including communication cables and earth conductors, shall be located at an appropriate depth to meet the applicable Standards and any other Employer's requirements, including Good Industry Practice.

Underground cables shall be laid on a clean layer of sand and always be covered with warning tape. Mechanical protection shall be provided and installed for LV and MV trenches. In case of LV trenches with cables running through adequate cable ducting, mechanical protection may not be required. Backfilling materials shall be free of rocks, roots, vegetation, or any element that could damage the cables or create cavities after compaction or during the 25-year Plant design lifetime. Bedding material should be tested and aligned with the thermal resistivity assumptions used in the cable sizing calculations.

The cable trench study shall assist in determining:

- The final trench design based on the final DC and AC collection system layout;
- The final trench design based on:
  - geotechnical study;
  - thermal resistivity measurements;
  - the surrounding conditions;
  - the soil conditions and obstructions in the soil;
  - filling material;
  - existing infrastructures; and,
  - DC cables, AC MV cables, fibre optic (FO) cable, and earth conductors' characteristics.

Earthing connections and splices that are directly buried in the soil must be permanently bonded using exothermic connections (where copper earthing is used) to equalize the potential differences and avoid joint corrosion over time.

Both physical and digital markers shall be provided at any direction change, any cable joint, and every 100 meters for each cable run. Subject to the Employer's acceptance, the requirement for physical markers for DC cabling may be waived after the final layout has been reviewed.

Trenches with mixed AC MV/LV circuits shall be avoided if possible. In case strictly necessary, higher voltage circuits shall be buried deeper than lower voltage circuits. The following depth of cover (distance between edges of conduit or cables to ground level and trench walls) shall be as per SANS 10198 and adhere to the following requirements among others:

- Cables laid at the bottom of the trench shall lay on a minimum 100 mm sand layer. The Contractor shall only be allowed to reduce the 100 mm sand layer requirement under prior acceptance from the Employer and under proper technical justification based on the thermal resistivity of the backfill material. In any case, a sand layer thickness of less than 50 mm shall not be acceptance;
- MV cables shall lay at the bottom of the trench at a minimum depth of 800 mm from ground level;
- LV (DC and AC) cables shall lay at a minimum of 300 mm above the MV cables and at a minimum depth of 600 mm from ground level;
- The depth of continuous signal/danger tape shall be at least 200 mm above cables and 300 mm below ground level. Trenches greater than 1 m wide should have two (2) or more equally spaced warning tapes above the cables. Signal/danger tape must be above each trefoil run of MV cables;
- DC cable shall lay at least 200 mm apart from AC cables (from nearest duct or cable edge);
- FO cables must be separated 125 mm from LV (DC and AC) cables and MV cables;
- At LV and MV road crossings, cables shall be laid in cased ducts concreted along their entire width of the road plus 1 m each side of the road crossing. The depth from the top of the encased ducts to the surface shall not be less than 0.6 m;
- Conductive (copper) signal cables will lay at least 200 mm apart from LV cables;
- Minimum separation from the cables (LV or MV) to the excavation walls shall not be less than 50 mm;
- Cables shall be displaced horizontally through the different layers so that deeper cables can be accessible for repair without causing damage to the cables above;
- All cables shall be surrounded by soft sand backfill (a fine-fill material to be used for LV cables) before trenches are backfilled. The thickness of the sand backfill above the cables shall align with the requirements of the trench design study, and the thermal resistivity of the sand backfill shall be as per the requirements of the trench design study;
- Earthing, where applicable, shall be laid at the lowest layer of the trenches;
- LV cables and MV cables should be mechanically protected. In case of LV trenches with cables running through adequate cable ducting, mechanical protection may not be required; and,

- On top of the sand backfill surrounding cables, the trenches shall be backfilled with clean fill material free from aggregate, debris, organic material, and stones. Trenches shall be backfilled in layers of no more than 150 mm each and mechanically compacted to 90 %- 93 % of maximum density at optimum moisture content, in order to avoid cavities that may cause collapse of trench top due to settling of the soil or sand. Backfilling material will have a 50 mm size as a maximum.

10.10 Security Fence and Gates

This section deals with the fence and gate requirements for the main Plant Site area only; and is not to be confused with the fence and gate requirements for the Project's Grid Connection Works components, which are addressed in section 16.

The complete set of technical specifications relating to the security fence and gates for the Project is presented in the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183, which forms part of the RfP documentation package and includes the Eskom Standards the Contractor must comply with relating to the security fence and gates.

The Contractor is responsible for all security of the Site during Construction. This may include the use of temporary barriers to restrict unauthorised access to the Site. Such barriers shall not comprise hazardous materials and shall be suitable for their given purpose.

Where applicable, and as agreed with the Employer, Site access roads which connect to public roads, intersect with existing fences or field boundaries, or cross existing public or private roads shall include new permanent stock-proof fencing, gates, and cattle grids to maintain the integrity of the existing road and field boundaries.

Where applicable, and as agreed with the Employer, boundaries between different landowners shall be separated by suitable fencing, gates, and cattle grid. These fences, gates and/or cattle grids shall be suitably designed to accommodate all cranes and other vehicles over the lifetime of the Plant.

Where the Site is located in a livestock farming area, and unless otherwise agreed with the Employer, Site road access gates shall be double-leaf type with one side fitted with a cattle grate. All gates shall be fitted with a hold-open and hold-closed device. The gate type, cladding, signage, and lock type shall all be agreed with the Employer..

10.10.1 Security Fence

Before the commencement of the Works at Site and delivery of any electrical equipment to Site, the Project areas shall be secured by the installation of a 3-tier non-lethal energised perimeter detection system (NLEPDS) security fence along the whole Site perimeter.

The requirements for the security fence, including each of its three (3) tiers is presented in the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183. The Contractor shall comply with all requirements of the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183 relating to the security fence.

The fence shall be continuous along the whole Site perimeter. No interruptions, temporary or permanent, shall be allowed. The fence shall be opened only at the Site entrance security gate and emergency gate. A pedestrian access gate shall also be installed, one for each tier close by to the main entrance gate.

The perimeter security fence shall be designed according to environmental and safety regulations and the Employer's Requirements. Limited entrance to the Site shall be governed by gate control and CCTV surveillance.

The Contractor will evaluate the environmental aggressiveness of the Site to assure that the corrosion protection or galvanisation of the security perimeter fence meets the adequate covering for the total

Project design lifetime (25 years). In addition, all metal surfaces shall be primed with galvanised coasting.

Fence posts, including CCTV and lighting posts, shall be equally spaced and installed into the ground with concrete. The foundation design of the posts shall follow the recommendations of the geotechnical assessment report.

The fence shall be permeable for birds and small animals and should include small openings at strategic locations at ground level. Corridors should be planned to allow larger animals to cross the area if deemed necessary according to the environmental permits and authorisations.

The NLEPDS security fence shall adhere to the Eskom Specification for non-lethal energized perimeter detection system (NLEPS) for protection of Eskom installations and its subsidiaries (240-78980848) and the Eskom Standard for High Security Mesh Fencing (240-76368574).

All security fencing shall be in compliance with all applicable local Standards, Codes, and Regulations.

10.10.2 Security Gate

A galvanised steel sliding gate shall be installed at the Site entrance and integrated into the security fence. This is preferred over a double leaf type gate due to security reasons (sliding gate is more difficult to force open) as well as the optimisation of space by opening sideways rather than inwards. The gate shall be wide enough to easily allow trucks and vehicles to enter the Site area but be not less than 5.0 metres. Operation of the Site entrance gate shall be monitored and actioned remotely from the security control room in the O&M building in addition to locally at the gate, with a suitable bypass mechanism installed to allow for access in the event of any systems (power) failure or outage. The remote monitoring and control of the security gate shall form part of the security SCADA system.

The Site entrance security gate shall be locked at all times and access shall be limited to authorised persons only. The gate shall be supervised by a security guard at all times.

An emergency steel sliding gate shall be installed in the perimeter security fence and is not to be located in proximity to the main security access gate. The emergency gate shall allow for quick exit from the Plant area if an emergency occurs.

Operation of the emergency gate shall be monitored and actioned remotely from the security control room in the O&M building, with a suitable bypass mechanism installed to allow for access in the event of any systems (power, communication etc.) failure or outage. The remote monitoring and control of the emergency gate shall form part of the security SCADA system. The gate shall remain locked at times when not an emergency.

The main security gate and the emergency gate shall both be designed according to environmental and safety regulations and the Employer's Requirements.

The Contractor will evaluate the environmental aggressiveness to assure that the corrosion protection or galvanisation of the main security gate and emergency gate meets the adequate covering for the total Project design lifetime (25 years). In addition, all metal surfaces shall be primed with two coats of zinc chromatic primer and painted with two coats of aluminium paint.

The Contractor shall comply with the requirements of the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183 relating to the security gates.

10.11 Civil Construction Material

10.11.1 Steel materials

Reinforcement bars shall conform to SANS 920 and shall have a yield strength of at least 450 MPa.

Steel bars shall be tested by the Contractor upon arrival on Site. The testing and frequency of testing shall be in accordance with the requirements of ISO 15630-1 or an equivalent national standard.

The material to be used will be hot-dip galvanised steel S275 and S355 with a yield stress of 275 N/mm^2 and 355 N/mm^2. S235 JR with Magnelis can be used only in auxiliary parts of the module mounting structure. All structural elements shall be subject to a process of hot dip galvanised thickness that ensures a minimum design lifetime, according to SANS 121 and SANS 14713-2 or equivalent ASTM and Standards.

All stainless-steel products shall be certified according to SANS 10162-4.

Hot rolled structural steel products shall be certified according to EN 10025 – Hot rolled products of structural steels.

10.11.2 Concrete materials

The concrete material shall comply with the following:

- Cement shall be Portland Type, unless the concentration of sulphates in the groundwater dictates stronger criteria;
- Aggregates shall consist of naturally occurring materials. The Contractor shall not use lightweight or metallurgical furnace slag aggregates;
- Water used in mixing concrete shall be clean and free from materials and chemical components (oil, acid, alkali, organic matter, or other deleterious substances) aggressive for concrete;
- Admixtures: The quantity and method of using admixtures shall be in accordance with the applicable Structural Code and manufacturer recommendations. The use of calcium chloride in any form is prohibited; and,
- Cement shall be provided from a cement plant with proper documentation to be submitted to the Employer prior to concrete delivery, according to the specific standards and building regulations for concrete poured.

All concrete materials must be in compliance with Eskom's Engineering and Structural Standards.

10.11.2.1 Concrete Mix

The Contractor shall submit, prior to the supply of any concrete mix, the following information:

- Name of all concrete components' suppliers with associated datasheets;
- Location of batching plants;
- Mixed concrete composition, including test results proving the mix complies with the specification;
- A copy of the ready-mix supplier's certificate of accreditation, if applicable; and,
- All concrete components suppliers' procedures relating to storage and batching of concreting materials, mixing, transporting, compliance testing, current calibration certificates for batch weighers, and compliance certificates for the constituent parts of the concrete.

10.11.2.2 Transport of Concrete Mix

Concrete mix shall be transported in truck mixers complying with the relevant norms and standards. The concrete shall be compacted in its final position within 2 hours of the introduction of cement to the aggregate. No water shall be added to the concrete either in transit or on Site before discharge, except under acceptance and supervision of the Employer's Representatives.

Before discharging the concrete at the point of delivery, the concrete supplier shall provide a delivery ticket for each batch of concrete in accordance with the relevant Standards, on which shall be printed, stamped, or written at least the following information as applicable according to National Standards and Good Industry Practice:

- The name of the mixed concrete plant;
- The serial number of the ticket;
- The date and time of loading;

- The truck number/vehicle identification, if applicable;
- The name of the purchaser;
- The name and location of the Site;
- Details of references to specifications;
- The amount of concrete in cubic meters;
- Declaration of conformity with reference to the specification and to the relevant Standards
- Name or mark of the certification body, if applicable;
- The specified strength class;
- The specified exposure classes;
- The specified chloride content class;
- The specified consistence class or target value;
- Limiting values of concrete composition, if specified;
- Type and strength class of cement, if specified;
- Type of admixture and addition, if specified;
- Special properties, if required;
- The maximum nominal upper aggregate size; and,
- The density class or target density, if applicable.

The following information shall be added to the delivery ticket at Site and records shall be kept by the Contractor, including, but not limited to, the following:

- The time of arrival on Site;
- The time of commencing unloading;
- The time of completing unloading;
- Sample references, if taken;
- Location of concrete pouring;
- The slump of the mix; and,
- Weather conditions.

The Contractor shall submit these tickets to the Employer as the Work progresses, which shall be included as part of the quality documentation for the relevant activity that uses the concrete.

10.11.2.3 Quality test of concrete

The concrete mix shall be tested during delivery by an independent accredited laboratory in order to attest the conformity of the characteristics of the concrete mix delivered on Site. The concrete mix shall be tested per batches, with a batch size to be defined according to the specific Standards and building regulations for the concrete poured. As a reference, it is expected that concrete testing will be done in batches of no more than 25 m^3, and from each batch, five (5) concrete cube test samples shall be taken (either 100 mm or 150 mm), two (2) of them to be tested at seven (7) days, two (2) at 28 days, and the remaining one (1) sample at 56 days.

All concrete shall be sampled (slump tests and test cubes) on Site.

Each cube should be clearly marked to identify it with a concrete delivery ticket and the section of the Works in which it was used. Cubes shall be tested at an independent and accredited test laboratory accepted by the Employer. The Employer shall be supplied with copies of the cube reports following completion of the testing.

Slump tests from all batches should also be taken on Site for each concrete pour; as a minimum, for each of the first three (3) concrete wagons, then for every third concrete wagon. The Contractor shall at all times keep a detailed record of all concrete tests taken, including at least the following information:

- Date and time the cube sample is taken;
- Cube number;

- The time at which the mixture was mixed and its duration of use;
- Truck delivery number;
- Mix code; and,
- Slump and items of work constructed from the batch.

All test specimens shall be cured and tested by an approved registered laboratory at the Contractor's cost. The Contractor shall submit test records not later than 14 days after testing. Cubes' test records shall include at least the following information:

- Date of test;
- Cube number;
- Age of concrete (days);
- Dimensions of the cube concrete mass and density;
- Capping details;
- Crushing load;
- Failure type; and,
- Concrete strength.

Concrete not meeting the standard expected of the Employer's Requirements shall be liable to rejection. Rejected concrete shall be removed and replaced at the Contractor's own expense.

Concrete samples shall be kept by the Contractor in a safe place to allow the Employer to check concrete quality at any future date.

<u>Concrete Works</u>

A concrete works method statement (including curing method) will be provided by the Contractor to the Employer for review prior to any concreting works on Site.

A testing schedule will be agreed with the Employer for all concrete works prior to the commencement. This will include the requirements for standard slump tests to be carried out and for sample concrete cubes to be taken from all concrete used on Site, as well as the arrangement of independent compressive tests to be carried out. The Contractor will give the Employer at least two (2) working days' notice of timing of concrete pour and removal of formwork to facilitate this. Any adverse comments or deviations noted will be addressed and rectified by the Contractor prior to the pour. The Contractor shall allow sufficient time in the Project schedule for this.

The Contractor will ensure that the surface temperature of the concrete at the time of placing is at least 5 °C and not exceeding 30 °C unless specific precautions are planned and executed.

Additional water to the reinforced concrete mix during pouring is completely prohibited.

<u>Curing</u>

Curing and protection should start immediately after the compaction of the concrete to protect it from:

- Premature dry out, particularly by solar irradiation and wind;
- Leaching out by rain and flowing water;
- Rapid cooling during the first few days after placing;
- High internal thermal gradients;
- Low/high temperatures;
- Frost/snow conditions; and,
- Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

Curing and protection shall start immediately after placing of the concrete.

10.11.3 Coal Ash Waste Resource

The Client has identified an opportunity to make use of coal fly ash waste from the adjacent coal power station as a construction resource material. Preliminary investigations have been conducted by the Client in this regard, covering applications such as road construction, encasing cables, and pylon stabilisation.

While the Client will look favourably upon Bid Responses that incorporate the use of the ash waste resource, the decision is left to Bidders to decide whether to use the ash waste as an alternative construction material. The Client acknowledges that the ash waste, while freely available, might not be the most cost-effective solution and might necessitate a longer Project construction time due to quality control processes. This would need to be evaluated against possible reduced maintenance costs. The Client will attempt to provide sufficient information on the physical and technical characteristics of the ash waste resource as part of the RfP documentation pack to allow Bidders to make an informed decision on whether to use the ash waste or not, and in which applications it may be cost effective to do so. The Client acknowledges that further detailed technical studies, besides those already conducted internally, may be required to evaluate properly the use of the available coal ash waste on site with respect to use in the Project.

10.12 BUILDINGS

10.12.1 General Building Design and Construction

All buildings and structures shall be designed and constructed in accordance with the requirements and recommendations of the Structural Code and SANS 10400. Final design of a building or structure shall be approved by a registered structural engineer and local authority as required by Applicable Laws, Permits, and Codes and Standards.

Provisions should be made in the design for easy offloading of the relay panels and other equipment into the different control rooms (i.e., due consideration shall be given to door size and height, as well as a slanted floor entrance).

All building layout plans shall be provided for the acceptance of the Employer prior to construction and the Contractor shall describe the proposed layout philosophy of the different buildings and their furnishings and equipment.

Building finishes shall suit the requirements of each building, its function, requirements of occupancy, and operation requirements. All buildings shall have appropriate signage. As a general rule for all buildings, the floors shall consist of a concrete slab, with the finish applied being tiled or epoxy-coated.

Sufficient clearance around all buildings must be provided for future maintenance (equipment replacement, transformer access, etc.). All the buildings shall have one (1) meter of sidewalk all around it.

Attention shall be given to the detailing, design, and construction of reinforced concrete pitched roof systems to ensure that crack widths in the concrete are minimised, and to ensure that the long-term integrity of waterproofing membranes are maintained.

All soffit slabs over rooms housing electrical equipment shall be watertight. Neither drainage pipework nor water supply pipes shall pass through the electrical equipment rooms.

The Contractor shall provide emergency doors with suitable quick exit mechanisms and/or panic bars at appropriate locations to provide safe means of escape in the event of an emergency.

Any cable basement shall be fully watertight reinforced concrete construction and shall extend at least 300 mm above the surrounding ground levels.

Cable, pipe, and services entries through technical floors and walls shall be designed such that after the cables and the like have been installed, the entries are closed completely to be smokeproof and fireproof. The sealing materials used for this purpose must be fire resistant and be easily removable for the installation of further cables, or services, in the future.

Lightning protection shall be provided for all buildings, structures, and shallow concrete foundations using down conductors connected to the overall underground earth grid/mat of the Plant, with material selection and design in compliance with the relevant Standards.

The buildings shall implement the necessary fire protection system and associated alarms as per Applicable Laws, Permits, and Codes and Standards.

All buildings shall be in compliance with ASCE 07-10 and SANS 10160.

All buildings shall be in compliance with the Eskom Ergonomic Design of Power Station Control Suites Guideline (240-56355808), Eskom C&I Computer & Equipment Rooms Civil and General Building Requirements Guideline (240-56355541), and Environmental Conditions for Process Control Equipment Used at Power Stations Standard (240-56355731).

10.12.2 O&M Building

The Contractor is responsible for the design, procurement, and construction of an O&M building, including all furniture and equipment required, with the necessary characteristics for use during the O&M of the Plant. All building layouts and furniture specifications shall be provided for the acceptance of the Employer prior to construction/installation.

The O&M building shall be separate from the substation/step-up transformer building.

The O&M building shall comply with the following requirements:

- Enclosed rooms and indoor spaces shall be suitably sized for the intended equipment and use;
- A rainwater harvesting system shall be employed, as far as reasonably possible, to supply the ablution requirement of the building. Where this is not reasonably possible, the rainwater harvesting system shall be used to supplement another form of water supply;
- Internal power distribution/supply shall be included with sufficient switches and sockets for the intended use of each area/room of the building;
- Adequate water supply, including drinking water, shall be provided;
- Adequate HVAC for the Site conditions shall be included in all the areas/rooms where the presence of people is expected (either permanent or sporadic);
- Infrastructure for connection to high-speed internet shall be provided;
- Building flooring shall be at a single level;
- The doors shall be sufficiently sized to facilitate easy installation and maintenance of all panels and control room[9] equipment. The doors and ceiling height shall be suitable for the future removal of panels and equipment without the need for adjustment or removal; and,
- The foundation of the building must include cable entry ducts to allow for cable installation and future maintenance of the cabling from outside of the building without future perforation into the walls.

The O&M building shall have the following general areas:

- One reception area;
- One management office;
- One engineer's/technicians' room (suitable for three (3) people);
- One Employer´s office (suitable for two (2) people);
- One general purpose office/meeting/conference room (suitable for 10 people);
- One kitchenette suitable for the preparation of drinks and light snacks;

[9] Central control room and security control room.

- Separate sanitary and restroom facilities toilets for male and female staff, including toilets, washroom facilities, changing rooms, and showers, with a sceptic tank if necessary;
- One security control room, including the security SCADA system;
- One central control room including the Plant SCADA system and control equipment (LV bay, auxiliaries, telecom, etc);
- One server room; and,
- Any others as required by HSE requirements and local regulations.

A designated area for car park spaces (minimum of four (4) car bays) including disabled parking, shall be provided adjacent to the building.

Central Control Room

All activities associated with the operation, control, and monitoring of the Plant shall be carried out from the central control room.

Equipment such as workstations for non-operations related work, meeting rooms, printers, engineering workstations, electrical cubicles, etc. shall be located in adjacent or separate rooms on the same floor with easy access from the central control room.

Server Room

A server room capable of housing the Plant SCADA system, security SCADA system, and UPS system shall be provided. This room shall have no windows. Adequate HVAC shall be provided to this room to ensure a temperature range of 10 – 20 °C within the room at all times.

Security Control Room

The security control room shall, if possible, overlook the Site's entrance gate. It shall include, at a minimum, the following:

- Wall-mounted video display of all CCTV feeds;
- Workstation for monitoring and controlling the intruder detection system; and,
- Workstation for the trunking radio base station of the security department.

Monitoring and management of the Project's security SCADA system shall take place from the security control room.

The O&M building shall be in compliance with ASCE 07-10, SANS 10400, and SANS 10160.

10.12.3 Warehouse Building

The Contractor is responsible for the design, procurement, and construction of a warehouse building. The warehouse shall include a storeroom suitably sized to store and handle the full set of spare parts as required under the Contract (as per minimum requirements stated in section 8.16.7), special tools and instruments that may be required (such as IV curve tracer, drones, and thermographic cameras), and a suitably sized workshop to carry out all routine off-plant servicing as well as breakdown maintenance.

The warehouse building shall comply with the following requirements:

- The storeroom shall have suitably shelved racks for proper and space-effective storage of spare parts;
- The storeroom shall have adequate handling and lifting equipment to load, handle, and unload spare parts as necessary, particularly for large and heavy spare parts;
- The storeroom shall include an area and suitable lockable service counter to control the reception and issue of spare parts and allow the installation of hardware required to manage the spare parts;

- The storeroom shall have a temperature-controlled environment (i.e., HVAC) to comply with manufacturers' guidelines for spare parts storage;
- The workshop shall be sized to allow the O&M Contractor to attend to miscellaneous repairs and maintenance activities typical for a Project of this magnitude and complexity;
- HVAC adequate for the Site conditions shall be included in all the areas/rooms where there is expected to be a presence of people (either permanent or sporadic);
- Internal power distribution/supply shall be included with sufficient switches and sockets for the intended use of each area/room of the building;
- Adequate water supply (including drinking water) shall be provided;
- A fire detection system connected to the O&M building shall be provided;
- Inflammable and hazardous materials, such as lubricating oil, chemical, paints, and dosing inhibitors, shall be stored in suitably covered and ventilated areas;
- The storeroom and workshop shall have suitably sized gates of a minimum height of 4 meters to allow forklift access and any other equipment/machinery expected to be required for the handing of spare parts and O&M services. Additional pedestrian doors shall be installed; and,
- Building flooring shall be at the ground level to enable the easy manoeuvre of lifting and carrying machines.

The warehouse building shall be in compliance with ASCE 07-10, SANS 10400, and SANS 10160.

10.12.4 Office Equipment

All regular furniture (office LANs, office computer, kitchen equipment, etc.) and special furniture (e.g., for control rooms, workshop, etc.) for all the buildings shall be provided by the Contractor.

10.12.5 Solar Plant Substation Building

The Solar Plant Substation building[10] will house switchgear, panel boards, bus coupler, auxiliary transformer, and battery tripping units. It is possible to place the secondary switchgear outdoors, however, due to the DC requirements the respective DC equipment is to be installed in a temperature-controlled environment. This typically results in the DC equipment being placed in a switchgear room with HVAC requirements; hence, it makes sense to house both the secondary switchgear and DC equipment indoors.

The detailed design shall include the size of the room not less than 10 m (length) x 8 m (width) x 2 m (height).

[10] This is not to be confused with the Solar Switching Substation (building). Both substations are discussed in greater detail in section 16.

11 MECHANICAL REQUIREMENTS

11.1 Tracking System

This section (section 11.1) is applicable predominantly to tracking systems for the PV module mounting structure. Sections 11.1.1, 11.1.2, 11.1.4, and 11.1.7 are to be considered for fixed tilt module mounting structures as well, where applicable.

11.1.1 General

The tracker system shall comprise of a single axis tracking system using motorised drives in order to track the movement of the sun from east to west, with a motion range of at least ± 50 degrees.

The tracker mounting structure shall meet the following technical requirements:

- Operational temperature of -20 ºC to 50 ºC;
- Suitable for a 1 500 V DC solar PV system;
- The mounting structure's earthing shall make use of a minimum of two (2) independent paths at either end of each tracker's table and shall be connected to the Plant's earthing protection system by an appropriate arrangement;
- The minimum height of the PV modules above ground at their lowest edge shall be the greatest of 500 mm or 100 mm above the highest expected flood level, at all times;
- All materials shall be suitable protected against corrosion; and,
- The mounting structure shall be equipped with a suitable lightning protection system.

The design of the tracker and its components shall comply with IEC 62817: Photovoltaic systems - Design qualification of solar trackers.

The tracker's components shall have a minimum IP rating of IP54, or IP55 for arid environments.

The design of the tracker and its components shall comply with IEC 62817.

The tracking system shall, at a minimum and where applicable, comply to the (safety) requirements of UL 3703.

The tracking system shall comply with UL 2703, particularly with respect to the mounting of the solar PV modules.

The tracker system shall be designed to withstand the maximum sustained gust wind speed conditions applicable to the extreme climatic conditions on Site and to requirements as per the Applicable Laws and Regulations, and Codes and Standards. To enhance the requirements of the relevant CTE and South African wind loading codes/standards, the Contractor shall undertake wind tunnel testing to determine the wind loads on a single tracker row. The Contractor shall determine, in detail, the mean net pressure coefficients and the peak negative and peak positive net pressure coefficients for the tracker row at each stow/operational position, and for all wind directions, taking into account wind loading requirements as per section 10.5.

The tracker shall be designed and installed for easy O&M (including cleaning), to provide reliable operation, and to withstand the environmental conditions at the Site, including wind loading, seismic loading, and corrosive characteristics of the air and ground according to IEC 62817. The tracking system's rows shall be designed to be independent of each other to allow for ease of cleaning a single row of modules without obstructing the adjacent rows. Dual-row trackers shall be able to be cleaned and have other necessary O&M work performed without obstructing the adjacent rows.

The tracker mounting structure and module mounting structure manufacturer/supplier shall have a proven track record in commercial[11] projects, and comply with the following requirements:

- The tracker mounting system manufacturer shall be ISO 9001, ISO 14001, and ISO 45001 compliant, and shall have a track record totalling 300 MWp in the past five (5) years;
- The mounting structure system (type/model) shall have been implemented in at least three (3) different commercial[12] projects of a similar size (in terms of nominal MWp capacity) and similar Site conditions in the previous two (2) years and that have been in successful operation for at least one (1) year;
- The mounting system manufacturer shall have an annual production capacity of at least 200 MWp; and,
- The mounting system manufacturer's major suppliers shall also be ISO 9001 compliant; and shall be adequately evaluated and selected by the manufacturer based on factory audit/inspection. The major suppliers' materials shall have corresponding certificates of conformance, which shall be submitted to the Employer. Training for the selected module mounting structure (e.g., installation, operation, etc.) shall be available on demand from the mounting system manufacturer on a rates basis.

11.1.2 Structure

The mounting structure of the tracker system shall be designed taking into account all components of the tracking system, including any additional loading effects from the components. The tracker shall be designed to limit the effect of deflection, twisting, unbalanced loading, expansion and contraction of the mounting structure and ensure these forces remain within the allowable design tolerances of the chosen PV module and tracking system, where possible.

All components which will experience wear during the tracker/Project lifetime, such as motors, gears, bearings, and pistons, shall be subject to accelerated life testing.

The mounting structure shall comply with all necessary manufacturers' specifications in relation to integration with the other Plant components.

The mounting structure design shall be compatible with the proposed PV modules to be installed in the Plant, with special attention to the bifacial type of PV modules if proposed. Consideration shall be given to the structure compatibility with the proposed PV module's frame in terms of bi-metallic corrosion. Where such conditions exist, barriers shall be included that insulate the metals from each other. For threaded connections, insulating bushes and washers shall be used.

The structure shall be designed and installed to ensure that the alignment of the PV modules is per manufacturers' specifications and that the minimum distance between PV modules specified by the PV module manufacturer is maintained during the 25-year Plant design lifetime in all operating conditions, motion range, and even after extreme loading events. The tracker manufacturer shall calculate, as part of the structural calculation report, the distance between the PV modules, considering applicable loads and the deflection of the torque tube.

The tracker structure shall be free of any sharp edges and allow for the integration of cable trays as much as possible where required. The cable runs from the tracker to string combiner boxes and/or inverters shall be trenched.

The tracking mounting structure design and all relevant installation works shall comply with any applicable Site-specific restrictions with regards to any relevant provisions or conditions in the environmental permits and authorisations. The structure design shall consider the maximum imposed loadings, including extreme climatic conditions and seismic load (as per section 10.5), ground conditions, thermal expansion and contraction, and be supported by a full set of design calculations

[11] Not demonstration or pilot projects.
[12] Not demonstration or pilot projects.

which shall be provided to the Employer for review and acceptance prior to any procurement. The structure shall be designed to withstand wind speeds encountered on Site as per SANS Standards and site-specific conditions.

The structure shall be suitable for the land profile on Site, with special consideration given to the east-west and north-south slopes and slope changes.

The mounting structure materials shall be appropriate with respect to design considerations. The structure components shall be made from galvanised steel, with an adequate thickness (considering the 25-year Plant design lifetime) as per EN ISO 1461, SANS 12944, BS EN 10346 or equivalent, or by an appropriate anodised aluminium of heavy-duty-type and alloy according to the standard EN 842, EN ISO 14171 or equivalent for the better anti-corrosion protection of the structures. Corrosion protection shall be sufficient for the 25-year Plant design lifetime and to minimise maintenance.

The structures shall be made from aluminium or galvanised steel and shall conform to the better of the following Standards and local equivalents:

- EN 1991-1-4 Eurocode 1. Actions on structures. General actions. Wind actions;
- EN 1991-1-6 Eurocode 1. Actions on structures. General actions. Actions during execution;
- EN 1993-1-1 Eurocode 3 Design of steel structures. General rules and rules for buildings;
- EN 1993-1-3 Eurocode 3. Design of steel structures. General rules. Supplementary rules for cold-formed members and sheeting;
- EN 1993-1-5 Eurocode 3. Design of steel structures. Plated structural elements;
- EN 1993-1-8 Eurocode 3. Design of steel;
- EN 1993-1-9 Eurocode 3. Design of steel structures. Fatigue;
- EN 1993-1-10 Eurocode 3. Design of steel structures. Material toughness and through-thickness properties;
- EN 1993-5 Eurocode 3. Design of steel structures. Piling;
- EN 1997-1 Geotechnical design. General rules;
- EN 1997-2 Eurocode 7. Geotechnical design. Ground investigation and testing;
- EN 1994-1-1 Eurocode 4. Design of composite steel and concrete structures. General rules for buildings; and,
- EN 10025 – Hot rolled products of structural steels.

All components are to be prefabricated, with no welding or formwork allowed on-Site.

All fastening connections, such as bolts and nuts, shall be stainless steel or compliant with other industry standard practices appropriate for the application defined, ensuring no corrosion risk.

The structure shall be designed to a suitable height to prevent shading over adjacent PV modules and to provide sufficient ventilation around the PV modules. The bottom edge of the modules shall consider the hydrology conditions and unplanned movement of fauna below the PV modules during the Project design lifetime (25 years).

Before installation of the mounting structure commences, the Contractor shall ensure that all relevant information relating to the mounting structure foundations is obtained from the mounting structure supplier. Any approvals, studies, permits or similar documents or documentation relating to the foundation design of the mounting structure shall be obtained before construction commences.

11.1.3 Driving mechanism

The trackers' drive units shall be based on either hydraulic pistons or electric motors; however, strong preference will be given to electric motors. Electrical motors, if selected, and all the control boxes associated with the tracker and installed outside of another container, shall be at least IP55 and the gear drive units at least IP54.

The torque tube can be driven by wires or levers. Different techniques can be accepted; however, there shall always be accessibility to the PV modules for maintenance and cleaning.

The tracking drive units shall be capable of moving all the trackers to the stow position from any position in the event of power outages[13], extreme weather events (e.g., hailstorms) or when the maximum operating wind speed threshold is exceeded. The system should be able to automatically revert to tracking mode once the power outage, weather or wind event has passed.

The Contractor shall provide evidence of studies confirming the tracker's optimal stow position (angle), based on the requirements of both the tracking system and PV module manufacturer's specifications. The optimal stow position shall include a suitable design safety margin to address events of extreme weather such as storms and high wind speeds, with a focus on Site-specific conditions.

All bearings and housings of the individual drive units shall have adequate protection from potential sand ingress and should have accelerated lifecycle and ingress tests performed. These tests should demonstrate that the bearings are able to withstand the potential sand ingress for the life of the Plant. The preferred material for the torque tube bearings is impregnated polyethylene or similar self-lubricated material to reduce the need for scheduled maintenance.

In order to control the frequency and magnitude of structure oscillations in case of high wind, dampers shall be installed at each tracker row.

In case of the use of plastic parts directly exposed to UV, particular attention shall be paid to their integrity during the entire 25-year Plant design lifetime according to the Site's climatic conditions. Cable ties exposed to direct sunlight shall be of stainless steel. Cables exposed to direct sunlight shall be encased in UV-resistant tubing.

11.1.4 Tracker purlins

The (omega) purlins used to mount the modules shall be fastened to the torque tube though an adjustable mechanism. This is to allow the purlins to be adjusted should the current modules require replacement/substitution with modules of a different physical size during the lifetime of the plant.

11.1.5 Earthing

The tracker structure must be earthed in accordance with the respective earthing design and applicable Standards, and the equipotential certificate must be provided to the Employer for acceptance.

The Contractor must ensure the electrical equipotential bonding and continuity between all tracker components (including tracker air termination rods, if applicable). The tracker equipotential bonds shall be fixed using existing holes or bolts on the metallic structures, or by using self-drilling stainless screws directly on the structures. Electrical continuity between module and tracker must be ensured through the standard PV module grounding connection point, serrated washers, or serrated clamps to remove the anodised coating of the PV module frame.

The earthing cables shall be connected neatly to the mounting structures. The connections of the PV module earthing cables to the mounting structures shall always be visible. Bare copper earth wire (BECW) shall be appropriately covered and shall not be visible.

The Contractor shall specify the maximum resistance of the metallic structure of the tracker, in ohms, before its connection to ground.

11.1.6 Tracker Control System

The tracking control system shall be based on an astronomical tracking system which estimates the sun's position using algorithms based on the time, date, and location. The accuracy of the tracking

[13] This shall be powered by the tracker's backup/auxiliary power supply.

system shall be at least ± 1 degrees, sufficient to achieve the maximum energy yield from the PV modules.

The tracking control system shall comprise a Programmable Logic Controller (PLC) controller with a minimum IP rating of IP65.

The tracker shall incorporate a back-tracking algorithm which reduces inter-row shading at early morning and late afternoon time periods in a day. This algorithm shall be optimised for the system, applicable to each tracker table and take into account any topographical changes across the entire Site. Where significant east-west slopes exists in the solar field, a 3D backtracking algorithm shall be considered for the individual adjustment of each tracker row and optimal performance of the tracker system and be optimised for the Site conditions.

The tracker control system shall include all the required elements to monitor and control the motion of the trackers and allow the complete monitoring of this system from the central control room of O&M building via the Plant SCADA system. The system shall be capable of controlling the tilt of the modules. The system should have an emergency stow functionality which overrides any other signal being sent to the controller, immediately moving the trackers to the stow position in the event of a high wind event triggered by the controller. Any different/other risk mitigation mechanisms incorporated in the tracker are to be communicated to the Employer.

The drive unit shall have sensory and alarm functionality enabling it to register an alarm when there is a mechanical or electrical fault in the system, as well as indicate the position of the tracker. The tracker controller shall allow recording and transmitting of the following alarms and parameters at a minimum:

- Tracker position and tracking error;
- Inclinometer failure check;
- Communications failure, with a network failure indicator on the tracking system's controller/PLC;
- PLC clock drift check (< 1 s per day);
- Wind speed status, with alarm issued if wind speed outside acceptable range;
- Wind sensor failure;
- Wind stow notification; and,
- Anemometer signal and alarm.

If hydraulic drive systems are used, pressure sensors should be included to indicate the pressure in the drive pistons and the levels of the oil reservoirs.

A self-powered tracker system is preferred.

Further requirements for the control system are described in section 13.

11.1.7 Tracker Installation

The Contractor shall ensure that all foundation piles and fastening elements are correctly aligned during installation of the tracker. All key distances, such as those between rows, connecting rods etc. shall be as per the reviewed design drawing(s), including design tolerances between tracker components.

Each tracker (table) shall be installed with a unique identification label to allow for quick and easy visual identification in the field.

The installation of the tracking system shall adhere to the requirements in the Eskom Requirements for Control and Power Cables for Power Stations Standard (240-56227443), Eskom Field Instrument Installation Standard: Junction Boxes and Cable Termination (240-56355815), Eskom Field Instrument Installation Standard (240-56355754)., and Eskom Power Plant C&I Level of Automation Guideline (240-129686484).

11.2 PV Module Installation

The PV module installation shall avoid misalignment and stepping between PV modules on the same mounting structure table at any operating condition, due to potential differential settlement of the supporting structure, structure flex, and vibration.

The PV module installation shall ensure that the minimum distance between PV modules required by the PV module manufacturer is maintained at all times.

The Contractor shall consider the use of specific tools and templates for the installation of the PV modules to ensure the correct positioning and alignment.

All fasteners, including nuts, bolts, and clamps, shall be made of a suitable material that has adequate protection from Site-specific (extreme) atmospheric conditions.

The PV modules shall be installed in compliance with the allowable torque defined by the PV module manufacturer. Torque signs shall be made to facilitate a visual check on the torque status.

Each PV module shall be fastened with at least two (2) anti-theft fasteners per PV module and only mounted in accordance with the PV module manufacturer's specification.

Each PV module shall be installed with suitable equipotential bonding as per SANS 10142-1 and SANS 10313, with an uninterrupted connection to the Plant's earthing system.

Each PV module string shall have suitable over-current protection as per SANS 10142-1, IEC/SANS 60364, and PV module manufacturer recommendations, including suitable protection against earth current faults where applicable.

11.3 Firefighting and Fire Protection System

11.3.1 General

The Contractor shall provide an alarm and detection system, including passive and active fire protection and safety measures, throughout the Plant in compliance with the Applicable Laws and Regulations and Codes and Standards.

The Contractor shall be responsible for obtaining all necessary compliance certification/operating permits from the appropriate authorities on completion of the Plant installation, and for any other approvals as required by Applicable Laws and Regulations and Codes and Standards.

The Contractor shall carry out a suitable fire and explosion risk assessment which shall form the basis of the overall fire protection philosophy for the Project. This shall be done in adherence to Eskom Fire Assessment Standard (240-54937439).

The scope of work for the firefighting installation shall comprise the complete system design and all related equipment including, but not limited to, the following:

- Fire detection: to guarantee a reliable and fault-free early warning system in the event of fire, so that orders for extinguishing the fire can be issued from a central location;
- The Plant shall be designed and built with provision of a safe operating environment for equipment and personnel. This shall be achieved by separating and segregating the equipment with sufficient distances and by selection of suitable equipment and materials; and,
- Hazardous areas shall be identified, and suitable equipment shall be selected for use in such areas. Different firefighting systems shall be adopted according to the operational characteristics of the particular Plant areas and buildings to be protected.

The firefighting and fire protection system shall be designed for a high level of availability and low maintenance and shall be a stand-alone/independent system.

11.3.2 Portable Fire Extinguishers

Portable and mobile fire extinguishers shall be provided in all areas throughout the Plant for first aid firefighting. This includes being located along normal paths of travel, including exits from areas.

In all areas the minimum requirement for quantities and locations of fire extinguishers shall be in accordance with NFPA 10. All areas of the Plant shall be classified as Extra (High) Hazard Occupancy, with the exception of office and similar accommodation, which shall be classified as Ordinary (Moderate) Hazard Occupancy. In addition, suitable fire extinguishers shall be installed in all switchgear, control and server rooms catering for electrical (class E) fires.

All portable fire extinguishers shall be provided, installed, and used in accordance with the following standards:

- SANS 1910: Portable refillable fire extinguishers;
- SANS 10105-1; and,
- SANS 1475-1: The production of reconditioned fire-fighting equipment Part 1: Portable and wheeled (mobile) rechargeable fire extinguishers.

11.3.3 Fire Detection and Alarm

An automatic and manual fire alarm system shall be provided to protect life and property throughout all buildings and MV stations. The fire alarm system shall be of the distributed analogue addressable type. The fire alarm system for the entire Plant shall be designed, supplied, and commissioned by a single, specialist subcontractor.

A central fire alarm control panel shall be provided in the central control room/O&M building with clear access (in case of an emergency). All system fire alarm and fault conditions shall be reported at a fire alarm control and indicating console that shall be integrated into the central control room/O&M building console.

All fire alarm control equipment, including control panels for gaseous extinguishing systems, shall be from the same manufacturer and installed in a suitable area with easy, free, and quick access.

Automatic fire detectors shall provide total (complete) coverage throughout the Plant. Automatic fire detection devices shall be selected to suit the particular risk and the environment in which they are installed. All the buildings shall possess their own respective fire extinguisher. The spaces immediately above indoor MV switchgear shall also be fitted with suitable fire detection devices.

The fire detection and alarm system shall include local audible and visual alarms; and remote (offsite) notifications independent of the Plant SCADA notification system. Illuminated sounders/sirens and break glass units shall also be provided.

All enclosed spaces where O&M activities may be necessary therein, including cable tunnels and cable spreading rooms, shall be provided with smoke detectors, resetting linear heat detection, or a combination of the two.

Detection devices shall be powered from a common, dedicated emergency supply (UPS) with backup internal rechargeable batteries. All detection devices shall be connected to the Plant SCADA system for the transmission of alarms and detection system health status (including notifications).

The fire detection and alarm system shall adhere to SANS 7240-16: Fire detection and alarm systems - Part 16: Sound system control and indicating equipment and SANS 7240-19: Fire detection and alarm systems - Part 19: Design, installation, commissioning and service of sound systems for emergency purposes.

The fire detection and alarm system shall adhere to the Eskom Fire Detection and Life Safety Design Standard (240-56737448).

11.3.4 Fire Safety Aspects of Design and Construction of Buildings

The design and construction of all Plant buildings and the provision of fire safety measures to ensure the protection of personnel and equipment shall comply with the requirements and recommendations of the applicable Standards.

In addition, provision of means of egress shall comply with all requirements of the local authorities.

11.3.5 Fire Safety Measures during Construction and Commissioning

The Contractor shall be responsible for fire safety during construction and commissioning. All requirements and recommendations of NFPA 241 and NFPA 850 shall apply.

All fire safety systems shall be commissioned and in service before commissioning of the Plant commences.

11.4 HVAC System

The Contractor must provide HVAC in all buildings such that the indoor environment is within the ambient condition requirements for any equipment and personnel located within the conditioned areas. The design shall ensure adequate HVAC for the operation and storage of equipment sensitive to dust, humidity, and temperature. The areas shall be positively pressurised as necessary to prevent the ingress of dust and other particulates.

The HVAC system must also be in compliance with the following requirements:

- The HVAC system shall be monitored and be centralised and controllable from the central control room/O&M building. However, there should be a separation of the HVAC systems for all rooms where there may be a possibility of gaseous emissions, such as the battery room;
- The HVAC system shall have the ability to raise an alarm to the Plant SCADA system indicating a fault has occurred;
- In the server room, and any other room where the climate requirements are stringent, when the temperature rises above a prescribed threshold the HVAC system shall be able to raise an alarm that registers in the central alarm log;
- Critical areas shall have redundant HVAC functionality, including the electrical power supply, for a minimum of 6 hours;
- The ventilation system for the inverters, where applicable, shall fulfil the manufacturer's requirements; and,
- All HVAC equipment to make use of air chillers and not water chillers.

The design of field equipment for the HVAC systems shall comply to the following Eskom Standards:

- Eskom Design Guideline for HVAC in the Eskom Coal Fired Power Stations (240-70164623); and,
- General Technical Specifications for HVAC Systems Standard (240-102547991).

The installation of field equipment for the HVAC systems shall comply to the following Eskom Standards:

- Pressure Measurement Systems Installation Standard (240-56355843);
- Flow Measurement Systems Installation Standard (240-56355789);
- Temperature Measurement Systems Installation Standard (240-56355888);
- Requirements for Control and Power Cables for Power Stations Standard (240-56227443);
- Field Instrument Installation Standard: Junction Boxes and Cable Termination (240-56355815);
- Field Instrument Installation Standard (240-56355754);
- Instrument Piping for Coal Fired Power Plants Standards (240-89147446); and,
- Standard for Welding Requirements on Eskom Plant (240-206628253).

12 ELECTRICAL REQUIREMENTS

12.1 Scope of Work

The electrical works shall include the design, supply, installation, testing and commissioning of the following items including, but not limited to:

- The generation equipment, including cabling, connection and all auxiliary systems;
- Protection and control equipment for the whole system, connection, interlocking and inter-tripping;
- SCADA system software;
- Electrical distribution system at voltages suitable for the layout and power requirements;
- Temporary construction power supplies;
- Internal and external normal and emergency lighting;
- Small power systems;
- UPS systems;
- Meteorological system;
- Security system;
- Lightning protection system; and,
- Plant earthing.

The electrical scope of supply shall include all electrical equipment, whether or not specifically referred to in this section, which is necessary to complete the Works.

All electrical supplies, electrical protection, communications, cabling, small wiring, lighting, heating, small power, earthing, and any other electrical items shall be provided by the Contractor. All the equipment shall be designed to be maintainable and replaceable with the minimum practicable impact on adjacent equipment and the minimum practicable requirements for enabling works and heavy equipment.

All monitoring, control, sampling, and access points shall be accessible without specialist equipment where possible.

12.2 Electrical Studies

The power distribution system shall be designed such that stability of operation, current carrying capacity and satisfactory fault levels are maintained throughout the complete works system under all possible operating, maintenance, and fault conditions. Detailed protection grading studies, fault level calculations and protection settings shall be submitted for acceptance to the Employer.

The Contractor shall provide the following power system studies:

- Load flow studies to assess equipment ratings, voltage profiles and losses;
- Fault Level Studies – Short circuit current levels and flows to assess equipment capabilities;
- Transient stability studies (with information from and to the requirements of the Grid Operator) to assess system responses to events such as fault disturbances and the effect of tripping major equipment (transmission line or transformer);
- Harmonic studies to assess harmonic distortion levels and penetration and effectiveness of any potential mitigation measures;
- Electrical protection studies;
- Equipment rating selection calculations;
- Insulation co-ordination in accordance with SANS 60071-1/2;
- Any other studies to prove the validity of the design;
- Earthing study;

Interlocking system study in accordance with industrial good practices; and,

- Grid Code compliance study, in accordance with all requirements of the National Standards and all Applicable Laws, Permits and Codes.

12.3 General Electrical Requirements

All equipment shall be designed to ensure the continuity of operation under all working conditions and climatic conditions on Site as the first consideration, and to facilitate inspection, maintenance and repairs and maximise availability. The system design shall ensure a high level of reliability which shall be achieved by adopting suitable redundancy and a sparing philosophy.

All precautions shall be taken in the design of equipment and of the Plant to ensure the safety of personnel concerned with the O&M of the Plant. Safety, isolation, locking and interlocking facilities shall comply with the Standards and Good Industry Practice.

Materials and equipment for use shall work efficiently and with a high level of reliability, with special consideration to:

- High ambient temperatures; and,
- Fire risk and flooding as a result of fire protection.

Unless otherwise specified, the minimum equipment enclosure classifications for non-rotating electrical equipment shall be as follows:

- Indoors only in totally enclosed rooms with provision for limiting ingress of dust: IP31;
- Indoors, except as noted otherwise: IP54;
- Indoors in areas subject to water spray, or heavy condensation: IP55 or better; and,
- Outdoors except as noted otherwise: IP55 or better.

Electrical equipment and installation and testing shall conform to the Standards and Good Industry Practice.

All switchgear, transformers, and other electrical equipment shall be capable of operating at their rated current continuously without overheating at full power, and shall take account of the temperature rise of the equipment from other sources, preferably without assistance from forced cooled ventilation or air conditioning. Where reliance on forced cooled ventilation or air conditioning is necessary, the cooling system shall be at least N+1 redundant.

Electrical equipment shall be constructed to withstand the specified maximum short circuit currents and duration without the temperature exceeding the value permitted for the related class of insulation. The equipment shall be considered as being operated at maximum permitted current prior to the inception of short circuit current.

The final temperature attained as a result of the passage of short circuit current shall not cause permanent damage or deterioration sufficient to reduce the normal operating characteristics below those specified.

Insulation materials shall be suitably finished to prevent deterioration of their qualities under the specified working conditions.

All switchboards, panels, cubicles, and the like shall incorporate thermostatically controlled electric heaters capable of providing movement of sufficient heated air to avoid condensation. The apparatus protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energised while the apparatus is in operation. Related thermostats shall switch off the heater circuits if the temperature exceeds an adjustable set point. Control panels, cubicles, and kiosks shall be provided with door-operated internal illumination lamps. Power supplies for commissioning and maintenance test equipment are to be located as required.

Electrical equipment located in hazardous areas shall be provided with special enclosures suitable for hard classification of the areas according to the guidelines provided in statutory regulations and codes. All equipment installed or used in hazardous areas shall be certified as suitable for such.

12.4 Grid Code Requirements

The Contractor shall ensure that the design complies with the requirements of the Grid Connection Code for Renewable Power Plants (RPPs) Connected to the Electricity Transmission System (TS) or the Distribution System (DS) in South Africa, and any other relevant Grid Code.

12.5 System Frequency, Voltages, Short Circuit Rating and Method of Earthing

The requirements stated in the latest edition of the Grid Code(s) shall be observed. The following voltage levels in Table 5 are pre-assigned and shall be used in the Project.

Table 5: Project's voltage levels

Item	Voltage	Star Point/ Neutral Treatment
Power Distribution System High Voltage	≥ 52 kV +- 10 % nominal, 50 Hz, 3-phase	Not earthed (to be confirmed by supplier)
Power Distribution System Medium Voltage	MV voltage > 1 kV & < 52 kV +- 10 % nominal, 50 Hz, 3-phase	Not earthed (to be confirmed by supplier)
Low Voltage system between inverters AC output and inverter transformers	As per inverter requirements (the Contractor shall be responsible for a proper coordination between the inverters and the inverter transformers design).	Not earthed (to be confirmed by supplier)
Power Distribution System Low Voltage	400/230 V +- 10 % nominal, 50 Hz, 3-phase + N + PE	Solidly grounded
Uninterruptable Power Supply (UPS)	400/230 V nominal, 50Hz, 3-phase + N + PE	Solidly grounded
Control DC voltage	110 Vdc	One pole earthed

12.6 Grid Connection

The Grid connection works to connect to the Grid shall be done by a separate HV Contractor as per the battery limits defined in section 3.3.

The Grid connection works are further defined under section 16.

12.7 MV/LV Transformers

12.7.1 General Requirements

This section sets out general requirements for all transformers designed, procured, installed, tested, and commissioned by the Contractor. The transformers shall comply with all Applicable Laws, Consents, Codes and Standards, specifically SANS 60076 and all references mentioned in it. It shall also meet SANS 555 (as applicable for mineral oil transformers). Any other relevant standard mentioned in the technical specification and the planning guidelines of the transformer must be respected.

All transformers shall be of low-loss design and the construction, performance and testing of the transformers shall be in accordance with SANS 60076.

Transformers shall be constructed and designed to ensure the Project's design lifetime (25 years). All transformers shall be oil-filled type except indoor type auxiliary transformers which shall be dry type.

The transformer windings shall be copper or aluminium and shall be suitably bonded and braced to provide adequate short circuit strength. All terminal connections shall be made of copper.

All transformers shall be equipped with tap changers. The diverter switches of all on-load tap changers shall be located in a separate conservator tank from that of the transformer windings. The oil level of each conservator tank (main tank and diverter switch tank) shall be maintained and monitored independently of each other. The no-load voltages, tap range, impedance, and losses shall be selected to enable full output under all operating conditions that allow for the highest and lowest system voltage operation, and shall not be restricted over the specified ambient range. The calculations of the tapping range shall be subject to acceptance by the Employer.

The radiators may be mounted separate from the tank or mounted on the transformer tank and shall be hot dip galvanized, whilst the transformers' tanks, conservators and marshalling kiosks shall be painted.

The protection class shall be at least IP55 for outdoor transformers and at least IP4X for indoor transformers.

Vibration and noise levels of all transformers shall be in accordance with the best commercial practice. Every care shall be taken to ensure that the design and manufacture of all transformers with their accessories shall reduce noise and vibration to an acceptable level, and to comply with special requirements on safety and reliability.

Where the bottom plate of the transformer tank will be in direct contact with the surface of the foundation, anti-vibration pads shall be provided for insertion between the transformer and its foundation.

The anti-vibration mountings shall be of oil and weather resisting rubber or other approved material, capable of operation at temperatures from -10ºC to +80ºC. Due regard shall be given to irregularities in the tank base and the plinth surface. Anti-vibration mountings for separately mounted equipment such as coolers and pumps are not required.

For MV/LV transformers with exposed electrical parts, access to the transformer must only be possible when the low voltage switch is open and the earth switch on the MV side is closed.

12.7.2 Oil Filled Transformers

All oil-filled transformers shall comply with the relevant environmental, fire safety, and local regulations and Standards. No oil filled transformer shall be installed indoors.

The oil used as insulating medium shall be biodegradable.

All oil-filled transformers shall be fully oil sealed without requiring any refilling activity for the entire Project lifecycle. The transformer shall be designed to withstand the three-phase short circuit on the low voltage side for maximum fault current and three second duration. Insulation material shall be Class A and it shall be constructed by thermally upgraded insulation paper.

Each oil transformer shall be complete with oil conservator, oil level indication/alarm, silica gel breather, oil temperature/alarm/tripping, pressure relief/alarm/tripping, quick pressure rise relay and Buchholz gas and surge protection/tripping/alarm. In addition, each oil transformer shall include winding temperature indication with alarm and tripping contacts.

A magnetic type of oil level gauge showing the full oil level range shall be provided for each individual section (main tank and on load tap changer as applicable) of the vessel. In addition, high and low oil level alarms back to the Plant SCADA system shall be provided together with the oil level indication and measurement of the oil temperature.

Oil transformers shall have sampling devices which shall be fitted at the top and bottom of the transformer main tank so that oil samples may be taken with the transformer energised. The sampling at the top of the MV/LV transformer shall include a down pipe and valve to enable the oil samples to be collected at the bottom of the tank (no more than 1.2 m from ground level).

Cooling shall be either Oil Natural Air Natural (ONAN) or Oil Natural Air Forced (ONAF). Where ONAF is proposed, the Contractor shall justify the use of ONAF cooling system.

12.7.3 Dry Type Transformers

Dry type transformers shall conform to the requirements of SANS 60076-11 and shall be categorized as follows:

- Climatic class C2;
- Insulation class F;
- Environmental class E2; and,
- Fire behaviour class F1.

Only flame retardant and self-extinguishing materials shall be used for the construction of dry type transformers. No fillers must be added to the cast-resin moulding material that would reduce its mechanical stability.

The thermal expansion of the windings (either copper or aluminium) and the cast-resin shall be duly considered, with room provided to take care of thermal stresses that might result from different thermal expansion coefficients.

Dry type transformers shall have Air Natural (AN) type of cooling.

Winding temperature indication shall be provided through two redundant winding temperature sensors PT100 with pockets at each low voltage winding of each phase. The temperatures will be monitored by the Plant SCADA system in the Control Room of the O&M Building.

12.7.4 MV/LV Inverter Transformers

The MV/LV transformers shall be used to connect the inverters to the MV AC collection system. MV/LV transformers shall step up the inverter output voltage to MV, where the rating of the transformer shall not be less than the maximum rated AC rating (at 20 degrees Celsius) of the associated inverter(s). The transformer manufacturer shall formally confirm the compatibility of the inverters with the MV/LV transformers.

The power load of the MV/LV transformer shall be designed to withstand the entire operating range of the inverters at different temperatures.

If the MV/LV Inverter transformers are located in the same housing/enclosure as the inverters, local requirements in terms of protection and separation between the two components shall be followed.

The MV/LV transformer shall comply with the following:

- Three (3) phase transformer;
- Equipped with cooling system suitable for intended installation on Site;
- Designed, procured and tested in compliance with SANS 60076 and local standards;
- Rated MV voltage level: to be determined by the Contractor according to MV grid rated voltage or MV/HV transformer rated voltage;
- Rated LV voltage level: to be determined by the Contractor according to PV inverter AC rated output voltage;
- Off-load tap changer with minimum five positions -5%, -2.5%, 0, +2.5%, +5%;
- Connection Group to be designed as per HV design specification, neutral treatment and Applicable Laws, Permits, Codes and Standards;
- Suitable protection against overload, short-circuit up to inverter, internal failure, over-temperature, overpressure;
- Suitable for the environment at the Project Site;
- Reduced inrush current;
- Reduced annual electric losses;
- Specific data of transformer shall be guaranteed: load and no-load losses, short circuit voltage (Ucc (%));
- Condition monitoring shall be provided (e.g., oil temperature, oil level, pressure, etc.); and,

- All documentation, certificates and test protocols shall be provided.

12.7.5 Auxiliary Transformers

The auxiliary transformers shall be designed so that with the whole Plant running at full load, the transformers' low voltage windings will be loaded as follows:

- 80% in case of 1 x 100% transformers; and,
- 40% in case of 2 x 100% transformers.

The auxiliary transformers shall be indoor/outdoor type. If they are indoor type, they shall be flame retardant dry cast resin transformers. Furthermore, they shall be located adjacent to the associated switchboards in a suitable safety enclosure, connected by busbars or by cable connection to the associated switchboard.

Connections to the transformer bushings shall be by flexible copper connections. It shall be possible to remove these flexible connections to permit testing of the cables and transformer separately.

Auxiliary transformers shall have a manually operated off-load tap-changer (2 x ± 2.5%, with changeable terminal connections) on the high voltage side.

The Auxiliary transformers shall be installed in controlled environments and encased in naturally air ventilated enclosures.

12.8 MV/LV Power Station

The Contractor shall consider compacted MV/LV power station solutions for the following equipment in the form of shipping containers, skids, or prefabricated buildings / enclosures:

- Indoor or outdoor MV/LV transformer;
- Indoor or outdoor MV Ring Main Unit;
- Indoor LV cabinet or outdoor auxiliary distribution box for auxiliary services and SCADA system;
- LV/LV auxiliary transformer;
- Communication equipment;
- Auxiliary equipment; and,
- Grounding system.

12.9 Switchgear

12.9.1 General

All switchboards shall be of the industrial, extensible, metal clad, withdrawable, cubicle type arranged as freestanding units with minimum ingress protection of at least IP54 and constructed and tested in accordance with the appropriate Standards.

All switchgear shall be equipped with suitable anti-condensation heaters and shall be designed for bottom entry cables only. Provision shall be made for enough space in the switchgear design to ensure neat cable management of the external cables. Appropriate glanding plates shall be used in all switchgear design.

All switchgear shall be designed as type tested assemblies.

Switchgear busbars, circuit breakers, cable compartments, and LV compartments shall all be contained in separate compartments. Barriers shall be provided between the compartments to prevent the spread of ionised gases.

Busbars shall be manufactured from electrolytic copper and shall be capable of carrying full current continuously along the entire length of the busbar without exceeding maximum allowable standard temperatures. Busbars, busbar connections and insulation materials shall be capable of withstanding, without damage, the thermal and dynamic effects of short-circuit fault current according to the outcomes of the studies conducted in section 12.2, equivalent to the short time rating of the associated switchgear. Facilities shall be provided to accommodate thermal expansion of the busbars and associated components. Fixed earthing points shall be provided on the busbar and on the incoming side of main incomer circuit-breakers. The Contractor shall provide information and calculations supporting the dimensioning of the busbars of the Design and their mechanical sizing to the Employer.

All switchgear shall be installed in a way which helps facilitate O&M and component repair and replacement as needed. If rear access to a switchgear panel is needed, there shall be a minimum space of 1 m working distance at the back of the panel.

All main switchboards, relay panels and control equipment shall be provided with duplicate 220 V DC power supplies for control and alarm purposes. This shall include voltage protection.

Check-synchronising facilities shall be provided as required. The switchgear main incomers, interconnectors and bus-section circuits shall be interlocked electrically to prevent the paralleling of two incoming supplies to a switchboard. MV switchgear shall have the interlocks to avoid incorrect manoeuvres according to SANS 62271-200.

For emergency operation of MV feeders and LV incomers, mechanical off switches shall be provided.

All the withdrawable units of the assemblies shall have the following positions:

- Service;
- Disconnected-test;
- Disconnected; and,
- Removed.

All switchgear sections shall have an engraved label with the respective circuit name and reference, if applicable, and adhere to the requirements stated in section 8.9.

Phasing of switchgear, cabling etc. shall be consistent throughout the Plant equipment and installation. Typically, this shall follow a L1-L2-L3, top-to-bottom-, left-to-right, and front-to-back methodology. The Contractor shall provide a phasing diagram, as one of the electrical layout diagrams, to the Employer displaying all Plant electrical equipment, terminal designations, and phase designations.

12.9.2 LV Switchgear

The LV switchgear shall be designed for a nominal voltage of 400/230 V (according to SANS 1019 and as per Table 5) and withstand a short-circuit current of minimum 10% higher than required by calculations for a duration of one (1) second. All LV cables shall be glanded.

The LV switchboard shall have a short circuit withstand capability of not less than 50 kA for one (1) second. Control of the LV switchgear shall be of the conventional hard-wired type and connected to redundant gateways or remote I/O cubicles of the Plant SCADA system.

LV switchgear shall comprise of air insulated busbars, air circuit breakers (ACBs) or moulded case circuit breakers (MCCBs), and contactor units as necessary. The circuit breaker selected per application shall be of the fault making, fault breaking, and load breaking type, rated for the associated system maximum fault current and capable of carrying the maximum continuous load current. If withdrawable type circuit breakers are used for the LV switchgear, protection covers shall be included around them to ensure the IP rating is maintained while the circuit breaker is in the isolated position.

Integral fault making earth switches for circuit and busbar earthing shall be included in all LV switchgear. The construction form shall be Form 4B as per the requirements of SANS 61439. Shutters shall be provided to cover each set of stationary contacts and shall be automatically operated on the withdrawal of the truck or part and shall include provision to lock the mechanism to prevent access to the contacts.

Auxiliary contacts for open, closed, in service (racked-in for withdrawable-type switchgear) and isolated (racked-out for withdrawable-type switchgear) positions shall be provided to the Plant SCADA system for all main incoming circuit-breakers. A disconnect type terminal shall be provided for each ganged alarm. The Plant SCADA system shall permit the bypassing of nuisance alarms by opening the disconnect terminal.

The Contractor shall provide a means of indicating the loss of any phase or incorrect phase rotation in the main LV switchgear. This can be achieved either through a fixed phase-fail relay provided from a MCB tapped off from the main busbar or indicated from the power electronics of Plant operating equipment such as inverters.

LV switchgear shall be designed in compliance with SANS 61439, SANS 1973-1, SANS 60947, and SANS 1973-3.

12.9.3 MV Switchgear

All MV switchgear shall be designed for a nominal voltage according to SANS 1019 and SANS 62271, to be internal arc certified IAC AFRL according to SANS 62271-200 and to withstand a short-circuit current of minimum 10% higher than required by calculations for a duration of three (3) seconds. A type test certificate compliant with the SANS Standard shall be supplied for the unit(s) offered. For RMU switchgear, the short-circuit rated duration requirement of one (1) second is acceptable.

MV switchgear shall be withdrawable with air insulated busbars, vacuum circuit breakers, and contactor units as necessary as per Eskom Standard 240-56227573. The circuit breaker selected per application shall be of the fault making, fault breaking, and load breaking type, rated for the associated system maximum fault current and capable of carrying the maximum continuous load current. Integral fault making earth switches for circuit and busbar earthing shall be included. The construction form shall be per the requirements of SANS 62271. Shutters shall be provided to cover each set of stationary contacts and shall be automatically operated on the withdrawal of the truck or part and shall include provision to lock the mechanism to prevent access to the contacts.

12.10 MV Ring Main Unit

The MV RMU shall be compact, hermetically sealed SF6-free GIS type, and shall be gas tight for life. A manometer shall be provided for monitoring the gas pressure. A voltage presence indicating system to monitor the cable voltage during operating and maintenance phases shall be provided.

The RMU shall include:

- Switch disconnectors on cable feeder circuits;
- Circuit breaker, IDMT, definite time overcurrent and earth fault protection on transformer feeder circuits;
- LV phase rotation meter;
- Voltage presence indicator;
- Cable clamping facilities;
- Two (2) incoming feeder functions for managing the energy that comes from the other inverter stations and optimally place into the internal MV network (depending on MV design);
- One (1) gas insulated switchgear of circuit breaker protection function to protect the transformer on the MV side;
- Be a modular unit, self-contained in a metallic enclosure with all equipment to perform a single function;
- Be controlled by interlocking keys where required to ensure strict compliance with correct operating/isolation sequences;
- All necessary relays for control of the switchgear will be state-of-the-art and comply with the relevant SANS standards;
- All necessary metering devices;

- Earthing switches in each cubicle; and,
- Capacitive voltage detectors in each cubicle.

Position indication of each RMU switching device shall be integrated to the Plant SCADA system.

Where a RMU is not used, appropriately sized separable tee connectors shall be used to terminate the cable to the transformer such that a failed transformer can be safely bypassed while keeping the rest of the radial circuit connected.

The RMU shall be appropriately rated such that a failed transformer can be safely bypassed while keeping the rest of the radial circuit connected. It shall not be close coupled to the transformers.

The LV auxiliary supplies shall be either of TN-S (separate PE and N conductors) or of the TN-C-S type with combined PE&N conductor (TN-C) from transformer to the main distribution, but separate PE and N conductors in the distribution and all connected consumers (TN-S).

12.11 Electrical System Control, Indications, and Alarms

Control and alarm facilities for the Plant's electrical AC and DC systems shall be provided.

Details of the required signal interchange with Distribution Network Operator (DNO) shall be developed during the design phase of the Project.

AC electrical systems shall be monitored and controlled from the Central Control Room (CCR) including all transformers, switchgear incomers and bus-sections via the Plant SCADA system.

The voltage of each switchboard and single-phase current of all main circuits (incomers and bus-sections) shall be displayed locally at each switchboard. This information shall be repeated in the CCR via the Plant SCADA system.

Trips and alarms shall be provided to indicate and announce all system warnings and faults at the CCR via the Plant SCADA system.

400-800/230 V AC sub-distribution systems and the DC systems shall be locally controlled only, but alarms shall be transmitted to the CCR via the Plant SCADA system.

The switchgear shall include all related circuit prominent coloured high-power LED type status and alarm lamps. The associated protection relays shall also include LED status/alarm indicators or flags.

12.12 LV AC and DC Sub-Distribution Boards

Sub-distribution boards shall be provided throughout the Plant for local lighting, small power, and welding supplies.

Outdoor sub-distribution boards shall be of the weatherproof enclosure type, IP65, indoor boards shall be IP54. Additionally, all outdoor installed sub-distribution boards must be equipped with totally enclosed sun canopies.

Switchgear installed in electrical operating rooms shall be provided with a minimum ingress protection of IP54. They shall be capable of withstanding the associated fault current until the related protection operates.

DC sub-distribution boards shall be provided throughout the Plant for control supplies to switchgear, control panel, and emergency lighting as required.

The incoming breaker of all sub distribution boards shall be able to accommodate a lock-out device and be equipped with a remote signal protection tripping relay with adjustable current and time scales.

The AC sub-distribution boards shall be either single phase or three phase with a neutral and earth bar, and the DC sub distribution boards shall be of the two-pole type. All distribution boards shall be rated for the full load current of the incoming supply and equipped with an incomer isolating MCCB

(4-pole for AC and 2-pole for DC) and with MCBs to provide over current protection to each sub circuit. All equipment installed inside the sub-distribution boards shall be designed and tested for the applicable voltage type (AC or DC).

All the space in the distribution boards shall not be fully utilised and shall contain 10% unused switch gear and an additional 20% space for future switch gear to be installed.

12.13 Emergency Power Supply

The Contractor shall provide a suitable emergency power supply is available to ensure that the essential (AC) functions of the Plant, such as the SCADA system, security system (including CCTV cameras, perimeter lighting, intruder detection system), firefighting and protection system, substation electrical protection equipment/devices, HVAC system, IT infrastructure, and PA system are able to continue operating in the event of a prolonged power outage or abnormal system behaviour as well as ensure that the Plant is able to continue operating in the event of a prolonged outage of the communication interface between subsystems/components. The emergency power supply shall also be able to facilitate a safe shutdown of the Plant in the case of an emergency or where the safe operation of the Plant is no longer guaranteed (i.e., low power levels of the emergency supply system). The autonomy of the emergency power supply shall be at least twelve (12) hours following the loss of its feeder supplies.

The emergency power supply shall consist of one dedicated UPS system (comprised of modular UPS units) situated in the air-conditioned server room of the O&M building and a separate dedicated UPS system situated in the DC room[14] of the Solar Plant Substation building. Each UPS modular unit shall be 120% rated for its related load and include an output automatic static transfer switch to an alternative supply and an emergency manual bypass switch with all necessary indications, local alarm lamps and remote (CCR) alarms. The UPS system voltage level shall be as per Table 5.

In addition to the UPS systems, the use of a diesel power generation system shall be considered to provide supplementary capacity to the respective Plant essential services. It should automatically start up during network outages, constraints, and loss of mains incidents with autonomy (diesel deposit) between 24-48 hours. During the Operations phase, diesel consumption shall be minimized. It shall not be possible to export power from the diesel power plant facility to the grid by any means. In order to do so, the diesel power plant facility shall be connected to an alternative busbar different to the MV busbar that is connected to the step-up transformer.

The diesel power generation system shall be suitably housed in proximity to the O&M Building and/or the Solar Plant Substation building.

The Contractor shall be responsible for the design, fabrication, testing, and inspection of the diesel power generator system including, but not limited to:

- Diesel engines and associated generators;
- Foundations and anchor bolts;
- Electrical and C&I control system including LV switchgear, control panels, main power transformer and MV switchgear;
- Power, control and fibre optic cables;
- Starting battery, redundant battery and charger;
- Fuel metering and filtration;
- Cooling water and tank;
- Exhaust gas system including silencers;
- Common base frame;
- Accessories;
- Spares and special tools; and,

[14] The DC room contains the control and electrical protection equipment/devices for the Solar Plant Substation.

- Installation, assembly, commissioning, and testing.

The provided equipment shall be factory-assembled to the greatest extent possible for convenient field erection. Accessories shall also be factory-assembled in modules. All piping and wiring shall be completed within each module and terminated for connection to other modules.

Equipment and materials shall be designed and installed for the environmental conditions such as freeze protection, moisture and dust controls, heat tracing and insulation for electrical motors. Engine air intake, enclosure and other critical systems shall be designed suitable for the site conditions specifically the ambient altitude and dust storms.

No valve-regulated lead acid (VRLA) batteries shall be used or considered.

The Contractor shall provide an emergency power supply system sizing report to the Employer for acceptance. This shall detail the sizing of the diesel power generation system and dedicated UPS systems and their optimisation for the provision of the required emergency power supply. Calculations shall be included in the report to determine the ratings of all system power components and the expected associated loads on each. This shall include all standby diesel generators (including fuel tank capacities, consumption rates, fuel supplies etc.) and DC systems (including batteries, battery chargers and UPSs).

12.14 MV AC Cables

MV AC cables shall be copper or aluminium and shall be screened, stranded single-core cables, designed with individually screened cores. MV AC cables shall comply with the following minimum criteria:

- XLPE or HEPR cables shall be used;
- MV cables shall comply with the corresponding Codes and Standards;
- MV cables shall be flame retardant as per SANS 60332-1 and SANS 60332-3;
- MV cables shall withstand the expected maximum electrical voltages during the lifetime of the Plant (25 years);
- All MV cables shall be permanent marked and properly identified;
- MV cables shall be designed with a maximum operation temperature of:
    - ≥ 90 ºC under normal operation; and,
    - ≥ 250 ºC under short circuit circumstances (five (5) second maximum).

The MV cable screen shall be connected in both sides. Only one side should be grounded to prevent a short circuit and any stray currents being induced in the screen, with a calculation provided that the voltage on the open end is not at a dangerous level (50V).

Cable jointing is limited per circuit and these shall be reviewed by the Employer as well as the joint specifications. Joints must be executed by trained personnel certified by the joint manufacturer. Topographical marking documentation of the position of MV/HV joints is to be provided in As-Built documents.

Suitable derating factors for current capacity of the cables shall be applied according to the applicable standards to prevent over heating under design conditions. MV cables shall be sized based on current ampacity, voltage drop and let through passing energy.

All power cables shall be suitable for service at maximum design load and minimum voltage conditions for the Site conditions and shall be capable of sustaining maximum through fault current without damage for the short time rating of the associated switchgear. Power cables with fuse/MCCB/MCB protection shall be capable of sustaining maximum prospective fault let-through current/time.

The following maximum voltage drop limits shall apply:

- Between main switchboards (i.e., supplied by a transformer) and sub switchboards: 2%;
- Between main switchboards (i.e., supplied by a transformer) and static load terminals: 5%; and,
- Between sub switchboards and lighting loads: 3%.

MV Cables shall comply with Eskom's Control and Power Cables for Power Stations Standard (240-56227443).

12.15 Cable Installation

Within buildings, cables shall be installed on hot dip galvanized cable trays or racking in a manner that shall prevent the cable being damaged and shall minimise the occurrence and spread of fire. Power cables shall be adequately clamped to prevent movement under short-circuit conditions. Single core cables shall be clamped in trefoil formation considering phase cable swapping every 100m.

Duplicated circuits, such as cables that service main distribution switchboards and those cables forming part of emergency/high integrity circuits, shall follow different routes or be separated as far as is practicable.

Separation shall be achieved by laying cables neatly on trays. MV cables, LV power cables, and control and communication cables shall be separated from each other. The MV cables shall be placed at the lowest level of the cable routes and in single layers only, followed by LV cables which shall be placed in the next higher levels, and lastly the control and communication cables placed at the highest levels. LV and control and communication cables may be laid to a maximum of two layers. Segregation levels will be according to SANS 10198. Out of the trays/racks and up to the equipment connection boxes, the cables shall be installed in galvanized steel conduits and metallic flexible conduits with external PVC insulation. All transitions from aerial to underground will be mechanically protected (conduit or cable tray with cover), extending 2 m above floor level.

All cables external to buildings shall be, as a minimum, laid in galvanized steel conduit or laid on tray or racks within reinforced concrete trenches or above ground on pipe racks. PVC conduits shall be used only for cables laid in ducts in the ground.

In all areas hot dip galvanized trays/racks or conduits shall be used and where any damage occurs, they shall be further protected with additional anticorrosion painting (such as cold galvanizing paint). No plastic, PVC or similar trays and conduits shall be used. Trays/racks installed outdoors shall be provided with covers for protection of the cables against sun radiation.

All cable racking/trays shall be bonded to each other as well as to the Plant earthing system. The cables trays shall be designed to allow for 20% spare space for future cables and shall have no more than 2 layers of cables in each cable tray.

Bottom entry power C&I cabling shall be used for switchgear, and the other main Plant and C&I equipment. There shall be clear separation of power and control/communication cabling. Cable access to enclosures shall be by compression type cable glands. Glands shall be of non-magnetic metal construction. Gland plates shall be of metal and shall be designed with sufficient inherent rigidity and strength to ensure no distortion with cables installed.

Cables and cable trays shall be clearly identified at both ends with a robust and weatherproof cable identification tag that carries the cable/tray number per the agreed identification system. Numbers shall be unique across the Plant and follow the AKZ or KKS system (to be confirmed at a later stage) . Cable rating shall be considered as per SANS 10198.

Electrical cables installed underground and/or in adequately meshed sized cable trays/cable ladders/welded wire mesh shall be designed to prevent faunal harm on cables and maintain the design lifetime.

Cable tray fixation shall be in accordance with Good Industry Practice, such as earthing, protection from the cutting angle of the structures, protection from UV, durable, regular fixation to prevent sagging, anchoring of the cable tray support to both cable tray and ground, such that the installation maintains the full performance of the electrical system.

Where applicable, the requirements in the Eskom Field Instrument Installation Standard: Junction Boxes and Cable Termination (240-56355815), Eskom Field Instrument Installation Standard (240-56355754), and Eskom's Control and Power Cables for Power Stations Standard (240-56227443) shall be adhered to.

12.16 Earthing System Design, Bonding, and Lightning Protection

The earthing and lightning systems shall be designed according to SANS 725, EN 50522, IEC/SANS 60364, SANS 62305, SANS 61936-1, and IEEE 665 Standards. All earthing connections will be secure and provided with bolt, nut and stop washers for a reliable and durable connection. Anti-corrosion coating shall be applied where applicable. Particular attention shall be paid to the following:

- Lightning ground potential rise in the context of wire-line technology;
- Lighting ground potential difference;
- Step and touch voltages;
- Electro-magnetic Zoning;
- Soil resistivity variation across the Site;
- Earth electrode resistance – resistance is a low frequency parameter whilst the assessment and analysis called for lightning with higher frequencies involved;
- Large earth electrodes (example solar PV field);
- Lightning electromagnetic pulse (LEMP) (All electromagnetic effects of lightning current via resistive, inductive, and capacitive coupling, which create surges and electromagnetic fields.); and,
- It will not be possible to use the structure steel piles as underground earthing electrodes. An independent buried earthing grid shall be installed to which the structure steel shall be connected.

The Contractor shall be responsible for the design, installation, and testing of a single earth grid/mat for the whole Project which will act as an earth grid/mat for all the Plant equipment, including PV module structures, LV equipment, MV/LV power stations, MV equipment, HV equipment, buildings and structures. The earth grid/mat shall consist of BECW (the Contractor can propose other suitable materials with relevant studies and supporting documentation for the Employer´s acceptance) cable all along the LV and MV electrical cable trenches, and along additional dedicated earth trenches in the solar field and the perimeter fence if required to achieve the necessary lightning protection and as per the earthing study. The final specification of the buried copper earth electrode will be according to SANS 60479, EN 50522/IEEE 80, recognised Good Industry Practice and the System Operator's approved design requirements. The earthing system shall achieve safe step and touch potentials according to the applicable national or international standard.

Each inverter will have a perimeter earthing grid constructed with BECW and copper earthing rods, as required by the earthing study. The short time current withstand rating of the total earthing installation shall be at least equal to the system designed fault current and backup protection time. The loop impedance of the earthing system shall ensure that all protective devices operate within the short time rating of the system, and such that prospective values of step and touch potential do not approach unsafe values. All underground joints shall be cad welded type.

All electrical equipment, metallic frames and supports, structural steel and in general all major metallic structures, fences, cable trays/racks shall be connected to the earthing system. Transformers and switchboards or assemblies containing switchgear equipment shall be provided with two (2) or more earth terminals and each shall be connected to the secondary earthing system.

A copper strip sized to withstand the maximum system earth current for one (1) second and to provide suitable mechanical rigidity shall be used. Earthing cable sizes shall be designed according to the respective standards.

The Contractor shall also provide a lightning protection system for the PV Plant which shall comply with SANS 62305 including the risk assessment and EM zoning as per the standard (EM Zones: SANS 61000-2-5, SANS 61000-4-5, and SANS 61000-4-9). Each lightning protection system shall be bonded to the main Plant earthing system. The Contractor shall ensure that equipment used in the different zones will be suitably rated for these EM zones.

The Contractor shall appoint an appropriately qualified third party to conduct a lightning risk assessment that shall inform the design of the lightning protection system for all components of the Plant to minimise the cost to repair physical damage to the Plant due to lightning.

12.17 Protection and Control

12.17.1 Plant Step up (PSU) Transformer Protection

The MV/LV transformers shall be provided with at least the following protection functions as per ANSI Standard Device Numbers (ANSI/IEEE Standard C37.2):

- Restricted earth fault (64REF);
- Overcurrent (50/51UAT);
- Buchholz Transformer Tank (96BT);
- Pressure relief device tank (63PT);
- Oil Temperature Alarm & Trip (49Q);
- Winding Temperature Alarm & Trip (49W); and,
- Oil Level (71Q).

12.17.2 Protection of Electrical Auxiliary Systems

All electrical circuits shall be adequately protected by relays and a suitably rated means of current interruption. The following electrical protection shall be provided as a minimum:

- Feeders shall be provided with Overcurrent Protection and Earth Fault Protection;
- A winding temperature indicator shall be provided for each auxiliary transformer, having contacts for high temperature alarm and trip functions; and,
- MV standby earth fault, (voltage displacement supervision) Buchholz relay, transformer winding temperature, transformer oil temperature, transformer rate of rise of pressure, and low oil level.

The above protection shall be realised with relays of the electronic digital type with facilities to enable testing of all functions during normal operation without imposing operational restrictions (i.e., leaving other protection functions active). The relays shall be capable of communicating with the Plant SCADA system so that alarms and trip conditions can be seen.

MV switchgear protection relays shall be of the electronic digital type with continuous self-supervision. Relays shall be capable of communicating with the Plant SCADA system so that alarms and trip conditions can be displayed.

LV protection relays shall have conventional relays/releases. Trip and alarm signals shall be hardwired to the Plant SCADA system. Uncontrolled feeders up to 25A shall be provided with MCB; for 25A and up to 630A MCCBs shall be provided.

13 CONTROL, INSTRUMENTATION, AND COMMUNICATION REQUIREMENTS

13.1 Plant Monitoring and Control System Design Philosophy

The control, monitoring, protection, and information management functions for the Plant shall be conducted using the SCADA and PPC systems from the central control room of the O&M building. The interface architecture between various Plant components and subsystems, such as the SCADA system (Plant and security), PPC system, and the solar field is shown in Figure 2.

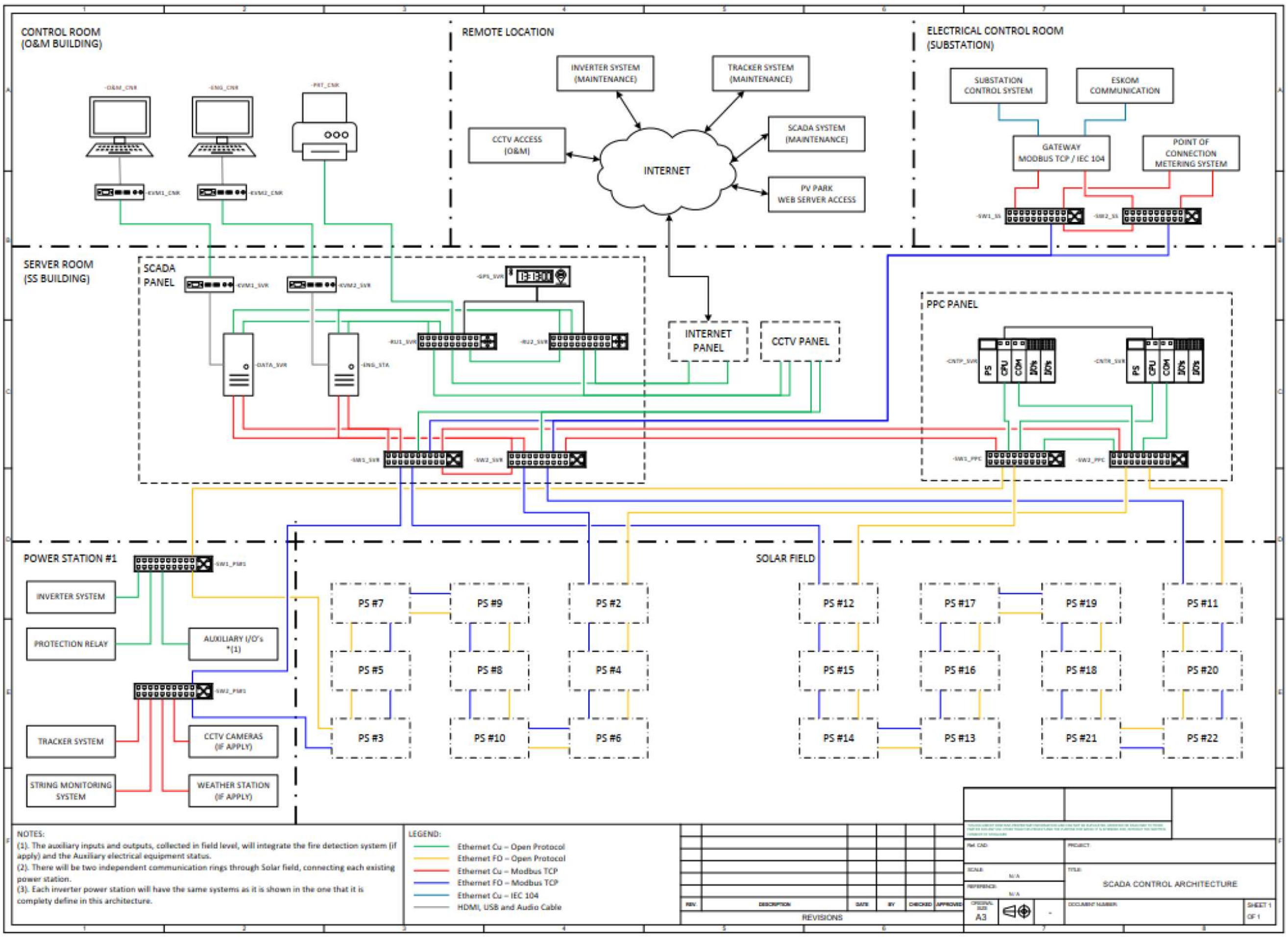

Figure 2: High-level Plant Interface Architecture

The design for the monitoring and control system[15] shall comply with the following general guidelines as a minimum:

- Enable the safe, reliable, and efficient operation of the Plant under normal or abnormal conditions;
- Allow communication with the field measuring elements, inverters, string combiner boxes, tracking controllers, protection systems, meteorological stations, field testing equipment, metering, and Plant substations[16];
- Allow remote access and interface with the Grid Operator in order to keep the Plant operating within the grid constraints;

[15] Monitoring and control system for the Plant includes the (Plant & security) SCADA system, PPC system, and all other control and monitoring subsystems and equipment.
[16] Solar Plant Substation and Solar Switching Substation.

- Generate a complete summary of the Plant status in order to allow the Plant Operator to monitor and manage power generation, take corrective actions, and perform maintenance and self-diagnosis actions;
- The monitoring system shall consist of local servers which host the software applications and data storage devices. It shall have workstations for computers composed of dual 32” monitors, a keyboard, and mouse allowing approximately six (6) operational staff access and approximately four (4) security staff access, and have routers allowing remote accessing via the internet/web;
- The communication with the measuring devices, inverters, weather stations, and other control devices shall be performed using MODBUS TCP or RTU. In case required, other standardized, open, and industry proven data communication protocols (i.e., DNP3.0, SANS 61850-7-420:2012) shall be implemented in the monitoring system by means of either a hardware solution (gateway) or a software driver;
- The design of the monitoring system shall be based on nodes of distributed periphery whose nodes are the MV/LV power stations. The communication inside these areas shall be performed using UTP 5e/6 cable, otherwise RS-485 cables (to be verified and informed by the lightning risk and zoning assessment);
- The communication between nodes shall be performed using redundant multimode/single mode FO;
- Collect and store the following data required to verify the Plant’s performance and energy output including, but not limited to:
  - Current, voltage, instantaneous DC power, and DC energy at string level;
  - Current, voltage, instantaneous AC power, AC energy, and frequency at each inverter;
  - Fiscal meter readings and energy generated by the PV Plant;
  - MPPT parameters, voltage and frequency set point, active and reactive power, and power factor;
  - Status and alarms of each inverter;
  - Measured meteorological parameters recorded by the sensors (temperature, irradiation, humidity, wind speed, wind direction); and,
  - All alarms related to Plant switchgear and transformers.
- C&I equipment shall have enclosure classification not less than IP54 according to SANS 60529 when mounted in an enclosed building and IP65 for mounting outdoors. Control cubicles installed in air-conditioned rooms shall be at least IP42;
- The lifecycle management of all C&I equipment shall be given due consideration, be addressed in the applicable O&M manuals, and adhere to all Eskom requirements and Standards;
- Eskom Standard for the Interconnection of Embedded Generation (240-61268576);
- Grid Connection Code for RPPs connected to the Electricity Transmission System or Distribution System in South Africa;
- Eskom Field Instrument Installation Standard: Junction Boxes and Cable Termination (240-56355815); and,
- Eskom Field Instrument Installation Standard (240-56355754).

13.2 Hardware

13.2.1 Control Rooms / O&M Building

In the O&M building, a 19” rack shall be installed to host the monitoring and control system server, the long-term data server (Redundant Arrays of Independent Disks (RAID)), a PLC, a UPS, and the PPC system.

This server shall be accessible through consoles in the central and security control rooms which shall include an operator workstation, desks, large screen, a printer, and any panels required for control, operation, and protection purposes.

The control system server shall be redundant. Any hardware element that, in the event of failure can make the control and data acquisition systems unavailable, shall be redundant.

The communication with solar field circuits, third party control, and monitoring equipment shall be performed by an industrial manageable switch with enough FO and Ethernet ports and a minimum of 20% spare ports allowed for future utilization.

The O&M building shall be equipped with secure HVAC facilities capable of maintaining the rooms therein within acceptable limits of temperature and humidity, under all external ambient conditions, as dictated by the manufacturers of the control equipment located inside each room and Table 6.

The network shall be arranged on the base of one or more managed closed fibre rings/loops. The fibre loop will start from the central control room to the first MV/LV power station, then to the next MV/LV power station. From the last MV/LV power station, the fibre will return directly to the central control room. These loops are made of multimode or single mode optical fibre depending on the segment length.

In each network, separate fibre cables, instead of separate pair cores of the same FO cable, shall be used to create the redundant loops for the Plant (redundant ring topology). The network shall be of Gigabit speed to allow all monitoring, control, and security flows to coexist without network congestion.

13.2.2 MV/LV Power Stations

Within these areas there shall be installed a monitoring cabinet that shall host power sources, electrical protections, communication equipment, gateways, routers, FO patch panels and pigtails, and other auxiliary devices when needed.

The monitoring cabinet shall be metallic and IP66 if installed outside.

The monitoring cabinet shall be equipped with at least the following equipment:

- One Industrial Manageable Ethernet switch;
- One FO patch panel for connecting and pigtail;
- One RTU/TCP gateway in case needed;
- One PLC for data gathering and control functions with CPU and memory loading in no case greater 60% of its capacity;
- One power supply; and,
- One backup UPS power supply

From this cabinet, the following elements shall be monitored:

- The inverters;
- Meteorological station, when applicable;
- Soiling stations;
- String Combiner boxes, when applicable;
- Trackers, when applicable;
- Transformers and their auxiliary equipment;
- MV line status; and,
- MV switchgear status.

13.2.3 Wiring

- Cable for RS-485 shall be 24 AWG 7-strand tinned copper, 2 twisted pairs, overall foil, and tinned copper braid shielding chrome grey PVC jacket. AWM Style 2919; EIA-485; CM/CL2.
- In principle, fibre optic cable shall be used for communication links. The Ethernet cable shall only be used for indoor applications with short distances, i.e., less than 100 m, and shall be Cat 5e or Cat 6;

- Data communications cable shall be stranded copper AWG 18-22, twisted pair, shielded Belden 1120 A, or equivalent;
- All cables/wires to be used outdoors will be suitably rated against UV, be anti-hygroscopic, and be protected against vermin/rats. Armoured cable shall be used for direct buried applications;
- Cables exposed to direct sunlight shall be encased in UV resistant trunking or tubing;
- FO cable must be of loose tube construction;
- Where FO cables are buried in trenches inside a subduct, pulling chambers shall be ideally located to allow the installation of the fibre by blowing or pulling;
- All FO cables and interconnecting devices to comply with SANS 60794-1-1, SANS 60794-1-2, SANS 60794-2. SANS 61073-1;
- The subduct joins must be 100% waterproof and adapted for burial installation in high groundwater areas;
- Any manufacturer specification on the cable datasheet in relation with the implementation, such as the minimal radius of curvature, the tensile strength, or the temperature condition, etc., should be adhered to; and,
- Each installed cable should be marked in a visible way at both ends.

Instrument and data cables shall have conductors and insulation appropriate for their duty/location.

13.2.4 Shielding and Grounding System

The shielding and grounding system must adhere to, and be in compliance with, SANS 10142-1 and the Eskom Standard for Earthing and Lighting Protection (240-56356396).

Grounding, shielding, and treatment of the common reference shall form a uniform system for the entire C&I system and DC supply throughout the Plant.

To avoid double earthing of cable shields by earth fault or by erroneous connection, a systematic shielding network with easy checking possibility shall be realised with only one side of the cable earthed. All applicable standards shall be considered.

The grounding of all cable shields shall be done systematically in the relevant terminals on an isolated bar with detachable connections. All isolated shielding bars of the individual cubicles shall be connected to a central earthing bar situated in the central control room/O&M building and be easily accessible for maintenance.

13.3 SCADA System

13.3.1 General Description

The SCADA system consists of a software application that collects data from the equipment placed in the PV Plant. The Contractor shall request and receive the Employer’s acceptance for the application of any proprietary software before use.

The SCADA system shall have a web-based interface that allows the user to operate the system, monitoring and controlling with requisite authority levels for ‘viewers’, ‘administrators’, and ‘operator’ roles based on the login credentials assigned. The web-clients will be remote users with authorised access for monitoring the plant in near real time via a web browser.

The information shall be shown using graphs, tables, tree-schemes, and drawings. Data may also be exported as text or .xls files in case further analysis is needed.

The database shall be organized in tables. The most important tables are the production table (including energy, power, performance, time of operation, and availability of each inverter unit) and the events table (equipment status, diagnosis, and alarms).

A daily report of the previous day’s production will be generated automatically and sent via email notification to authorised users.

The SCADA system shall also allow performing personalized queries.

13.3.2 Software Architecture

The SCADA system shall allow communication from the field equipment (inverters, meteorological station, transformers, trackers, string combiner boxes, CCTV cameras etc.) with the supervisory equipment in the central control room/security control room, and further, with soft clients via web server.

13.3.3 Design Criteria

The SCADA system shall be developed using the following criteria:

- Availability: the system shall be designed to ensure high availability, i.e., greater than 99.9%;
- Safe storage of data, avoiding data losses. Data shall be stored locally and externally, with periodic backups performed with external hard drives which are to be kept in a secure location;
- Quick access via internet/web, with adequate cyber security safeguards in place and in compliance with Eskom's Standard for Demilitarised Zone (DMZ) Designs for Operational Technology (240-79669677), Information Security – IT/OT and Third Party Remote Access Standard (32-373), Eskom Cyber Security Standard for Operation Technology (240-55410927), and Human Machine Interface Design Requirements Standard (240-56355728);
- Scalability: the system shall be designed to permit horizontal scalability and vertical scalability. Horizontal scalability means that the expansion of the power plant can be absorbed without major changes in the architecture. Vertical scalability means that the system can include more functionality without major changes;
- Modularity: the system shall be designed in independent modules, allowing for evolving maintenance and upgrading;
- Simplicity: the system shall be designed in the simplest way that matches with the Employer's Requirements;
- Redundancy: The SCADA system, communication network, and field control system shall be equipped with redundant configuration in order to achieve the highest possible availability;
- Open data exchange: data exchange interface must make it possible for the Employer's centralized control and monitoring system to exchange data with the SCADA system for both real time and historical data;
- The Plant SCADA system and field control system shall allow for automatic start-up and shut down of the Plant;
- The field control system shall be designed to ensure normal operation even in the event of loss of software communication link;
- The Project must adhere to the Grid Code, dispatch requirements of the System Operator, and maximize compliance with any dispatch requirements by the System Operator and the Eskom Standard for the Interconnection of Embedded Generation (240-61268576);
- The Contractor shall ensure that the SCADA system has an operational life span of 25 years from the Plant's Commercial Operations Date (COD), which involves being capable of adapting to software updates. The Contract shall provide a lifecycle management plan for the SCADA system hardware and the OS and APP software;
- PPC functions shall be included in the SCADA system if and as required by the System Operator Technical Requirements;
- A minimum of ten (10) user licenses shall be provided to the Employer, and it shall be possible to restrict user-access to rational levels so as to protect the integrity of the system and prevent unwanted, unwarranted, and/or unsafe Project configuration changes;
- The SCADA system vendor must be able to offer technical support for the operational life of the system. The Contractor shall provide a lifecycle management plan for the SCADA hardware and OS and APP software; and,
- The Employer will require licenses and access to make changes to the SCADA system/PLC system and all programmable devices as and when required.

13.3.4 Internet connection

The Employer requires a permanent connection to the SCADA system through a secured Virtual Private Network (VPN).

The Contractor shall provide every device necessary in compliance with the relevant Eskom, national and international standards for cyber security to avoid unauthorized access to the SCADA system from the internet such as firewall, Intrusion Detection Systems (IDS), Intrusion Prevention Systems (IPS), etc.

The SCADA system shall be compatible with modern communication technologies for access to the Internet. The web server will be compatible with the Google Chrome and Mozilla Firefox web browsers.

13.3.5 Network Topology

The network topology is the name given to devices called nodes (e.g., switches, computers, or PLCs) that are physically connected in a network. There are four common types of topologies, namely: star, bus, ring, and mesh topologies. A hybrid topology containing a mix of two or more different topologies is possible to implement. The network topology chosen for the SCADA system network shall consider technical and financial benefits.

Ring topology is where nodes are connected to form a loop (Figure 3). Data is transmitted from one node to the next until the data reaches the destination node. Data travels in one direction using a control signal known as a 'token'.

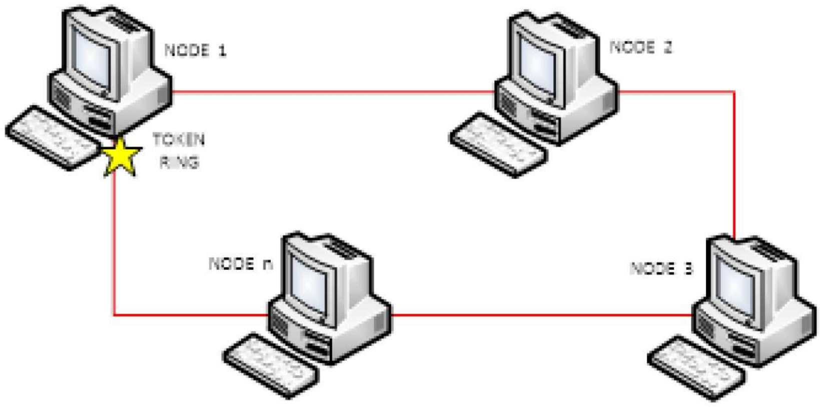

Figure 3: Ring network topology

Bus topology contains a single bus or line cable that connects all nodes together (Figure 4). At each end of the bus is a 'terminator' which is a hardware component that prevents signals from bouncing back and forth in the network.

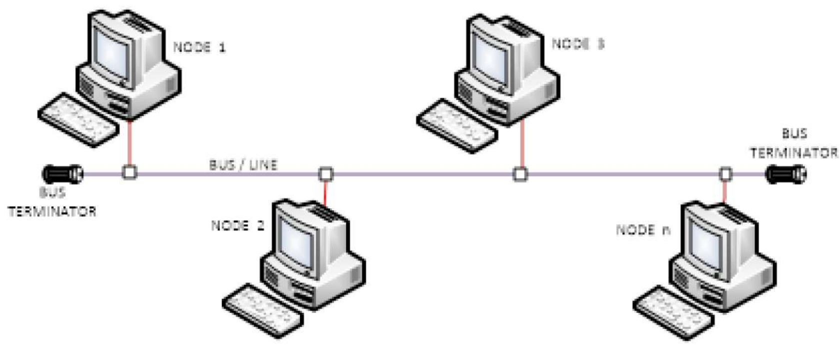

Figure 4: Bus network topology

Although the final topology depends on the Contractor's design, the preferred solution is to implement a ring topology as the core SCADA system Local Area Network (LAN). Ring topologies are commonly used in utility scale solar power plants due to the great distance between network nodes. The ring topology will employ redundancy management protocols that allow the LAN to be logically configured with single fault tolerance over a single physical loop by making use of managed Ethernet network switches. Because of its physical loop architecture, the ring topology results in lower cable length when compared to a star topology and thus lower cabling costs. It should be noted that this is a recommendation and does not have to be adhered to.

The bus topology is preferred for establishing communication of the field devices such as inverters, string combiner boxes and weather stations. The data communication standard that is widely used to connect field devices in a bus topology is RS-485.

13.3.6 Network Communication Medium

Data communication medium represents the physical material through which data is transferred. The communication mediums to be considered for implementation are outlined below.

The data communication networks shall be configured such that no single point of failure exists within the core SCADA system network. The network shall be configured to optimise traffic flow between devices.

Fibre optic cables shall be installed to create the core SCADA system LAN by implementing the managed Ethernet network switches and VLANs.

STP Ethernet cables will be used between devices in a room or rooms that are within close vicinity from each other. Ethernet cable lengths should be limited to a maximum of 100 m between two devices. STP cables will be used on RS485 networks to establish communication with field equipment. Surge protection equipment will be installed on each RS485 bus network. RS485 cable length will be limited to 1000 m per segment.

The recommended interface solution for all SCADA system network and Building Management System (BMS) interfaces to external networks to allow for remote monitoring of signals depends on the selected interface solution during the next baseline of this project (both being viable solutions). The selected interface solution which the C&I designs are based on for this document include a radio link interface solution. This is because it would form the more complex technical solution compared to a fibre optical solution.

13.3.7 SCADA System Network

An optical fibre ring (topology) is the recommended LAN for the SCADA system network. The LAN will communicate using the Ethernet standard. The ring network will be single fault tolerant by making use of redundancy management protocols. The ring will form part of the core SCADA system network that enables data communication between the field equipment, SCADA system servers, and Human Machine Interface (HMI). Any fault in a single segment of the ring should not cause data communication failure between the control room and the plant. The core network will provide for full duplex communication.

Plant SCADA System

Each PV block (i.e.,1 MVA capacity) on the PV plant will contain a Plant SCADA system network panel that connects the various sub-systems of the block to the Plant SCADA system network. These sub-systems include:

- Central inverters;
- Auxiliary power (LV) and generator transformers (MV);
- Switchgear MCCBs and status indication relays;
- String combiner boxes; and,
- Weather stations.

The Plant SCADA system network panel will be installed inside a well-ventilated section of the inverter cabin. The O&M Building and Solar Plant Substation will each include a Plant SCADA system network panel that connects to the Plant SCADA system ring network. The panel will interface to:

- Switchgear MCCBs and status indication relays;
- Energy meters;
- Protection systems;
- BTUs; and,
- HVAC panel (at switchgear rooms).

According to the AC and DC SLDs developed as the reference design, the Plant SCADA system ring network will contain 16 nodes that comprise of the following plant areas:

- PV field (10 nodes);
- Plant central control room (O&M Building) (2 nodes);
- Server room (O&M Building) (2 nodes); and,
- Solar Plant Substation (2 nodes).

There will be one pair (2) of redundantly configured Plant SCADA system servers and one pair (2) of redundantly configured network switches that will be installed in the server room to store the Plant data, process the data, and present information to the Plant operators via the HMI of the operator systems. The master-slave redundant configuration is employed for the dual redundantly configured SCADA system servers located at the server room. Each SCADA system server will include a historian (i.e., database server) which will store all data for the lifespan of the Plant. The Plant is required to have a minimum of two (2) Plant Operators, therefore, two operator systems comprising thin client PCs will be required in the central control room. The Plant SCADA system software application will be installed onto the SCADA system servers for control and monitoring of all Plant equipment.

At an operational level, redundancy will be employed such that any failure of a server, or a thin client, or network switch should not result in loss of operations and monitoring of the entire Plant.

A common network switch will be installed in the SCADA system network cabinet of the server room for interfacing to systems such as:

- The SCADA system servers and thin clients;
- A GPS based, network time synchronisation system;
- The Plant SCADA system UPS at the Plant server room; and,
- A SCADA system network printer.

The SCADA system firewall, webserver, and VPN gateway is required for highly secured and stable connectivity of the Plant to the internet for remote monitoring.

13.3.8 SCADA System Servers

There will be one pair (2) of redundantly configured SCADA system servers[17]. The servers will operate as a primary-standby configuration. The standby server will continue full operation if the primary server fails to operate normally. A high speed (watchdog) interface will interconnect both servers to establish a dual redundant configuration. Each server machine of the redundant pair will include the following hardware:

- RAID configuration;
- Redundant power supplies with dual power input ports;
- 19” rack-mountable type enclosure;

[17] It is a design decision for the Contractor whether to implement a single shared system server for both the Plant and security SCADA systems, with appropriate virtualization or software-based separation, or to have an independent server system for each SCADA system (Plant and security). Regardless, a standby secondary server(s) will be required as backup.

On-board memory to continuously process and store all real time plant data for the lifespan of the plant; and,
- Removal media such as a Digital Versatile Disk (DVD) writer and front accessible Universal Serial Bus (USB) ports.

The dual redundant SCADA system servers will accomplish multiple functions that include:

- Hosting the latest Windows operating system, on which the SCADA servers and all workstations need to run;
- Hosting single SCADA system application software for operating and monitoring of all equipment;
- Hosting anti-virus software;
- Store all engineering logic and SCADA system network configuration settings;
- Processing of Plant data via the redundant information servers and storage of data onto the CPU database for the life of the Plant;
- Communicating to the thin clients for Plant operation and network configuration;
- Network configuration, logic development, mimic development, antivirus, and software updates;
- An OPC protocol software to communicate between multi-vendor systems on the Plant to remotely transmit data to the Eskom PDS in MWP via the PDS network at the Plant;
- Automatic copying of data from the CPU's built-in historian onto the removable media at pre-configured intervals; and,
- Saving of information, backing up of data onto removable media, closing all running applications, and shutting down the CPU in an automatic sequence after detecting the loss of the input power to the UPS system.

The operating system and application software versions will be confirmed during tender clarifications.

13.3.9 Operator System Thin Clients

There will be two (2) thin client machines for the operator HMI of the Plant SCADA system network. The thin clients will be configured such that each thin client can be used to operate and monitor the entire plant with full functionality. Both thin client machines will be configured to run simultaneously (i.e., 100% operational redundancy). Each thin client machine shall be powered by an independent separate power source.

Thin clients 1 and 2 will connect to the following HMI peripherals, respectively:

- 1 x thin client terminal, capable of connecting up to four (4) display monitors;
- 2 x 32" Liquid Crystal Display monitors (LCD);
- 1 x 50" LCD monitor;
- 1 x USB keyboard; and,
- 1 x USB mouse.

The two (2) thin client machines' hardware shall be installed on the Plant Operators desks in the central control room. The layout of the thin client machines' hardware must be ergonomically friendly to the end-user (Plant Operators).

Five (5) thin client licenses shall be issued to the Employer for use by the Plant Operators. These licenses shall allow remote users to access the Plant SCADA server from the central control room.

There will be two (2) thin client machines for the operator HMI of the security SCADA system network. The thin clients will be configured such that each thin client can be used to operate and monitor the security system with full functionality. Both thin client machines will be configured to run simultaneously (i.e., 100% operational redundancy). Each thin client machine shall be powered by an independent separate power source.

Thin clients 1 and 2 will connect to the following HMI peripherals, respectively:

- 1 x thin client terminal, capable of connecting up to four (4) display monitors;
- 2 x 32” Liquid Crystal Display monitors (LCD);
- 1 x 50” LCD monitor;
- 1 x USB keyboard; and,
- 1 x USB mouse.

The two (2) thin client machines’ hardware shall be installed on the security personnels’ desks in the security control room. The layout of the thin client machines’ hardware must be ergonomically friendly to the end-user (security personnel).

Four (4) thin client licenses shall be issued to the Employer for use by the security personnel. These licenses shall allow remote users to access the security SCADA server from the security control room.

The Contractor shall provide a backup solution for both the Plant and Security system and data backups.

13.3.10 Installation of Thin Clients

Thin clients will be installed at the server room. The thin clients will either be tower type or 19” rack type installed in the network cabinet. KVM (keyboard, video, and mouse) extenders will be required to extend the use of the peripherals between the thin clients at the server room and the HMI peripherals at the control room. The advantage of using KVM extenders is realised through the benefit of installing the thin clients inside a controlled environment. The disadvantage of this method is the additional cost for KVM extenders.

This is recommended in order to maintain a fixed operating temperature of the thin client machines. This ensures that the lifespan of the equipment will not deteriorate and that the control room temperatures can be adjustable to suit the security personnel and Plant operators needs respectively.

13.3.11 Network Switches

Industrial Ethernet network switches shall be installed to communicate between the multiple network nodes. Each switch shall include as a minimum:

- Managed type with Redundancy Management (RM) capability;
- Configuration via the respective SCADA system server and thin clients;
- Monitoring of the port connections, communication link status, bandwidth, and device health status indicating alarms and faults to the server and remote users;
- Compatibility with Simple Network Management Protocol version 3 (SNMP v3) and Internet Protocol version 6 (IPv6) or other acceptable protocols;
- Power supply from dual redundant power sources (230 Vac or 24 Vdc);
- Dual power input ports;
- Mounted on a Deutsche Industrie Norm (DIN) rail in SCADA system network panels (see Section 13.3.12), or, mounted on a 19” network cabinet for the switches located in the server room;
- Ingress Protection (IP) 20 rating as minimum;
- 20% spare network ports (rounded up);
- Wide operating temperature range for switches installed in extreme temperatures on site;
- Optical fibre and Ethernet ports;
- Auto negotiation; and,
- Auto crossover (MDIX).

13.3.12 Network Panels

One (1) SCADA system network panel will be installed inside each inverter cabin (for central inverters) or mounted adjacent on a suitable structure with an appropriate level of protection (direct sun exposure etc.) (for string inverters), and one (1) in the switchgear rooms of the substation buildings. The network panels will be IP54 rated.

The following equipment should be considered for installation inside each SCADA system network panel:

- A managed type network switch with Ethernet and optical fibre ports;
- Network protocol or medium convertors (e.g., RS485 to Ethernet);
- Digital or analogue input or output (I/O-Ethernet modules) to measure signals from the ambient air temperature and relative humidity sensors inside each network panel;
- An optional PLC with on-board I/O cards and protocol converters;
- Splice trays for fibre optic cables (located in a separate compartment of the network panel);
- Cable channels, terminal strips; and,
- 24 V DC DIN rail mounted power supply.

All electronic equipment installed inside the SCADA system network panels shall be suitable for continuous operations in an uncontrolled environment subjected to wide temperature ranges (i.e., between -40˚C to +65˚C).

The PLC will replace the dedicated I/O-Ethernet modules and protocol convertors. Each PLC will include an OPC client-server application to allow connectivity to multi-vendor systems.

Each network panel shall be designed such that the following equipment is physically segregated from each other within the panel:

- Electronic network equipment (switches, protocol or media convertors, I/O cards, PLCs, internal temperature sensors, etc.);
- Power supply and associated equipment (MCBs, SPDs, etc.); and,
- Splice trays and patch panels for optical fibre cabling.

13.3.13 Network Cabinets

13.3.13.1 Server Room

The SCADA system servers, thin clients, redundant network switches, and modular UPS units of the dedicated UPS system of the emergency power supply will be installed in 19” rack-type network cabinets. It is preferred that patch panels be mounted in separate network cabinets from the servers. The server room network cabinets will have the following characteristics:

- Network and power cabling will be bottom entry with clear separation of power and control/communication cabling. Cable entries shall be well managed and orderly for ease of O&M and cable identification;
- Cables and cable trays shall be clearly identified at both ends with a robust cable identification tag that carries the cable/tray number per the agreed identification system. Numbers shall be unique across the Plant and follow the AKZ or KKS system (to be confirmed at a later stage);
- Grommets will be installed where panels are cut for communication and power cable entry;
- Internal cable channels or traces to neatly route cables inside the cabinet (internal cable management system for both horizontal and vertical cables);
- Removable blanking panels on all unused slots or sections;
- No open spaces between the slots and sides of the rack enclosure for correct air flow management;
- Cabinets to be vermin and insect proof;
- Free space of approximately 200 mm to allow air circulation around cables in the rear;
- Perforated front and rear door panels and side panels to allow circulation of air;
- Flexible brushes to be used to prevent air leakage via cable entries or cut-out;
- Include 19” racks and DIN rails to mount equipment;
- Removable front and rear door panels;
- Doors with manual locking mechanism and automatic open/close detection;
- Internal lights for illumination;
- IP 20 rating or one suitable for the environmental conditions;

- 20% uninstalled space on the racks and DIN slots to install spare equipment;
- Internal air temperature and relative humidity sensors monitored and alarmed on the network cabinet (local) and at the BMS HMI. Internal temperature to be controlled at 22 ˚C ± 2 ˚C; and,
- Suction and extraction fans for forced air circulation.

As far as possible, all connectors on rack mounted components must be rear facing in the cabinet for easier cable management.

The server room shall have an automatic fire suppression system installed.

13.3.13.2 Uncontrolled Environments

For those network cabinets installed out in uncontrolled environments, the following requirements shall apply:

- IP rating suitable for the given environmental conditions network cabinet shall be subjected to, with due consideration given to extreme conditions;
- Cabinets and all mechanical components shall be sufficiently corrosive resistant;
- UV rating suitable for the given environmental conditions network cabinet shall be subjected to, with due consideration given to extreme conditions;
- Network and power cabling will be bottom entry with clear separation of power and control/communication cabling. Cable entries shall be well managed and orderly for ease of O&M and cable identification;
- Internal cable channels or traces to neatly route cables inside the cabinet (internal cable management system for both horizontal and vertical cables);
- Doors with manual locking mechanism and automatic open/close detection; and,
- Cabinets to be vermin and insect proof.

13.3.14 SCADA System functions

The SCADA system functions shall include the following:

- Monitor and control of every local electrical equipment;
- Interface with PPC system / Power Plant Control (Plant SCADA only);
- Ancillary services and Automatic Generation Control (if required);
- HMI interface;
- Central historical logging;
- Open Data Exchange (including full remote access);
- Interface with Grid Operator system for remote monitoring and load dispatch;
- The local data acquisition and controls (SCADA) system uses standard, proven, and open protocols: Modbus, DNP3, SANS 61850-7, SANS 60870-5-101/104, and OPC;
- The SCADA system must provide open port, e.g., Modbus TCP/IP, for collecting site data from third party data-loggers;
- All licenses required to operate the system for the duration of the 25 years Plant lifetime;
- Easy WEB access to the SCADA system from any PC, Mac, smartphone, or tablet;
- Safe connection at least via https;
- SANS 61724-1 compliant (Photovoltaic system performance – Part 1: Monitoring);
- Utility integration: the system acquires and makes available the data required by the local utility (i.e., System Operator) and is compliant to the local grid interconnection requirements.
- Asset Management systems integration (cloud platforms): the system can exchange data virtually and on any Cloud platform, Employer's Central SCADA system, or DIST Control Centre without extra costs;
- Situational awareness: the system provides an easy overview of the main KPIs and the status of all the elements of the Plant;
- Automatic report generation: the system generates automatic production reports avoiding repetitive tasks;

- Remote desktop control software, such as Teamviewer or Anydesk, installed on a local computer;
- Dedicated software accessible from the Wide Area Network (WAN); and,
- Dedicated VPN;.

13.3.15 Commands Requirements

The SCADA system shall allow central and remote automatic and manual control.

Off-site remote shall only be through the DIST NSP interface gateway for specific remote-control functions as required by the Grid Code.

To ensure safe working conditions in the Plant, it must be possible to set, by a Plant Operator from the Plant SCADA system HMI, Plant equipment in ‘service mode’ in case of maintenance activities in the Plant or in the electrical substations. This action shall disable the remote controlling of the respective electrical equipment in the Plant. (This service shall not replace a PTW or trapped key interlock system).

All electrical equipment shall comply with the command requirements of Eskom Standard for Air-Insulated Withdrawable AC Metal-Enclosed Switchgear and Control Gear for Rated Voltages above 1kV up to and including 52kV (240-56227573).

The Plant SCADA system shall be able to set the tracker tilt angle to predefined set points (if a tracker mounting structure is used). Rejection of invalid commands and set points must be communicated clearly to the operator.

All commands and set points activation must be stored in the event log with information on the Plant operator who activated the command and set point.

Remote control function shall be protected by a password in the central monitoring system.

The Plant SCADA system and PPC system shall allow for automatic start-up of the PV Plant after a grid failure or downtime. This shall be performed by internal functionality and backup power sources.

Every command will be tested during the implementation and the commissioning of the SCADA system.

The following commands shall be checked and respected by the SCADA system (as applicable to the two separate SCADA systems):

- It must not be possible to exceed min/max limits when entering new parameters;
- When commanding, interlocking (local/remote switch) functions must be respected;
- When the PPC system is in local mode, remote commands must be rejected;
- The following commands and set points must be available for the entire Plant:
  - Set points according to the Grid Code;
- The following commands and set points must be available for the Plant’s controller:
  - Points for active power, reactive power, power factor, voltage, frequency, and ramp control; and,
  - Close circuit-breakers and disconnectors of the electrical substation.
- All commands and set points require confirmation from the Plant Operator (both remote and local) before activation;
- The Plant SCADA system shall provide at least the following control capabilities:
  - Enable/disable inverter operation of any individual unit or of all units;
  - Set inverter real power limit;
  - Set Plant active / reactive power control;
  - Set Plant power factor;
  - Set Plant ramp control;

  - Set Plant frequency control;
  - Set Plant voltage control;
  - Emergency disconnection;
  - Ancillary services; and,
  - Automatic Generation Control.

13.3.16 Monitoring System

13.3.16.1 Data Acquisition

The monitoring system shall acquire data from:

- Meteorological station;
- Soiling station;
- Inverters;
- Trackers (if applicable);
- String combiner boxes (if applicable);
- Transformers;
- MV switchgear;
- Fiscal meters and accredited meters;
- Contacts from auxiliary equipment;
- Fire Detection equipment;
- UPS system;
- PLCs;
- Plant substations SCADA elements;
- Plant protection and control system; and,
- Security system.

Data shall be acquired and recorded at least with the following time steps as minimum requirement and the record time interval shall be adjustable and shall be decided during the project detail engineering stage:

- The main AC meter data shall be recorded at one (1) minute intervals;
- DC meter data shall be recorded at one (1) minute intervals;
- Inverter data and fault codes shall be recorded at one (1) minute intervals; and,
- Environmental data shall be recorded at one (1) minute intervals.

The parameters to be monitored shall be agreed at a later stage during the detail engineering phase without cost impacts to the Employer. As a minimum the signals included in the list below shall be gathered by the monitoring system:

- Fiscal meters and accredited meters
  - Active energy; kWh
  - Reactive energy; kVArh
  - Active Power; kW
  - Reactive Power; kVAr
  - Voltage L1, L2, L3; V
  - Voltage L12, L23, L31; V
  - Current phase L1, L2, L3; A
  - Frequency; Hz
  - THD-R current L1, L2, L3; %
  - THD-R voltage L1, L2, L3; and, %
  - Power factor. Lag/Lead
- Plant protection and control system
  - Active energy; kWh

- Reactive energy; kVArh
- Active Power; kW
- Reactive Power; kVAr
- Grid voltage L1, L2, L3; V
- Grid voltage L12, L23, L31; V
- Current phase L1, L2, L3 at the POC to the grid; A
- Grid frequency (Hz); Hz
- Over/Under Voltage trip;
- Over/Under Frequency trip;
- Voltage unbalance trip;
- Vector shift protection trip;
- Rate of change of frequency protection trip;
- Trip due to directional overcurrent limit;
- Neutral voltage displacement trip;
- Earth fault current limit trip;
- Ground surge time-overcurrent protection trip;
- Overcurrent limit trip;
- Time-overcurrent protection trip;
- Current unbalance trip;
- Capacitive/Inductive PF limit protection trip;
- Trip due to reaching the No AC Reclose limit;
- Low Backup battery;
- Over or undervoltage of the power supply;
- Phase sequence is correct/opposite with antiphase; and,
- Remote / manual opening of CB.

- Inverters
  - DC Current (total and per phase per inverter module); A
  - DC Voltage; V
  - DC Power; kW
  - DC Power (1m); kW
  - AC Current; A
  - AC Current L1, L2, L3; A
  - AC Voltage; V
  - AC Voltage L1, L2, L3; V
  - AC Voltage L12, L23, L31; V
  - AC Power; kW
  - AC Power (1m); kW
  - AC Power L1, L2, L3; kW
  - AC Reactive Power; kVAr
  - AC Apparent Power; kVA
  - AC Frequency; Hz
  - AC Power factor;
  - Operating hours; h
  - Insulation Resistance DC; Ohm
  - Inverter internal and main component temperature; °C
  - Inverter Status / Alarms;
  - Temperature protection activation;
  - Inverters On/Off switch indication and activation;
  - DC/AC fuse status, if possible;

  - Inverter internal failure – error code;
  - Ground fault protection;
  - Humidity control;
  - Emergency stop;
  - General AC & DC protection & disconnection;
  - Module AC & DC protection & disconnection;
  - Overvoltage protection; and,
  - Lightning protection.
- DC String Combiner Boxes (if applicable)
  - String Current (per string) ; A
  - Total output current; A
  - Total output voltage; V
  - Total output power at the boxes; kW
  - Internal enclosure Temperature (if available); °C
  - DC fuses status, if available; and,
  - SPD status, if available.
- Weather Station & Soiling Station
  - Global horizontal Irradiance; W/m^2
  - Plane of Array Irradiance; W/m^2
  - Ambient temperature; °C
  - Photovoltaic module temperature ; °C
  - Wind speed; m/s
  - Wind direction; grades
  - Humidity; %
  - Precipitation quantity; mm
  - Precipitation type; Rain/Snow
  - Hailstorm sizes; mm
  - Ambient air pressure; hPa
  - Maximum power of soiled and cleaned reference module; W
  - Short-circuit of soiled and cleaned reference module; and, A
  - Temperatures of soiled and cleaned reference module, if available. °C
- Transformers
  - Winding temperature; °C
  - Oil temperature; °C
  - Internal enclosure temperature (above transformer), if available; °C
  - Buchholz relay status;
  - Over oil temperature (1st set); °C
  - Trip max. oil temperature (2nd set); °C
  - Oil level;
  - Winding temperature; °C
  - Gas pressure; and, Pa
  - Pressure relief valve.
- Switchgears / RMU
  - Internal enclosure temperature, if available; °C
  - Circuit Breaker status – OPEN/CLOSED;
  - Gas[18] level low alarm;
  - External trip signal from transformer; and,

[18] SF6-free gas for MV secondary distribution equipment.

  - Spring fail-to-charge alarms.
- UPS system
  - Battery level; V / Ah
  - Battery temperature; °C
  - Battery level status;
  - Battery temperature status; and,
  - Failure alarms.
- Electrical components and other signals and parameters
  - Emergency stop status;
  - Surge arrester status;
  - Circuit breaker status;
  - Switch status;
  - SPD status;
  - Enclosure dehumidifier station status;
  - Enclosure heater station status; and,
  - Enclosure fan station status.

The monitoring system shall be able to periodically send these files to an external system. In case of hyper vision, the period of sending can be once a day.

- At least one FTP server for Employer services (external system);
- An e-mail with standardized subject and content and an attached file; and,
- SFTP server

13.3.16.2 Calculated Points
The monitoring system shall generate calculated data points that show new values based on the values of any monitored or calculated data points. Calculated data points shall be available for alarming and trending.

13.3.16.3 Real-Time Supervision
The monitoring system shall allow the user to monitor and supervise the equipment of the Plant by the means of diagrams or graphs in real time.

Alarms shall arise when they happen in order to allow for corrective actions.

The monitoring system should include tools to allow for queries and to generate reports that help the Plant Operator to evaluate the performance of the Plant.

The system shall manage all alarms generated by field equipment, sort them by sequence of events with a time stamp and alarm severity and show them to the Operator.

The CPU and memory loading of the monitoring system shall not be greater than 60% of its capacity.

The card slots in cabinets shall be in accordance with the total number of I/O signals required, plus 20% of the installed spare signals accommodated, plus 15% of the slots for additional cards.

13.3.16.4 Historians
The monitoring (and control) system shall allow data storing by means of the long-term data servers via the RAID station installed in the SCADA system server rack. The servers shall be capable of storing and reporting data points at intervals of one (1) minute for the first three (3) years, every five (5) minutes subsequently up to the first 10 years and every 15 minutes for the remaining duration until the end of Plant operation. Data to be accessible by Employer Head Office following discussion with Contractor.

13.3.16.5 SCADA System HMI
The Plant SCADA system HMI shall have at least the following views and screens:

- Overview based on the Plant layout;
- SLD (entire electrical reticulation);
- SCADA Network Line Diagram;
- Device detail: the Operator shall be able to access every device (inverter, string, combiner box, tracker, weather station, monitoring and control, etc.) on a separate screen. Every device's screen shall show alarms, operating parameters, control functions, status, etc.;
- Auxiliary and ancillary systems (fire detection and alarm detection. HVAC, water and sewage systems etc.);
- Inverter summary: it shall include operating status, operating parameters, power factor, alarms, alerts, AC voltage and current, DC voltage and current, etc.;
- Communication status: it shall indicate the communication status of every device;
- Alarms: it shall provide an alarm list showing status and acknowledgment;
- Alarm configuration. The Operator shall be able to set thresholds for alarms on any monitored data point, alarm level, and notification options;
- Alarm triggering: it shall trigger alarms based on alarm threshold exceedance e.g., water levels, and provide recommended mitigation actions to be taken. A mechanism shall be included to suppress a nuisance alarm for a temporary period;
- Performance: it shall show the available solar resource, project output, performance ratio, and comparison of actual to expected output. The performance screens shall allow viewing for a single day, past week, past month, month to date, past 24 months, and year to date performance summaries;
- Trending: The user shall be able to configure and graph all monitored data over relevant time frames at a minimum of five (5) second interval. The Plant SCADA system shall allow users to save trend screens for future re-use. Each parameter shall be clearly distinguishable with different colours;
- System view: only accessible via administrator role to allow programming or any other system modification; and,
- Customized development of the Plant SCADA system HMI GUI will be conducted through a minimum of five (5) full-day workshop engagement sessions between the Contractor and the Employer prior to acceptance of the GUI.

The security SCADA system HMI shall have at least the following views and screens:

- Overview of key focus points such as the security perimeter fence and substations showing all CCTV cameras;
- Communication status: it shall indicate the communication status of the CCTV cameras and IDS on site;
- Alarms: it shall provide an alarm list showing status and acknowledgment;
- Alarm configuration. The Operator shall be able to set thresholds for alarms on any monitored data point, alarm level, and notification options;
- Alarm triggering: it shall trigger alarms based on alarm threshold exceedance e.g., water levels, and provide recommended mitigation actions to be taken. A mechanism shall be included to suppress a nuisance alarm for a temporary period;
- Security SCADA system network line diagram;
- Performance: it shall a non-looping live feed with no interruptions from the CCTV cameras.
- System view: only accessible via administrator role to allow programming or any other system modification; and,
- Customized development of the security SCADA system HMI GUI will be conducted through a minimum of one (1) full-day workshop engagement sessions between the Contractor and the Employer prior to acceptance of the GUI. This shall take place subsequent to the development of the Plant SCADA system.

The HMI GUI will conform to proven and best industry practices for utility scale PV SCADA systems, and shall adhere to the Eskom Human Machine Interface Design Requirements Standard (240-56355728) with respect to the following:

- Alphanumeric characters;
- Numeric data;
- Abbreviations and acronyms;
- Labels;
- Icons and symbols;
- Colours for HMI graphics;
- Cursors;
- HMI graphics;
- Menus;
- Windows; and,
- Errors.

13.3.16.6 Security

The monitoring system shall be protected from undesired and malicious access by means of a firewall, antivirus software, and a complete role management. The remote control function shall be protected by a hard key or dongle in the SCADA system. Adequate interlocks shall be provided to prevent unsafe operation of the Plant while (O&M) personnel are working on the equipment.

Parameterization and configuration modification can only be done by authorized users, accessed using passwords.

All security measures shall be in compliance with the applicable Standards, including Eskom (governance) requirements and Standards, relating to IT and OT systems.

13.3.17 Response Times

All control, instrumentation, and control hardware and software shall be required to achieve the following response times:

- The response time for Command outputs (running time command from the HMI up to signal change at the Field Device) must not exceed 2 s;
- The response time for updating of variables in HMI displays (running time of signal from signal change on the Field Device up to change of the appropriate variables on the video display) must not exceed 2 s;
- The maximum time taken to completely populate an HMI graphic with dynamic data shall not exceed 2 s;
- The average time taken to completely populate any HMI graphic with dynamic data shall be less than 1 s;
- The maximum time taken to completely populate a trend with dynamic data shall not exceed 3 s; and,
- The average time taken to completely populate any trend with dynamic data shall be less than 1.5 s.

13.3.18 Reports

The SCADA system shall record and report all necessary operational details obtained and process data into information for the warranty agreements.

The software provided shall be capable of undertaking the warranty calculations and providing daily/monthly/yearly operations and management reports to an agreed format.

The Plant SCADA system shall be capable of producing reports for evaluation of Availability and analysis of the Performance Ratio. It shall be capable of providing supporting data as required for O&M reporting. The Performance Ratio shall be calculated and created for any user selectable date range, irradiance range, and active power range. The Performance Ratio and Availability calculation shall be done according to the contractual formula as defined in the (EPC and O&M) Contract. Additionally, calculations shall be made on definitions that are generic, transparent, unambiguous, and based on realistic measurements. All records of inverters in the historical data (5 minutes data) shall be recorded and assigned to the required categories as defined in the contracts. The Availability shall be calculated over any time period (although typically one (1) year).

The Plant SCADA system HMI must provide a tool for generating the Performance Ratio for the inverters and Plant.

Summary analysis reports for daily/monthly/yearly or other defined time periods shall be automatically produced in an agreed format. They should be produced on demand or automatically at set times. They should provide extensive analysis and viewing functions for statistical and event data.

13.3.19 Documentation

The SCADA system shall be supplied with comprehensive, complete, and up-to-date documentation relevant to all the hardware and software supplied (documents in PDF format, in modifiable format, and USB flash drive for software installed).

This will include at a minimum:

- A comprehensive user manual explaining the operation and use of all hardware and functions (installation, operation, and maintenance manual);
- A complete electrical wiring diagram showing connections to the controller and the communications links;
- System architecture layout, detailing the port used in each device, colour topology according to the protocol of each network communication, types of protocols used, IP address of the machines, type of connector in the end of the connections, and model of each;
- Functional drawing for every panel and cabinet;
- Location of all the accessories;
- Data sheet of each equipment and device;
- Lists of signals for each communication channel (variables of the Plant and of electrical substation, list of signals available for the Control Centres (Plant and security) of the Employer);
- Quality control, installation, and commissioning documentation including detailed test procedures;
- List of licences provided by the Contractor; and,
- List of passwords issued to the Employer.

Manuals regarding the maintenance of equipment shall be supplied in English.

13.3.20 Contractor main point of contact

The Contractor must designate a contact person for the Employer who will take responsibility for every request about the SCADA system and be the person in charge for every security event relevant to the Employer as well.

13.3.21 Incident Handling

The Contractor must implement an incident handling policy to determine:

- What actions to take when an incident is detected;
- Whom to alert;
- Who should coordinate crisis management actions; and,
- What initial steps should be taken.

The Contractor must also complete a post-incident analysis to determine the source of the incident, whether it can spread to other parts of the system, and how to improve the SCADA system's overall (cyber) security.

13.3.22 Hardening Workstations

SCADA system workstations must be hardened to reduce the scope for attack:

- Unnecessary or unused physical ports (hardware) (debugging interfaces, USB ports, Ethernet interfaces, etc.) shall be deactivated;
- Unnecessary or unused services, functionality, and software (Telnet, FTP, service discovery, network services, development tools, etc.) must be deactivated and, if possible, uninstalled;
- All access must be protected by, at a minimum, a hardened password (as applicable) and must be restricted to the authorized persons;
- Anti-virus software must be installed; frequent updates shall be done in a controlled manner without direct access to the internet. Centralized monitoring and logging are required;
- The security flaws which are discovered and available security corrections must be provided to the Employer through the dedicated contact person;
- The services and applications must be executed with the minimum necessary privileges (for example, not under an administrator account); and,
- Compliance shall be in accordance with the Eskom cyber security Standards and an assessment report after the installation shall be provided.

The Contractor must create white lists of authorized applications to prevent the use of unauthorized software. If not, it must specify what other steps it will take to detect unauthorized software use.

13.3.23 Data Backup

Full data back-up facilities shall be provided. To eliminate the impact of a physical incident (theft, fire, etc.), the backup system must be stored off-site at a location which shall be accepted by Eskom's IT Department.

An automatic backup system shall be provided with the SCADA system. Files and directories to be saved shall be listed and documented. A clear separation between database and the executable programs would be advantageous.

A procedure for a manual backup and to modify the configuration of the backup shall be provided by the Contractor to the Employer.

A recovery procedure shall be provided to fix the SCADA system database in case of corruption.

The copies of backup must be retained at minimum for a period of five (5) years.

13.4 Monitoring and Control System External Interfaces

The monitoring and control system shall allow external interfaces with third parties as necessary via redundant links. Some third party system as envisaged is listed below; however, it is the Contractor's responsibility to ensure the interfaces satisfy the specific requirements for this project and comply with Eskom's requirements/Standards:

- Interface to the Plant substation(s)[19] control and monitoring system;
- Interface with the electricity metering system; and,
- Interface with the Plant office LAN system and other control and surveillance systems (such as fire detection system and security system).

[19] Solar Plant Substation and Switching Station Substation.

The system shall be secure such that security breaches of the Plant's monitoring and control system do not influence the Grid Operator's system and the Employer's existing systems to which the Plant interfaces.

13.4.1 Inverters

Inverters include their own built-in control and protection system. The on-site Plant SCADA system will interface to the inverter control system to monitor data in real time. Open/close commands will be sent from the Plant SCADA system thin clients to start/stop the inverters from the central control room.

13.4.2 DC String Combiner Boxes

DC string combiner boxes used in solar PV plants combine multiple parallel strings from the PV array. The combined DC power from the string combiner box is supplied over a single DC cable to an inverter, or a second combiner box. Intelligent DC string combiner boxes shall be installed with measurement and data communication capabilities to monitor individual string current, average DC voltage, isolation switch status, and the internal temperature of the box.

13.4.3 Switchgear

MV switchgear panels at the inverter cabins, the Plant switchgear rooms (in substation buildings), and at the Point of Utility Connection (PUC) will be controlled using vacuum circuit breakers as per Eskom Standard 240-56227573. The Plant SCADA system will interface to the switchgear panel to monitor the status of the MCCBs. Commands to open/close each MCCB will be initiated via the Plant SCADA system at the central control room. The switchgear panel will include 24 V DC interposing relays to allow the Plant SCADA system to interface using digital I/O cards with potential free terminals. This method is commonly known as hardwiring.

Emergency or protection stop/trip signals will be hardwired from the push button switch directly to the switchgear breaker. No emergency or protection trip/stop commands shall be communicated to the switchgear via the Plant SCADA system network.

13.4.4 Energy Meters

The Contractor shall provide, install, and commission at minimum the following energy meters for measuring the Plant's performance:

- One (1) bulk energy meter for each PV block feeder supply;
- One (1) bulk energy meter and one (1) check energy meter prior to each HV/MV transformer located at the Point of Generator Connection (PGC) at the Plant Solar Substation;
- One (1) bulk meter and one (1) check meter located at the Point of Connection (POC) for handover to the Grid Operator to be used for billing purposes; and,
- One (1) bulk meter and one (1) check meter located at the Point of Connection (POC) for use by the Employer in calculating Plant Performance Ratio and Availability.

All energy meters which are installed at the Plant, PGC, and POC are required to interface with, and communicate data to, the on-site Plant SCADA system, which shall include the Energy Metering and Data Acquisition System (EMDAS), *except* for the two energy meters (one bulk meter and one check meter) at the POC which are to be handed over to the Grid Operator to be used for billing purposes.

All meters installed shall provide tariff metering, bi-directional energy measurements, and power quality measurements. The meters procured must adhere to the Eskom List of Approved Electronic Devices to be used on Eskom Power Stations Standard (240-56227589). All meters shall comply to the Eskom Standard for Metering and Measurement Systems for Power Stations in Generation (240-56359083).

The two (2) non-Grid Operator energy meters located at the POC shall each include at least two (2) spare Ethernet ports for direct connection to a laptop and for future integration to the Power Station.

For standardization purposes, the same type of meters should be used at the POC and in the PV Plant.

There is a project aimed at installing a dedicated stand-alone EMDAS system at Eskom’s generating plants. This will be applicable to Lethabo Power Station. The energy meters at the Plant should allow for an interface to EMDAS and the Plant SCADA system. The purpose of EMDAS is to ensure that accurate, reliable and auditable metering data is stored, archived, and provided to the Plant and Eskom as a whole. The energy meters must have bus interface capabilities using open published communication protocols such as Modbus, DLMS COSEM, or DP. To access EMDAS, the meters will be connected to the nearest secure network point through an Ethernet cable. The two Grid Operator meters at the POC shall form part of the Grid Operator’s own EMDAS separate to the Plant’s SCADA system.

13.4.5 Building Management System

As part of the C&I scope of work, the BMS is a standalone network system that monitors and controls the balance of plant services such as fire detection and HVAC systems. The BMS network shall consist of the following equipment:

1. BMS server

   The BMS server will comply with the requirements as specified in section 13.3.8.

2. BMS network switch

   The BMS network switch will comply with requirements as specified in section 13.3.11.

3. BMS network cabinet

   The BMS network cabinet to comply with the requirements as specified in section 13.3.13.

4. BMS thin client

   The BMS thin client to comply with the requirements as specified in section 13.3.9. The BMS thin client will include 2 x 32” LCD monitors.

5. Datalogger/IO/PLC

   The datalogger will be used to monitor the temperature sensors of the network cabinets and the level sensors of the potable water and sewage tanks.

The Plant BMS network will connect to the following systems:

13.4.5.1 Fire Detection System

A Fire Detection System (FDS) shall be installed as part of the Plant. The FDS is required to be monitored at the central control room.

A detailed fire risk assessment shall be conducted by the Contractor to determine the type and number of sensors, warning indicators, and fire panels that will be required prior to the design of the FDS.

The Plant O&M building, substation buildings, and all inverter cabins require monitoring and alarming as part of the FDS. Real time data and alarms of the FDS shall be monitored and stored.

The number of fire panels required will be dependent on the design layout of the Plant. The master fire panel will be installed inside the Plant server room in the O&M building. Communication between fire panels will be via optical fibre if multiple fire panels are required to be installed on the Plant. Each fire panel is required to have an on-board display and siren for local monitoring and alarms. Each fire panel is required to be monitored at the central control room via a local BMS HMI. The fire panels shall be powered from a highly available auxiliary power source. The fire panels will include an internal back-up power supply with a battery, with a required 2 hour back-up period.

The design and installation of the FDS will be carried out by a company that is registered by SAQCC and the FDIA.

Due to the Plant Operators not working on a 24 h basis, an interface is required to alert emergency firefighting services in the event of a fire.

For more information on the firefighting and fire protection system requirements for the Plant, please refer to section 11.3.

13.4.5.2 HVAC System

The indoor conditions and areas to be provided with HVAC equipment as part of the Plant HVAC system shall include the following (Table 6). All HVAC systems and equipment shall comply with the Eskom Design Guideline for HVAC in the Eskom Coal Fired Power Stations (240-70164623) and the General Technical Specification for HVAC Systems Standard (240-102547991).

Table 6: Indoor conditions and areas to be provided with HVAC equipment

Area/Building	Indoor Temperatures	Relative Humidity
1. Central Control room	22°C±2°C	50% ± 10%
2. Security Control room	22°C±2°C	50% ± 10%
3. O&M Server Room	20°C±2°C	45% ± 5%
4. Warehouse (Spare Parts/ Workshop)	6°C above ambient	Not Controlled
5. Sanitary and restroom facilities	6°C above ambient	Not Controlled
6. Switchgear rooms (incl. substation buildings)	22°C±2°C	75% max, no condensation
7. Offices	22°C±2°C	Relative humidity to be controlled in accordance with ASHRAE 55: Thermal Environmental Conditions for Human Occupancy
8. Meeting/conference room	22°C±2°C	Not Controlled
9. Kitchenette	6°C above ambient	Not Controlled
10. Reception Area	6°C above ambient	Not Controlled
11. General purpose storage space(s)	6°C above ambient	Not Controlled
12. Engineers/technician's room	22°C±2°C	Not Controlled

The HVAC control system is required to be monitored at the Plant central control room via a **dedicated** BMS HMI. Data and alarms of the HVAC control system will be monitored and stored. Typical parameters include:

- System fault;
- Air flow;
- Pressure;
- Temperature; and
- Humidity.

In the event of a fire, the Plant BMS will command the HVAC control system to close the fire dampers to contain the fire and smoke.

The master HVAC panel will be installed inside the Plant server room in the O&M building and interface with the other HVAC panels and the BMS server on-Site.

System Description:

The central and security control rooms are to be serviced by two (2) off-dedicated direct expansion split units complete with an evaporator and matching air-cooled condensing units. The cooling and heating plant is based on air-cooled outdoor units which are connected to an indoor unit via a single refrigerant circuit, comprising suction and liquid refrigerant pipework. Both the indoor and outdoor units are inverter type units which provide space cooling or heating depending on the individual space requirements.

The O&M server room will be equipped with running and standby under ceiling type indoor units together with air-cooled outdoor units. The HVAC equipment will be configured to operate on running and standby mode for redundancy, including automatic change-over between the units in case of failure of any one unit, and at pre-set intervals to allow equal running time between the units.

The switchgear rooms are to be serviced by two (2) off-ducted direct expansion air handling units together with matching air-cooled condensing units. The air handling units will be supplied complete with cooling and pressurisation functions. The filtration system will be supplied complete with a fresh air primary filter of 92% average gravimetric efficiency and return air filtration of 85% dust spot efficiency.

The switchgear rooms and server room HVAC systems will be configured to operate on running and standby mode for redundancy, including automatic change over between the units in case of failure of any one unit and will be set at pre-set intervals to allow equal running time between the units. The units will have a cooling-only mode of operation and will provide cooling 24 hours a day, seven days a week throughout the year.

The HVAC units will be controlled by wall mounted controllers which allow the occupants to set the room temperature, fan speed, and turn the units on and off. The room temperatures will be sensed at a wall-mounted thermostat which will automatically adjust its cooling or heating to maintain the room set point. The switchgear rooms and server room HVAC systems will be programmed such that the controller automatically starts the standby unit, should the temperatures within the respective rooms rise above 26 °C, or should a fault occur on the running unit.

Outdoor filtered air is to be provided by means of fresh units which are connected to an external insulated galvanized sheet metal ductwork. Air is to be introduced into the space by means of Constant Air Volume (CAV) diffusers/grilles.

Sanitary and restroom facilities and the warehouse (spare parts/workshop) ventilation is to be provided by a ducted extraction system and window extractor fans. This discharges contaminated air to the outside and supplies make-up air from the surrounding areas via door grilles.

13.4.5.3 Water System

The potable water supply for the O&M building shall consist of a holding tank of at least 7500 litres capacity. As a minimum, the tank's design should meet the following requirements:

- The tank must be constructed and designed in accordance with the information contained within SANS 10400-P:2010 standard;
- The tank must be designed such that all requirements of the Occupational Health and Safety Act (Act No. 85 of 1993) and its regulations are adhered to;
- The tank must be watertight at all times and must not allow for any storm water inflow. The tank must be constructed of materials which are not susceptible to excessive corrosion. The interior must be plastered with a waterproof material; and,
- Adequate water supply must always be available for use with a water connection point available within the vicinity of the tank;

The potable water supply for the O&M building shall be supplied through a connection to the Lethabo Power Station's potable water system/infrastructure, with a meter installed to record the water usage.

A separate non-potable water supply will be used for the washing of the PV modules, which shall be subject to confirmation post Project award but prior to Contract signature. An appropriate water treatment mechanism, subject to approval by the PV module OEM, shall be used to treat the water prior to use with the PV modules.

<u>Monitoring:</u>

The potable water holding tank shall include an appropriate monitoring mechanism, such as continuous level sensors monitored at the Plant BMS. The level sensors shall interface to a PLC / I/O installed inside the BMS network cabinet for control purposes. The BMS cabinet shall also be used to control the associated pumping and infrastructure facilities relating to the holding tank and O&M building water supply. If water is used from a local water infrastructure supply point (as opposed to a borehole), a meter shall be installed to measure the water usage. This applies to all water use purposes and applications.

A rainwater harvesting system shall be implemented at the O&M building to help supply the ablution requirement of the Operator. Where this is not reasonably practicable, the rainwater harvesting system shall be used to supplement another form of water supply required for the Plant.

13.4.5.4 Sewage System

Sewage disposal and its reticulation system is to consist of a sewage conservancy tank[20] of at least 5000 litres capacity that is embedded in the ground and sized for at least one month retention time for 6 staff working a 12-hour shift on site. As a minimum, the tank's design should meet the following requirements:

- The tank must be constructed and designed in accordance with the information contained within SANS 10400-P:2010 standard;
- The tank must be designed such that all requirements of the Occupational Health and Safety Act (Act No. 85 of 1993) and its regulations are adhered to;
- The inlet must be designed such that blockage by the scum layer is prevented;
- The depth of the tank must be designed in line with acceptable standards;
- The tank must be designed with two compartments to allow for periodic desludging. The tank must be easily accessible;
- The tank must be watertight at all times and must not allow for any storm water inflow. The tank must be constructed of materials which are not susceptible to excessive corrosion. The interior must be plastered with a waterproof material; and,
- Adequate water supply must always be available for use with a water connection point available within the vicinity of the tank.

Monitoring:

The sewage conservancy tank shall include appropriate monitoring mechanisms, such as continuous level sensors monitored at the Plant BMS. The level sensors should interface to a PLC / I/O installed inside the BMS network cabinet. Weekly scheduled level checks of the conservancy tank shall be conducted to monitor the capacity level. If water is used from a local water infrastructure supply point, a meter will need to be installed to measure the water usage.

A warning system with an audible alarm must be installed in order to prevent the discharge of raw sewage to the environment and protect the public health by preventing backup of sewage and subsequent discharge. This alarm must be triggered at 80% capacity in order to give sufficient warning to the onsite personnel. This will give sufficient time to arrange for removal.

Reticulation:

The sewage conservancy tank must be linked with pipes from the kitchenette and toilets in the O&M building. The kitchenette waste must pass through a grease trap before entering the drain. This grease trap requires regular cleaning and maintenance that must not be neglected.

Location and accessibility:

The sewage conservancy tank must be situated where it is accessible to vacuum tankers for sludge and scum removal, noting that no erection of any building is permitted over the tank.

The installation of field equipment for the potable water and sewage treatment systems shall comply to the following Eskom Standards:

- Pressure Measurement Systems Installation Standard (240-56355843);
- Flow Measurement Systems Installation Standard (240-56355789);

[20] The sewage conservancy tank shall comply with any applicable municipal by-laws regarding the (registration of a) sewage tank.

- Requirements for Control and Power Cables for Power Stations Standard (240-56227443);
- Field Instrument Installation Standard: Junction Boxes and Cable Termination (240-56355815);
- Field Instrument Installation Standard (240-56355754);
- Instrument Piping for Coal Fired Power Plants Standards (240-89147446);
- Standard for Welding Requirements on Eskom Plant (240-206628253); and,
- Power Plant C&I Level of Automation Guideline (240-129686484).

13.4.5.5 Public Address system

A public address (PA) system shall be installed as part of the Project for emergencies, evacuation and announcements made from the central control room and security control room.

The PA system amplifier and control station shall comprise of one (1) dedicated cabinet at the central control room and one (1) dedicated cabinet at the security control room.

The PA system shall use Voice over Internet Protocol (VoIP) communication protocol. Optical fibre cable to be installed as the interface media. Audio signal will be converted to VoIP or Audio over Fibre at the respective control room and converted back to audio in the PV Plant field.

The PA system shall meet and comply with the Eskom Emergency Preparedness Public Address System Standard (240-64720986), Eskom Standard for Security Public Address Systems for Substations and Telecoms High Sites (240-170000098), SANS 7240-16, and SANS 7240-19.

The PA system shall also comply with the requirements of the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183.

13.5 Power Supply

The monitoring and control system power supply shall be fed from a redundant UPS system with backup battery banks designed to maintain power supplies to the control systems for a minimum of 12 hours following the loss of its feeder supplies.

UPS systems shall follow the standard SANS 62619 and/or UL 1973 or any similar standard for other technologies than Li-ion cells. Any other standard compliance of the battery cells or battery system shall be indicated. All certificates and tests completion results shall be provided.

Particular attention shall be given to the thermal management of the battery enclosure. The Contractor shall provide all technical notes justifying its design choices, notably the sizing of the cooling units.

The design must include prudent provisions for technology improvement. Battery modules shall allow for upgrade or replacement with higher performance cells to the extent practical. Where such changes are made to a battery module, all modules in that battery string must also be upgraded before the upgraded modules are placed into service.

No VRLA batteries shall be used or considered.

13.6 Labels, Tags, Plates, and Inscriptions

The Contractor shall supply and install for every piece of C&I equipment all labels, tags, name, ratings, instructions, and warning plates necessary for the identification of the works, to allow safe and correct operation, easy testing, and efficient maintenance.

The material and size of all label-, tag-, plate-, and inscription categories shall be according to the specification in this Employer’s Requirements.

All signals shall include a AKZ or KKS system code (system to be confirmed at a later stage) which should be referenced and used in all documentation as well as the SCADA system.

13.7 Meteorological Station

The Contractor shall design, supply, install, and commission at least four (4) complete meteorological stations for the Plant. The meteorological stations shall be located near the PV module arrays and distributed across the Plant boundaries. Their specification, installation, and operation and maintenance shall comply with the manufacturer's guidelines and that set forth in the World Meteorological Organisation best practices, as well as SANS 61724-1.

The minimum equipment specification for the meteorological station is shown in Table 7.

Table 7: Minimum Technical Requirements of the Meteorological station

Irradiance Sensors	
Quantity	One (1) pyranometer on the horizontal plane to measure the Global Horizontal Irradiance (GHI). One (1) Plane-of-array (PoA) pyranometer to measure the PoA irradiance. For bifacial modules: One (1) horizontally mounted albedometer installed away from the solar array in an unobstructed area to measure the horizontal albedo and optionally diffuse irradiance, and use an optical model, such as a view-factor or ray-tracing model, to estimate rear-side irradiance; or, Three (3) in-plane rear-side irradiance or, optionally, spectrally matched in-plane rear-side irradiance albedometers.
Type	Spectrally flat Class A (secondary standard) pyranometers conforming to international standards ISO 9060 and SANS 61724-1
Accuracy	± 2%
Location	The horizontal pyranometers shall be installed in a flat horizontal surface. The POA pyranometers shall be installed in the plane of the array with the same tilt and azimuth as the PV modules and shall be adequately located across the site to provide an average measured irradiance that is representative for the site. The albedometer(s) shall be installed at the same location as, but in the opposite direction to, the POA pyranometers. The Contractor shall provide the respective specifications for Employer's review and acceptance. All pyranometers/albedometers to be mounted a minimum of 1 m from the ground.
Temperature Sensors	
Type	PT1000 with minimum IP54 protection class. Implementation of the module temperature sensor shall follow SANS 61724-1
Quantity	One (1) temperature sensor to measure cell temperature (securely fastened to back of the PV module) and one (1) temperature sensor to measure ambient temperature (shielded ventilated).
Range	-40 to +100 °C
Accuracy	±1 °C
Location	Module temperature sensor shall be adequately bonded to the module and in the middle of a cell at the centre of the module, and the ambient temperature sensor shall be installed out of the shade, in direct sunlight.
Anemometer	
Operational temperature	-20 to 70 °C
Speed range	0 to 70 m/s
Accuracy Threshold	The higher between 0.5 m/s or 5%
Location	At a height of the top row of modules representative of the PV array conditions.
	Tracker: At a height and a location in accordance to stow position requirement from tracker manufacturer.
Wind speed measurement uncertainty	≤ 0.5 m/s for wind speeds ≤ 5 m/s ≤ 10% for wind speeds > 5 m/s
Direction	0 to 360°
Wind direction accuracy	±5°
Relative Humidity	

Range	0 to 100% RH
Overall accuracy	±2%
Response time	20 s (T90) or less
Soiling sensor	
Type	Dust IQ (or other equipment subject to Employer's approval).

Further meteorological station requirements are as follows:

- The design of the meteorological stations shall be such that 100% of all maintenance work can be accomplished while the equipment remains in operation;
- The measurement equipment shall be provided with the necessary protection against ambient conditions on Site. However, it must be easily accessible for maintenance and inspection purposes;
- The meteorological station shall have appropriate type 1 and type 2 surge protection;
- The station shall be connected to the Plant monitoring and control system;
- The meteorological station shall be self-powered or draw power and communications from the nearest available location. All cables shall be properly routed, protected, and fastened to avoid mechanical damage and direct UV exposure;
- The meteorological station shall be powered by a UPS backup power source with at least 24 hours of uninterrupted power supply capacity. The status of the UPS devices (like battery level, UPS temperature etc.) must be monitored at all times by the monitoring system, and alarms must be triggered in case of values exceeding specific ranges; and,
- Location of the meteorological station should be placed so that it is not shaded. The final location of the meteorological station(s) shall be reviewed and accepted by the Employer prior to construction.

All instruments and equipment shall be supplied with calibration certificates not older than six (6) months. All sensors shall be calibrated and recalibrated in accordance with the manufacturer's specifications and as a minimum on a yearly basis. The Contractor shall be responsible for all the calibration processes and costs according to manufacturer requirement up to the date of issuance of the Performance Certificate. Calibration frequency shall not be less than two (2) years.

The pyranometers shall be placed where no shadows are received at any time during the day. In case this it is not possible to mount them within the trackers, an independent installation will be required following the same inclinations as the PV arrays. The position of the pyranometers must be agreed with the Employer before fixing their position.

The meteorological stations shall be installed according to SANS 61724-1. Each meteorological station shall be compatible and fully integrated with the Plant SCADA system. The minimum, average, maximum, and standard deviation shall be recorded for all parameters. Calibration certificates, detailed configuration, and O&M manuals for the meteorological station(s) and their associated equipment shall be provided to the Employer in both physical and digital formats.

13.7.1 Meteorological Station Data Logger

Each meteorological station shall contain a data logger which shall have an adequate number of analogue and digital sensor channels, including spare ports for redundancy (N-1). The logger shall be connected locally to the Plant SCADA system by fibre connection or a similar high-speed connection technology. The logger shall have an LCD screen or allow connection from a PC (laptop) to view live measurements and real time data status. A time synchronization system shall be provided for the data logger using satellite or server time as reference.

Data loggers shall have an online-type UPS with enough capacity to allow for continued operation for a minimum of 24 hours following loss of mains power supply. The data logger shall have provision to record data for a minimum of three (3) months and a Micro SD card port for memory expansion.

The data logger panel/enclosure shall have an IP65 rating. If necessary, an external ventilation and heater unit shall be installed to remove precipitation and frost from the data logger panel/enclosure. The data logger shall be able to activate the ventilation & heater unit as necessary.

13.7.2 Soiling Station

The Contractor shall supply, install and commission at least four (4) soiling stations for the Plant, preferably a Dust IQ type of component. The soiling station shall be installed according to SANS 61724-1. The soiling station shall be cleaned in accordance with the manufacturer's specifications and as per the O&M cleaning regime.

13.8 Station Clock

A GPS synchronized station master clock system shall be provided complete with all necessary hardware, software, and firmware to achieve an integrated Plant-wide system capable of communicating with and synchronising the monitoring and control system. The station master clock system shall be provided with all necessary interfaces for synchronising the SCADA system and other control and monitoring systems.

13.9 Security System

The site perimeter serves as an enclosure for all key areas of the Site. Physical protection is thus integral, especially for those areas that can be attacked to compromise or reduce Plant effectiveness and reliability, and to prevent forceful intrusion or attack against the facility.

The Contractor shall provide an integrated and complete operational security system for the Plant, one designed for a high level of availability and low O&M needs. It shall function as a standalone/independent system.

The security fence and security gate requirements are addressed in section 10.10 and the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183, which forms part of the RfP documentation package and includes the Eskom Standards the Contractor must comply with relating to the Project's physical security design.

The security system for the Plant shall comply with the Eskom Specification for integrated access control system (IACS) for Eskom sites (240-86738968).

An access security system shall be provided for the Plant gate, buildings, and dedicated rooms. It shall be fully automated and shall provide for secure access to the specified locations including time attendance record. In order to prevent the unauthorised access of individuals and vehicles to the Plant and/or to prevent the unauthorised removal of assets and information, the area shall be secured with access being strictly subject to formal authorisation.

All the Plant's substations and buildings shall be secured by the security system in compliance with the Applicable Laws, Permits, and Codes and Standards.

Current and relevant emergency services contact information permanent signage shall be installed adjacent to each control panel.

<u>Site planning and landscaping:</u>

- All-weather roads/paved surfaces and walkways shall be provided as necessary to facilitate the required surveillance of and response to security threats within secured areas; and,
- The ground cover and landscaping shall not introduce barriers that will have a negative impact on surveillance of the area and perimeter.

<u>Buildings and facility design:</u>

- Openings into buildings and structures protecting equipment shall be kept to a minimum, and be consistent with operational requirements and emergency evacuation plans; and,
- Consideration shall be given to ensure that the construction of the physical barriers (walls, doors, ceilings, etc.), and openings into core and production areas, shall offer the same protection against intrusion.

Patrol roads or paths:

Patrol roads must be on the inside or outside of the internal perimeter barrier throughout the entire perimeter.

- Where other entry points enter or pass under or through the site perimeter such as emergency gates, storm water drains, and culverts; vents, ducts, and similar openings shall be hardened and protected to give the same protection as the rest of the boundary and monitoring capability; and,
- All openings in the core security area barriers shall be protected to ensure that the integrity of the barrier is not decreased.

Security control facility:

The site management shall ensure that:

- The security control room monitor all access to and alarms at the site;
- Plant security team respond to all alarms at the site;
- It must be fully independent with redundant wire and wireless communication with local law enforcement agencies;
- The design of the communication system shall ensure that all non-portable communication is provided with an independent source of emergency power when the normal power supply is not available;
- The design of the security communications system shall ensure that there are no areas where communication is not possible; and,
- The security communication system shall be protected, and tamper protected.

Alarm systems:

- All alarms shall annunciate at the security control room;
- Alarm annunciation, audible, and visible intrusion alarm indication shall also be provided in all access control points; and,
- The design of the system shall provide for the installation of duress alarms at the entrances to the site.
- All alarm systems shall comply with the Eskom Specification for the integrated security alarms system for protection of Eskom installations and its substations (240-86738968).

Security guard and response force:

- An armed security response force is required 24/7; and,
- The response force capability must be capable of responding to a security breach or incident with a response time less than the delay time of the physical security measures.

Backup Power Supply

The security system shall have a suitable backup electrical power supply as per the requirements of the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183.

13.9.1 CCTV Surveillance System and Perimeter Lighting

The Contractor shall provide a suitable Closed-Circuit Television (CCTV) camera surveillance system for the Site. It shall cover the points of entry to the respective Plant and the following critical areas as a minimum:

- Site entrance gate;
- Plant substations, all Plant buildings and MV stations, O&M building, central control room, security control room, and spare parts housing (warehouse);
- Security fence;
- CCTV and thermal IR cameras covering the whole Plant perimeter;
- Pan, tilt and zoom (PTZ) cameras shall be placed at key areas of the Plant, such as the main access gate, control building, and MV stations. The final locations shall be subject to Employer’s review and acceptance; and,
- The CCTV surveillance system shall consider providing an overall view of the solar field in order to detect a potential fire event during daytime operation.

CCTV / thermal IR cameras shall be suitably weatherproofed and include remote control facilities. The CCTV / thermal IR cameras shall be able to monitor the whole Plant perimeter without dead areas. Purpose-built poles must be provided to achieve suitable viewing positions for the cameras where necessary. The cameras shall have video analytics, with suitable lens focal length and minimum resolution in order to ensure effective detection of movements of people and vehicles for the entire designed field of coverage of the Plant. They shall have an embedded web interface for settings and video view. The codec shall be either H.264 or H.265 to minimize network traffic. In case of IR cameras, they shall be equipped with infrared lights able to illuminate the entire designed field of coverage.

Cabling for the perimeter fence cameras must be buried along the perimeter fence at a depth of no less than 60 cm. Cabling to each camera must be routed vertically from the cable trench along the fence line and up the fence post in a steel conduit to prevent tampering.

The following system design requirements shall be met:

- Night vision capability;
- PTZ capability;
- Secure power supply;
- Provision of sufficient cameras for full coverage;
- Image recording, playback system and video-analysis system;
- Automatic tracking;
- POE capability; and,
- Remote control or central control of all images, either during normal operation, or during emergency situations to clarify security conflicts. This includes the control room/building, the gate house, and third parties alarm monitoring station.

<u>Illumination:</u>

- Area/perimeter lighting shall provide sufficient illumination to isolation zones and exterior areas to enable the response force to accurately assess intrusion detections and alarm annunciations;
- Illumination shall be designed in co-ordination with the CCTV surveillance system design and the placement of lights shall ensure enhanced surveillance;
- The illumination design shall make use of two independent electricity supply systems to ensure that at least 50% of the lights continue to function when a loss of power is experienced;
- Extensive use shall be made of LED technology to ensure low energy usage, low maintenance requirements and prolonged reliability;
- Proper lighting simulations for perimeter lighting and lighting in the buildings shall be conducted and submitted to the Employer for review and acceptance prior to installation; and,
- Area/perimeter lighting solutions proposed to be tested prior to acceptance by the Employer.

Streetlights for the Plant shall adhere to the Eskom Standard for LED Street lighting for Eskom Properties (240-126210656).

The CCTV surveillance system and perimeter lighting shall be integrated into the security SCADA system and allow for remote monitoring and control from the security control room in the O&M building.

The CCTV surveillance system shall comply with the Eskom Specification for CCTV Surveillance with Intruder Detection (240-91190304) and the requirements of the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183.

The perimeter lighting shall comply with the Standard for Security Lighting for Eskom Applications (240-139282493) and the requirements of the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183.

CCTV surveillance system tampering (e.g., wire cutting, loss of supply, etc.) shall trigger alarms.

The CCTV surveillance system shall comply with all relevant national, regional, and local codes and standards.

13.9.2 Network Video Recorder

The signal from the individual cameras must be connected to a Network Video Recorder (NVR). The NVR shall be installed in the security control room of the O&M building of the Plant.

Any storage should be either a flash card or a solid-state disk with redundancy (RAID system). It can be remotely monitored and operated via a web interface or similar. It shall be able to record from all CCTV cameras simultaneously with at least 12 frames per second. The data from the cameras installed should be available for at least 30 days before being overwritten; the storage means chosen shall have the space available to store this data. All recordings shall have camera ID, location, date, and time of recording.

The NVR shall include for the following functions:

- Search function in the recorded videos;
- Video copy and export in one of the common formats, .avi or .wmv.;
- Digital video compression and format of H.264, H.265, MJPEG, or MPEG-4; and,
- Tamper alarms via email & security SCADA system alerts.

All CCTV outputs shall be displayed on a video wall in the security control room with control of the PTZ cameras. All surveillance system outputs must all be accessible through a web interface.

CCTV analytics must be integrated with the intruder detection system as described in the following sections of this document.

The cameras and NVR system shall have adequate backup power supplies in place. The NVR shall be connected to the security SCADA system for the transmission of alarms and surveillance system health status. The security SCADA system shall include local audible and visual alarms and shall be able to generate offsite notifications independent of its own notification system in the event of the CCTV surveillance system's alarms being triggered. Illuminated sounders/sirens and emergency services push buttons shall also be provided in the security control room.

13.9.3 Intruder Detection System

A video-analytics surveillance system shall be the main intruder detection system for the Plant. Additional technology for the IDS can be proposed by the Contractor; however, IR and microwave barriers shall be avoided. The IDS shall be designed for multiple zones around the perimeter fence and shall include gate magnetic detectors at all gate locations, entrance to the O&M building, warehouse storage room / building, and all fence mounted outdoor enclosures. This system shall be integrated with the CCTV Surveillance System of the Plant.

The zoning of the Site along the perimeter fence shall comply with the requirements of the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183.

Intruder detection and surveillance equipment suitable for day and night, including thermal IR cameras, shall be provided for the Site to deter unauthorised access to the Site while permitting ease of access to authorised staff and visitors. All security measures shall be fully integrated to initiate incident response by the security personnel and to allow continuous operator surveillance.

The IDS shall allow for identification of the specific location or fence section on Site where intrusion has occurred.

It is the responsibility of the Contractor to ensure that all security subsystems including the IDS as a whole comply with all relevant national, regional, and local regulations, Codes and Standards.

The Intruder Detection System shall comply with the Eskom Specification for CCTV Surveillance with Intruder Detection (240-91190304) and the requirements of the Physical Security Design for Lethabo PV Plant 375-LET-AABB-D00138-183.

Detection devices and emergency services alarm trigger push buttons shall have adequate backup power supplies in place (emergency power supply). All detection devices shall be connected to the security SCADA system for the transmission of alarms and detection system health status. The security SCADA system shall include local audible and visual alarms and shall be able to generate offsite notifications independent of its own notification system in the event of the IDS's alarms being triggered. Illuminated sounders/sirens and emergency services push buttons shall be provided in the security control room.

IDS tampering (e.g., wire cutting, loss of supply, etc.) shall trigger the alarms.

13.9.4 Cyber Security

The cyber security system must adhere to, and be in compliance with, the Eskom Cyber Security Standard for Operation Technology (240-55410927).

The system shall be protected from undesired and malicious access by means of a firewall in accordance with the Eskom governance documents for OT/IT systems, antivirus (software) installed on all computer equipment which may be vulnerable to cyber attacks, and a complete role management. Remote control function shall be protected by a hard key or dongle in the SCADA system. Adequate interlocks shall be provided to prevent unsafe operation of Plant while personnel are working on the equipment.

Parameterization and configuration modification can only be done by authorized users accessed using passwords.

13.10 Permanent ICT Infrastructure

Eskom Group IT will implement an ICT solution through the use of its own established suppliers and contractors which will replace the temporary equipment installed by the Contractor.

This will include the following:

- IT network infrastructure for e-mail, SAP, FLIP and other business applications.
- Firewalls between the IT and OT environment establishing a DMZ to accommodate middle-ware infrastructure.
- VoIP technology will be utilized to provide voice service for all telephone points necessary for fixed phones.
- A Dual WAN link for plant data exchange, EMDAS hourly generated figures and Internet and cloud connectivity.
- A VPN connection for remote support.
- Wi-Fi coverage over the entire PV site

The Contractor will ensure that UPS Power Requirements and Server room space requirements for ICT equipment are met as set out in "240-03022021- IT HIGH LEVEL DESIGN FOR Lethabo SOLAR PV SITE" and "Information Technology User Requirement Specification for Lethabo 75MW Solar PV Plant – document number to be confirmed".

The Contractor shall make provision of 10 kVA for the ICT Infrastructure’s power requirements.

13.11 TWO-WAY RADIOS

The Contractor will provide two-way radios to its staff for communication during the construction phase only. After completion of the works, radios will be required for Security, Maintenance and Operating activities. The Employer will provide two-way radios for this purpose through its established National contracts with two-way radio providers.

14 INSPECTION AND TESTING

14.1 GENERAL

The Works shall be subject to inspection and testing during, and on completion of, the manufacturing and installation/erection of the Works and equipment on Site to ensure compliance with the Employer's Requirements, all Applicable Laws, Permits, Codes and Standards, and to confirm that the satisfactory functionality, operability, and acceptance criteria of the Plant (as defined in the Contract) as well as the performance guarantees have been achieved, including, but not limited to, the Guaranteed Performance Ratio and Guaranteed Availability.

The Plant shall be commissioned and tested in compliance with the Employer's Requirements, Standards and Good Industry Standards for solar PV plants.

In summary, the testing and commissioning of the Works shall include, but not be limited to, the following:

- FATs – inspection and tests during manufacturing prior to transporting equipment to Site;
- SATs;
- Inspection and tests during construction based on ITP;
- Tests before Date of Completion (Commissioning);
  - Commissioning (Cold Commissioning)
    - Visual inspection;
    - Functional tests; and,
    - Electrical safety tests.
  - Grid Code compliance test;
  - Commissioning (Hot Commissioning);
    - MV inverter transformers' energisation;
    - Inverters' commissioning ;
    - Trackers' commissioning (if applicable);
    - SCADA system and monitoring system commissioning;
  - Provisional Acceptance Tests;
- Tests after Date of Completion;
  - Annual Performance Ratio test; and,
  - Annual Availability test.

Additionally, the Contractor shall undertake any tests as required under the Applicable Laws, Permits, Codes and Standards.

The Contractor shall bear the responsibility for all aspects of testing and commissioning preparations and execution, including the provision of procedures, temporary facilities, consumables, utilities, labour, special tools, measurement equipment, spare parts, etc. To the maximum extent possible, tests on Site shall make use of the permanently installed instrumentation, in particular for the Performance Ratio tests.

The Contractor shall remain fully responsible for the operation, maintenance, and cleaning of equipment as necessary throughout the commissioning and testing period up to the Date of Completion. All test instrumentation shall be properly calibrated by the Contractor prior to testing and rechecked after testing. Valid calibration certificates from independent third parties shall be provided for all instrumentation to be used during the tests as part of the test protocol to be submitted to the Employer prior to the commencement of the commissioning process.

The lack of acceptance criteria shall not relieve the Contractor from its contractual obligations, such as compliance with the Applicable Standards and technical requirements defined in the Employer's Requirements and all Applicable Laws, Permits, Codes and Standards.

If any portion of the Works fails under test, further tests or re-testing shall be conducted to demonstrate the successful completion of such tests (and compliance with the Contract) by the Contractor. The whole costs of retesting, including costs incurred by the Employer in witnessing such tests, shall be borne by the Contractor.

For each of the systems as defined, the inspection and tests during Construction (as per the corresponding ITP) shall have been completed prior to the commencement of the commissioning activities.

Any test required to demonstrate compliance with the environmental requirement shall also be performed prior to the commencement of the Provisional Acceptance tests, or as agreed with the Employer and all relevant consenting authorities. The requirements of the environmental permits shall be satisfied at all times during testing.

14.1.1 Documentation

The Contractor shall provide for the Employer's review, at least two months prior to the commencement of any commissioning activities, all the testing procedures and protocols. Additionally, as stated in Section 6.4.8, the Contractor shall provide for the Employer's review the TOP documentation for all the different systems at least two (2) weeks prior to commencement of the commissioning activities for said systems. The Employer may call for additional tests it may consider necessary. Further description is included in section 6.4.8.

The Contractor shall provide the ITP for all the construction activities at least two (2) weeks prior to the commencement of the associated works. The Employer will then indicate those items that it wishes to witness for which the Contractor needs to notify the Employer with sufficient notice in advance.

The Contractor shall provide all the test reports covering manufacturing and construction activities.

14.1.2 Right to Witness Inspections and Tests

All Works are subject to review and inspection by the Employer including manufacturing and construction activities. The Employer shall have the right to be present during all FATs, inspection and testing during construction, commissioning activities, and tests before and after the Date of Completion.

The Contractor shall submit to the Employer the ITP for all manufacturing and construction activities. The Employer shall indicate which items it wishes to witness, for which the Contractor shall provide the following notice to the Employer before the commencement of such items:

- FATs: 21 days; and,
- Construction ITPs: 5 days.

In the case where the Employer does not wish to be present at a test that they had previously declared they wished to witness, the Employer shall inform the Contractor.

The Contractor shall be responsible for co-ordinating any inspections and tests. Delays caused by the scheduling of third party tests/attendance shall not entitle the Contractor to any extension of time or additional costs.

Written advance notices shall be provided for all inspections and tests requiring the involvement of third parties, and such notice periods shall, in any case, be not less than that required by relevant Authorities or third parties (i.e., Grid Operator) involved. The Contractor shall be responsible for co-ordinating any inspections and tests required by third parties. The Contractor shall make allowance for third parties (i.e., Grid Operator) to witness key tests and to receive copies of the corresponding data and reports.

All inspections and testing shall be scheduled to commence during ordinary business hours, unless specifically agreed in advance with the Employer.

In general, the erection, commissioning and functional test requirements are to be notified during daily and weekly erection/commissioning meetings held at site. This shall include upcoming Site inspections/tests where applicable.

No section of the Works shall be covered up or proceed without carrying out any test or inspection required under the Contract or for which the Employer has notified it wishes to witness such a test. Should this not be followed, the Employer may require the Contractor to uncover or redo (the section of) the Works at the Contractor's cost.

14.1.3 Safety measures

The testing and commissioning may only be performed by well-qualified and trained personnel. Relevant PPE must always be worn.

The Contractor shall pay special attention to electrical risks during the testing and commissioning works for multiple power sources and circulating currents.

The following five safety rules must be managed and observed by the Contractor at any time under all circumstances, particularly for switching operations and for voltage disconnection:

- Disconnect;
- Secure against re-connection;
- Check for zero potential;
- Connect to ground and short-circuit; and,
- Cover or barrier neighbouring live parts.

Further rules are applicable such as avoiding servicing fused loaded disconnectors in the inverters and in the terminal boxes under load.

14.2 Test Procedures and Reporting Requirements

For each system within the Plant, the Contractor shall supply the TOP documentation as specified in section 6.4.8 at least two (2) weeks prior to commencement of commissioning of the system/equipment that it relates to. The TOP documentation shall include detailed commissioning procedures (including associated protocols and checklists) and test procedures for each system.

The following information shall be included as a minimum in the test procedures:

- Objectives and scope of the test and definitions of the test boundaries;
- Acceptance criteria;
- Health and Safety procedures and implications for all parties on site;
- Codes and Standards to be used or referenced, in particular the following standards:
  - Grid Connection Code for Renewable Power Plants (RPPs) connected to the electricity Transmission System (TS) or the Distribution System (DS) in South Africa, Latest Version;
  - SANS 61724-1: Photovoltaic system performance – Part 1: Monitoring; and,
  - IEC 62446-1: Photovoltaic (PV) systems – Requirements for testing, documentation, and maintenance – Part 1: Grid connected systems – Documentation, commissioning tests and inspection.
- Quality assurance procedures proposed for testing;
- Test duration and number of runs, starting and stopping criteria;
- Plant operating conditions, permissible modes of control and operational limits during the tests;
- Prerequisites and precautions for conducting the tests, including safety checks and Power Plant stability requirements;
- Methods of data collection, identification of instrumentation to be used for tests, sampling requirements;
- Test schedules showing major activities planned for performing all required tests;
- Sample calculations demonstrating how test results will be corrected (if any);

- Test report requirements;
- Test organisation including designation of test director, testing personnel operator responsibilities, communication schedule, witnessing and preparation of test reports;
- A list of all the required settings of all protective devices and alarms for that section of the Plant; and,
- Copies of the Contractor's check sheets for the pre-commissioning and commissioning activities done prior to the given test.

The Contractor shall supply to the Employer, as soon as is practicable after a test or inspection has been conducted, an electronic copy of the test reports which shall contain details of each test performed. Records, results and calculations of all tests shall be provided.

The test reports shall include as a minimum the following information:

- Reference to the test procedure used;
- Description of test conditions;
- Description of any deviations from the test procedure or unusual events which occurred during the tests;
- Summary of test results;
- Calculations with definition of terminology;
- Copy of raw data the Contractor has collected during the tests immediately following each series of tests, as well as the test data sheets;
- Copies of instrument calibration records; and,
- All information reasonably necessary to evaluate the results of the tests conducted.

14.3 Factory Acceptance Tests

All equipment after the Works shall be subjected to visual, dimensional, material, non-destructive, functional, and performance tests as applicable at the manufacturing facilities, at the manufacturing facilities based on an appropriate sample size and inspection level and at a minimum in accordance with the relevant Standards, such as ISO 2859. All relevant material and instrumentation certificates shall be available at the time of any test at the manufacturing facilities. All electrical equipment shall be 'routine' and 'type' tested in the manufacturing facilities in accordance with the applicable Standards. Type tests shall not be repeated if type test certificates of identical or similar ('similar' according to the definition of SANS or IEC) equipment are available.

The Contractor is expected to participate and witness the inspections and tests included in the manufacturing Quality plans/ITP. For the equipment defined in Table 8, the Contractor shall employ a first-class international inspection agency such as Bureau Veritas, TUV, SGS, Enertis or OCA (the "Inspection Agency") to monitor the implementation of the ITP and witness inspections and test included in the ITP.

Table 8: Inspection Agency QA/QC

No.	Equipment	Sampling Ratio	Action by	QA/QC
1	PV Modules	According to ISO 2859-2	Inspection Agency	Witnessing, inspections, audits, production monitoring, performance and degradation tests, thermographic inspections, acceptance tests, and approve the tests defined on the ITP
2	Inverters	• Central inverters: 100% • String inverters: According to ISO 2859-2	Inspection Agency	Witness and approve the tests defined on the ITP

No.	Equipment	Sampling Ratio	Action by	QA/QC
4	MV Transformers	100%	Inspection Agency	Witness and approve the tests defined on the ITP
5	MV Switchgears	100%	Inspection Agency	Witness and approve the tests defined on the ITP

The Inspection Agency shall report to the Contractor in complete transparency. The Employer shall receive a copy of all the information submitted by the Inspection Agency to the Contractor simultaneously.

Prior to the undertaking of the FATs, the Contractor shall provide to the Employer all relevant FAT procedures which shall include, at the least, the following information:

- Test programme (dates, location and duration of each test);
- Test standards;
- Type of inspection and tests;
- Reviewed design drawings/document relevant for the test;
- Material certificates that will be attached to the FAT report and technical data sheets relevant for the test;
- Methodology of tests;
- Checklists including process data to be recorded where applicable;
- Equations for process data where applicable;
- Description of the instrumentation to be used (including, but not limited to, the AKZ or KKS system code (system to be confirmed at a later stage), type of instrument, measuring range and accuracy), including calibration certificates of testing equipment;
- Forms of test records and test report template; and,
- Complete factory QA/QC dossier of the inspections performed prior to the respective FAT.

The Contractor shall submit a FAT report no later than ten (10) days after completion of each FAT. The FAT report shall include the data as recorded, including valid calibration certificates (dating back no more than twelve (12) months for temporarily installed performance test instrumentation, unless a more restrictive validity period is imposed by the applicable Standards), and contain at least the following information:

- The type of test, applicable test procedure and test standards;
- The date and time of each test, including the start and completion time of the test;
- A description of conditions under which the test was conducted;
- A summary of the quality control procedures, instrumentation used and instrument calibration instructions from the OEM, including historical and up-to-date calibration certificates;
- A summary of test results;
- A comparison of test results to relevant contractual values where applicable;
- The conclusion from the test results, including whether the acceptance criteria were met; and,
- The identification of any abnormal conditions present during the test period.

14.3.1 PV Modules Factory Acceptance Tests

The FATs for the PV modules must specifically demonstrate:

- The manufacturer's safety requirement specifications are at par with applicable SANS, IEC or other International Standards;
- In-house testing parameters and procedures are at par with general operating practices; and,
- Performance parameters are at par with the Employer's Requirements.

PV modules FATs shall include the following:

- Manufacturing process and product quality inspection;

- Routine tests; and,
- Pre-shipment tests.

Routine tests and pre-shipment testing shall be based on batches of PV modules. A batch is defined as 10MWp of PV Modules produced in the same workshop, and, ideally, the same BOM combination. Batch definition could be adapted to align with the corresponding shipment lots.

The PV Module manufacturer shall implement a clear traceability procedure between single module identification and its corresponding batch and modules packing box with its corresponding batch.

14.3.1.1 Manufacturing process and product quality inspection

The Contractor shall perform a complete manufacturing workshop pre-production inspection to the PV module manufacturer's factories and workshops officially assigned for the fabrication of the PV modules for the Project. Any additional workshop assigned during the production of the Project modules shall be subject to the same production inspection.

Pre-production workshops inspection should be conducted at least ten (10) calendar days prior to the official manufacturing commencement. The inspection shall consist of checking and evaluating the following processes and procedures. Examples of inspection tasks and checkpoints are listed below:

- Incoming inspections and preparation of materials – warehouse;
- Sorting and test of cells;
- Solar cell tabbing and connection to strings;
- Interconnection of strings;
- Compilation of material layers (module sandwich);
- Lamination process;
- Electrical Connection;
- Framing;
- Electrical safety tests;
- Control of output power;
- Evaluation of all equipment and procedures for quality control tests (such as earth leakage, wet leakage and Hi-pot);
- Quality assurance/control (storage and handling of materials, production areas, staff training, claim handling);
- Handling of test and calibration equipment;
- Documentation of process data;
- Directing of faulty products; and,
- Conditioning of the finished product.

The inspection may be performed by a third party as the Contractor's representative. During the inspection, a list of valid quality standards, manufacturing certification, module certification and BOM shall be made available via email before pre-production inspection completion. During the inspection it shall be verified whether all materials used by the manufacturer conforms to the BOM.

A report of the inspection shall be issued to the Employer and in case findings or deviations are found, preventive or corrective actions shall be implemented for the manufacturing of the PV Modules for the Project, including additional (on-factory/off-factory) testing needed to assist the root cause analysis and overcome any quality issues for the duration of the entire production process of PV Modules for the Project.

14.3.1.2 Routine tests

Routine testing shall be conducted in the PV module manufacturer's manufacturing facilities, unless otherwise agreed to by the Employer.

Routine testing shall be done for batches of PV modules, with a batch defined as 10MWp of PV modules. The sampling per batch shall be based on the SANS 2859-1 Standard.

The lists of tests, sample size, applicable standards and pass/fail criteria for the routine tests are shown in Table 9. The specific sample of PV modules to be tested shall be selected by the Employer based on the flash test data generated and provided by the PV module manufacturer.

Table 9: FATs – Routine tests details

Test	Sample size	Test as per standard	Acceptable Quality Levels (AQL)
Visual Inspection	As per SANS 2859-1 Normal Inspection, Special Inspection level S-4	As per module manufacturer internal procedure and visual inspection criteria, which must cover at least, quality requirements set out in IEC 61215-2 (MQT 01)	Critical defects – AQL (0) Major defects – AQL (2.5) Minor defects – AQL (4.0)
Maximum Power at Standard Conditions (STC).	As per SANS 2859-1 Normal Inspection, Special Inspection level S-4	IEC 61215-2 (MQT 02)	AQL (1) for individual PV modules. The Module peak power of each and every one of the sample PV modules shall be greater or equal to the Module nameplate power. No test tolerance nor uncertainty will be considered for this requirement. AQL (0) for the average peak power of the module sample.
Electroluminescence (EL) Test	As per SANS 2859-1 Normal Inspection, Special Inspection level S-4	As per PV module manufacturer internal procedure and criteria for EL inspection, which must cover at least, quality requirements set out in IEC 60904-13	Critical defects – AQL (0) Major defects – AQL (2.5) Minor defects – AQL (4.0)
Insulation test	As per SANS 2859-1 Normal Inspection, Special Inspection level S-4	IEC 61215-2 (MQT 03)	AQL (0)
Bifaciality test	As per SANS 2859-1 Normal Inspection, Special Inspection level S-4	IEC TS 60904-1-2	AQL (1) for individual PV modules. The PV module bifaciality factor of each and every one of the sample PV modules shall be greater or equal to the nameplate value. No test tolerance nor uncertainty will be considered for this requirement. AQL (0) for the average bifaciality factor of the module sample.

For the visual inspection and EL tests, the defect classification on Critical (Cr) / Major (Ma) / Minor (Mi) shall be agreed between the Contractor and the Employer; nonetheless, the following criteria shall be considered:

- Critical (Cr): A latent of overt defect that is likely to result in a hazardous or unsafe condition for the individual using the module, contravenes mandatory regulations and/or may cause damage to other products or property;
- Major (Ma): A latent or overt defect that could impair the usability or result in under-performance or premature failure of the module; and,
- Minor (Mi): A latent or overt defect that does not impair the usability of the PV module, but is nevertheless considered a workmanship defect beyond normal, acceptable quality standards.

14.3.1.3 Pre-shipment tests

Pre-shipment tests shall be performed at a SANS 17025 accredited laboratory, either at the PV module manufacturer's facilities or at a 3rd party laboratory.

Pre-shipment tests shall be done for batches of PV modules, with a batch defined as 10MWp of PV modules. The sampling plan per batch shall be based on the SANS 2859-1.

The lists of tests, sample size, applicable standards and pass/fail criteria for the Pre-Shipment tests is shown in Table 10. The specific sample of PV modules to be tested shall be selected by the Employer based on the flash test data generated and provided by the PV module manufacturer.

Table 10: FATs – Pre-shipment tests details

Test	Sample size	Test as per standard	Acceptable Quality Levels (AQL)
LID Test	As per SANS 2859-1 Normal Inspection, Special Inspection level S-1	IEC 61215-2 (MQT 19)	AQL (0.65) 3.0% maximum drop in absolute Maximum Power values before and after LID testing. No test tolerance nor uncertainty will be considered for this requirement.
PID Test	As per SANS 2859-1 Normal Inspection, Special Inspection level S-1	IEC 61215-2 (MQT 21)	AQL (0) Pass/Fail requirements as per IEC 61215-2 and also 5.0% maximum drop in absolute Maximum Power values before and after PID testing. No test tolerance nor uncertainty will be considered for this requirement.
Wet Leakage Current Test	As per SANS 2859-1 Normal Inspection, Special Inspection level S-1	IEC 61215-2 (MQT 15)	AQL (0) Pass/Fail requirements as per IEC 61215-2 and also 5.0% maximum drop in absolute Maximum Power values before and after PID testing. No test tolerance nor uncertainty will be considered for this requirement.
LeTID Test	As per SANS 2859-1 Normal Inspection, Special Inspection level S-1	IEC 61215-2 (MQT 23)	AQL (0)
Peel-off test	2 modules per batch	SANS 61730-2 (MST 35)	AQL (0)
Robustness of termination	As per SANS 2859-1 Normal Inspection, Special Inspection level S-1	IEC 61215-2 (MQT 14)	AQL (0) Pass/Fail requirements as per IEC 61215-2 and also 5.0% maximum drop in absolute Maximum Power values before and after PID testing. No test tolerance nor uncertainty will be considered for this requirement.

Should bifacial modules be proposed, testing shall be done in compliance with IEC 60904-1-2.

All batch test data, results and reports, certificates, and type test reports shall be provided to the Employer for review a minimum of one (1) week prior to the shipment of the batch to the Site. The relevant batch shall not be released from the PV module manufacturer's factory until authorisation has been issued by the Employer.

14.3.1.4 Retests

If any of the routine tests or pre-shipment tests fail, the associated batch must be retested with a new random sample of PV modules using the same size of the samples for inspection, conditions of the tests and the pass/fail criteria at the Contractor's expense. If testing fails again, the Employer is entitled to reject the entire batch. If the Contractor and/or the PV module manufacturer prove that the reason for failing the test is unrelated to the quality of the PV modules forming the batch (for instance, an error in the testing equipment), the Employer shall have the option to waive the rejection of the batch and allow for a subsequent test to be performed.

All PV modules from the batch being inspected must be quarantined at the module manufacturer's facility during inspection. Once the inspection has been successfully passed inspection and testing, the quarantined PV modules may be released for shipment.

None of the non-compliant PV modules (irrespective of the defect class: minor, major, critical, and irrespective of the test) shall be shipped and delivered to the Employer. Any non-compliant PV module shall be replaced by a compliant PV module at the cost of the Contractor prior to shipping.

14.3.2 Transformers Factory Acceptance Tests

The Contractor shall provide evidence of type tests for transformers of similar rating and construction as specified in SANS 60076, including:

- Temperature-rise type test (SANS 60076-2);
- Dielectric type tests (SANS 60076-3);

- Determination of sound level (SANS 60076-10) for each method of cooling for which a guaranteed sound level is specified;
- Measurement of the power taken by the fan and liquid pump motors; and,
- Measurement of no-load loss and current at 90 % and 110 % of rated voltage.

In the absence of satisfactory evidence, type tests shall be carried out by the Contractor.

Evidence of a short-circuit withstand test as per SANS 60076-1 11.1.4 and SANS 60076-5 or a rated short-time neutral current withstand test as per SANS 60076-6 (for earthing transformers) shall be available for transformers of similar rating and construction as specified in SANS 60076:2011. Otherwise, demonstration of the transformer’s thermal ability to withstand short circuit and the ability to withstand the dynamic effects of short circuit is required either by test or by calculation and design and manufacturing considerations.

The following routine tests are required in the factory for all transformers to be supplied:

- Voltage ratio & Vector Group Verification
  - SANS 60076-1: Power Transformers Part 1 (Clause 11.3).
- Winding Resistance test
  - SANS 60076-1: Power Transformers – Part 1 (Clause 11.2).
- Insulation resistance test
  - SANS 60076-1: Power Transformers – Part 1 General (Clause 11.1.2.2)
- No-Load Test and magnetising current.
  - SANS 60076-1: Power Transformers – Part 1 General (Clause 11.5)
- Short Circuit Impedance and Load losses
  - SANS 60076-5: Power Transformers – Part 5 Ability to withstand short circuit; and,
  - SANS 60076-20: Power Transformers – Part 20 Energy Efficiency.
- Leak testing with pressure for liquid-immersed transformers (tightness test)
  - SANS 60076-1: Power Transformers – Part 1 General (Clause 11.8).
- Applied Voltage Test (AV)
  - SANS 60076-3: Power Transformers – Part 3 Insulation levels, dielectric tests and external clearances (Clause 11).
- Line terminal AC withstand voltage test (LTAC)
  - SANS 60076-3: Power Transformers – Part 3 Insulation levels, dielectric tests and external clearances (Clause 12).
- Induced voltage test with partial discharge measurement (IVPD)
  - SANS 60076-3: Power Transformers – Part 3 Insulation levels, dielectric tests and external clearances (Clause 11).
- Lightning impulse and switching impulse test
  - SANS 60076-4, Power transformers – Part 4 Guide to the lightning impulse and switching impulse testing — Power transformers and reactors.
- Capacitance windings-to-earth and between windings and Dissipation Factor (Tan δ)
  - SANS 60076-1: Power Transformers – Part 1 General.
- Measurement of dissolved gasses in dielectric liquid from each separate oil compartment except diverter switch compartment
  - Before all tests;
  - After temperature rise ONAF test;
  - After temperature rise ONAN test;
  - After impulse test; and,
  - After all electrical tests;
- Ratio and Polarity Test of internal CTs
  - SANS 61869-2: Instrument Transformers – Part 2: Additional requirements for current transformers.

- Operation of on-load tap changer;
  - SANS 60076-1: Clause 11.7.
- Wiring 2 kV insulation test
  - SANS 60076-3: Power Transformers – Part 3 Insulation levels, dielectric tests and external clearances (Clause 9).
- Bushings
  - SANS 60137 Insulated bushings for alternating voltages above 1000 V.
- Tests applied to devices with alarm and tripping contacts
  - NRS 054 Clause 5.3.
- Gas and oil actuated relay tests
  - NRS 054 Clause 5.5.
- Digital thermometers
  - NRS 054 Clause 5.6.
- Dimensions, general assembly, painting and documentation.

Special tests shall be quoted and offered by the Contractor as part of optional and additional tests to be carried out in the factory. The Employer will later decide the final special tests to be carried out as follows:

- No-load current harmonics
  - SANS 60076-1: Power Transformers – Part 1 General (Clause 11.5);
  - full wave and chopped wave test;
  - SANS 60076-3: Power Transformers – Part 3 (Insulation levels, dielectric tests and external clearances); and,
  - SANS 60076-4: Power Transformers – Part 4 (Guide to lightning impulse and switching impulse testing – Power transformers and reactors).
- Induced overvoltage withstands test IVW
  - SANS 60076-3: Power Transformers – Part 3 Insulation levels, dielectric tests and external clearances (Clause 11).
- Zero sequence impedance test
  - SANS 60076-1: Power Transformers – Part 1 General.
- Sweep Frequency Response Analysis (SFRA)
  - SANS 60076-18 Measurement of frequency response.
- Temperature Rise (ONAN, ONAF). Infrared images to be taken of the main tank and to be included in the test report. DGA samples to be taken before, during and after temperature rise test
  - SANS 60076-2: Power Transformers – Part 2 Temperature rise for liquid-immersed transformers.

14.3.3 HV and MV Switchgear

HV and MV switchgear shall be factory tested as per SANS 62271 “Standards for high voltage switchgear and control gear”.

A certificate from an independent third party shall be made available to demonstrate that all equipment (and its component parts) has been fully type tested in accordance with the appropriate SANS/IEC Standards and the specified ratings. In the absence of satisfactory evidence, type tests shall be carried out by the Contractor. Type test shall not be repeated; however, a valid Type Test report & Certificate for the similar type of switchgear shall be provided.

Each switchgear system shall be routine tested in accordance with SANS 62271 “Standards for high voltage switchgear and control gear”.

14.3.4 MV cables

MV cables shall be factory tested as per SANS 60502-4.

A certificate from an independent third party shall be made available to demonstrate that MV cables have been fully type tested in accordance with the appropriate SANS/IEC Standards and the specified ratings. In the absence of satisfactory evidence, type tests shall be carried out by the Contractor. Type tests shall not be repeated; however, a valid Type Test report & Certificate for the similar type of switchgear shall be provided.

Routine tests shall be carried out on each type of manufactured cable drum. The number of lengths can be reduced only if accepted by the Employer according to the agreed quality control procedures. The routine tests shall include, but not necessarily be limited to, the following:

- Non-electrical tests (radial dimensions, thickness of insulation, embossing and marking);
- Hot set test of insulation;
- AC high voltage test and/or spark test;
- Conductor resistance;
- Insulation resistance;
- Capacitance test measurement;
- Partial discharge test; and,
- DC test on outer sheath.

14.4 Site Acceptance Tests

As far as applicable, the Contractor will carry out SATs for all materials and equipment on Site. Where materials can be tested on Site, the Contractor shall not incorporate materials into the Works until site acceptance testing has been carried out. Upon arrival on Site, and during the performance of the Works, all items of materials shall be inspected and tested by the Contractor as appropriate to ensure there is no delay in construction, installation and commissioning arising from defects, damage and/or deterioration of parts. The Employer has the right to review the material reception report from the Contractor.

Materials reception and warehouse management procedure shall be issued by the Contractor as part of the Quality Plans. As a minimum criterion for all mechanical and electrical equipment received on Site, the following shall be checked:

- Identification and traceability data is provided;
- Equipment certifications and type test certificates are provided; and,
- Visual inspection shall be performed, including packaging.

14.4.1 PV modules Site Acceptance Tests

All PV modules containers and pallets delivered to the Plant Site shall be visually inspected for any damages.

Upon delivery of the PV modules on Site, the Contractor shall submit the post-production flash test reports for each PV module at STC in electronic format (Excel files) to the Employer. As part of the As-Built documents, the Contractor shall provide a summary spreadsheet containing all the documentation on the PV modules.

14.4.1.1 Visual inspection of each container before unloading

The containers must be in good condition (no water ingress, debris, or damage). There shall be no indication of pallets or packaging being damaged.

The Contractor must include shock sensors/indicator labels within the PV modules pallet (one sensor per pallet). Furthermore, visual, flash electroluminescence (EL) testing shall be carried out in case the shock sensor of the pallet is activated.

14.4.1.2 Sample-based inspection of modules

The Contractor shall perform the following on Site tests by use of an accredited PV module testing mobile laboratory on samples as defined as follows:

- Visual inspection – two (2) modules per container;
- Maximum Power determination (Flash test) – two (2) modules per container; and,
- EL testing – two (2) modules per container.

The description of the tests shall be reviewed by the Employer before performing the tests. The specific PV modules to be tested shall be selected by the Employer.

If the first test fails, the Contractor shall have the right to perform a re-test on the same PV modules in a mutually agreed independent third party accredited mobile testing laboratory. If the re-test fails, the Contractor shall perform a whole inspection on the related containers in which the non-conformant PV modules were transported and replace the unqualified modules at the Contractor's own cost.

Any delays to scheduled installation dates caused by rejected PV modules, the provision of replacement PV modules and the inspection and testing of replacement modules are the responsibility of the Contractor.

The Employer, at its sole discretion, may perform additional testing on samples of PV modules delivered on Site. These additional tests shall be for the account of the Employer unless such test results indicate additional issues, in which case the cost shall be borne by the Contractor.

14.4.2 Inverters

The following SATs are to be conducted with respect to the inverters on site (with auxiliary power provided and used where necessary), in addition to the SATs in the applicable Codes and Standards:

- Adequate and operational ventilation system of the inverters.
- Functionality tests.
    - Inverter AC side isolation.
- Correct earthing of inverter (mechanical & electrical).
- Inverter and its components (including cables) correctly labelled.
- Check that all schematics, diagrams, warning notices and labels, technical documentation, and other similar information are present.
- Check that the inverter nameplate is present and correct.
- Check that the inverter cables are properly and securely fastened, terminated, and connected, with the correct lugs, glands, and terminations used.
- Check that all filters are clean and correctly mounted.
- Check that all inverter inlets and outlets are free from any obstacles.
- Insulation resistance test.
- High voltage overvoltage test.
- Earthing resistance tests and earthing residual current monitoring test.
- Anti-islanding functionality tests.
- Final torqueing of the primary circuit, and a low resistance ductor test on the primary circuit.
- All barriers, transparent covers, and other finger IP covers over live conductors present and correctly installed.
- Check that any HMI displays/screens are in good condition and display clear and correct results/messages.
- Check that DC circuit-breaker(s) functional.
- Check that DC insulation monitoring is present and has been correctly installation.
- Confirmation of all DC-entrance fuse ratings.
- Verification of adequate protection measures against self-loosening of clamps, bolts, and screws; and,
- Verification of correct torque values applied to all inverter fasteners as per inverter manufacturer specifications.

14.4.3 Mounting structure

The thickness of the galvanization of mounting structures and its compliance with structure shop drawings and the soil corrosion results of the geotechnical assessment report shall be verified on Site. A report verifying the thickness of galvanising shall be provided for all hot dip galvanised components. A report verifying the thickness of anodising shall be provided for all anodised components. Welding reports shall be provided for any welded material. No welding is permitted to take place on Site. The tightness of all module clamps and fasteners shall be verified. The proper alignment of the array frame, module rows and the inclination of the modules shall be confirmed. The Contractor shall provide the Employer with survey reports of the pile which shall meet the requirements of the manufacturer's installation manual.

14.4.4 Transformers

The following SATs are required for all transformers (substation and inverter station levels). The tests shall be non-intrusive and shall not adversely affect the performance of the transformer in question in a material manner.

- Visual inspection of transformers including alignment, earthing, labelling, wiring, etc.
- Functional check of all wiring against the approved transformer drawings.
- Testing and calibration of all transformer control, protection, and monitoring devices, with any adjustments recorded.
- Insulation resistance test (HV-E, LV-E, HV-LV).
  - SANS 60076-1: Power Transformers – Part 1 General
- Functional test of off-circuit tap changer; and check of the continuity of all windings (only for transformers at the substation level).
- Turns ratio test on all taps (for transformers at the substation level only).
- Winding resistance test (for transformers at the substation level only).
  - SANS 60076-5: Power Transformers – Part 5 Ability to withstand short circuit; and,
  - SANS 60076-20: Power Transformers – Part 20 Energy Efficiency.
- Dissipation Factor (Tangent δ) testing (for transformers at the substation level only).
  - SANS 60076-3: Power Transformers – Part 3 Insulation levels, dielectric tests and external clearances
  - For transformers at the substation level only.
- Oil sampling and off-site DGA testing (especially when transformer has been in stand-by condition for 6 months).
- Alarm and trip contact verification (Buchholz, thermal, overpressure, etc.)

14.4.5 HV & MV Switchgear

The following SATs are required for all HV and MV switchgear (substation and inverter station levels) as per SANS 62271 "Standards for high voltage switchgear and control gear" unless specified otherwise. The tests shall be non-intrusive and shall not adversely affect the performance of the switchgear in question in a material manner.

- Mechanical functional test of all components.
  - SANS 62271-200: Standards for high voltage switchgear and control gear Part 200 AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (Clause 8.2)
- Mechanical interlock test as per approved interlocking matrix
  - SANS 62271-200: Standards for high voltage switchgear and control gear Part 200 AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (Clause 8.2)
- Electrical functional test of all control and protection wiring as per the approved switchgear design drawing pack.

  - SANS 62271-200: Standards for high voltage switchgear and control gear Part 200 AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (Clause 8.3)
- Secondary injection test on all protection relays to confirm satisfactory operation of the protection scheme. Verification of the protection settings against the approved protection study.
  - SANS/IEC 60255: Measurement relays and protection equipment
- Insulation resistance test and dielectric test
  - SANS 62271-1: Standards for high voltage switchgear and control gear Part 1 General SANS 60076-1: Power Transformers – Part 1 General
- Circuit-breaker timing test (applicable at substation level only)
  - SANS 62271-100: Standards for high voltage switchgear and control gear Part 100 Alternating-current circuit-breakers
- Disconnector contact resistance test (applicable at substation level only)

SANS 62271-200: Standards for high voltage switchgear and control gear Part 200 AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (Clause 8.4).

14.5 Inspection and Tests during Construction

The inspection and testing activities shall be performed in a logical and sequential manner, including the division of the Plant into different systems and sub-systems. These shall undergo different quality control levels, allowing for all items identified during the initial quality control levels to be traced through the entire quality control and testing process until they have all been completed.

During the construction and erection, the Contractor shall undertake all installation checks and preliminary mechanical and electrical checks, proving the integrity of all connections (mechanical and electrical), safety systems, and verification that the entire Plant is functionally complete.

Throughout construction, all incomplete work and deficiencies shall be recorded in a punch list, of which the latest version prior to the commencement of the commissioning activities (i.e., only non-rectified items) shall be included in the TOP documentation for each system.

Inspection and tests during construction shall include, but not be limited to, the following:

- Trenches;
- Roads;
- Fences;
- Foundations;
- PV modules;
- Mounting structure;
- DC wiring;
- String combiner boxes (if applicable);
- Inverters;
- MV/LV power stations;
- AC cabling;
- AC distribution boards;
- Power and earthing transformers;
- Current transformers;
- Voltage transformers;
- Disconnector and earthing switches;
- Surge arrestors;
- Earthing system;
- Meteorological station;

- Security system;
- SCADA system / Monitoring Equipment;
- Firefighting and fire protection system;
- Lightning protection system; and,
- MV switchboards and RMUs.

In performing the inspection and tests during construction, the Contractor shall verify that all systems and components of the Plant comply with the Contract and that all equipment has been installed according to their manufacturers' installation manuals and guidelines.

For the avoidance of doubt, the tests during construction shall not require any connection to the grid.

Successful completion of the inspection and tests during construction, together with the delivery of the associated test reports and checklists to the Employer, are required for the achievement of Provisional Acceptance.

14.5.1 Trenches

The Contractor shall check the compliance of the following items with the civil works drawing(s):

- Trench routing; and,
- Position of the trench traps.

The Contractor shall check the compliance of the following items with the trench drawing(s):

- Depth;
- Length;
- Width;
- Thickness of the bottom sand layer;
- Diameter, position and colour of the sleeves;
- Thickness of the top sand layer;
- Quality and composition of the backfill material;
- Presence, position and colour of the warning net; and,
- Presence, type of material and size of the earth cable.

The Contractor shall check the correct installation:

- Sleeves have not been damaged; and,
- Connection between sleeves is fully tightened.

14.5.2 Roads

The Contractor shall check the compliance of the roads routing with the civil works drawing(s). Further, the Contractor shall check the compliance of the following items with the civil works technical specification(s):

- Length, width and thickness of the roads;
- Presence and type of the geotextile layer (if applicable);
- Size of the material (gravel, stones, etc.); and,
- Completion of compaction.

14.5.3 Fences

The Contractor shall check the compliance of the following items with the fence technical specification:

- Type of fence;
- Dimensions of the fence;
- Mesh size;
- Thickness of the galvanisation on fence poles; and,
- Colour.

The Contractor shall check that on the whole length of the fence, the following is true:

- The fence has been installed correctly according to the fence drawing(s);
- The fence is not damaged;
- The fence is installed vertically correctly;
- The distance between the ground level and the bottom of the fence is correct;
- Distance between rods is correct;
- Depths of driving in of the rods is correct;
- Quantity of concrete on the rods' foundations by a visual inspection;
- The gates have been installed vertically correctly;
- The opening/closing of the gates is correct; and,
- The locking/unlocking of the gates is correct.

14.5.4 Foundations

The Contractor shall check the compliance of the following foundation items with the foundation drawing(s):

- Position;
- Length;
- Width;
- Depth;
- Thickness;
- Presence, type of material and size of the earth cable;
- Thickness and depth of the sand layer; and,
- All cable entrances inside the inverter transformer station basement are sealed and waterproofed according to the inverter transformer station specification.
- Details of all applicable foundation structural interface components, such as holding down bolts, base plates etc.

For the respective concrete foundations:

- Compliance of the iron framework with the iron framework drawing or to the calculation note;
- Quality of concrete through a visual inspection; and,
- Concrete cube test results.

14.5.5 PV Modules

With respect to the PV modules, the Contractor shall:

- Inspect the PV modules as installed, verify the absence of any breakages, frame distortions and bending/warping or any signs of incorrect or incomplete installation of each PV module;
- Visually inspect the PV modules for potential damage or discolouring;
- Verify that each PV module string's cables have been marked and numbered, and are in accordance with respective cable schedules provided by the Contractor to the Employer;
- Inspect the DC cabling between each PV module, verify the cable types, sizes, lengths, and cable connector types in test reports;
- Verify the integrity of surge protection devices and all earthing connections;
- Verify the expansion spacing between the modules;
- Verify the installation of correct clamps as per the Employer's Requirements;
- Verify the correct orientation for the PV modules;
- Verify the torque of all bolts as per supplier's specifications;
- Provide a PV module register for each and every installed PV module to the Employer:
  - Serial number;
  - Geolocation in the Plant; and,

  - Location in the electrical configuration including location in the string, string number, string combiner box number (if applicable), inverter number, transformer number, and subfield number.

The PV module register shall be stored in a cloud-based software platform and shall be able to be accessed and interrogated by office and site personnel using standard devices. Site personnel should be able to use mobile applications to direct themselves to a specific module easily and obtain the relevant module data from the PV module register.

14.5.6 Mounting Structure

With respect to the mounting structure, the Contractor shall:

- Verify overall set-out distances, tilt differences, surfacing, alignment, and completeness of the assembly;
- Verify galvanization thickness, galvanization, and rectify scratches or defects;
- Verify proper alignment of mounting structure, of PV module rows, and of mounting to the tracker/structure;
- Verify that all PV module fasteners have been installed properly;
- Verify the torque of all bolts as per supplier's specifications;
- Verify that the supplier quality certificates of steel and galvanisation of the structures are in accordance with applicable standards, including those defined in the Employer's Requirements;
- Verify the earthing of trackers (including connections between piles and rotating components); and,
- Verify the installation of equipotential cables as required by the design.

14.5.7 DC Wiring

With respect to DC wiring, the Contractor shall:

- Verify that the cable identification is in place, and correct for identification and durability according to the specifications in sections 8.9 and 9.7;
- Verify the condition of the cables;
- Verify the cables are landed and lugs are torqued to the appropriate value(s) in accordance with the manufacturer's data and specifications;
- Verify that any applicable electrical safety certificates have been issued by the relevant authority;
- Verify that all cabling is installed as per the design with service loops and cable protection conduits as a UV barrier;
- Cabling must not be exposed to the sun;
- Verify that all the cables are fastened at regular intervals and that no sharp edges may affect the cables;
- Verify that all cable transitions (e.g., above ground to below ground, etc.) are appropriately fastened using weather resistant jointing elements which are also rodent barriers for prevention of egress into the cable conduits; and,
- Verify that any cable bending complies with the minimum bending radius as per the supplier's specification.

14.5.8 String Combiner Box

With respect to string combiner boxes (if applicable), the Contractor shall perform and record the following verification actions:

- Visual inspection of the string combiner box;
- Earthing terminations;

- Proper installation, configuration, number of cabling, overcurrent protections, overvoltage protections, DC fuses rates, etc.;
- Proper IP rating;
- Proper internal ventilation features;
- Proper local isolation of the combiner box and individual points of insolation;
- Proper communication printed circuit boards and necessary electrical protection devices, if any;
- Protection screen against each electrical live component(s);
- Door and locking system;
- Proper SLD and folder;
- Proper internal and external labelling;
- Proper location of the surge production device; and,
- Proper torque level and marks.

14.5.9 AC Cabling

For the AC cabling, both LV and MV cables, the Contractor shall:

- Compare cable data with drawings and specifications;
- Verify cable identification is in place and correct for identification and durability according to the specifications in sections 8.9 and 9.8;
- Verify the condition of the cables;
- Verify that the cables are landed and torqued to the appropriate value(s) in accordance with the manufacturer's data and specifications; and,
- Verify that any cable bending complies with the minimum bending radius as per the supplier's specification.

14.5.10 AC Distribution Panels

With respect to commissioning tests for AC distribution panels, the Contractor shall:

- Inspect AC cabling and switches and verify that the types, sizes and lengths are in accordance with the Agreement requirements, are correctly labelled and are in line with respective diagrams;
- Verify the lightning protection controls, if applicable;
- Verify the voltage controls; and,
- Verify the protection device calibration.

14.5.11 Power and Earthing Transformers

The Contractor shall execute the following actions and checks where power and earthing transformer devices are installed and/or where applicable:

- Visual inspection;
- Check correct earthing;
- Check tightening torque of bolted connections after completion of all tests;
- Check oil leakages;
- Check oil level;
- Check protection devices;
- Check alarms and trip initiation (oil level, Buchholz, temperature, overpressure valve); and,
- Check saturation of dehumidifying salt.

14.5.12 Current Transformers

The Contractor shall check the compliance of the following items:

- Visual inspection including corrosion and alignment;
- Check windings not used are short circuited and earthed;

- Check earthing;
- Completeness of installation and cleanliness of insulators;
- Check gas[21] pressure or oil level;
- Check connections;
- Check ratios and data sheet parameters;

14.5.13 Voltage Transformers

The Contractor shall check the compliance of the following items:

- Visual inspection including corrosion and alignment;
- Check windings not used are open circuited and earthed in one end;
- Check earthing;
- Check tightening of bolts;
- Completeness of installation and cleanliness of insulators;
- Check oil level;
- Check connections; and,
- Check ratios and data sheet parameters.

14.5.14 Disconnector and Earthing Switches

The Contractor shall check the compliance of the following items:

- Check grounding;
- Check tightening of bolts;
- Completeness of installation and cleanliness of insulators; and,
- Verify greasing of main contacts and moving parts.

14.5.15 Surge Arrestors

The Contractor shall check the compliance of the following items:

- Check grounding of supports;
- Check grounding of dischargers;
- Check grounding of counters;
- Check tightening of bolts; and,
- Completeness of installation and cleanliness of insulators.

14.5.16 Earthing

The Contractor shall check the compliance of the following items with the earth grid drawing or calculation note:

- Position of the earth cables and rods;
- Dimensions and type of material of the earth cables and rods;
- Welding of the earth cables and rods together, through a visual inspection; and,
- Position of the earth plugs above ground level.

14.5.17 Meteorological station

The following items shall be inspected on the meteorological stations' equipment:

- Calibration certificates for the meteorological station components, including anemometers connected to the tracker system, pyranometers, soiling stations, temperature sensors, and calibrated cells have been provided;
- Meteorological stations have been installed at the correct locations according to the layout;
- The meteorological station supports have been secured;

[21] To be SF6-free gas for MV secondary distribution equipment.

- The pyranometer's support plate has been oriented according to the correct tilt (tolerance ±0.1°) and orientation (tolerance ±0.1°);
- For the pyranometers, a space is available on the same supporting plate to allow the installation of a second pyranometer for test purposes;
- The pyranometers are clean and not damaged;
- A UV sheath has been installed around the pyranometers' cable;
- The pyranometers have been installed in a shading free zone;
- The PV module temperature sensors have been installed at the correct locations according to the layout;
- The PV module temperature sensor has been solidly pasted to the module; and,
- The PV module temperature sensor has been installed in the middle of a cell of a PV module located in the middle of a table, away from any building fan exhaust.

14.5.18 Security system

The Contractor shall check the compliance of the following items with the anti-intrusion drawings:

- Position of the CCTV cameras and perimeter floodlights which are integrated in the IDS functionality as described in the Employer's Requirements;
- Height of the cameras & floodlights support poles;
- Installation of the IDS along the full length of the fence (mounted on fence and buried along the outer boundary of the fence;
- Installation of the IDS on the full length of the gates;
- Installation of the IDS On/Off switch;
- Installation of magnetic contact switches at all perimeter gates and key entrances in the PV Plant; and,
- Ensure there are no blind spots.

The Contractor shall check the compliance of the following items with the anti-intrusion technical specification:

- Type and accuracy of the cameras; and,
- Type of intrusion detection system for the perimeter fence.

14.5.19 SCADA System

With respect to commissioning tests for the SCADA system, the Contractor shall:

- Verify compliance to requirements and standards;
- Verify accuracy classes are within requirements and inspect calibration certificates; and,
- Verify that all electricity meters (input and output), where applicable, and corresponding circuits are sealed.

14.6 Energisation

Prior to the energisation of the Plant for the first time, the Contractor shall liaise with the HV Contractor and ensure that all the necessary works, commissioning, and testing as required by the relevant Authority and all Applicable Laws and Regulations, Permits, and Codes and Standards are completed either by the Contractor or a third party as required.

The Contractor shall inform the Employer with at least 21 days' notice of the date it intends to energise and connect/synchronise the Plant to the Grid for the first time.

Once a component or system is charged, energised, or otherwise made live, the Contractor shall conduct further tests to demonstrate that the system and its constituent components function collectively as designed and in accordance with all applicable Standards and manufacturer's specifications and guidelines.

14.7 Tests Before Date on Completion

The Tests before Date on Completion shall include, but are not limited to, the following:

- Pre-Commissioning (Cold Commissioning):
  - Visual inspection;
  - Functional tests; and,
  - Electrical safety tests.
- Grid Code Compliance test;
- Commissioning (Hot Commissioning):
  - MV inverter transformers' energisation;
  - Inverters' commissioning;
  - Trackers' commissioning; and,
  - SCADA system and monitoring system commissioning.
- Provisional Acceptance tests.

14.7.1 Personnel

The Contractor shall procure the services of an Authorised Person (OEM Approved) during testing and commissioning of the PV Plant for all switching, linking, safety testing, and earthing operations.

14.7.2 Pre-Commissioning (Cold Commissioning)

The Pre-commissioning shall include, but is not limited to, the following:

- Visual inspection;
- Functional tests; and,
- Electrical safety tests.

The minimum required information shall be provided prior to commencement of the pre-commissioning tests including, but not be limited to, the following:

- Rated component capacity (DC and AC);
- PV Modules:
  - Manufacturer;
  - Model;
  - Datasheet;
  - OEM installation manual;
  - Quantity of modules;
  - PV modules' serial numbers;
  - PV modules' Flash test data; and,
  - Warranty documentation for PV modules, detailing the date of inception of the warranty and duration of warranty remaining.
- Inverter
  - Manufacturer;
  - Model;
  - Datasheet;
  - OEM installation manual;
  - Quantity of inverters;
  - Inverter serial numbers; and,
  - Warranty documentation for inverters, detailing the date of inception of the warranty and duration of warranty remaining.
- Detailed design pack consisting of the following:
  - Up to date SLD of the facility;
  - DC design detailing number of strings, number of modules per string, and number of strings per string combiner box (if applicable). The DC design should also provide DC string cable

sizes, length and type of cable used; this should also apply to string combiner box cables to inverters;
- Specification of overvoltage protection devices (current and voltage rating). Location, type and rating of overvoltage protection devices should be specified;
- Details of all LV, MV and HV cables used on site; this includes cable type, size, OEM, and length;
- A SLD detailing all earthing, lightning protection system and details of the surge protection devices installed;
- A SLD detailing the AC isolators and over current protection devices, location, type and rating; and,
- Mechanical design information and datasheet of array mounting structure (static report).

14.7.2.1 Visual Inspection

The envisaged scope of the visual inspection will consist of, but is not limited to, the following:

- The Plant is free from any defect other than minor defects that do not exceed one percent (1%) of the Contract price, not including those defects that have an adverse effect on the safety, operation, and performance of the Plant;
- The component(s) have been installed and wired in accordance with the approved design and good practice, relevant standards and codes and OEM guidelines;
- The selection and usage of materials and proper installations is appropriate with the environment in which the component(s) are to be utilised;
- The readiness of the installation and the calibration of all protection and signalling equipment;
- The availability of electrical drawings, safety manuals, usage handbooks, factory test reports or quality test reports from manufacturer, when applicable;
- Spare parts available on Site;
- Labelling and identification of cables, fuses, panels cubicles etc.; and,
- Adequate protection from live parts.

Visual checks are applicable on all the components that form part of the Plant, and shall include as a minimum the following parts:

- Inverters;
- Foundations;
- PV modules and DC installation;
- Tracking systems;
- Trenches, cabling, electrical boxes and protection devices;
- Monitoring System including any UPS;
- LV installation, including protection equipment;
- MV installation, including transformers and protection equipment;
- Interconnection Facilities;
- Security system;
- Grid connection line and fitting system;
- Equipment labelling in agreement with plans; and,
- Health and safety signage.

In addition to the aforementioned, the visual inspection shall verify the installation of the system components complies with the design. This includes a review of the following:

- Durable, easily legible labels and markings;
- Durable, easily legible, safety signs in accordance with local laws, regulations and standards;
- Rated power of components;
- Number of components;

- Distances, heights and positions of components and systems in accordance with OEM guidelines and national standards;
- Verify sizing of cables, wires and busbars are in accordance with the design;
- Tightening torque of bolts; and,
- Module flash tests.

14.7.2.2 Functional Test

The Facility shall be subject to functional tests which shall include confirmation that components operate within the expected parameters as well as respond correctly to transient conditions. The functional tests shall be in accordance with IEC 62446-1 (Photovoltaic (PV) systems – Requirements for testing, documentation, and maintenance – Part 1: Grid connected systems – Documentation, commissioning tests and inspection). The following tests shall be included as a minimum as part of the functional tests:

PV modules

- Polarity test (100% of the strings);
- Open circuit voltage tests (100% of the strings);
- DC current tests (100% of the strings);
- Short circuit current tests (100% of the strings); and,
- PV strings IV curves (100% of the strings).

No string may have a measured V_{oc} that differs by more than 5% from the average V_{oc} of the strings connected to one inverter, a measured I_{sc} that differs by more than 5% from the average I_{sc} of the strings connected to one inverter, or an incorrect polarity. The average V_{oc} of the strings connected to one inverter shall not differ by more than 5% from the expected V_{oc} as determined from the module datasheet. The average I_{sc} of the strings connected to one inverter shall not differ by more than 5% from the expected I_{sc} as determined from the module datasheet. All strings that do not meet these requirements shall be considered as non-operational, and the test must be repeated.

Mounting structure

- Cold commissioning tests recommended by the manufacturer including, but not limited to, emergency stow, stow due to wind speed, and stop functions, motor functionality, tracking limits, tracking mode (including backtracking, if applicable) and orientation accuracy within manufacturers specifications.
- Verify wind stow position using inclinometer (measurement to be accurate to ±1˚)

MV/LV power stations

- Check operation of circuit breakers and ancillary equipment;
- Verify operation of ventilation system;
- Verify operation of mechanical and electrical interlocks;
- Verify operation of auxiliary equipment; and,
- Point to point wiring and insulation resistance checks of all interconnecting wiring.

Power and earthing transformers

- Power transformers shall be commissioned by the transformer manufacturer or an authorized representative of the transformer manufacturer using the transformer manufacturer's specified procedures. Commissioning reports shall be issued in a format provided by the manufacturer.

Plant SCADA system

- Verification of all communication cable signals;
- Obtain attenuation measurements on all optical fibres;
- Test communications with inverters;

- Verify format and handling of acquired data set;
- Check threshold alarm controls;
- Inspect UPS operation and correct dimensioning;
- Inspect the Site communication systems – broadband cable distribution and GSM;
- Control of remote system access and data downloading;
- System is ready for on-load commissioning;

Security system (including Security SCADA system)

- Verification of the physical security system;
- Verification of all communication cable signals;
- Obtain attenuation measurements on all optical fibres;
- Verify format and handling of acquired data set;
- Check threshold alarm controls;
- Illumination survey of perimeter lighting and lighting in the buildings;
- Inspect UPS operation and correct dimensioning;
- Inspect the Site communication systems – broadband cable distribution and GSM;
- Control of remote system access and data downloading; and,
- System is ready for on-load commissioning.

14.7.2.3 Electrical Safety Tests

The electrical safety tests shall include but not be limited to:

LV system

- LV DC and AC cables shall be tested for insulation resistance in accordance with IEC/SANS 60364, IEC 60364-6 and SANS 60364-7-712;
- Continuity testing of all DC and LV AC cable;
- Verify the polarity and voltage of each pair of conductors at the string combiner box (if applicable) and inverter;
- LV protections and switchgear tests; and,
- Verification of hot spots in electrical connections.

MV system

- MV protections and switchgear tests;
- Verification of hot spots in electrical connections;
- Perform and record conductor continuity testing;
- Perform and record insulation resistance testing;
- Perform dielectric strength testing;
- Perform VLF testing;
- Perform partial discharges testing;

Power and earthing transformers

- Insulation check (with measurement of insulation resistance) (primary to secondary – primary to earth – secondary to earth);
- Measurement of voltage ratio at each tap setting and vector group;
- Measurement of no-load losses and current;
- Measurement of short circuit impedance and load losses;
- Measurement of winding resistance at each tap setting;
- AC voltage withstand test;
- Tan delta tests performed on all bushings with test taps;
- Test tap changer manual and electrical operation;
- Dielectric tests;

- Functional tests (feedings and auxiliary circuits, ventilators, cooling fans, oil pumps);
- SFRA; and,
- No-load test (when applicable).

Current transformers

- Measurement of winding resistance;
- Ratio and Polarity Test;
- Turn ratio test;
- Check saturation curves of protection cores; and,
- Verification by injection of current to the primary.

Voltage transformers

- Measurement of winding resistance;
- Check voltage ratio; and,
- Verification by injection of voltage to the primary.

Disconnector and Earthing Switches

- Check setting of limit switches;
- Check interlocking between earthing and disconnector;
- Perform electrical manoeuvres;
- Perform mechanical manoeuvres;
- Functional tests; and,
- Measure resistance of main contacts.

Surge Arrestors

- Measure insulation resistance;
- Register number of discharges recorded by the counter before activation; and,
- Measure residual resistance before activation.

Earthing

The Contractor shall supply to the Employer the results of all tests associated with the earthing system, including without limitation the results of:

- Earth resistance tests for each isolated PCU;
- Earth conductor continuity and resistance tests; and,
- Electrical continuity of the Project earthing (all metallic and electrical equipment).

Full compliance with relevant local standards shall be verified by way of current injection tests and step and touch voltage measurements and analysis.

The earth grid shall be tested in accordance with IEEE Std. 81 2012, NESC Rule 011A2, IEEE 2778, SANS 10142-1, SANS 10142-2 and the Eskom Standard for Earthing and Lighting Protection (240-56356396) and IEC/SANS 60364.

Validation tests shall be undertaken including:

- Conductor tests of all the earth grid;
- An 'off-frequency' current injection test to determine the impedance and earth potential rise of the complete earthing system;
- Voltage gradient tests to determine the extent of earth potential rise contours; and,
- Step, touch, and transfer potential measurements throughout the Project to determine the performance of the installed earthing system under simulated fault conditions.

14.7.3 Grid Code Compliance Tests

It is the Contractor's obligation to ensure that the design and installation of the Plant is in compliance with all Applicable Laws, Regulations, Codes and Standards, and regulatory approvals including Grid Code requirements (Latest revision of Grid Connection Code for Renewable Power Plants (RPPs) connected to the electricity Transmission System (TS) or the Distribution System (DS) in South Africa) and the Eskom Standard for the Interconnection of Embedded Generation (240-61268576). The responsibility is on the Contractor to support and drive all required permitting and application process for the grid connection in coordination with the HV Contractor as required.

The Contractor shall ensure all required hardware that is to be specified to allow for grid connection is included in its scope. All required SLD's and layouts shall be submitted as part of the design package in support of the grid connection application.

The results of any tests shall be presented in a manner that will be acceptable to the Grid Operator and the Employer.

Grid Code compliance testing is to be undertaken as required by the Grid Operator and as appropriate and convenient during the commissioning and testing period, but, in any event, prior to the commencement of the Provisional Acceptance tests. Further, the Provisional Acceptance tests shall only commence once the Plant has reached the satisfactory conditions for continuous uninterrupted operation.

14.7.4 Commissioning (Hot Commissioning)

Hot commissioning activities shall only start when the earthing system commissioning has been completed and the results accepted by the Employer. The commissioning tests are performed to determine and verify the proper operation of all component parts, sub-systems, and systems constituting the works and of the project in its entirety.

The Commissioning shall include, but is not limited to, the following:

- Mounting structure commissioning;
- Inverters' commissioning;
- Transformer commissioning;
- SCADA system and monitoring system commissioning test;
- Security system commissioning tests;
- Protection systems/settings, in accordance with agreed design and the requirements of the power interconnection system; and,
- Connection facilities commissioning.

The equipment shall be tested and commissioned by OEM approved procedures and trained personnel.

14.7.4.1 Mounting Structure and Tracker Commissioning

The mounting structures and trackers shall be commissioned and tested according to the manufacturer's procedures.

The following tests and checks shall be performed:

- Visual inspection;
- Torquing of bolted connections;
- Installation angles, heights, etc. against manufacturer allowed tolerances;
- Corrosion protection;
- Grounding connections; and,
- Operation of the trackers, including limits, stowing, manual override, etc.

14.7.4.2 Inverter Commissioning

Each inverter shall be commissioned according to manufacturer specifications and industry best practice. The commissioning process shall be undertaken by the OEM or an authorised representative of the OEM.

These tests on the inverters shall be performed after passing the manufacturer installation protocol and the following shall be performed:

- Visual inspection of the outer and inner parts;
- Continuity check;
- Insulation check (with measurement of insulation resistance);
- Tests under voltage for power and auxiliary circuits;
- Loss of control power;
- Loss of array;
- Anti-islanding;
- Harmonic distortion;
- Power factor;
- Active/reactive power;
- Closed loop Plant controller;
- Test of basic grid management functions (frequency and automatic voltage regulation);
- Check of ventilation system;
- Check of protection devices;
- Protection selectivity check;
- Emergency stop;
- Rated current test;
- Output voltage and current quality test;
- Check of filters and fuses;
- Software updates and data acquisition communication test; and,
- Noise level test.

14.7.4.3 Transformer Commissioning

Transformers (HV/MV – MV/LV – MV/MV – LV/LV transformers) shall be commissioned by the transformer manufacturer or an authorized representative of the transformer manufacturer using the transformer manufacturer’s specified procedures.

Commissioning reports shall be issued in a format provided by the transformer manufacturer.

The commissioning engineer shall execute at least the following tests and checks where devices are installed and/or where applicable:

- Visual inspection;
- Check correct grounding;
- Check tightening torque of bolted connections;
- Insulation check (with measurement of insulation resistance) (primary to secondary – primary to earth – secondary to earth);
- Measurement of turns ratio and vector group;
- Measurement of no-load losses and current;
- Measurement of short circuit impedance and load losses;
- Measurement of winding resistance;
- AC voltage withstand test;
- Test tap changer;
- Check oil leakages;
- Check oil level;
- Check overpressure valve;

- Check of protection devices;
- Check of alarms (oil level, Buchholz, temperature);
- Check saturation of dehumidifying salt;
- Dielectric tests;
- Functional tests (feedings, ventilators, etc.); and,
- No-load test (when applicable).

Where power transformers have been transported to Site and contain accelerometers:

- The Contractor shall assess (only after final positioning) the accelerometer data for compliance to all applicable Laws and Standards and manufacturers' specifications;
- The accelerometer data shall be provided to the Employer within 1 day of it becoming available to the Contractor;
- The accelerometers should be designed to record individual shocks greater than 1G; and,
- In instances where transformers are transported by sea, additional devices should be installed to summate the number of lesser shocks exceeding 0.7G.

All tests shall be executed according to SANS 60076, SANS 60270, IEC 60156, and all other applicable Laws and Standards.

14.7.4.4 HV and MV switchgear

HV and MV switchgear Transformers shall be commissioned by the respective HV/MV manufacturer or an authorized representative of the HV/MV manufacturer using the HV/MV manufacturer's specified procedures.

Commissioning reports shall be issued in a format provided by the HV/MV switchgear manufacturer.

The commissioning engineer shall execute at least the following tests and checks[22] where devices are installed and/or where applicable:

- Mechanical functional test of all components.
  - SANS 62271-200: Standards for high voltage switchgear and control gear Part 200 AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (Clause 8.2)
- Mechanical interlock test as per approved interlocking matrix
  - SANS 62271-200: Standards for high voltage switchgear and control gear Part 200 AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (Clause 8.2)
- Electrical functional test of all control and protection wiring as per the approved HV/MV switchgear design drawing pack.
  - SANS 62271-200: Standards for high voltage switchgear and control gear Part 200 AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (Clause 8.3)
- Secondary injection test on all protection relays to confirm satisfactory operation of the protection scheme. Verification of the protection settings against the approved protection study.
  - SANS/IEC 60255: Measurement relays and protection equipment
- Insulation resistance test and dielectric test
  - SANS 62271-1: Standards for high voltage switchgear and control gear Part 1 General SANS 60076-1: Power Transformers – Part 1 General
- Circuit-breaker timing test (applicable at substation level only)

[22] These tests and checks apply at both the inverter-transformer station level and at the main transmission station (MTS) level.

  - SANS 62271-100: Standards for high voltage switchgear and control gear Part 100 Alternating-current circuit-breakers
- Disconnector contact resistance test (applicable at substation level only)
  - SANS 62271-200: Standards for high voltage switchgear and control gear Part 200 AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (Clause 8.4).

14.7.4.5 SCADA system and Monitoring System Commissioning Tests

The SCADA system and monitoring system shall be commissioned according to manufacturer specifications and industry best practice. Tests shall verify the correct operation of the SCADA system, meters, sensors, weather station instruments, and all inverters, while verifying the correct data input logging from trackers, breakers, and other components monitored by the system. The SCADA system shall be fully accessible remotely.

Every instrument required for the measurement of data would have been previously calibrated and certified by third party experts according to the applicable Standard(s) and industry good practice. Calibration certificates shall be provided for the instruments at the time of testing. The costs involved in preparation of calibration certificates shall be borne by the Contractor.

Prior to the Provisional Acceptance tests, every test instrument required for the measurement of test data shall be checked and recalibrated if necessary. This test shall verify that the data collected is correctly received by the SCADA system and can be used to produce any required performance or operation reports. Each row of data shall report the exact date and time in a suitable format.

The Employer shall review the calibration certificates of each sensor and all related documentation like certifications and installation manuals.

Formal approval and acceptance from the System Operator as to the correct interfacing of the SCADA system with their systems is required for Taking Over. All FO cable installations are to be compliant with SANS 10340-1/2.

14.7.4.6 Security System Commissioning Test

Security system equipment shall be commissioned, tested, and calibrated by a certified installer of the equipment manufacturer using the manufacturer’s specified procedures.

Security system testing shall include testing of all operating modes and alarm conditions, including testing of:

- Cameras and dome cameras;
- Image analyser;
- Infrared sensors / projectors;
- Infrared barriers, microphonic cables, microwave barriers (if any);
- Lights;
- Sirens; and,
- Reaction time of security company.

A security system commissioning protocol or report shall be provided by the Contractor to the Employer.

14.7.4.7 Connection Facilities Commissioning

All tests prescribed by the manufacturers shall be executed in accordance with the prescriptions contained in the respective installation and commissioning manuals. The following list of tests shall be complied with by the Contractor whenever manufacturers’ tests are less restrictive than what is presented below.

<u>MV Circuit Breakers</u>

- Check grounding;
- Completeness of installation and cleanliness of insulators;
- Gas pressure[23];
- Functional tests;
- Tests for verifying opening / closing time;
- Measurement of power absorption of the coils; and,
- Measurement of resistance of the main contacts.

Current Transformers

- Check grounding;
- Completeness of installation and cleanliness of insulators;
- Gas pressure[24] or oil level;
- Check connections;
- Check ratios and data sheet parameters;
- Turn ratio test; and,
- Verification by injection of current to the primary.

Voltage Transformers

- Check grounding;
- Check tightening of bolts;
- Completeness of installation and cleanliness of insulators;
- Oil level; and,
- Check ratios and data sheet parameters.

MV Disconnects

- Check grounding;
- Check tightening of bolts;
- Completeness of installation and cleanliness of insulators;
- Verify greasing of main contacts and moving parts;
- Check setting of limit switches;
- Check interlocking between earthing and disconnector;
- Perform electrical manoeuvres;
- Perform mechanical manoeuvres;
- Functional tests; and,
- Measure resistance of main contacts;

Surge Dischargers

- Check grounding of supports;
- Check grounding of dischargers;
- Check grounding of counter;
- Check tightening of bolts;
- Completeness of installation and cleanliness of insulators;
- Measure insulation resistance;
- Register number of discharges recorded by the counter before activation; and,
- Measure residual resistance before activation;

[23] MV Primary distribution equipment to be AIS with vacuum switchgear. MV Secondary distribution equipment to be SF6-free GIS technology.
[24] MV Primary distribution equipment to be AIS with vacuum switchgear. MV Secondary distribution equipment to be SF6-free GIS technology.

MV Cables

- Check clamping;
- Check correct positioning and orientation of toroids;
- Check grounding of shields;
- Dielectric test according to Laws and Standards; and,
- Check compliance to SANS 1339.

MV Switchgear

- Check correct mounting and fixing;
- Check correct grounding;
- Verify correct setting of protections;
- Functional tests;
- Check gas[25] pressure and humidity level;
- Measure insulation resistance; and,
- Perform dielectric tests.

AC and DC Panels

- Check correct mounting and fixing;
- Check correct grounding;
- Verify correct setting of protections; and,
- Functional tests.

Battery Chargers and Rectifiers

- Check correct mounting and fixing;
- Check correct grounding;
- Check correct installation of battery units;
- Check levels of liquids (if applicable);
- Check seal and filler caps (if applicable);
- Check proper functioning of HVAC system in the battery room;
- Check feeding voltage and phase sequence;
- Check output voltage (Facility and battery side);
- Check polarity; and,
- Check alarms and signals.

Protection Devices

- Check correct mounting and fixing;
- Check correct grounding;
- Check feeding voltage;
- Verify correctness of settings;
- Functional tests; and,
- Check rational and correct tripping of protections, including discrimination.

Fire Alarms, Lightning Protection System, Diesel Generator, and Other Systems

- Check correct mounting and fixing;
- Check correct grounding;
- Verify correct setting of protections; and,

[25] MV Primary distribution equipment to be AIS with vacuum switchgear. MV Secondary distribution equipment to be SF6-free GIS technology.

- Functional tests.

14.7.5 Provisional Acceptance tests

14.7.5.1 General

Prior to commencing the Provisional Acceptance tests, the cold commissioning and hot commissioning activities shall be completed and passed, and energisation shall be successfully achieved.

Prior to commencing the Provisional Acceptance tests, all non-conformities are to be remedied and closed out. The Provisional Acceptance tests may not commence until all non-conformance report(s) have been reviewed and accepted by the Employer.

The Contractor shall develop a test protocol covering each Provisional Acceptance test. A test protocol shall be submitted to the Employer for review and acceptance no later than thirty (30) days prior to the commencement of the specific Provisional Acceptance test for the Employer's review, following the review period stipulated in the Contract. The test protocol shall include a calculation spreadsheet in native Excel format implementing the methodology and formulae defined in the test protocol for the assessment of the outcome of the Provisional Acceptance test, if applicable.

The Employer and Contractor shall have agreed the test protocol before the commencement of any test.

At the conclusion of the Provisional Acceptance test, the Contractor shall provide a test report including all raw data used in the calculations in sufficient detail to allow the Employer to repeat any calculation.

During the Provisional Acceptance tests, all pyranometers installed in the Plant shall be cleaned on a daily basis at the commencement of each testing day outside of sunshine hours.

During the Provisional Acceptance tests the Contractor shall provide daily updates to the Employer on the progress of the tests including daily raw data and shall be available for daily meetings on Site to discuss the tests.

14.7.5.2 Thermographic Inspection

The Contractor shall perform a drone thermographic inspection of 100% of the PV modules while the Plant is in operation, which could coincide fully or partially with the period in which the Performance Ratio test is done in order to detect non-conformities such as hotspot and diode failure. Remedial action plan required under the thermographic inspection results shall be submitted for Employer's acceptance.

The thermographic inspection shall be carried out according to the following requirements:

- Thermal camera specification:
  - Thermal camera resolution: 640 x 512;
  - Thermal camera lens: 13 mm lens; and,
  - Thermal camera framerate – 30 Hz or higher.
- Flight Planning:
  - Flying Altitude: A maximum of 23 m from the module surface to comply with IEC TS 62446-3;
  - Flying Speed: A slow flight speed e.g., 4.4 m/s to provide good image quality and ensure no blurred images; and,
  - Image Capturing: The thermal camera set up with the correct thermal parameters for emissivity, reflected apparent temperature, ambient temperature at operational altitude.
- Irradiance:
  - Target irradiance to perform the thermographic inspection shall be 600 W/m^2; and,

  - Thermographic inspection shall not be carried out with irradiance below 400 W/m^2 (except with prior acceptance by the Employer).
- Wind Speed:
  - Maximum 8.5 m/s, unless otherwise accepted by the Employer and allowed by the drone provider.
- Radiometric thermal Images, JPEG and TIFF format:
  - Radiometric images allowing adjustment to be made to the data post-flight; and,
  - RGB Digital images captured alongside the thermal images. RGB images will assist with classifying specific faults such as soiling shading and broken modules.
- Image analysis, reporting and fault classification:
  - Identification of the location of potential faults to be done automatically by a dedicated software (i.e., no human visual analysis of the images needed);
  - Classification of the fault / thermal anomalies – cell fault, substring fault, junction box, broken module, local soiling (i.e., bird droppings), general soiling (i.e., pollen, dust, leaves), open circuit module / string / inverter, etc.;
  - For each fault, measured global irradiance (via sensor on the drone) converted to irradiance to the Plane of Array (PoA) irradiance with a mathematical model using location and installation angle;
  - Measured temperature gradient for each fault is recalculated by normalising to the irradiance of 1000 W/m^2 based on the calculated PoA irradiance nearest to that anomaly;
  - List of faults with the location for each of the faults at the minimum string number and location of the module within the string;
  - Classification of faults by root cause, e.g., soiling;
  - Tabulated report file format including all relevant fault and location information;
  - Anomaly images (RGB and thermal) to be saved with reference linking back to the report;
  - Faults and anomalies to be mapped on the site layout drawing or accurate representation linking the report data and the anomaly images;
  - Recording irradiance in module plane throughout the inspection and using this data to normalise the thermal gradient to STC; and,
  - Quality Assurance on each report from a Level 1 thermographer, according to SANS 9712.

14.7.5.3 Performance Ratio tests

The Performance Ratio test is a measure of the quality and reliability of operation of a solar PV Power Plant, independent of weather and location. It is expressed as a percentage, stating the relationship between the actual and theoretical electricity generation output of the Plant. It thus indicates the percentage of electricity actually available for export to the Grid after accounting for efficiency and energy losses (PV module degradation, cable losses, soiling losses etc.), energy consumed for operation of the Plant itself, and unavailability of the Grid.

The Performance Ratio tests shall have at least a fifteen (15) days' duration and shall comply with SANS 61724-1 and with the following criteria:

- Periods when irradiance is >100 W/m^2 will be available for the test;
- Any single day of the testing period, the daily cumulative irradiation on the PoA shall exceed 4 kWh/m^2. The test duration shall be extended by the relevant number of days that do not reach the daily cumulative irradiance of 4 kWh/m^2 until reaching 15 days satisfying the daily cumulative irradiance condition;
- The availability of the PV Plant and the grid shall be not less than 99% over the duration of the test. Should events occur resulting in Plant unavailability other than events which are outside of the Contractor's control, the testing period shall be extended by the relevant number of days; and,

- In the event that the test is carried out across two consecutive months, the average monthly PV module temperature (T_{mod}) shall be calculated weighting the number of days of each respective month for which the test has been performed.

The PR shall be calculated on the basis of operating data recorded by the Plant SCADA system, in conjunction with the meter data, as follows:

$$PR_{PAC} = \frac{\sum_j E_{1,j}}{P_{Available} * (1 - \mathrm{LID}) * \mathrm{X(t)} * \sum_j \left(\left(\frac{G_j}{G_{ref}} \right) * \left(1 - \frac{\beta}{100} * (T_{ref} - T_{cell,j}) \right) \right)}$$

$$X(t) = 1 - d_{annual} * n_{(\mathrm{t})}$$

$$n_{(t)} = \frac{\frac{\mathrm{last.install} - \mathrm{first.install}}{2} + measure.start - \mathrm{last.install} + \frac{measure.end - measure.start}{2}}{365}$$

Where:

- PR_{PAC} = the Plant PR during the PAC testing period;
- $E_{1,j}$ = Energy measured (in kWh) over each metering interval j at the meter;
- $P_{available}$ = Available peak nominal DC power of the Plant in kWp (sum of the individual module power of all installed modules as per the relevant datasheets);
  $P_{available}$ = P_{nom} if the Plant is not subject to any unavailability or downtime during the PR test.
  $P_{available}$ < P_{nom} if the Plant is subject to any unavailability or downtime. Every inverter affected during the PR test will not be used for this PR test. For the affected inverters, a separate PR value will be calculated in another fifteen (15) day period when no unavailability or downtime is experienced;
- LID_loss = The LID loss, which shall be determined from the module datasheet (1st year module degradation minus subsequent annual module degradation). This loss may be revisited based on the LID test report to be provided as part for the RfP documentation submission pack. Bidders are advised not to double count this loss in their proposed Performance Ratios and EYAs as part of their Bid;
- X(t) = Accumulated degradation of the modules during the Project lifetime;
- d_{annual} = Annual linear module degradation, as per the module datasheet;
- $n_{(t)}$ = Time period under consideration for degradation purposes for the Plant to date as per the test period;
- last.install = The date when the last solar PV module was installed;
- first.install = The date when the first solar PV module was installed;
- $measure.start$ = The date when the system measurements started;
- $measure.end$ = The date when the system measurements ended;
- G_j = Average irradiation in kWh/m² measured per each metering interval j as the average of the readings of all the on-Site pyranometers with an identical inclination as the PV modules (i.e., PoA); Outlier values with a 30% difference to the median of the pyranometer readings of the same metering interval j will be excluded to avoid biasing the average. Any values clearly identifiable as being erroneous per metering period j will be excluded;
- G_{ref} = 1 kW/m^2, irradiance at the reference STC conditions;

- $T_{cell,j}$ = the average PV module temperature measured during each metering interval j by the temperature sensors placed on the reverse side of the modules (in °C). When several module temperature sensors are installed then the average measurement of the installed module temperature sensors will be considered. Outlier values with a ±30% difference to the median of the temperature readings of the same metering interval j will be excluded to avoid biasing the average;
- T_{ref} = the average reference monthly PV module cell temperature in °C (or temperatures if the test is conducted across more than one month);
- β = Maximum power temperature coefficient of the PV modules as per the relevant datasheets. For the avoidance of any doubt β shall be a negative value; and,
- j = 15 minutes time interval.

In the case of bifacial PV modules, irradiation on the rear side shall be considered with the respective bifaciality factor according to the following formula for the average irradiation:

$$Gj = G_{POA} + G_{rear} \cdot \varphi_{Pmax}$$

Where:

- G_{POA} = front-side plane-of-array irradiation in kWh/m² measured per each metering interval j with on-Site pyranometers with an identical inclination as the modules;
- G_{rear} = rear-side plane-of-array irradiation in kWh/m² measured per each metering interval j with on-Site pyranometers with an identical inclination as the modules;
- Φ_{Pmax} is the bifaciality factor of maximum power obtained from PV module datasheets and should be measured according to IEC TS 60904-1-2;

The Provisional Acceptance Performance Ratio test shall be considered successfully passed once the following condition has been met:

$$\frac{PR_{meas}}{PR_{GUARANTEED}} \geq 1$$

Where:

- PR_{meas} = Performance Ratio measured and calculated using the Performance Ratio test as described above; and,
- $PR_{GUARANTEED}$ = Guaranteed Performance Ratio by the Contractor according to the Contract.

For avoidance of doubt, the Performance Ratio test will be based on measurement readings at the POC.

The data recorded for the Performance Ratio test shall comply with the requirements as per Table 11.

Table 11: Data Recorded Requirements

Item	Specifications
Data to be recorded	Energy Output at the Fiscal Meter Module Temperature PoA Irradiation Ambient Temperature Plant Availability Visible Weather Observations (cloudy, raining, clear sky, wind etc) Time and Date at which the data is recorded.
Sampling interval	The sampling interval for all parameters shall be consistent with the capability of the instruments and shall be as close as practicable to 30 seconds for all parameters which vary directly with irradiance. The averaging interval is set at 15 minutes. Visible weather observations will be taken every two hours.

Item	Specifications
Data Quality	All recorded data shall be checked for consistency, any gaps shall be identified and obvious anomalies recorded prior to any detailed analysis being conducted. A reasonable set of limits shall be defined for each recorded parameter, based on the known characteristics of the parameter, the Plant, and the environment.
Data Format	Processed data shall be prepared in an Excel spreadsheet of 15 minutes interval values recorded in each row. Each row of data shall contain the information (columns) consisting of the monitored signals listed above.

If an event beyond the Contractor's control or responsibility causes the Plant or a part thereof to stop operating, to be disconnected temporarily, or reduce the performance of the Plant due to the tracking system moving to the stow position when the maximum operating wind speed threshold is triggered (evidenced with the weather stations' / Plant SCADA system data), then the test shall be suspended during the period affected for such event and, following restoration of normal operations, the test shall resume for the remaining period until the test has run for the required 15 day duration. A maximum of three (3) cumulative hours of any such event are allowed in the 15 days test period and the testing period shall be extended as needed until this condition is reached. The Contractor shall maintain a log of any such event including the cause, duration, and times at which the test was suspended and resumed. The Contractor shall provide written notice to the Employer within 24 hours following each such test suspension and resumption. Tests may only be resumed if the test pre-requisites remain satisfied.

If the Contractor determines that it is unlikely to pass the Performance Ratio test, the Contractor shall notify the Employer and may discontinue performing the Performance Ratio test. The Contractor may subsequently commence a new Performance Ratio test run, subject to compliance with this testing procedure and all applicable Contract requirements.

14.8 Punch List

For each of the Plant systems, a construction punch list shall be provided as part of the TOP documentation before the respective system moves to commissioning. Once all the individual construction punch lists have been provided as part of the TOP a single punch list shall be compiled.

During the commissioning period the Contractor shall complete items included in the punch list and joint inspections shall be performed by the Contractor and the Employer to agree on the closure of the punch lists. The Contractor shall provide regular updates to the Employer on the status of the punch list

As a condition for Provisional Acceptance, the Employer and Contractor shall agree on a final Punch List which shall only include minor defects or pending work detected which does not adversely affect the correct operation, production, or performance yield of the Project and the safety of persons or property on Site. The Final Punch list items shall not exceed the value of 1% of the Contract Price.

14.9 Tests after Date of Completion

For a period of two years after the Date of Completion, an annual PR test and annual Availability test shall be performed after the completion of year 1 and year 2.

Periods of force majeure and periods during which the grid connection characteristics fall outside the ranges defined in the Grid Code shall not be considered in the calculation of the annual PR test and annual Availability test.

Force Majeure events or any other event outside the Contractor's control (i.e., Grid unavailability or periods during which the grid characteristics fall outside the ranges defined in the Grid Code) shall not be considered in the calculation of the annual PR test and annual Availability test. Nonetheless, the Contractor shall document each such event noting duration of occurrence and affected equipment and responsible entity. Any undocumented event shall not be considered for exclusion from the Performance Ratio and Availability test.

14.9.1 Annual Performance Ratio tests

As part of the annual Performance Ratio tests, the aggregate Performance Ratio shall be determined after the completion of year 1 and year 2.

Only periods during which the average irradiance measured in the plane of the PoA pyranometers is above 100 W/m^2 (irradiance threshold) shall be considered.

For avoidance of doubt, the Performance Ratio will be based on measurement readings at the POC.

The annual Plant PR shall be calculated as follows:

$$PR_{annual} = \frac{\sum_j E_j}{P_{nom} * (1 - \mathrm{LID}) * \mathrm{X(t)} * \sum_j \left(\frac{G_j}{G_{ref}}\right) * D_{plant} * A}$$

$$X(t) = 1 - d_{annual} * n_{(\mathrm{t})}$$

$$n_{(t)} = \frac{\frac{\mathrm{last.install} - \mathrm{first.install}}{2} + measure.start - \mathrm{last.install} + \frac{measure.end - measure.start}{2}}{365}$$

$$D_{plant} = 1 - \frac{\sum_{i=1}^{m}(G_{mp}^{i} * P_{nom}^{i})}{(G_j * P_{nom})}$$

Where:

- PR = the average Plant PR at the end of year 1 and year 2;
- j = 15 minute time interval;
- E_j = Energy (in kWh) over each metering interval j measured at the meter;
- P_{nom} = Nominal installed DC power capacity of the Plant in kWp. Sum of the individual module power of all installed modules as per the relevant module datasheet;
- LID = LID loss, which shall be determined from the module datasheet (1st year module degradation minus subsequent linear annual module degradation). This loss may be revisited based on the LID test report to be provided as part for the RfP documentation submission pack. Bidders are advised not to double count this loss in their proposed Performance Ratios and EYA as part of their Bid;
- X(t) = Accumulated degradation of the modules during the Project lifetime;
- d_{annual} = Annual linear module degradation, as per the module datasheet;
- $n_{(t)}$ = Time period under consideration for degradation purposes for the Plant to date as per the test period;
- last.install = The date when the last solar PV module was installed, given no undue project delays not attributable to force majeure events;
- first.install = The date when the first solar PV module was installed;
- $measure.start$ = The date when the system measurements started;
- $measure.end$ = The date when the system measurements ended;
- G_j = Average irradiation in kWh/m² measured per each metering interval j as the average of the readings of all the on Site pyranometers with an identical inclination as the modules (i.e., PoA). Outlier values with a 30% difference to the median of the pyranometer readings of the same metering interval j will be excluded to avoid biasing the average. Any values clearly identifiable as being erroneous per metering period j will be excluded;
- G_{ref} = 1 kW/m^2, irradiance at the reference STC conditions;

- D_{plant} = Downtime coefficient of the Plant during year y, considering the impact of events outside of the Contractor's control on the Plant. For the purpose of this provision, events being outside of the Contractor's control shall include, but not be limited to, the following events:
  - Outage of utility's switching/substation or Employer's energy line failures;
  - Period of mechanical interruption due to a breakdown in the utility grid, disturbances or reductions in the capacity related to the utility grid (including power limitations at POC and curtailments, or required disconnections due to the production cap), to the extent that the conversion groups cannot supply electricity to the grid according to the technical specifications;
  - Theft or vandalism, provided that the O&M Contractor responsible for the relevant Works' security acted with due care and diligence;
  - Grid downtimes or variations in grid parameters which will cause a breakdown of inverters or other equipment;
  - Outage of the facility due to the instructions or actions of the relevant Employer or the relevant Employer's Representative or the Independent Engineer;
  - Force Majeure as defined in the Contract;
  - Downtime due to examinations carried out by the technical authorities in charge of surveillance or others carried out at the request of the Employer; or,
  - Periods of interruption due to the relevant Employer's failure to comply with his obligation to cooperate.

  If the total accumulated weighted unavailability period exceeds 30 days during any 12-month period of the 24-month period for the Test after Completion, a corresponding period should be added to the test. Irreversibly lost irradiation and temperature data points have to be estimated by approximation; if impossible – corresponding production has to be adjusted for.

  There is no abnormal (compared to the level assumed in the PVSYST) thermal losses adjustment factor since the measurement period is expected to cover two full annual cycles, and the temperature range is expected to be representative of the one assumed in the PVSYST.

- i = Number of 15 minute time intervals, totalling m, during which the Plant has been partially or totally unavailable;
- P_{nom}^{i} = Peak nominal rated power (kWp) not available during the unavailability period i due to causes outside of the Contractor's control;
- G_{mp}^{i}= irradiation in the module plane (kWh/m^2) measured during the unavailability period; and,
- A = Availability of the Plant, as stated in the Contract.

In case of bifacial PV modules, average irradiation on the rear side shall be considered with the respective module bifaciality factor, according to the following formula:

$$Gj = G_{POA} + G_{rear} \cdot \varphi_{Pmax}$$

Where:

- G_{POA} = in-plane front-side average irradiation in kWh/m² measured per each metering interval j with on Site Secondary Standard pyranometers with an identical inclination as the modules;
- G_{rear} = rear-side plane-of-array irradiance average irradiation in kWh/m² measured per each metering interval j with on Site pyranometers with an identical inclination as the modules; and,
- Φ_{Pmax} is the bifaciality factor of maximum power obtained from PV module datasheets and should be measured according to IEC TS 60904-1-2.

The Performance Ratio tests after Date of Completion shall be considered successfully passed once the following condition has been met:

$$\frac{PR_{meas}}{PR_{GUARANTEED}} \geq 1$$

Where:

- PR_{meas} = the average Plant PR or year 1 and year 2; and,
- $PR_{GUARANTEED}$ = Guaranteed PR by the Contractor according to the Contract for year 1 and year 2.

No temperature correction will be performed for the annual PR tests.

In the event that an error occurs with both energy generation readings and pyranometers readings during a period of downtime/unavailability, SolarGIS Prospect satellite incline irradiation data will be used in place of the PoA pyranometer readings for the D_{plant} Downtime coefficient calculation, at the Contractor's cost.

In the event that a part of the entire Plant is unavailable or experiences downtime for an acceptable reason, the downtime will be determined on a per tracker row (with a set of transposition factors accounting for the ratio of incline irradiation to horizontal irradiation) and per string level basis, as applicable.

14.9.2 Annual Availability test

As part of the annual PR tests, the annual Plant Availability shall be determined after the completion of year 1 and year 2.

Only periods during which the average irradiance measured by the Plane of the array pyranometers is above 10 W/m^2 (irradiance threshold) shall be considered.

For avoidance of doubt, the annual Availability test will be based on measurement readings at the POC.

The annual Availability test shall be calculated at the string level as per the following formula:

$$Avail_{string} = \frac{\sum_{j=1}^{k} Pa_j}{\sum_{j=1}^{k} P_j}$$

Where:

- j = 15 minutes time interval;
- k = number of time steps during the test period (i.e., Force Majeure events or any other event that outside the Contractor's control shall not be considered);
- P_{aj} = the sum of the time intervals (accumulated in the testing period) during which the string current output is greater than 0; and,
- P_j = sum of the time intervals (accumulated in the testing period) during which the measured solar irradiance is equal or higher than the 10W/m^2 irradiance threshold.

For the avoidance of doubt, a PV string will be considered unavailable in the respective time step (k) if the irradiance is equal or higher than the irradiance threshold and the string is not conducting any current (which means it's current is 0.0A)

Annual availability shall be calculated as follow:

$$Avail = \frac{\sum_{n=1}^{m} Avail_{string_n} \cdot P_{nom,string,n}}{\sum_{n=1}^{m} P_{nom,string,n}}$$

Where:

- n = each of the strings installed in the Plant;
- m = total number of strings installed in the Plant; and,
- $P_{nom,string,n}$ = nominal DC power of the string n as sum of the individual module power of that string as per the relevant datasheets.

For the avoidance of doubt, if an inverter is completely unavailable all strings connected to that inverter shall be considered unavailable.

14.9.3 Final Acceptance

At the completion of the Defects Liability Period, provided the Plant has passed the annual Performance Ratio tests and annual Availability tests by meeting or exceeding the guaranteed levels, the Employer shall issue the Contractor with a Final Acceptance Certificate (FAC).

Prior to the issue of the FAC, a final inspection of the entire Plant by the Contractor and Employer shall be conducted, including all civil works, electrical works, all (sub)systems, equipment, and components, and auxiliary systems to verify that the Plant is in good condition. All defects, non-conformities, and (final) punch list items shall have been remedied accordingly by the Contractor to the satisfaction of the Employer.

Prior to the issue of the FAC, any performance liquidated damages as per the Contract due to the Employer shall be paid by the Contractor.

15 PERFORMANCE GUARANTEES

15.1 General Requirements

The Contractor shall provide guarantees and warranties as defined in the Contract.

The Contractor shall undertake all tests that are required to demonstrate that the Plant meets the defined performance guarantees as required by the Contract and the Employer's Requirements.

The Contractor shall guarantee that the Plant and equipment shall be completely new, advanced in technology, superior in quality, free from any defect in design, material and workmanship, suitable for the use, and purpose specified in the Employer's Requirements.

The Contractor shall warrant the Plant against defects for two (2) years from Date of Completion.

15.2 Performance Guarantees

15.2.1 AC Capacity Guarantee

The Contractor shall guarantee a Maximum Export Capacity of 75 MWac at the POC with a power factor of one (1) and 50 ºC of operational temperature.

15.2.2 Installed DC Capacity Guarantee

The Contractor shall guarantee the installed capacity (DC peak power) of the Plant as set out in the Contract.

The sum of the peak power of all installed PV modules as stated in the factory flash test list (to be provided by Contractor in electronic format to the Employer) shall be equal to or greater than the guaranteed installed capacity. The Employer shall retain the right to verify the correctness of the PV module peak power by requesting sample PV modules to be tested at independent laboratories (as agreed by both Parties).

If the Contractor breaches this obligation, the Contractor shall either provide and install additional PV modules to achieve the guaranteed capacity or the Contract Price shall be reduced to reflect the actual installed capacity as determined from the flash test list.

15.2.3 Guaranteed Plant Performance Ratio during Tests on Completion

The Contractor shall guarantee that the Performance Ratio of the Plant as measured at the fiscal meter during the Provisional Acceptance Tests shall be equal to or greater than the guaranteed value set out in the Contract.

The Contractor shall provide the guaranteed Performance Ratio data for the Provisional Acceptance Tests in the monthly breakdown format for the monthly Guaranteed Performance Ratio, as well as the monthly Contractor's expected average PV module temperature with which the Guaranteed Performance Ratio values were calculated by the Contractor. These guaranteed Performance Ratio values for the Provisional Acceptance Tests shall be included in the Contract.

The Plant Guaranteed Performance Ratio shall be tested as part of the Provisional Acceptance Tests as described in section 14.7.5.3. If the Contractor breaches this obligation, it shall be liable for liquidated damages for performance shortfall as described in the Contract.

15.2.4 Guaranteed Annual Performance Ratio

The Contractor shall guarantee that the annual Performance Ratio (as described in section 14.9.1) for the first and second operational years from the Date of Completion shall be equal to or greater than the guaranteed value set out in the Contract. If the Contractor breaches this obligation, it shall be liable for liquidated damages as described in the Contract.

15.2.5 Guaranteed Annual Availability

The Contractor shall guarantee that the annual availability (as described in section 14.9.2) for the first and second operational years from the Date of Completion shall be equal to or greater than 95 %. If the Contractor breaches this obligation, it shall be liable for liquidated damages as described in the Contract.

15.3 Extended Defects Liability Period

In addition (and without prejudice to the Defects Liability Period), the Contractor shall provide a warranty on the equipment (including but not limited to strategic part warranty) that shall be back-to-back with the OEM warranties under the respective supply agreements between the Contractor and the OEM.

The equipment warranties continue for all the periods set forth in Table 12. No equipment warranty shall limit another warranty or vice versa.

Table 12: Minimum Warranty Period of Main Components

Equipment	Minimum Warranty
PV modules	Product warranty of 12 years. Power warranty of 25 years
Inverters	5 years with option to secure an extended warranty (10 to 20 years)
MV transformers	5 years
String Combiner boxes	5 years
MV switchgears	5 years
HV switchgears	5 years
Mounting Structure	10-year product warranty for all steel structure components; 20-year product warranty against corrosion; 5-year product warranty for the tracker motors and gears (if applicable); and 2-year product warranty for the communication and control system (as applicable)
Civil works	**10-year latent defect warranty.**

The Contractor shall also provide a serial defect warranty (with the same duration as the product warranty) and a latent defect warranty of five (5) years for all Plant equipment and 10 years on all Civil works for the Plant. The serial defect failure threshold shall be as follows:

- PV modules: 5 %;
- Inverters: 10 %;
- Transformers: 10 %; and,
- Mounting structure: 10 %.

15.4 PV modules warranty terms

The PV Module Supplier shall provide warranties commencing at the earliest six (6) months from the delivery of the PV modules to the Project Site and minimum warranty terms under the supply contract.

PV module defects covered under the warranty terms shall include, without limitation, one or more of the following criteria for any individual PV module:

- SANS 61215 (IEC 61215-1/1-1) non-compliance;
- Glass fracture, crack, or break;
- Chips in the edge of glass that impair structural stability, sealing, or deeper than 2 mm;
- Foreign material, except tin/strip residues larger than 10 mm inside the laminate, or conductor foreign material connected with the live part;
- Delamination of the laminate;
- Cord plate (junction box) damages that impair proper functioning or sealing;
- Lead wire or connector damage that impairs proper function;

- No serial number;
- Damage to the frame that impairs structural stability or function;
- Gaps or damage to the edge seal;
- Failure of the bypass diode;
- Improper or damaged cell connections;
- Any cracks, pinholes, broken cells, discoloration, or edge “V” chips exceeding either 0.1 mm in length or 20 % of wafer thickness;
- More than six instances of cells in a given module with edge breakages or cracks affecting 10 % or more of a cell area; or any instances of dark cells; and,
- At EL testing, any instances of dark cells.

The power measurement uncertainty which is considered for the determination of the actual power of a module shall not exceed 3 %.

If a PV module fails to exhibit the guaranteed power output in any given warranty year, the PV module supplier will either:

- deliver additional PV module(s) to replace the loss of power output with no change in module dimensions; or
- compensate the Employer with an amount equivalent to the loss of revenue which shall be calculated on the Net Present Value of the amount of loss of revenues from such a year.

Responsibility of costs for removal of suspected defective PV modules, laboratory testing in support of a claim, PV module supplier personnel and transportation costs, and shipment of additional PV modules will be borne by the PV module supplier in case of a valid claim.

The PV module supply contract shall include the following response times:

- Ticket opening and claim receipt acknowledgement: one (1) business day;
- Response on the validity of the claim: two (2) weeks from ticket opening date;
- PV module replacement and delivery to Site: five (5) weeks from claim validity date; and,
- Defective PV module removal: five (5) weeks from claim validity date.

As stated in this section, the PV module serial defect warranty shall be 12 years. In the event of disagreement on serial defect claim validity between Employer and PV module supplier, a third party consultant to be agreed between the Employer and the Contractor shall be engaged and paid for by the party losing the claim. The third party consultant shall be granted access by the PV module supplier to all the PV module manufacturing and delivery data, including BOM, raw material supplier, production lines, manufacturing equipment, testing equipment, factory indoor environment, involved labour in each operation, quality records, etc. The study result outcomes of the third party consultant shall be binding on both Parties.

16 GRID CONNECTION WORKS

16.1 SCOPE OF GRID CONNECTION WORKS

Eskom Generation, through its Renewables Division, has entered into, or is in the process of entering into, a self-build agreement with Eskom Distribution for the connection of a solar farm to the Eskom Distribution Grid.

The Grid Connection Works consists of the following main parts:

- New 2x80 MVA 88/33 kV rating Solar Substation, to be taken over, owned, operated, and maintained by Eskom Generation. References to Solar Substation in the context of the Grid Connection Works refers to this substation. The substation name must be agreed upon within Eskom (between Eskom Generation and Eskom Distribution) so as to ensure there are no conflicting or duplicating names, e.g., Lethabo Solar Plant Substation.
- New 88 kV 2-bay Eskom switching station, to be taken over, owned, operated, and maintained by Eskom Distribution (FSOU). References to Eskom Switching Station refers to this substation. The substation name must be agreed upon within Eskom (between Eskom Generation and Eskom Distribution) so as to ensure there are no conflicting or duplicating names, e.g., Lethabo Solar Switching Station.
- New ±4.5 km long 88 kV single circuit overhead line, to be taken over, owned, operated, and maintained by Eskom Distribution (FSOU).
- 1x additional 88 kV bay extension, inclusive of busbar extension and control plant extension at the RWB Lethabo Substation, to be taken over, owned, operated, and maintained by Eskom Distribution (FSOU). References to this substation will read as RWB Lethabo Substation.

The Project SLD is depicted in Figure 5 (for more detail, see Annexure D).

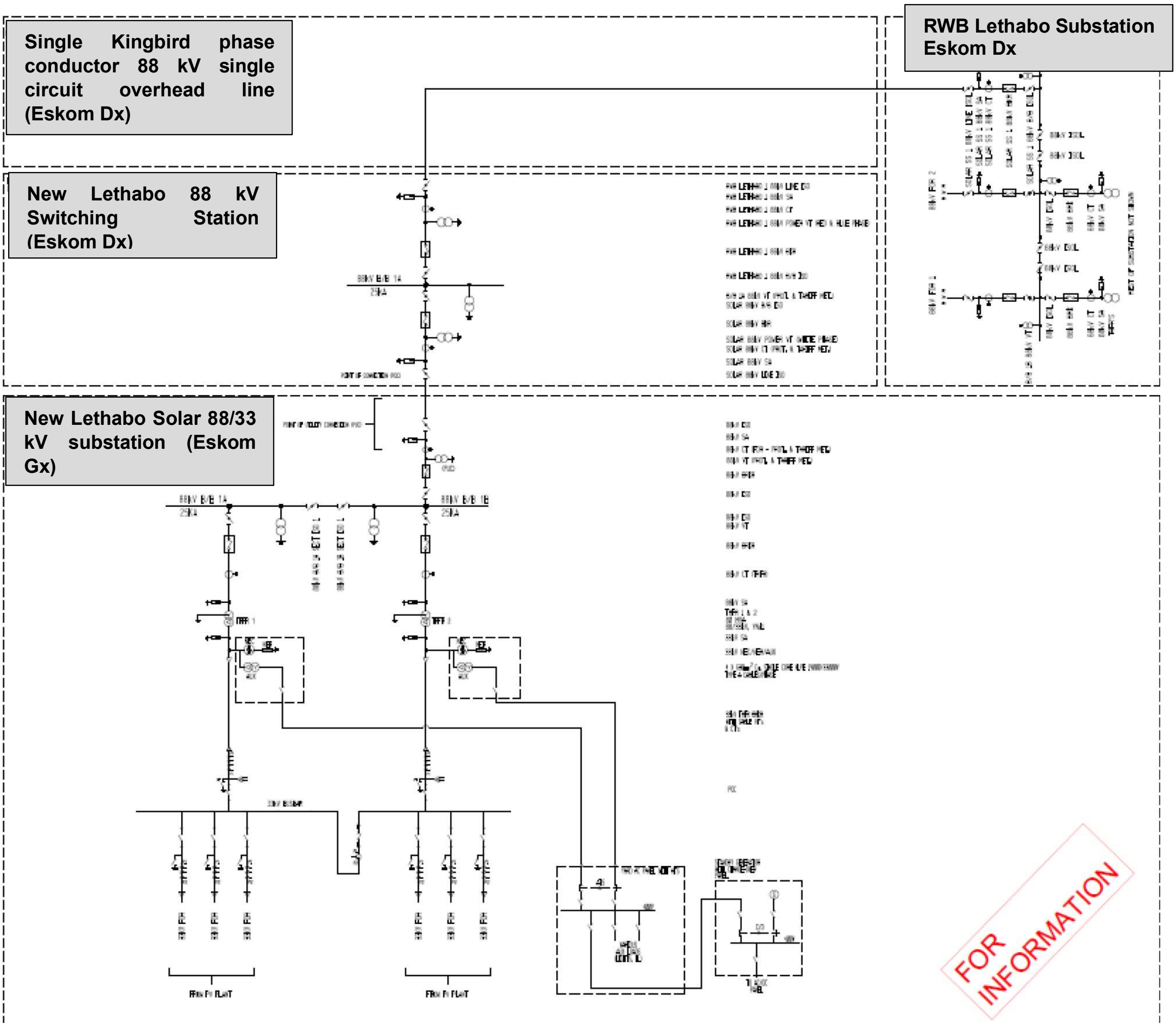

Figure 5: Eskom Lethabo Solar PV Facility SLD

The detailed scope for the above works is as follows, but not limited to:

16.1.1 88 kV Eskom Lethabo Solar Switching Station

16.1.1.1 Primary Plant Scope of work

- Establish a two-bay 88 kV switching station at the solar plant's connection point (POC), comprising a line feeder bay from RWB Lethabo substation and a line feeder bay to the Solar Plant, with 88 kV busbar, including isolators, earth switches, surge arrestors, circuit breakers, CT's, VT's and junction boxes;
- Supply & Install 2 x 1-ph 88 kV power VT's, including junction boxes;
- Supply & Install 1 x 3-ph set 88 kV busbar VT's, including junction boxes; and,
- Build a Switching Station control room (separate building).

16.1.1.2 Control Plant Scope of work

The Contractor will be responsible for materials and designs. Eskom CPM Vaalpark will commission the 88 kV switching station and Eskom PC & C Bloemfontein to provide the 88 kV control and protection equipment settings.

16.1.1.3 Protection

- Supply & Install 2x Line Feeder protection schemes. The Lethabo Solar Plant feeder to have full unit protection; and,
- Pre-commission and commission all protection schemes.

16.1.1.4 Metering

- Supply & Install full four (4) quadrant tariff metering schemes;
- Only Eskom approved meter types shall be used;
- The Tariff metering installation shall be in accordance with Eskom specification no. 240-56364444 - Standard minimum requirements for the metering of electrical energy and demand. This includes, but is not limited to, the requirements around the accuracy class of the meters, CTs and VTs; and,
- Pre-commission and commission all metering installations.

16.1.1.5 AC / DC Supplies

- Supply & Install AC and DC panels, Nicad standby battery banks and chargers;
- The above AC/DC boards to comply with Eskom Standard no.240-75658628, Distribution Group's specific requirements for AC/DC Distribution Units; and,
- Pre-commission and commission all AC and DC supply installations.

16.1.1.6 SCADA system

- Supply & Install a SCADA system RTU panel; and,
- Pre-commission and commission all SCADA system installations.

16.1.1.7 Telecoms

- Supply & Install a MSAP telecommunication panel;
- Supply & Install 1 x 48-Core fibre optic patch panel (with 1300nm single core patch leads); and,
- Pre-commission and commission all Telecoms equipment installation.

16.1.2 88/33 kV Lethabo Solar Plant Substation

16.1.2.1 Primary plant

- Supply & Install 3x 88 kV outdoor switchgear bays with 88 kV busbar (1x Eskom inter-connector bay and 2x transformer bays), including isolators, earth switches, surge arrestors, circuit breakers, CT's, VT's and junction boxes;
- Supply & Install 2x 88/33 kV 80 MVA step-up power transformers including MV and HV surge arrestors;
- Supply & Install 2x NECRT's. Rating to be determined by Contractor. The NECRT supplies the auxiliary power to the Solar Substation;
- Supply & Install 33 kV switchgear panels, with bus-sectionalizer, transformer feeders, and Solar PV MV feeder incomers;
- Supply & Install MV cable termination structure(s), MV cabling, cable trenches;
- Supply & Install all civil engineering and structural works including, but not limited to, foundations, fire walls, oil holding dam and associated pipework, fencing, transformer runway, storm water management, drainage etc., complete;
- Supply & Install substation earth mat; and,
- Build substation building consisting of switch room, Solar Plant Substation control room, and battery room.

16.1.2.2 Control Plant

Generator protection must cater for the below requirements according to Eskom Standard No. 240-61268576 (Standard for the Interconnection of Embedded Generation).

16.1.2.3 Protection

- Supply & install 1 x 'Eskom' feeder protection scheme - design same as used by Eskom, with 1 x new line current differential feeder protection scheme and panels. The scheme must feature directional back-up overcurrent and earth fault protection;
- Supply & install 2x 88 kV power transformer feeder protection panels;
- Supply & install 2x 88 kV power transformer control panels, including tap-changer control;

- Settings configuration to incorporate synchronism check, loss of grid protection and other relevant configurations required to attain full functionality;
- Complete settings revision on adjacent substations to suit; and,
- Pre-commission and commission all control and protection systems

16.1.2.4 Metering

- Supply & install 1x tariff metering scheme for 88 kV (generation) supply to Eskom;
- Supply & install generator feeder metering schemes;
- Supply & install Power Quality Metering at the PUC; and,
- Pre-commission and commission all metering schemes.

16.1.2.5 Telecommunication

- Supply & Install 1 x FO patch panel (with 1300 nm single core patch leads);
- Supply & Install a MSAP telecommunication panel;
- Install 1300 nm optic fibre link between the Eskom Distribution Switching Station and the Solar Substation; and,
- Pre-commission and commission all telecommunication schemes

16.1.3 HV Line

- Build approximately 4.5 km 88 kV 3-ph line (self-supporting single circuit steel transmission monopole line) from the 88 kV Eskom Switching Station to RWB Lethabo substation, inclusive of OPGW shield wire.
- A servitude alignment is already defined, and the Contractor and his design team shall design and install the line within the servitude.
- There are existing 22 kV and 88 kV lines to be crossed *en route*.

16.1.4 RWB Lethabo substation

16.1.4.1 Primary Plant Scope of Work

- Install 1 x 88kV line feeder Bay at RWB Lethabo substation, including isolators, earth switches, surge arrestors, circuit breakers, CT's, VT's and junction boxes, busbar extension and line termination structures.

16.1.4.2 Control Plant Scope of Work

16.1.4.3 Protection

- Install a line current differential feeder protection scheme on the new feeder bay at RWB Lethabo Substation;
- Replace the existing non-standard AC/DC panel to accommodate the new installation;
- Install 1 x CT JB on the new 88 kV CTs;
- Pre-commission and commission all protection systems.

16.1.4.4 Metering

- Install statistical metering equipment on the new 88 kV feeder bay at RWB Lethabo Substation;
- Install a standard 19" rack metering panel; and,
- Pre-commission and commission all new metering schemes.

16.1.4.5 SCADA system/RTU / Telecommunication

- Expand I/O module to accommodate the new installation;
- Pre-commission and commission Telecoms equipment;
- Install FO Ground Wire (OPGW) shield wire on the new 88 kV RWB Lethabo – Eskom Switching Station line; and,
- Pre-commission and commission the new Fibre Optic telecommunications link as well as SCADA system/RTU panels.

16.2 Engineering design

It is a requirement by Eskom Distribution (FSOU) that the Engineering Design performed under the self-build agreement by the Contractor, be performed by a consulting engineer accredited by Eskom Distribution (FSOU) for Substations, Control Plant and HV lines. The same consultant shall also design the Solar Substation as both the Solar Substation and the Eskom Switching Station will share a common platform and adjacent earth mats.

The Contractor shall appoint such an Eskom accredited consultant who shall be responsible for the design as well as the submission for approval to Eskom in terms of Eskom Distribution (FSOU) processes.

In terms of the self-build agreement requirements by Eskom Distribution (FSOU), the Eskom accredited Engineering Consultant shall remain involved during the construction process to oversee that the design is correctly implemented. The Engineering Consultant shall also provide an Eskom approved Clerk of Works with suitable High Voltage Regulations (ORHVS) certification to act as Clerk of Works on behalf of the Contractor, and who shall carry out all inspections prior to, during and after all visits by Eskom Distribution (FSOU)'s Clerk of Works. The Contractor's Engineering Consultant's Clerk of Works shall maintain the hand-over file for handing over to Eskom at the end of the project. The Hand-over file shall contain all test certificates, copies of inspections sheets, test reports and eventually, the As-Built drawings. The Eskom accredited Engineering Consultant or his appointed Clerk of Works shall maintain a full-time presence during factory acceptance tests, site acceptance tests and commissioning, to witness the tests performed.

The design of the Grid Connection Works (balance, not taken over by Eskom Distribution) will be reviewed by Eskom Generation.

16.3 Grid Connection works subcontractor

It is a requirement by Eskom Distribution (FSOU) that the construction works performed under the self-build agreement be performed by a contractor accredited by Eskom Distribution (FSOU) for Substations, Control Plant, and HV lines.

It is advisable that the Contractor appoints the same subcontractor to construct both the Solar Plant Substation as well as the Eskom Distribution's part of the Grid Connection Works.

16.4 Civil Engineering and Building Works Requirements

16.4.1 General

16.4.1.1 Scope of the Works

Civil works shall include the design, procurement, and construction of the following items, including, but not limited to:

- Site investigations and surveys, including topographic survey, geotechnical study (field and lab tests, hydrologic study, POT);
- Site preparation, including clearing and grubbing of land, excavation, backfilling, compaction, grading, levelling, earthworks, soil improvement, and rehabilitation of parts of the Site as affected by the Contractor's activities;
- Permanent fencing and gates. Both Solar Substation and Eskom Switching Station fences and gates shall comply with Eskom's substation fencing standard no. 240-100183119**.** Where any part of a substation fence is integrated into the boundary fence of the Project, the requirements for step and touch potential limits shall be upheld. The substation fence(s) cannot be installed prior to the earth mat being installed due to the requirement for the earth mat to extend beyond the substation perimeter fence. It is recommended that the Contractor provide the fenced off

substations (Eskom Switching Station and Solar Substation combined and separated by a fence) either
  - completely outside of the solar plant's (site) overall boundaries; or,
  - completely within the Plant's (site) overall boundaries so that the substation fence can be equipped with a 1.2 m wide site perimeter barrier zone outside of the substation fence where the earth mat still provides protection against step and touch potentials, and this zone does not fall outside of the Plant's boundaries.
- All necessary access roads (internal to the solar plant or external to the solar plant) to construct, and subsequently operate and maintain, the Eskom Switching Substation by Eskom Distribution (FSOU) and Solar Substation as well as Eskom Generation staff. The access road must be able to accommodate the heaviest component, being a single 80 MVA transformer being transported;
- Drainage system;
- Electrical, telecommunication, duct system, earthing and cable trenches;
- Road crossings and directional drilling as required for underground cabling, utilities, rivers/stream;
- Solar Substation and Eskom Switching Station control room buildings, including foundations;
- Sewers and sewage systems;
- Water supply and storage;
- Afford temporary facilities with offices for the Contractor's team and the Employer's representatives including the Employer's Owner's Engineer team, meeting room, and restrooms, including furnishing and equipping. The latter shall be serviced facilities for the duration of the Contract;
- Utilities for temporary facilities (power, water, telecom, waste);
- Temporary Roads and parking;
- Site rehabilitation following construction works completion;
- Rectification of defects under warranty; and,
- Vehicular access in substations. The substations shall be designed to have adequate vehicular clearance and movability inside the substation for maintenance purposes. The vehicle access inside the substation shall be as per the Eskom standard 240-170000918 – Design for Maintenance Vehicle Access in and Around Substations.

16.4.1.2 Existing Service

The Contractor is responsible for the identification and demarcation of all existing underground and overhead services within the Project Site. If encountered during the course of the Works, all live pipes, mains cables, transmission lines, and services of any kind are to be maintained in position or diverted to a location reviewed by the Employer, protected and kept in working order unless otherwise directed by the Employer.

No works in this regard shall commence without the prior acceptance in writing by the Employer of the Contractor's proposed method statement and programme.

16.4.2 Environmental Aggressiveness

The Contractor shall take into account the conditions found at the Site and in the subsurface layers in order to avoid any corrosion problems above and underground, especially with equipment installed outdoors. Additionally, respective environmental requirements shall be included and taken into consideration after the respective EIA submission. Given the location of the Site, the Contractor shall confirm the ambient atmospheric conditions and soil corrosivity category for further observation and proper design accordingly protection to SANS 12944 Standard Parts 1 to 8 for steel structures. Additionally, corrosion protection shall be designed, as a minimum, for a design operational lifespan of 25 years and the specific location conditions, such as soil chemical testing results, humidity, wind loading, ambient temperature, proximity to ocean/see for salt mist concentration and air corrosivity, etc.

The Contractor shall ensure that precautions are taken in packing and crating to avoid damage to the protective treatment during transportation to the Site. Any damage to paintwork which occurs during transport shall be made good at Site. All surfaces shall be thoroughly cleaned and prepared prior to any painting, in accordance with the requirements of the specific paint used.

Paint shall be stored in dry covered conditions and shall not be used if it has been in storage for more than three (3) months or not used for more than six (6) months after the manufacture date.

Unless otherwise specified, galvanising shall be hot dip galvanising in accordance with SANS 121 and SANS 14713-2. Bolts, nuts and washers together with all other threaded components used as fasteners shall be finished with a centrifugal galvanised coating in accordance with this standard.

The thickness of zinc on every galvanized element shall be higher than the calculated minimum thickness required on all its sides and parts. Prevalence of localised mean thicknesses below the minimum calculated thickness shall be avoided.

All drilling, punching, stamping, cutting, and welding of parts together and removal of burrs shall be completed before articles are galvanised in accordance with SANS 121 and SANS 14713-2. Any Site modifications of galvanised steelwork shall be made good with an approved cold galvanising system as reviewed by the Employer.

Materials and coatings for all structures shall be based on the findings of the soil chemical testing and with a projected durability of at least 25 years.

Details shall be provided of any special finishes including those on components manufactured from sheet aluminium or steel.

All ferrous metals shall be protected from corrosion in accordance with SANS 121, SANS 14713-1, SANS 12944 or equivalent local or internationally recognised standard(s). The exposure conditions to be used shall be entirely suitable for the type and intended purpose of each structure, taking full account of the components' and Plant's location.

Where the Contractor shall use a paint system for corrosion protection, the Contractor shall ensure that it shall be applied in full accordance with the manufacturers' recommendations and that each coat applied to any member shall be from the same manufacturer.

The Contractor shall submit full details of its proposals for corrosion protection for the Employer's consideration. Proper analysis for avoidance of galvanic reaction due to contact between different metals shall be done and justified if required.

All external coating systems shall be designed to be UV resistant across the UV radiation spectrum expected for the Site.

Considerations must be given to fauna protection of all equipment and materials which may come into contact with rodents or other vermin. This includes cable sheaths, outdoor switchboards transformers and switchgear buildings, etc. Means of protection shall satisfy planning approval conditions and the environmental management plan.

The Works shall be adequately protected against any kind of frost damage if applicable to the location.

16.4.3 Earthworks

16.4.3.1 Site preparation

Prior to the commencement of any construction works, the Contractor shall clear the Site of all rubbish, debris, building rubble, vegetation, and unwanted materials of any description and remove and dispose of the same in line with the local Environmental requirements and through licensed contractors permitted accordingly by the local approving authorities.

The Contractor shall carry out a topographical survey and evaluate if relevant slopes are observed to fall within the minimum and maximum recommended slope gradients.

16.4.3.2 Construction Phase Earthworks

Levelling and grading of the Site, if required for the Contractor's design, shall take cognisance of the existing surrounding ground levels to facilitate free drainage of the Site. Additional fill material required to achieve the falls necessary for free draining shall be a suitable imported fill material. The finished Site shall be well compacted in layers according to the SANS 1200 & SANS 2001 Standards.

Cutting and filling slopes shall be indicated as 'H:V' gradient. The substation platform gradient shall be in accordance with Eskom Distribution (FSOU) requirements.

Finished ground floor level of technical buildings/enclosures shall be at least 0.25m higher than the 1:100 year return period maximum water level, in order to ensure free drainage of the surrounding grounds away from the buildings. For any case where the flood risk assessment / hydrological impact assessment report requires specific higher ground floor levels, these shall take priority. The Contractor shall also refer to the recommendations of the hydrological studies in terms of finished ground floor levels as well as SANS 10400.

The Contractor shall carry out its construction activities in such a manner as to avoid damage to, or deterioration of, the final surfaces of excavations. The Contractor shall not allow water to accumulate in any part of the Works unless required to do so under the Contract; water arising from, or draining into, the Works shall be drained or pumped to an approved disposal container/area. Any contaminants whose presence would render water unsuitable for discharge into water courses or drains external to Site shall be effectively removed prior to discharge and, where appropriate, such extracted contaminants shall be transported to a licensed facility. The stormwater management plan should include the aforementioned considerations and actions.

All excavated materials for reuse (especially all excavated topsoil) or disposal off site shall be placed in stockpiles prior to processing and final classification in accordance with the Soil / Material Management Plan. Where required, unacceptable material shall be processed by mechanical or chemical testing or other means to render the material acceptable for use in the permanent Works. Classification and disposal of any contaminated material shall be the responsibility of the Contractor, subject to the agreement of the Employer and in line with Environmental Legislation.

The Contractor shall provide to the Employer documentation to prove the source of materials brought into the Site and that sufficient chemical analysis testing has been performed to demonstrate beyond reasonable doubt that these materials are free of pollutants.

The Contractor shall prepare and re-dress the Site as necessary with free-draining granular material to facilitate the efficient movement of personnel during the construction of the Works and shall maintain the surfacing as required such that construction is not interrupted nor water is allowed to collect on the surface.

The Contractor shall establish a temporary Site drainage system including settlement/attenuation ponds, depending on the flooding risk during construction, to be evaluated by the Employer. Oil interceptors and wheel washes shall be required, if applicable under the EA and EMP. Any contaminants whose presence would render water unsuitable for discharge into water courses or drains external to the Site shall be effectively removed prior to discharge and, where appropriate, such extracted contaminants shall be transported to a licensed disposal Site.

16.4.3.3 Permanent earthworks

In anticipation of the difference in the existing ground levels across the Site, the Contractor shall carry out the earthworks within, and in the immediate vicinity of, the Plant. The earthworks shall be designed to minimise the amount of cut and fill. The slope of the access roads shall also be given consideration. Excavated materials shall be disposed of in line with environmental requirements and legislation.

The filling back for foundations purpose will be done in layers of no more than one hundred and fifty (150) mm and compacted to 93% (or better) of maximum density at optimum moisture content.

Adequate laydown areas suitable for the Plant, equipment and/or vehicles using them shall be provided for the proper operation and maintenance of the Plant.

If design of platforms is required due to earthworks, as well as the slopes, it shall comply with the required bearing capacity, either for a foundation or roads, and will depend on the geo-mechanical parameters obtained from the geotechnical report. The minimum layer of topsoil specified in the geotechnical report shall be removed and used / spread over other free areas and perimeter for later environmental restoration activities.

16.4.4 Structural Design Principles

All structural design calculations shall be in accordance with SANS 10160 and further codes shall be followed where the Structural Code needs to be complemented. The Contractor will take full responsibility for these structures.

All design reports, calculations and drawings prepared by the Contractor shall be signed by a certified structural engineer.

Design calculations shall be signed by a professionally registered structural engineer, or equivalent.

Consideration of wind speed accelerations caused by near obstacles, hills or escarpments shall be considered and properly substantiated.

Dynamic loads (including possible instability that might occur due to vortex shedding, wake buffeting etc.) shall be considered when these might lead to higher stresses, and they shall be estimated using state-of-art design tools and methodologies. A modal analysis shall be performed when necessary.

Fatigue assessment shall be performed should fatigue be considered as critical for the component under evaluation. Estimations shall be performed using state-of-art design tools and methodologies.

In the calculation reports and drawings notes to be provided to the Employer, the following information shall appear:

- Detailed Supporting Structure characteristics (type, dimensions, etc.);
- Detailed materials characteristics (concrete technical specifications, steel grade, protection against corrosion, etc.);
- Detailed design assumptions (environmental conditions, load combinations, modelling software, etc.); and,
- Detailed calculation results for all load combinations.

16.4.4.1 Load Assumptions

In designing the Project, the Contractor shall take into account all the reasonably expectable loads that the Project Works might be subject to, including, but not limited to:

- Self-weight loading;
- Wind loading;
- Thermal loading;
- Seismic loading;
- Snow loading, where applicable;
- Water (flooding) loading;
- Actions induced by cranes and machinery operation;
- Actions imposed during execution; and,

- Basis for geotechnical design and actions outline.

The Contractor shall consider the loads and load combinations in accordance with SANS 10160.

The Contractor is responsible for system survivability over the design lifetime of the Project.

16.4.4.2 Wind Loads

Design wind loads shall be defined according to SANS 10160-3.

The Contractor shall document the assumptions made using available wind data and any supporting material demonstrating the suitability of the structures and components for the Site Conditions.

Each component forming part of the Project shall be designed for, or verified against, the expected imposed wind loads. This includes, but is not limited to, foundations, buildings, towers, fences etc.

Wind loads shall be duly combined with other loads as prescribed in the Laws, Consents and Standards by implementing adequate safety factors. Consideration of wind accelerations caused by near obstacles, hills or escarpments shall be considered and properly substantiated.

The Contractor shall perform its own investigation as to the maximum expected wind conditions over a return period compatible with the projected Project design lifetime.

The Contractor shall seek to support his assumptions and calculations using wind load test results, such as wind tunnel tests or CFD tests whenever necessary to demonstrate compliance with the aforementioned conditions and the Laws, Consents and Standards.

16.4.4.3 Seismic load

The Contractor shall perform its own investigation as to the maximum expected seismic accelerations over a return period compatible with the design lifetime and use of the Project according to SANS 10160-4.

Each component forming part of the Project shall be designed or verified against the expected seismic loads. This includes, but is not limited to, foundations, buildings, towers, fences etc.

16.4.5 Corrosion Protection

The Contractor shall demonstrate that all metal structures are adequately protected against corrosion, both due to the ground aggressiveness and atmospheric conditions. An independent third party corrosion ambient report shall be provided by the Contractor. Where metal surfaces are protected against corrosion through the application of hot-dip galvanizing, the galvanizing shall be appropriate for all Site conditions (climate, soil conditions, agricultural practices, anodic and cathodic reactions etc) for the Design Lifetime of the Project (25 years) in accordance with SANS 121 and SANS 14713-1/2 or equivalent local or ASTM standards. The Contractor shall obtain galvanizing certificates confirming such compliance. For underground steel, DIN 50929-3 Standard shall be followed and adhered to.

Pre-galvanization or similar treatment as G90 is not allowed for any part of the structure in contact with the ground.

The entire scope of painting and corrosion protection shall be inspected by the Employer's Representative during the Defects Liability Period and before the Final Acceptance Certificate is issued.

16.4.6 Foundations

Foundations shall be designed according to the relevant local and international Standards.

The Contractor shall assume the ground risk as stipulated within the Contract conditions. Prior to construction, the Contractor shall carry out all necessary geological and geotechnical investigations and studies so as to satisfy itself of the ground conditions prevailing.

In the Contractor's design packages (reports and drawings), the following information, as a minimum, shall be made available to the Employer:

- Detailed foundations design documentation for all required foundations (type, dimensions). Reinforcement characteristics (steel reinforcing bars diameter, separation, grade and finish – Y or T) ;
- For steel structural elements protection against corrosion;
- Concrete mix design (grade, composition);
- Design basis statements and supporting calculations;
- Specific construction methodology and testing criteria requirements; and,
- Specific bearing capacity requirements.

Foundations shall be designed to withstand the Site conditions encountered for the entire Design Lifetime of the Project (25 years), without being replaced.

16.4.6.1 Other foundations

The Contractor shall perform all required geotechnical and other studies, to the extent deemed necessary, to assess the ground conditions of the Site and determine the type of foundations and any ground improvement techniques to be employed as necessary (soil improvement; compaction, etc.).

The Contractor shall provide a detailed structural analysis demonstrating that the design conforms with the Site's climatic wind speeds, seismic loads, and snow loads, and to the Standards, and shall clearly state in the design basis report(s) the loads combinations, assumptions, and the design specifications.

The foundations shall be able to transfer all actual load combinations, including horizontal and uplift forces, safely to the support soil material. The Contractor shall state in the calculations the maximum permissible foundation settlement that may be tolerated consistent with normal operation of the Works.

The material used for the foundation will be steel reinforced concrete. Overall, the minimum strength of structural concrete for the foundation shall be strength class 25MPa, unless otherwise specified. The Contractor is to specify higher grade of concrete where required and submit all designs for review by the Employer. All below ground concrete structures shall be adequately waterproofed. Likewise, the concrete design mix will be specified according to the aggressiveness and the geomechanical properties of the ground conditions and groundwater shown in the geotechnical report and laboratory analyses of samples.

Should a risk of excessive soil erosion and/or dune formation be identified, suitable mitigation measures will be implemented to manage any long- and short-term impact, subject to the Employer's acceptance.

The detailed design documentation and drawings shall include, but not be limited to, the following:

- Detailed foundations characteristics (type, dimensions, material technical specifications, etc.);
- Geotechnical design assumptions and verifications;
- Specific construction requirements and testing criteria;
- Climatic condition assumptions and verifications (wind, snow, humidity, temperature, etc.);
- Concrete foundations:
  - Reinforcement characteristics (diameter, steel grade, protection against corrosion, etc.); and,
  - Design mix requirements (grade, composition, etc.).

The Contractor is responsible for the sealing of cable ducts that enter buildings or other areas, which will be suitable for the construction phase (temporary sealing) and for the Design Lifetime (permanent sealing).

16.4.6.2 Excavations and backfilling for foundations

Foundation excavations shall be designed and performed to ensure their stability and the Works in safe conditions and to allow for concrete placing avoiding any mixing with *in situ* soil. Excavated material shall be stored in a suitable place, preventing any disturbance. Topsoil shall be stripped to avoid contamination with excavated subsoil. Excavations dimensions shall comply with foundation design.

The final sub-formation level (excavation bottom) shall be inspected by the Contractor to demonstrate compliance with the final detailed design specifications for bearing capacity. That shall be inspected by the Employer's representative to verify the finalized foundation design specifications for the founding ground. Excavation shall be backfilled with suitable material and properly compacted in layers not exceeding 0.25 m thickness in order to achieve the compaction density required for supporting structure stability and resistance against erosion and light vehicles traffic loading.

In the event of water ingress (groundwater or surface water) into the foundation area, the excavation will be drained before foundation construction works activities commence. The Contractor will supply any temporary equipment and take such action necessary to ensure all foundation excavations are kept free from water during the foundation construction works activities period. The Contractor shall consider environmental constraints for location of outfall discharge for each location where pumping is required.

16.4.7 Roads

The Contractor shall be responsible for any permit requirements and liaise with local authorities in order to ensure permanent access during construction and during operation to the Plant.

The access road to the substations shall be the responsibility of the Contractor. The access road to the Eskom substation shall traverse a registered road servitude that recognises Eskom's rights to utilize the access road.

The Contractor shall develop and carry out a construction Traffic Management Plan and best practice traffic management procedures, including a traffic incident response plan, where required.

The design, construction, and maintenance of all roads shall be entirely suitable for the size of vehicles to be used for the O&M activities that will be required for the 25-year design life of the Plant. The road structural layers shall be defined considering the most arduous scenario (construction phase–-heavier loads, longer turning radii).

The required CBR shall be established from the geotechnical investigation to determine the required mechanical design strength of the road subgrades and basecourses.

Roads and surfaces shall be designed in conformity with a specialist geotechnical report to support the use of heavy vehicles needed for the transportation of Goods, Materials, and Plant to and within the Site during the Construction and O&M phases of the Project. The assigned wheel and/or axle loads shall be submitted for all road designs. Furthermore, the Contractor shall take into consideration the loading capacities and clearances of existing services and connecting roads when carrying out transportation logistics studies.

Suitable materials, according to the SANS or COTO soil classifications, from excavations, may be re-used in road construction, provided the material is uncontaminated and deemed appropriate for the required load-bearing capacity.

Roads and parking areas shall be designed to suit Site Conditions and compacted crushed rock shall be used as a construction material if periods of wet weather are anticipated. The maximum size of crushed rock shall be 40 mm. The compaction ratio for each layer of the roads shall be defined according to SANS or COTO standards (using Modified Proctor test methodology).

Road widths (the usable surface) shall be at least 4.0 metres wide, or as deemed required by the component manufacturer(s) requirements, and turning radii shall be sufficient, but at least 10m radius measured from the central axis of the road, to allow access for maintenance and replacement of the largest components and for emergency personnel mobility. Minimum projection above the adjoining ground level shall be equal or higher than 0.1 m.

All surfaces shall be designed to allow proper drainage, both across and longitudinal drainage. During the road's construction, roads shall be backfilled with suitable material and properly compacted in layers not exceeding 0.25 m depth, to achieve the density required for supporting structure stability and resistance against erosion and light vehicular traffic movement and loading. All surfaces shall be designed to afford proper drainage.

The Contractor shall be responsible for keeping the roads clean and usable during all weather conditions for the areas within its limit of supply.

Different tests *in situ* and laboratory tests shall be developed by the Contractor among others: compaction grades, bearing capacity or vertical deformation of foundation road and topographic survey-road levels according with SANS or COTO Standards.

16.4.8 Drainage Systems

With reference to Site Conditions (specifically climatic data and especially the rainfall data and the Site's configuration and topography), the Contractor shall design and build a drainage system suitable for the Design Lifetime in order to protect the Project against erosion and flash-flooding or other types of flooding. The drainage works shall be located within the area secured for the Site. No additional area outside of the Site will be provided nor may be utilized.

Based on the hydrological study and flood risk assessment, the Contractor shall design a drainage system that handles the runoff from a projected extreme storm event thereby preventing the Project site from being flooded.

In this regard, the drainage philosophy will require two parts:

- External drainage cut-off: This drainage protects the Plant from external water runoff though the watershed (cut-off drain) from upstream of the Plant location; and,
- Internal drainage: This refers to the runoff generated from rainfall within the Site.

For the external drainage, the design return period required is 1:50 year flooding / precipitation / rainfall. Conditions shall also be checked for the 1:100 and 500 year probability events to assess the risk of floor levels being inundated and a flood risk assessment presented to the Employer with the conclusions. Mitigation measures taken (if any), shall be subject to the Employer's acceptance. The internal drainage system will be designed, taking into account the 1:50 year return period, such that water drains away as intended from the permanent Site infrastructure following periods of rainfall. The drainage system shall be designed in a manner such that other infrastructure (such as trenches, ducts or cable conduits) does not act as part of the drainage system.

Roads and trafficable areas shall be designed to guarantee a minimum transverse slope of at least 2% gradient, to allow surface water runoff to drain away, in accordance with formal flood risk assessments indicating acceptability.

Existing drainage courses shall be maintained as far as possible. Before any discharges off-Site, the discharge water shall be treated to retain or neutralize unacceptable pollutants.

Surface drainage in areas which may be contaminated by oil shall be routed via an appropriate oily water drainage system with oil separator.

All drains and liquids discharged from the Plant shall be disposed in accordance with the EIA, the EMP, the EA, and all relevant permits.

The Contractor shall be responsible to line the ditches with a concrete layer in case the same is needed due to the storm water flow rate to avoid erosion at the bottom of the ditch.

A maintenance plan shall be submitted for the Employer’s review and acceptance prior to commencement of implementation.

Records of the drainage designs and construction shall be submitted to the Employer for review and record purposes at each development stage.

No water-induced erosion is allowed within the Site and the drainage system shall be designed to prevent erosion.

16.4.9 Trenches, Ducts, and Manholes

Underground cable runs, including communication cables and earth conductors, shall be located at an appropriate depth to meet the applicable Standards and any other Employer’s requirements as provided in the Contract and Good Industry Practice.

Buried underground cables shall be laid on a clean layer of sand, always covered with warning tape. Mechanical protection shall be provided and installed for LV and MV trenches. Backfilling materials shall be free of rocks, vegetation or any element that could damage the cables or create cavities after compaction. Bedding material should be tested and aligned with the thermal resistivity assumptions used in the cable sizing/rating calculations.

The cable trench study shall define:

- The final trench design based on the final DC and AC power distribution design and control cable inter-connecting cable requirements
- The final trench design based on:
  - geotechnical study
  - thermal resistivity measurements
  - the surrounding conditions
  - the soil conditions and obstructions in the soil
  - filling material
  - existing infrastructure
  - DC cables, AC LV and MV cables, control and FO cable and earth conductors’ characteristics

Earthing connections and splices that are directly buried in the soil must be permanently bonded using exothermic connections (where copper earthing is used) to equalize the potential differences and avoid joint corrosion over time. Cable joint specifications shall be of the water block type.

Both physical and digital cable route markers shall be provided at any direction change, any cable joint and maximum every 100 meters for each cable run. Subject to the Employer’s acceptance, the requirement for physical markers for DC cabling may be waived after the final layout has been reviewed.

Trenches with mixed AC MV / LV voltage circuits shall be avoided where possible. In case strictly necessary, higher voltage cable circuits shall be buried deeper than lower voltage cable circuits. The following depth of cover (distance between edges of conduit or cables to ground level and trenches edges) shall be as per SANS 10198 and be adhered to, among other considerations:

- Cables laid at the bottom of the trench will lie on a 150 mm thick sand layer. The Contractor shall only be allowed to reduce the 150 mm sand layer requirement under prior acceptance from the Employer and under proper technical justification based on the Thermal Resistivity (TR) of the backfill material. In any case, a sand layer thickness of less than 50 mm shall not be considered for MV cables.

- MV cables will lie at the bottom of the trench, at a minimum depth of 1000 mm.
- LV (DC and AC) cables to be a minimum of 300 mm above the MV cable layer and laid at a minimum depth of 600 mm.
- The depth of warning tape must be at least 200 mm above cables and 300 mm below the surface to warn contractors of the presence of buried cables below. Trenches greater than 1 m wide should have two or more equally spaced warning tapes above the cables.
- Separation distance between DC and AC cables will be a minimum of 200 mm (from nearest duct or cable edge).
- Fibre optic cables must be separated minimum 125 mm from LV cables and MV cables.
- In LV and MV crossings with roads, cables shall be laid in encased ducts concreted along their entire length. The depth from the top of the protection tube to the surface shall be not less than 0.80 m.
- Conductive (copper) signal cables will lie at least 200 mm apart from LV cables.
- Minimum separation from the cables (LV or MV) to the excavation walls, shall be not less than 50 mm.
- The Contractor shall displace cables horizontally through the different layers (MV cables should be accessible for repair without causing damage to the cables above).
- All cables to be surrounded by soft sand backfill (a fine-fill material to be used for MV and LV cables). The thickness of the sand backfill above the cables shall align with the requirements of the trench design study and the thermal resistivity (TR) of the sand backfill shall be per the requirements of the trench design study. Under no circumstances will river sand or any soil with unsuitable TR be allowed.
- Earthing, where applicable, will be laid at the lowest layer of the trenches.
- LV and MV AC cables should be mechanically protected and buried appropriately within the trench as above.
- Trenches shall be backfilled with clean fill material free from aggregate, debris, organic material, and stones. Trenches shall be backfilled in layers of no more than 150 mm each and mechanically compacted to 93% of maximum density at optimum moisture content, to avoid cavities that may cause collapse of trench top due to settling of the soil or sand.

16.4.10 Fence and Gates

This section deals with the Substation fence and is not to be confused with the requirements for the Solar Plant's fence.

The Substations' fences and gates shall comply with Eskom's substation fencing standard no. 240-100183119. Where any part of a substation fence is integrated into the boundary fence of the Project, the requirements for not exceeding specified step and touch potentials shall be upheld. The substation fence cannot be installed prior to the earth mat being installed due to the requirement for the earth mat to extend beyond the substation fence. It is recommended that the Contractor provide the fenced off substations (Eskom Switching Station and Solar Substation combined and separated by a fence), either:

- completely outside of the Plant's overall boundaries; or,
- completely within the Plant's overall boundaries so that the substation fence can be equipped with a 1.2 m zone outside of the substation fence where the earth mat still provides protection against step and touch potentials, and this zone does not fall outside of the Plant's boundaries.

16.4.11 Civil Construction Material

16.4.11.1 Steel materials

Steel reinforcement bars shall conform to SANS 920 Standard and shall have a yield strength of at least 450 MPa.

Steel bars shall be tested by the Contractor upon arrival on Site. The testing and frequency of testing shall be in accordance with the requirements of ISO 15630-1 or equivalent national standard.

The material to be used shall be hot-dip galvanized steel grade S275 and S355 with a minimum yield stress of 275 N/mm^2 and 355 N/mm^2 respectively. Grade S235 JR with Magnelis can be used only in auxiliary parts of the tracker structure. All structural elements shall be subject to a process of hot dip galvanizing achieving a minimum thickness that ensures a minimum design lifetime consistent with the specified design life of the Project, according to SANS 121 and SANS 14713-1/2 or equivalent ASTM and local standards.

All stainless-steel products shall be certified according to SANS 10162-4.

16.4.11.2 Concrete materials

The Contractor shall, at least three (3) weeks prior to concreting, supply documentation and advise of the source and test results of concrete constituent materials, for acceptance.

- Cement shall be Portland Type, unless the concentration of sulphates in the groundwater dictates stronger criteria;
- Aggregates shall consist of naturally occurring materials. The Contractor shall not use lightweight or metallurgical furnace slag aggregates;
- Water used in mixing concrete shall be clean and free from materials and chemical components (oil, acid, alkali, organic matter or other deleterious substances) which are aggressive for concrete; and,
- Admixtures: The quantity and method of using admixtures shall be in accordance with both the Structural Code and manufacturer recommendations. The use of calcium chloride in any form is prohibited.

16.4.11.3 Mixing and transporting of Concrete Mix

The Contractor shall submit for the Employer’s Representatives acceptance, prior to the supply of any concrete mix, the following information:

- Name of all concrete constituents suppliers with associated datasheet(s);
- Location of batching plants;
- Mixed concrete composition including test results proving the mix design complies with the specification;
- A copy of the ready-mix supplier’s certificate of accreditation, if applicable; and,
- All concrete components suppliers’ procedures relating to storage and batching of concreting materials, mixing, transporting, compliance testing, current calibration certificates for batch weighers and compliance certificates for the constituent parts of the concrete.

16.4.11.4 Transport of Concrete Mix

Concrete mix shall be transported in truck mixers complying with the relevant norms and standards. The concrete shall be compacted in its final position within 2 hours of the introduction of cement to the aggregate. No water shall be added to the concrete either in transit or on Site before discharge, except under strict supervision of the Employer’s Representative.

Before discharging the concrete at the point of delivery, the concrete supplier shall provide a delivery ticket for each batch of concrete in accordance with the relevant norms and standards, on which will be printed, stamped, or written at least the following information as applicable according to local regulations and local common practices:

- The name of the mixed concrete plant;
- The serial number of the ticket;
- The date and time of loading;
- The truck number/vehicle identification, if applicable;
- The name of the purchaser;
- The name and location of the Site;
- Details of references to specifications;
- The amount of concrete in cubic meters;
- Declaration of conformity with reference to the specification and to the relevant norms and standards;
- Name or mark of the certification body, if applicable;
- The specified strength class;
- The specified exposure classes;
- The specified chloride content class;
- The specified consistence class or target value;
- Limiting values of concrete composition, if specified;
- Type and strength class of cement, if specified;
- Type of admixture and addition, if specified;
- Special properties, if required;
- The maximum nominal upper aggregate size; and,
- The density class or target density, if applicable.

The following information shall be added to the delivery ticket at Site and records will be kept by the Contractor, including, but not limited to:

- The time of arrival on Site;
- The time of commencing unloading;
- The time of completing unloading;
- Samples references if taken;
- Location of concrete pouring;
- The slump of the mix; and,
- Weather conditions.

These tickets have to be provided to the Employer's Representative as the Work progresses and filed in the Quality Plan.

16.4.11.5 Quality test of concrete

Concrete mix shall be tested during the deliveries by an independent accredited laboratory in order to attest to the conformity of the characteristics of the concrete mix delivered on Site.

16.4.11.6 Concrete strength

All concrete shall be sampled (slump tests and test cubes) on Site. Unless otherwise directed by the Employer, the rate of sampling shall be in accordance with Structural Code standards and building regulations (SANS 10400) for concrete poured.

Compliance with the specified characteristic compressive strength shall be based on tests made on cubes at an age of 28 days.

From each tests sample, five (5) concrete samples shall be taken (either 100 or 150 mm), two (2) to be tested at 7 days, two (2) at 28 days and the remaining one (1) at 56 days. Each cube should be clearly marked to identify it with a concrete delivery ticket and the section of Works in which it was used.

Cubes shall be tested at an independent and accredited test laboratory accepted by the Employer. The Employer shall be supplied with copies of cube reports following completion of the testing.

Slump tests from all batches should also be taken on Site. For each concrete pour, as a minimum for each of the first three (3) concrete wagons, then for every third concrete wagon. Where more than one plant is involved, the concrete shall be sampled separately. The Contractor shall at all times keep a detailed record of all concrete tests taken, including at least the following information:

- Date and time cube are taken;
- Cube number;
- Truck delivery number;
- Mix code; and,
- Slump and items of work constructed from the batch.

The Contractor shall submit this information to the Employer not later than 14 days after testing.

All test specimens shall be cured and tested by an approved registered laboratory at the Contractor's cost. The Contractor shall submit test records to the Employer not later than 14 days after testing. Cube test records shall include at least the following information:

- Date of test;
- Cube number;
- Age of concrete (days);
- Dimensions of the cube;
- Concrete mass and density;
- Capping details;
- Crushing load;
- Failure type; and,
- Concrete strength;

Concrete not meeting these Employer's Requirements shall be liable to rejection. Rejected concrete shall be removed and replaced at the Contractor's own expense.

Concrete samples shall be kept by the Contractor in a safe place to allow the Employer to check concrete quality at any future date.

16.4.11.7 Concrete Works

A concrete works method statement, including curing method, shall be provided by the Contractor to the Employer for review prior to any concreting works on Site.

A testing schedule will be agreed with the Employer for all concrete works prior to the commencement. This shall include the requirements for standard slump tests to be carried out and for sample concrete cubes to be taken from all concrete used on Site, and the arrangement of independent compressive tests to be carried out.

The Contractor shall give the Employer at least two (2) working days' notice of timing of concrete pour and removal of formwork to facilitate this. Any adverse comments or deviations noted will be addressed and rectified by the Contractor prior to the pour and the Contractor shall allow sufficient time in the project schedule for this.

The Contractor shall ensure that the surface temperature of the concrete at the time of placing is at least 5°C and not exceeding 30 °C unless specific precautions are planned and executed.

Additional water to the reinforced concrete mix during pouring is completely and strictly prohibited.

16.4.11.8 Curing

Curing and protection should start immediately after the compaction of the concrete to protect it from:

- Premature dry out, particularly by solar radiation and wind;
- Leaching out by rain and flowing water;
- Rapid cooling during the first few days after placing;

- High internal thermal gradients;
- Low/high temperatures;
- Frost/snow conditions; and,
- Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

Curing and protection will start immediately after placing of the concrete.

16.4.12 Buildings

16.4.12.1 General Building Design and Construction

All buildings and structures shall be designed and constructed in accordance with the requirements and recommendations of the Structural Code and SANS 10400. Final design of the building shall be approved by a structural engineer and the presiding local authority.

All design and construction work are subject to review, inspection, and acceptance by the Employer.

Provisions should be made in the design for easy offloading and lay-down of the relay panels and other equipment into the control room (i.e., due consideration shall be given to door size and height and consider a slanted floor entrance).

Building finishes shall suit the requirements of each building, its function, requirements of occupancy and operation requirements. All buildings shall have appropriate signage. As a rule for all buildings, the floors shall be epoxy coated. All the buildings shall have one (1) meter of apron all around it, sloped away from the building.

Attention shall be given to detailing, design, and construction of reinforced concrete pitched roof systems to ensure that crack widths in the concrete are minimised and to ensure that the long-term integrity of waterproofing membranes are maintained.

All soffit slabs over rooms housing electrical equipment rooms shall be watertight. Neither drainage pipework nor water supply pipes shall pass through the electrical equipment rooms.

The Contractor shall provide emergency doors with suitable quick exit mechanisms and/or panic bars at appropriate locations to provide safe means of escape in the event of an emergency.

Any cable basement shall be fully watertight reinforced concrete construction and shall extend at least 300 mm above the surrounding ground levels with no possibility of water draining from outside cable trenches into the building.

Cable, pipe, and service entries through technical floors and walls shall be designed such that after the cables and the like have been installed the entries are closed completely to be smoke/fireproof. The sealing materials used for this purpose must be fire resistant, and easily removable for the installation of further cables, or services, in the future.

Lightning protection shall be provided for all structures exposed to lightning strikes. The down conductors shall connect to the primary below ground earthing system. Pedestrian reinforced shallow foundations shall have their own grounding earthing system and it shall be connected to the PV grounding grid. Component materials for the installation and the protective system shall conform to relevant standards.

The Contractor shall consider all the requirements for fire protection system and associated alarms and implement them in the design.

16.4.12.2 Control Room / Substation

The Contractor is responsible for the design, procurement, and construction of the Eskom control room and substation buildings, and for the provision of all furniture and equipment required.

Enclosed rooms and indoor spaces shall be suitably sized for the intended equipment and use. The Contractor shall provide the Employer with proposed furniture specifications and layout plans prior to installation for the Employer's acceptance. This shall apply to all buildings specified in the subsections below.

All building layouts shall be provided for the acceptance of the Employer and the Contractor shall describe the proposed layout philosophy of the control room and equipment.

The buildings flooring shall be at a single level. The doors to the buildings shall be sufficiently sized to facilitate easy installation and maintenance of all panels and control room equipment. The doors and ceiling height shall be suitable for future removal of panels and equipment without the need for adjustment or removal. The foundation of the building must include cable entries ducts to allow for cable installation and future maintenance of the cabling from outside of the building or the Security section of the building without future perforation into the walls.

The control building and O&M warehouse shall be separate from the step-up transformer building.

16.5 Mechanical Requirements

16.5.1 Firefighting and Fire Protection System

16.5.1.1 General

The Contractor shall provide the fire alarm and fire detection system, the passive and active fire protection measures throughout the substation in compliance with statutory requirements, local and national standards.

The Contractor shall be responsible for obtaining all necessary compliance certification/operating permits from the appropriate authorities on completion of the installation and for any other approvals required by the laws applicable in South Africa.

The Contractor shall carry out a fire risk assessment, which shall form the basis of the overall fire protection philosophy and design.

The scope of work for the firefighting installation shall comprise the complete system design and all related equipment including, but not limited to the following:

- Fire detection: To guarantee a reliable and fault-free early warning system in the event of fire, so that orders to extinguish the fire can be issued from a central location;
- The substations shall be designed and built with provision of a safe operating environment for equipment and personnel. This shall be achieved by construction of firewalls, separating, and segregating the equipment with sufficient separation distances and by selection of suitable equipment and materials; and,
- Hazardous areas shall be identified, and suitable equipment shall be selected for use in such areas. Different firefighting systems shall be adopted according to the operational characteristics of the Plant areas and buildings to be protected.

16.5.1.2 Portable Fire Extinguishers

Portable and mobile fire extinguishers shall be provided in the substations for first aid firefighting.

In all areas the minimum requirement for quantities and locations of fire extinguishers shall be in accordance with NFPA 10. The substations shall be classified as Extra (High) Hazard Occupancy. Portable fire extinguishers shall be located along normal paths of travel, including exits from areas.

All portable fire extinguishers shall be provided, installed, and used in accordance with the following standards:

- SANS 1910;
- SANS 10105-1; and,
- SANS 1475-1.

16.5.1.3 Fire Detection and Alarm

An automatic and manual fire alarm system shall be provided to protect life and property at the Eskom Switching Station and Solar Substation buildings. The fire alarm system shall be of the distributed analogue addressable type. The fire alarm system for the substation buildings shall be designed, supplied, and commissioned by a single, specialist Subcontractor.

A central fire alarm control panel shall be provided in the control room/building. All system fire alarm and fault conditions shall be reported at a fire alarm control and indicating console that shall be integrated into the control room/building console.

All fire alarm control equipment, including control panels for gaseous extinguishing systems, shall be from the same manufacturer.

Automatic fire detectors shall provide total (complete) coverage throughout both substation buildings. Automatic fire detection devices shall be selected to suit the particular risk and the environment in which they are installed. All the buildings shall possess their own fire extinguisher.

Cable tunnels and cable spreading rooms shall be provided with smoke detectors, resetting linear heat detection, or a combination of the two.

16.5.1.4 Fire Safety Aspects of Design and Construction of Buildings

The design and construction of all substation buildings and the provision of measures to ensure the protection of personnel and equipment shall comply with the requirements and recommendations of the applicable standards.

In addition, provision of means of egress shall comply with all requirements of the local authorities.

16.5.1.5 Fire Safety Measures during Construction and Commissioning

The Contractor shall be responsible for fire safety during construction and commissioning. All requirements and recommendations of NFPA 241 and NFPA 850 shall be applied.

The fire systems shall all be commissioned and in service before commissioning of the substation commences.

16.5.2 HVAC System

The Contractor must provide HVAC equipment such that the environment shall be within the ambient condition requirements for any equipment and personnel located within the conditioned areas with a design and service life matching that of the Plant.

HVAC shall be provided in the Solar Substation control room. HVAC must also be provided for the Eskom control room of the Eskom Switching Station, should Eskom Distribution (FSOU) require it.

16.6 Electrical Requirements

16.6.1 Overall Scope

The overall scope of supply for electrical works shall include the design, supply, installation, testing, commissioning, and defects warranty of the following, but not limited to:

- Primary plant and inter-connections;
- Protection and Control equipment for the whole system, connection, remote systems interfacing and integration, interlocking and inter-tripping;
- Temporary construction power supplies;
- Electrical distribution system at voltages suitable for the layout and power requirements;
- Internal and external normal and emergency lighting;
- Small power systems;
- DC and UPS systems; and,

- Plant Earthing.

The electrical scope of supply shall include all electrical equipment, whether or not specifically referred to in this section, which is necessary to complete the Works. No additional cost shall be allowed for any item which the Contractor has not considered but which is needed for the proper completion of the works in every respect, so that the Works are designed, specified, manufactured, constructed, installed, tested, and commissioned for the safe, efficient, and reliable operation and minimum maintenance over the design life of the Plant (25 years).

All electrical supplies, electrical protection, telecommunications, cabling, small wiring, lighting, heating, small power, earthing, and any other electrical items shall be provided under this Contract for a full working substation and related works. All the equipment shall be designed to be maintainable and replaceable with the minimum practicable impact on adjacent equipment and the minimum practicable requirements for enabling works and accessing heavy equipment.

All monitoring, control, sampling, and access points shall be accessible without specialist equipment where possible.

16.6.2 Electrical Studies

The power distribution system shall be designed such that stability of operation, current carrying capacity, and satisfactory fault levels are maintained throughout the complete Works system under all possible operating, maintenance, and fault conditions. During the Contract stage detailed protection grading studies, fault level calculations, and protection settings shall be submitted for approval. Eskom Distribution (FSOU) will provide settings for the works.

The Contractor shall provide the following power system studies:

- Load flow studies to assess equipment ratings, voltage profiles and losses;
- Fault Level Studies - Short circuit current levels and flows to assess equipment capabilities;
- Transient stability studies (with information from and to the requirements of the Grid Operator) to assess system responses to events such as fault disturbances and effect of tripping major equipment (transmission line or power transformer);
- Electrical protection studies shall provide draft and final copies of a protection relay and grading report. Information derived from the power system studies described elsewhere shall be used in the production of the report. The report shall include a comprehensive description of all relay types and ranges and CT and VT parameters, together with supporting evidence including magnetisation curves and calculation sheets to confirm their adequacy for the plant offered. The report shall cover all protection relays supplied under this contract and include settings for the relays taken over by Eskom Generation. Relay settings shall be provided as an appendix to the report and be clearly tabled circuit by circuit;
- Equipment rating selection calculations;
- Insulation co-ordination in accordance with SANS 60071-1/2;
- Any other studies to prove the integrity of the design;
- Earthing study;
- Interlocking system study in accordance with industrial good practices; and,
- Network (Grid Code) compliance study, in accordance with the requirements of the South African regulations and NERSA's RETEC requirements.

16.6.3 General Electrical Requirements

All equipment shall be designed to ensure the continuity of operation under all working conditions at the Site as the first consideration and to facilitate inspection, maintenance, and repairs. The system design shall ensure a high level of reliability, which shall be achieved by adopting suitable redundancy and sparing philosophy.

All precautions shall be taken in the design of equipment, substations, and overhead line to ensure the safety of personnel concerned with the O&M of the Plant. Safety, isolation, locking, and interlocking facilities shall comply with requirements of the Employer and international standard requirements, as applicable.

Materials and equipment for use shall work efficiently and with high level of reliability, with special consideration given to:

- High ambient temperatures; and
- Fire risk and flooding as a result of fire protection operating.

Unless otherwise specified, the minimum equipment enclosure classifications for non-rotating electrical equipment shall be as follows:

- Indoors only in totally enclosed rooms with provision for limiting ingress of dust: IP31;
- Indoors, except as noted otherwise: IP54;
- Indoors in areas subject to water spray, or heavy condensation: IP55 or higher; and,
- Outdoors except as noted otherwise: IP55 or higher.

Electrical equipment and installations, including their erection and testing, shall conform to good engineering practices, applicable codes and standards, and relevant regulations.

All switchgear, transformers and other electrical equipment shall be capable of operating at its rated current continuously, without overheating, at full site rating, and shall take account of the temperature rise of the equipment from other sources and preferably without assistance from forced cooled ventilation or an air conditioning plant. Where reliance on forced cooled ventilation or an air conditioning plant is necessary, the cooling plant design will be at least N-1 (single contingency) redundant.

Electrical equipment shall be constructed to withstand the specified maximum short circuit currents and duration without the temperature exceeding the value permitted for the related class of insulation. The equipment shall be considered as being operated at maximum permitted current prior to the inception of short circuit current.

The final temperature attained as a result of the passage of short circuit current shall not cause permanent damage or deterioration sufficient to reduce the normal operating characteristics below those specified.

Insulation materials shall be suitably finished to prevent deterioration of their qualities under the specified working conditions.

All switchboards, panels, cubicles, and the like shall incorporate thermostatically controlled electric heaters facilitating natural movement of sufficient heated air to avoid condensation. Heater elements shall be screened to obviate inadvertent human contact with heater surfaces. The apparatus protected shall be designed so that the maximum rated ambient operating temperature is not exceeded if the heaters are energised while the apparatus is in operation. Related thermostats shall switch off the heater circuits if the temperature exceeds an adjustable set point. Control panels, cubicles, and kiosks shall be provided with door operated internal illumination lamps. Power supplies for commissioning and maintenance test equipment to be located as required.

Electrical equipment located in hazardous areas shall be provided with special enclosures suitable for classification of the areas according to the guidelines provided in statutory regulations and codes. All equipment installed or used in hazardous areas shall be certified as suitable for such.

The requirements of the Employer shall be met, and the Contractor shall ensure familiarity with all relevant standards, codes, and agreements.

16.6.4 Grid Code Requirements

The Contractor shall ensure that his design complies with the requirements of the national Grid Connection Code for Renewable Power Plants (RPPs) Connected to the Electricity Transmission System (TS) or the Distribution System (DS) in South Africa.

In addition, the protection and telecommunication system of the Solar Substation and Eskom Switching Station shall comply with Eskom Standard for The Interconnection of Embedded Generation (240-61268576).

16.6.5 Transformers

16.6.5.1 Power transformers

The power transformers shall be selected to ensure the Plant can transfer the stated capacity plus the grid code requirement for power factor in an N-1 configuration in the event of a failure. The power transformer shall have a 100% rating backup.

Power transformers shall comply with the requirements of Eskom Specification 240-68973110 – *Specification for Power Transformers rated for 1.25 MVA and above and highest voltage of 2.2 kV or above* in conjunction with the relevant AB Schedules.

The insulating medium shall be biodegradable.

The Contractor shall make commercial allowance for appointment of a 3rd party power transformer specialist to form part of the technical design reviews and factory acceptance tests.

16.6.5.2 NEC/NER/AUX Transformers (NECRT's)

A NEC/NER/AUX transformer (NECRT) will be installed for each transformer. The combined unit shall provide neutral earthing compensation on the delta side of the transformer and shall further also provide earth fault current limitation by means of a neutral earthing resistor. An auxiliary transformer shall also be provided as an integral part of the NECRT and shall be used as a backup 400V, 3-phase auxiliary supply for the substation.

The NECRT shall be properly rated in terms of the voltage, earth fault current limitation, insulation, capacity etc., as well as instrumentation such as the Buchholz relay, oil and winding temperature sensors, auxiliary contacts etc.

The NECRT shall further comply to the Eskom drawing D-DT 6142 and the Eskom standard 240-57648848 – Specification for Combined Three-Phase Neutral Electro-Magnetic Couplers with Neutral Earthing Resistors and Auxiliary Transformers (NECRT's).

The Solar Substation's auxiliary transformers shall supply power to the Solar Substation only and will not supply the Solar Plant O&M building. The O&M building shall be supplied from a separate transformer provided for in the Solar Plant's electrical design. Auxiliary power to the Eskom Switching Station will be derived from Power VT's and not from Eskom Generation's auxiliary transformers.

The substation auxiliary transformers shall be designed so that, with the whole substation running at full load, the transformers' low voltage windings will be loaded as follows:

- 80% in case of 1 x 100% transformers; or,
- 40% in case of 2 x 100% transformers.

or less.

The auxiliary transformers shall be outdoor design type. Furthermore, they shall be located adjacent to the associated power transformer.

Connections to the auxiliary transformer bushings shall be by flexible copper cable connections. It shall be possible to remove these flexible connections to permit testing of the cables and transformer separately.

Auxiliary transformers shall have a manually operated off-load tap-changer (2 x ± 2.5% taps, on the high voltage side).

The insulating medium shall be biodegradable.

16.6.6 MV Switchgear

All switchboards shall be of the industrial, extendible, metal-clad, withdrawable, cubicle type arranged as freestanding units with minimum ingress protection of at least IP54 class and constructed and tested in accordance with the appropriate Standards.

All MV switchgear shall be designed for a nominal voltage according to SANS 1019 and SANS 62271, to be internal arc certified IAC AFRL according to SANS 62271-200 Standard and to withstand a short-circuit current of minimum 10% higher than required by calculations, for a duration of three (3) seconds. A type test certificate compliant with SANS shall be supplied for the unit(s) offered.

The switchgear shall be equipped with suitable anti-condensation heaters and shall be designed for bottom entry MV cables.

The LV switchgear shall be designed for a nominal voltage of 400/230 V (according to SANS 1019) and to withstand a short-circuit current of minimum 10% higher than required by calculations for a duration of one (1) second.

Switchgear busbars, circuit breakers, cable compartments, and LV compartments shall all be contained in separate compartments. Barriers shall be provided between the compartments to prevent the spread of ionised gases.

Busbars shall be manufactured from electrolytic copper and shall be capable of carrying full current continuously along the entire length of the busbar without exceeding maximum allowable standard temperatures. Busbars, busbar connections, and insulation materials shall be capable of withstanding without damage the thermal and dynamic effects of short-circuit fault current according to the outcomes of the fault level studies, equivalent to the short time rating of the associated switchgear. Facilities shall be provided to accommodate thermal expansion of the busbars and associated components.

All main switchboards, relay panels, and control equipment shall be provided with duplicate 110 V DC standby power supplies for control and alarm purposes.

Check-synchronising facilities shall be provided as required. The switchgear main incomers, interconnectors, and bus-section circuits shall be interlocked electrically or via the SCADA system to prevent the paralleling of two incoming supplies to a switchboard. MV switchgear shall have the interlocks to avoid incorrect manoeuvres according to SANS 62271-200 Standard.

For emergency operation of MV feeders and LV incomers, mechanical off/trip switches shall be provided.

All the withdrawable units of the assemblies shall have the following positions:

- Service;
- Disconnected-test;
- Disconnected; and,
- Removed.

The MV switchgear design shall incorporate draw-out type circuit breakers using air-insulated busbar with vacuum circuit breaker as the breaking medium and shall include integral fault making earth switches for circuit and busbar earthing. The circuit breaker shall be of the fault making, fault breaking, and load breaking type rated for the associated system maximum fault current and capable of carrying the maximum continuous load current.

All MV switchgear shall comply with the requirements of Eskom Standard for Air-Insulated Withdrawable AC Metal-Enclosed Switchgear and Control Gear for Rated Voltages above 1kV up to and including 52kV (240-56227573).

16.6.7 HV Circuit Breakers

HV circuit breakers will be used for the HV feeder bays and transformer HV bays. The system voltage on the high voltage side will be 88 kV, however, all HV circuit breakers shall be rated for 132 kV. All HV circuit breakers shall be 3-Pole, Post Type SF6 circuit breakers and shall be suitably rated for the operating current, fault current, voltage, insulation levels, control voltage as well as instruments such as gas pressure monitoring, status monitoring etc. The HV circuit breakers shall have a specific creepage of 31 mm/kV. The HV circuit breakers shall be mounted on standard Eskom steelwork and foundations.

The HV circuit breakers shall further comply with the Eskom standard drawing D-DT 6250 and the Eskom standard 240-56063756 – Outdoor circuit breakers for systems with nominal voltages from 6.6 kV up to and including 765 kV standard.

16.6.8 HV Isolators

HV isolators will be used for the HV feeder bays, transformer HV bays as well as for the HV bus-sectionaliser. The system voltage on the high voltage side will be 88 kV, however, all HV isolators shall be rated for 132 kV. All HV isolators shall be 3-Pole Centre-Rotate-Double-Break Hand-Operated isolators. The HV isolators shall be suitably rated for the operating current, fault current, voltage, insulation levels, control voltage as well as auxiliary contacts for status monitoring etc. The HV isolators shall have a specific creepage of 31 mm/kV. The HV isolators shall be mounted on standard Eskom steelwork and foundations.

The HV Isolators shall further comply with the Eskom standard drawing D-DT 6302 and the Eskom standard 240-56063815 - High Voltage Outdoor Disconnectors and Earthing Switches Standard.

16.6.9 HV Current Transformers

HV current transformers will be used for the HV feeder bays and transformer HV bays. The system voltage on the high voltage side will be 88 kV, however, all HV current transformers shall be rated for 132 kV. All HV current transformers shall be Post Type multi-ratio current transformers and shall be suitably rated for the operating current, fault current, voltage, insulation levels, CT classes etc. The HV current transformers shall have a specific creepage of 31 mm/kV. The HV current transformers shall be mounted on standard Eskom steelwork and foundations.

Each HV CT shall have the following cores:

- 2 x Protection Cores;
- 2 x Buszone Cores; and,
- 2 x Metering Cores;

All Protection and Metering cores shall be 2400/1 multi-ratio CT’s. All Buszone cores shall be 1600/1 multi-ratio CT’s.

Note: Current transformers used for Tariff Metering shall be Class 0.2S and not the standard Class 0.2 only.

The HV current transformers shall further comply with the Eskom standard drawing D-DT 6190 and the Eskom standard 240- 56062864 – Eskom standard for Current Transformers up to 132 kV.

16.6.10 HV Voltage Transformers

HV Voltage transformers will be used on the HV Busbars. The HV voltage transformers shall be rated for 88 kV. All HV voltage transformers shall be Post Type voltage transformers and shall be suitably rated for the voltage, insulation levels, core classes etc. The HV voltage transformers shall have a specific creepage of 31 mm/kV. The HV voltage transformers shall be mounted on standard Eskom steelwork and foundations.

The HV voltage transformers shall further comply with the Eskom standard drawing D-DT 6171 and the Eskom standard 240-56062765 – Inductive Voltage Transformers Eskom Specific Requirements up to 132kV.

16.6.11 HV Power Voltage Transformers

HV Power Voltage transformers will be used on the HV Feeder bays and will be used for providing auxiliary power to the HV Eskom Switching Station. The HV power voltage transformers shall be rated for 88/0.4 kV, 16 kVA. The specific ratio shall be 88 kV/√3 / 400 V/√3. All HV power voltage transformers shall be Post Type voltage transformers and shall be suitably rated for the voltage, insulation levels etc. The HV power voltage transformers shall have a specific creepage of 31 mm/kV. The HV power voltage transformers shall be mounted on standard Eskom steelwork and foundations.

The HV power voltage transformers shall further comply with the Eskom standard drawing D-DT 6315 and the Eskom standard 240-105478209 – High Voltage Single Phase Power Voltage Transformers Standard.

16.6.12 HV & MV Surge Arrestors

HV Surge Arresters will be used on the HV Feeder bays and transformer HV bays. MV Surge Arresters will be used on the transformer MV bays. All surge arresters shall be station class surge arresters and shall be suitably rated for the voltage, insulation levels, surge current etc. All surge arresters shall have a specific creepage of 31 mm/kV. Surge Arresters shall be mounted on surge arrester brackets mounted to HV isolator steelwork and transformers.

The HV power voltage transformers shall further comply with the Eskom standard drawing D-DT 6211 for the HV Surge Arresters and D-Dt 6214 for the MV Surge Arresters as well as the Eskom standard 240-75540566 – Specification for Station Class Metal Oxide Surge Arresters.

16.6.13 Substation Conductor, Hardware & Clamps

Aluminium conductors and clamps shall be used for connections between equipment as well as for connections between equipment and busbars. Tubular aluminium busbars shall be used for all outdoor busbars and cable end supports.

The following conductors shall/may be used:

- Centipede AAC Conductor;
- Bull AAC Conductor;
- Hornet AAC Conductor; and,
- 120 x 4 mm Tubular Aluminium Busbars (Minimum size).

The conductor used shall be suitably rated for the specific bay, busbar, or connection in terms of current rating, fault current rating, material, and corrosion.

Substation clamps shall be used to connect conductors to equipment and busbars. Clamps shall be suitably rated for current rating, mechanical strength, and corrosion. Clamp ratings shall not be less than the specific conductor rating used. For all main current carrying conductors and equipment, such as isolators, circuit breakers, current transformers and power transformers, compression type clamps shall be used on the conductor side. All voltage type equipment, such as VTs and surge arresters, may have bolted type clamps on the conductor side.

Only 132 kV Station Type Post Insulators shall be used on the HV busbar. 66 kV Station Type Post Insulators shall be used for cable end supports as per the Eskom standard.

All conductors, clamps and hardware shall be as per the various Eskom specifications and D-DT drawings.

16.7 High Voltage Overhead Line

16.7.1 General

A new 88 kV Overhead Line will be constructed between the 88 kV Eskom Switching Station and the RWB Lethabo Substation. The line shall be designed at 132 kV standard. The line shall further be designed according to SANS 10280-1 which deals with the design of overhead power lines for conditions prevailing in South Africa. The line shall further be designed using the PLS CADD software which shall be set up with the correct criteria files.

16.7.2 Structures And Foundations

Steel monopole structures shall be used. The structures shall be as per the Eskom requirements in terms of material, electrical clearances, hardware connections, strength requirements etc. Structures shall be manufactured from steel with a grade of S355JR. All steel structures shall be hot dip galvanized.

Structures shall generally be planted and stayed. Where necessary, steel poles can be self-supporting structures which can either be planted or base plate mounted onto a concrete foundation which can either be a pad- type or piled foundation.

Phase clearances shall be a minimum of 2.2 m. The clearance from the shield wire/OPGW to the top phase shall also be 2.2 m. Each pole shall have the necessary hardware attachment points, such as strain assembly attachment plates, post insulator brackets, shield wire/OPGW attachment plates etc. Sectionalised poles shall also be equipped with the necessary jacking lugs and stay attachment plates.

Steel poles shall be manufactured by a reputable company and shall be manufactured strictly in accordance with Eskom Standards 240-75883378 and 240-75883830. The manufacturer shall further provide detailed shop drawings for each structure type, which have been designed and signed off by a professional structural engineer.

Foundations shall be designed according to the geotechnical report that was done for the site. Test holes shall be done along the line route. Foundations shall be designed by a professional structural engineer for the typical soil types (Types 1 to 4 as per the Eskom soil type classification). Each hole shall be classified by the structural engineer according to the soil type for which the applicable foundation as per the soil type shall be used. Foundation designs shall also take the pole bending moment for each pole into consideration.

Stays shall be as per the Eskom standards for stay assemblies such as D-DT 7323.

16.7.3 Conductors And Shield Wires

The main phase conductor to be used shall be Kingbird ACSR conductor. The Kingbird conductor shall be as per D-DT 3136. The appropriate shied wires and or OPGW shall be used. The OPGW to be used shall be the single mode 48-Core OPGW and shall be as per D-DT 13000. If needed, steel stranded shield wire can also be used. The steel stranded shield wire shall be as per D-DT 7036.

16.7.4 Labelling

The overhead line shall be labelled as per the Eskom standard 240-120804300 – Standard for the Labelling of Electrical Equipment within Eskom Wires Networks.

16.7.5 Insulation And Hardware

All insulators and hardware shall be as per the Eskom standard. Strain assemblies shall be as per D-DT 7311 and D-DT 7321 for jumpers on strain poles. Intermediate poles shall have long rod suspension assemblies. Only crimp dead ends shall be used. Tests crimps shall be provided by the Contractor. Assemblies shall generally further be as per the Eskom standard 240-60777474.

OPGW strain and suspension assemblies shall be as per the recommendation of the OPGW supplier. Only Eskom approved OPGW suppliers may be considered.

Shield wire strain and suspension assemblies shall be as per the Eskom standards D-DT 7324 and D-DT 7326.

OPGW and Shield wire assemblies shall be insulated or non-insulated and shall be as per the Eskom standard 240-75880946 – Earthing Standard.

Stockbridge type vibration dampers shall be used for the phase conductors and spiral type vibration dampers shall be used for the OPGW/Shield wire. Vibration dampers shall be as per the Eskom standard 240-98155879.

16.7.6 Line Templating and Profiling

The phase conductors shall be templated at 70 °C Hot. The OPGW and shield wires shall be templated at 15 °C EDT. The correct catenary constant shall be used for both the phase conductor and OPGW/Shield wires. For the phase conductors the catenary constant is generally 1800 at 15 °C EDT and 2100 for the OPGW/Shield wires at 15 °C EDT.

Clearances between phases, other power lines, ground, other structures, roads etc., shall be adhered to as per the Eskom standard 240-125383428 – Building Line Restrictions, Servitude Widths, Line Separations and Clearances from Power Lines. These clearances must be adhered to under all defined weather conditions and design criteria.

Staking Tables, Construction Staking Tables and Stringing Charts shall be provided for the line. Wind and Weight Span reports shall also be provided for the construction of the line and the manufacturing of the steel poles.

All relevant construction drawings shall be provided.

16.8 Electrical System Control, Indications And Alarms

Control and alarm facilities for the Plant's (Solar Substation and Eskom Switching Station) electrical AC and DC systems shall be provided.

Details of the required signal interchange with the DNO shall be developed during the design phase of the project.

AC electrical systems shall be monitored and controlled from the CCR, including for all transformers, switchgear incomers, and bus-section via the plant SCADA system.

The voltage of each switchboard and single-phase current magnitude of all main circuits (incomers and bus-sections) shall be displayed locally at each switchboard. This information shall be repeated in the CCR via the plant SCADA system.

Trips and alarms signalling shall be provided to indicate and annunciate all system warnings and faults at the CCR via the plant SCADA system.

400/230 V AC sub-distribution systems and the DC systems shall be locally controlled only, but alarms shall be transmitted to the CCR via the plant SCADA system.

The switchgear shall include all related circuit prominent coloured high-power LED type status and alarm indication lamps. The associated protection relays shall also include LED status/alarm indicators or flags.

16.8.1 400/230 V AC And 110 V DC Sub-Distribution Boards

Sub-distribution boards shall be provided throughout the Plant for local lighting, small power, and welding supplies.

Outdoor sub-distribution boards shall be of the weatherproof enclosure type and IP65 rating; indoor boards shall be IP54 rating. Additionally, all outdoor installed sub-distribution boards must be equipped with totally enclosed sun canopies.

Switchgear installed in electrical operating rooms shall be provided with a minimum ingress protection of IP54 rating. They shall be capable of withstanding the associated fault current until the related protection operates.

DC supply sub-distribution boards shall be provided throughout the Plant for control supplies to switchgear, control panel and emergency lighting as required.

The incoming breaker of all sub distribution boards shall be able to accommodate a lock-out device and be equipped with a remote signal protection tripping relay with adjustable current and time scales.

The AC supply sub-distribution boards shall be either single phase or three phase with a neutral and earth bar. The DC sub distribution boards shall be equipped with two-pole type miniature circuit breakers. All distribution boards shall be rated for the full load current of the incoming supply and equipped with an incomer isolating MCCB (4-pole for AC ad 2-pole for DC) and with MCBs to provide over current protection to each sub circuit. All equipment installed inside the sub-distribution boards shall be designed, rated, and tested/certified for the applicable voltage rating (AC or DC).

All the space in the distribution boards shall not be fully utilised and shall contain 10% unused but equipped switchgear circuits and an additional 20% space for future switchgear circuitry to be installed.

16.8.2 Batteries and Battery Chargers

Substation control rooms shall be equipped with suitably rated batteries and battery charging units in accordance with Eskom Distribution’s Design Standard for TeleProtection Systems (240-90353855). The same standards and principles shall apply to the Solar Substation.

No Valve-regulated Lead-acid batteries will be accepted.

16.8.3 AC Cables and Installation

Where three (3) single-core MV cable designs are used, the MV cables shall be screened, stranded copper or aluminium single-core cables. Where three-core cables are used, the individual cable cores shall be individually screened stranded copper or aluminium cores. MV Cables shall comply with the following minimum criteria:

- XLPE insulation cables shall be used;
- MV cables shall comply with the corresponding codes and standards such as SANS 10198;
- MV cables shall be flame retardant as per SANS 60332-1 and SANS 60332-3;
- MV cables shall withstand the expected maximum electrical voltages during the lifetime of the Plant;
- All MV cables shall be permanently marked and properly identified;
- Colour code: Red, Blue, Yellow (phases) and Black (Neutral).
- For earthing: Green and yellow-coloured combination;
- AC cables shall be designed with a maximum operation core temperature of:
    - ≤ 90 ºC under normal operation; and,
    - ≤ 250 ºC under short circuit circumstances (five second maximum).

Instrument and data cables shall have conductors and insulation appropriate for their duty/location.

MV cable screen will be connected in both sides for three-core cables, and at the source side for single-core cables (transformer interconnection cables).

No joints shall be allowed on any cables between the power transformer, NEC/NER/NECR/NECRT (as may be appropriate), and the MV switchgear circuit breaker(s).

Suitable derating factors for current capacity of the cables shall be applied according to the applicable standards to prevent overheating under design conditions. MV and LV cables shall be sized based on current ampacity, voltage drop, and let through passing energy capacity.

All power cables shall be suitable for service at maximum design load and minimum voltage conditions for the Site conditions and shall be capable of sustaining maximum through fault current without damage for the short time rating of the associated switchgear. Power cables with fuse/MCCB/MCB protection shall be capable of sustaining maximum prospective fault let-through current/time duty.

The following maximum regulation (voltage drop) limits shall apply:

- Between main switchboards (i.e., supplied by a transformer) and sub switchboards: 2%;
- Between main switchboards (i.e., supplied by a transformer) and static load terminals: 5%; and,
- Between sub switchboards and lighting loads: 3%.

Within buildings, cables shall be installed on hot dip galvanized cable trays or racking in a manner that shall prevent the cable being damaged and minimise the risk of occurrence and spread of fire. Power cables shall be adequately clamped to prevent movement under short-circuit conditions. Single-core cables shall be clamped in trefoil formation considering phase cable (phase) transposing every 100m.

Duplicated circuits, such as cables that service main distribution switchboards and those cables forming part of emergency/high integrity circuits, shall follow different routes or be separated as far as is practicable.

Cables between the substation yard and the control room shall run in cable trenches. MV and LV control cables shall run in separate trenches. MV cables may be installed in sleeves and not necessarily in a constructed cable trench. Rating of cables shall take the sleeve / duct / trench environment into consideration for when considering derating factors as per SANS 10198.

Control cables inside the substation buildings between switchgear and control panels may be run on cable racks mounted above the panels and switchgear.

In all areas hot dip galvanized trays/racks or conduits shall be used and, where any damage may occur, they shall be further protected with additional anti-corrosion painting (such as cold galvanizing paint). No plastic, PVC, or similar trays and conduits shall be used. Trays/racks installed outdoors shall be provided with covers for protection of the cables against solar radiation.

All cable racking/trays shall be bonded to each other as well as to the Plant's earthing system. The cables trays shall be designed to allow for 20% spare space for future cables and shall have no more than 2 layers of cables in each cable tray.

Cable access to enclosures shall be by compression type cable glands. Cable glands shall be of non-magnetic metal construction. Gland plates shall be of metal construction and shall be designed with sufficient inherent rigidity and strength to ensure no distortion with cables installed. Where necessary, gland plates associated with termination of single core cables above a certain current rating shall be made of non-magnetic material.

Cables and cable trays shall be clearly identified at both ends with a robust and weatherproof permanently indelible cable identification tag that carries the cable/tray number as per the agreed identification system. Numbers shall be unique across the Plant and follow the AKZ or KKS system (to be confirmed at a later stage) for the Solar Substation taken over by Eskom Generation, and in accordance with Eskom Standard 240-62629353 (Substation labelling standard) as may be required for the Substations taken over by Eskom Distribution (FSOU) (Eskom Switching Station).

Cable tray fixation shall be in accordance with Good Industry Practice, such as earthing, protection from the cutting angle of the structures, protection from UV radiation, durable, regular fixation to prevent sagging, and anchoring of the cable tray support to both cable tray and ground conductor such that the installation maintains the full performance of the electrical system.

16.8.4 Earthing System Design, Bonding, and Lightning Protection

The earthing and lightning systems shall be designed according to SANS 725, EN 50522, IEC/SANS 60364, SANS 62305, SANS 61936-1, and IEEE 665 Standards. All earthing connections shall be secure and provided with bolt, nut, and stop washer for a reliable and durable connection. Also, anti-corrosion coating will be applied where applicable particular attention shall be paid to the following:

- Lightning ground potential rise in the context of wire-line technology;
- Lightning ground potential difference;
- Step and touch voltages;
- Electro-magnetic Zoning;
- Soil resistivity variation across the site;
- Earth electrode resistance - resistance is a low frequency parameter, whilst the assessment and analysis called for shall consider lightning induced phenomena with higher frequencies involved; and,
- LEMP (All electromagnetic effects of lightning current via resistive, inductive, and capacitive coupling, which create surges and electromagnetic fields.).

The Contractor shall be responsible for the design, installation, and testing of a single (common) earthing grid for the two adjoining substations which will act as an earthing grid for the LV. MV and the HV equipment, in line with Eskom Distribution Substation standards. The earthing grid will consist of BECW (or other suitable material as demonstrated by relevant studies and reviewed by the Employer and Eskom Distribution) cable all along the electrical cable trenches and, if necessary, along the perimeter fence of the Site. The final specification of the buried copper earth electrode will be according to SANS 60479, EN 50522/IEEE 80 and recognised Good Industry Practice and the System Operator’s approved design requirements. The earthing system shall ensure safe step and touch potentials are maintained according to the applicable international standard. The substation earthing grid design shall further comply with the Eskom standard 240-134369472 – Substation Earth Grid Design standard.

The short time current withstand rating of the total earthing installation shall be at least equal to the system rated fault current and backup protection operation time. The loop impedance of the earthing system shall be such as to ensure that all protective devices operate within the short time rating of the system, and such that prospective values of step and touch potential do not approach unsafe values. All underground earthing conductor joints shall be exothermic cad welded type.

All electrical equipment, metallic frames and supports, structural steel and in general all major metallic structures, fences, cable trays/racks shall be bonded to the earthing system.

Transformers, Switchyard equipment and switchboards or assemblies containing switchgear equipment shall be provided with two (2) or more earth terminals (preferably at diagonally opposite ends) and each shall be connected to the earthing system.

The copper strip sized to withstand the maximum system earth current for one (1) second and to provide suitable mechanical rigidity shall be used. Earthing cable sizes shall be designed according to the respective standards.

The Contractor shall also provide a lightning protection system for the PV plant which shall comply with SANS 62305, including the risk assessment and EM zoning as per the standard (EM Zones: SANS 61000-2-5, SANS 61000-4-5, and SANS 61000-4-9). Each lightning protection system shall be bonded to the Plant's earthing system. The Contractor shall ensure that equipment used in the different zones shall be suitably rated for these EM zones.

Lightning Protection shall generally be done using the "Rolling Sphere" method and shall be in accordance with the Eskom standard 240-109589380 – Direct Lightning Stroke Protection of Substations. Lightning protection layout drawings shall be provided to prove that each substation is adequately protected against lightning.

16.8.5 Substation Lighting

Substation lighting shall be provided by installing LED lamps at a height of 10 m onto the lightning/lighting masts. Lighting shall be as per the Eskom standard 240-113163905 – LED Floodlights for Distribution Substation Applications.

Proper lighting simulations shall be provided.

16.8.6 Protection And Control

16.8.6.1 Plant Step up (PSU) Transformer Protection

The Step-up transformers shall be provided with at least the following protection functions as per ANSI Standard Device Numbers (ANSI/IEEE Standard C37.2):

- Restricted earth fault (64REF);
- Phase Instantaneous and Inverse Time Overcurrent (50/51UAT);
- Earth/Neutral Instantaneous and Inverse Time Overcurrent (50G/N / 51G/N);
- Buchholz Relay Transformer Tank (96BT);
- Over-Pressure relief device tank (63PT);
- Oil Over-temperature Alarm & Trip (49Q);
- Winding Over-temperature Alarm & Trip (49W);
- Abnormal Oil Level (71Q);
- Transformer Differential protection (87T) shall be provided for the transformer. The HV substations shall have protection in line with Eskom protection standards. The Contractor shall note that Eskom is in the process of upgrading from Generation 4 to Generation 5 protection scheme designs; and,
- Transformer On-Load Tapchanger Control & Protection.

16.8.7 Protection of Electrical Auxiliary Systems

All electrical circuits shall be adequately protected by relays and a suitably rated means of current interruption. The following electrical protection shall be provided as a minimum:

- Feeders shall be provided with Overcurrent Protection and Earth Fault (GFT) Protection;
- Auxiliary transformers shall be installed in controlled environments and encased in naturally air ventilated enclosures;
- A winding temperature indicator shall be provided having auxiliary contacts for temperature high alarm and trip functions; and,
- MV standby earth fault, (voltage displacement supervision) transformer Buchholz, transformer winding temperature, transformer oil temperature, transformer rate of rise of pressure and low insulation (liquid) level.

The above protection shall be realised with relays of the electronic digital/numeric type with facilities to enable testing of all functions during normal operation without imposing operational restrictions (i.e., leaving other protection functions active). The relays shall be capable of communicating with the SCADA system so that alarms and trip conditions can be seen.

MV switchgear protection relays shall be of the electronic digital type with continuous self-supervision. Relays shall be capable of communicating with the SCADA system so that alarms and trip conditions can be displayed.

LV protection relays shall have conventional relays/releases. Trip and alarm signals shall be hardwired to the Plant SCADA system. Uncontrolled feeders up to 25 A rating shall be provided with a MCB rated to suit; for 25 A and up to 630 A MCCBs shall be provided.

16.9 Inspection And Testing

16.9.1 General

16.9.1.1 General

The connections to respective substations and materials shall be subject to inspection and testing during, and on completion of, the manufacture and erection of the Works to ensure compliance with the Employer's Requirements, the requirements of the regulatory authorities, and to confirm the satisfactory functionality, operability, and acceptance criteria of the Plant have been achieved, including the performance guarantees.

In summary, the testing and commissioning of the Plant and transmission connection to the respective substation shall include, but not be limited to the following:

- Factory Acceptance Tests - inspection and tests at manufacturer's works;
- Site Acceptance Tests ;
- Inspection and tests during construction;
- Tests on Completion (Commissioning);
- Commissioning (Cold Commissioning);
  - Visual inspection;
  - Functional tests; and
  - Electrical safety tests.
- Grid Code compliance tests; and,
- Commissioning (Hot Commissioning).

Additionally, the Contractor shall undertake any tests as specifically required under the Contract documents and by the Project's permits and consents.

The Contractor shall have the responsibility for all aspects of testing and commissioning preparations and execution, including the provision of procedures, temporary facilities, consumables, utilities, labour, special tools, measurement equipment, spare parts, etc. To the maximum extent possible, the on-Site tests will make use of the permanently installed instrumentation. This same instrumentation shall be suitable for use for the Performance Ratio tests.

It will be expected that the Plant commissioning and tests will follow the guidelines set forth in these Employer's Requirements. The Contractor shall provide at least two (2) months prior to the commencement of the commissioning activities, testing procedures and protocols that need to be reviewed and commented on by the Employer. Additionally, the Contractor shall provide TOP documentation for the different systems at least two (2) weeks prior to commencement of the commissioning activities for the relevant system for Employer's review. The Employer may call for additional tests it considers necessary.

The Contractor shall provide a proposed Inspection and Test plan covering the construction works. The plan shall identify all inspection points and reporting actions and have the Employer witness and hold points at both at the Site and manufacturers' works.

Written advance notices shall be provided for all inspections and tests requiring the involvement of third parties and such notice periods shall in any case be no less than that required by statutory authorities or third parties (i.e., Grid Operator). The Contractor shall be responsible for coordinating any inspections and tests required by third parties. The Contractor shall make allowance for third parties (i.e., Grid Operator) to witness key tests and to receive copies of the corresponding data and reports.

The Contractor shall inform the Employer on the date it intends to synchronise the Plant to the Grid. Al least 21 days written notice shall be provided.

The Contractor shall remain fully responsible for the operation, maintenance, and cleaning of equipment as necessary throughout the commissioning and testing period up to the Date of Completion. All test instrumentation shall be properly calibrated by the Contractor prior to testing and rechecked after testing. Valid calibration certificates shall be provided for all instrumentation to be used during the tests as part of the test protocol to be submitted to the Employer prior to the commencement of the commissioning.

The lack of an acceptance criteria shall not relieve the Contractor from its contractual obligations, such as compliance with the applicable standards/technical requirements or the proper design and installation of the Plant.

Once the component or system is charged, energised, or otherwise made live, the Contractor shall conduct further tests to demonstrate that the system and its constituent components function collectively as designed and in accordance with all the applicable standards and manufacturer's specifications and guidelines.

If any portion of the Works fails under test, such further tests or re-testing shall be conducted to demonstrate the successful completion of such tests (and compliance with the Contract) by the Contractor. The whole costs of retesting, including costs incurred by the Employer in witnessing such (repeat) tests, shall be borne by the Contractor.

16.9.1.2 Test Sequence

The erection, mechanical completion milestone, cold commissioning, and appropriate third party tests and checks on the interconnection related systems shall have been completed by the Contractor prior to the application for energisation.

Tests to demonstrate interactive operation of components within the system shall also be completed prior to first energisation.

Grid Code compliance testing is to be undertaken as required by the Grid Operator and as appropriate and convenient during the commissioning and testing period, but, in any event, prior to the commencement of the Provisional Acceptance Tests. Further, the Provisional Acceptance tests shall only commence once the Plant has reached the satisfactory conditions for continuous uninterrupted operation.

For the systems as defined in section 2, Tests during Construction shall have been completed and the Mechanical Completion milestone achieved prior to the commencement of the commissioning activities (Tests on Completion).

Any test required to demonstrate compliance with the environmental requirements shall be also performed prior to the commencement of the Acceptance tests, or as agreed with the Employer and all relevant consenting authorities. The requirements of the environmental permits shall be complied with at all times during testing.

16.9.1.3 Right to Witness Inspections and Tests

The Employer shall have the right to be present during inspections, commissioning activities, all FATs, and all equipment tests at Site.

The Contractor and the Employer shall agree the list of witness and hold points for manufacturer’s works prior to the Contractor’s signature of supply agreements. Not less than fourteen (14) days written notice shall be given for all inspections and tests requiring the involvement of the Employer.

In the case where the Employer does not wish to be present at a test, the Employer shall inform the Contractor accordingly.

The Contractor shall issue all relevant tests certificates to the Employer.

The Contractor shall be responsible for co-ordinating any inspections and tests. Delays caused by the scheduling of third party tests/attendance shall not entitle the Contractor to any extension of time or additional costs.

16.9.1.4 General Test Notification Requirements

No later than fourteen (14) days’ notice shall be given to the Employer of all inspection and tests in order that the Employer may be present to witness the tests.

All inspections and testing shall be scheduled to commence during ordinary business hours, unless specifically agreed in advance by the Employer.

In general, the erection, commissioning, and functional test requirements are to be notified during daily and weekly erection/commissioning meetings held at Site; this shall include upcoming site inspections/test, where applicable.

No section of the Works shall be covered up without carrying out any test or inspection required under the Contract. The Contractor shall discuss and agree on the work which the Employer's personnel shall be entitled to examine, inspect, and/or witness of functional tests before it is covered up, consistent with the Employer’s Requirements.

16.9.1.5 Safety measures

The testing and commissioning may only be performed by well qualified and trained personnel. Relevant PPE must always be worn.

The Contractor shall pay specific attention to electrical risks posed during the testing and commissioning works when connecting multiple power sources and potential circulating currents.

The following five safety rules must be managed and observed by the Contractor at any time under all circumstances, particularly for switching operations and for voltage disconnection:

- Disconnect;
- Secure against reconnection;
- Check for zero potential;
- Connect to ground and short-circuit; and,
- Cover or barrier neighbouring live parts.

16.9.2 Test Procedures And Reporting Requirements

The Contractor shall also submit detailed specific test procedures and commissioning procedures (and the associated testing protocols or checklists) for each test or series of tests described in the following sections and in accordance with the relevant codes and standards as detailed in the Contract. The Employer shall respond with written comments and the Contractor shall subsequently revise and resubmit the test procedure as per the Contract. The test procedure and revisions shall be referenced in the test notification.

The following information shall be included as a minimum in the test procedure:

- Objectives and scope of the test and definitions of the test boundaries;
- Acceptance criteria;
- Health and Safety procedures and implications for all parties on Site;
- Codes and standards to be used or referenced, particularly the following standards:
  - Grid Connection Code for Renewable Power Plants (RPPs) connected to the electricity Transmission System (TS) or the Distribution System (DS) in South Africa, Latest Version;
  - SANS 61724-1: Photovoltaic system performance–- Part 1: Monitoring;
  - IEC 62446-1: Photovoltaic (PV) systems – Requirements for testing, documentation, and maintenance - Part 1: Grid connected systems - Documentation, commissioning tests and inspection;
- Quality Assurance procedures proposed for testing;
- Test Duration and number of runs, starting and stopping criteria;
- Plant operating conditions, permissible modes of control and operational limits during the tests;
- Prerequisites and precautions for the conducting of the tests, including safety checks and Power Plant stability requirements;
- Methods of data collection, identification of instrumentation to be used for tests, sampling requirements;
- Test schedules showing major activities planned for performing all required tests;
- Sample calculations demonstrating how tests results will be corrected;
- Test report requirements;
- Test organisation including designation of test director, testing personnel operator responsibilities, communication schedule, witnessing and preparation of test reports;
- A list of all the required settings and configuring of all protective devices and alarms for that section of the Plant; and,
- Copies of the Contractor's check sheets for the pre-commissioning, commissioning, and testing of the Plant item or system.

The Contractor shall supply to the Employer as soon as practicable, but not later than two (2) weeks after a test or inspection has been conducted, an electronic copy of the preliminary test reports which shall contain details of each test performed and shall be prepared as required by Employer. Records, results, and calculations of all tests shall be provided.

The test report shall include as a minimum but not limited to the following information:

- Test procedure;
- Description of test conditions;
- Description of any deviations from the test procedure of unusual events which occurred during the tests;
- Summary of test results;
- Calculations with definition of terminology;
- Copy of raw data the Contractor has collected during the tests immediately following each series of tests, test data sheets;
- Copies of instrument calibration records; and,
- All information reasonably necessary to evaluate the test results.

Once the preliminary report is reviewed a final report shall be submitted to the Employer within fourteen (14) days of receipt of the Employer’s comments, including two (2) hard copies and an electronic version.

16.9.3 Factory Acceptance Tests

All items under the Contractor’s scope of work shall be subjected to visual, dimensional, material, non-destructive, functional, and performance tests as applicable at the factory facilities. As a minimum the tests to be carried out shall be strictly in accordance with the relevant standards. All relevant material and works certificates shall be available at the time of test.

All electrical equipment shall be 'routine' and 'type' tested in the factory in accordance with the applicable standards. Type tests shall not be repeated if *bona fide* type test certificates of identical or similar ('similar' according to the definition of SANS/IEC) equipment are available.

The detailed testing procedures shall be agreed with the Employer during the detailed design phase, and shall include, but not be limited to, the following:

- Power Transformers;
- HV & MV switchgear, HV CT's and VT's; and,
- Relay control panels, battery chargers, SCADA system/RTU & telecommunication panels.

The Contractor shall attend the FATs in person (or via Subcontractor(s)), and prior to the performance of the FATs the Contractor shall provide to the Employer all relevant FAT procedures, which shall include, at least, the following information:

- Test program (dates, location and duration of each test);
- Test standards;
- Type of inspection and tests;
- Reviewed design drawings/document relevant for the test'
- Material certificates that will be attached to the FAT report and technical data sheets relevant for the test'
- Methodology of tests'
- Checklists including process data to be recorded where applicable'
- Equations for process data where applicable;
- Description of the instrumentation to be used (including, but to not limited to, the AKZ or KKS system code (system to be confirmed at a later stage), type of instrument, measure range and accuracy) including calibration certificates of testing equipment;
- Forms of test records and test report template; and,
- Complete factory QA/QC dossier of the inspections performed prior to the respective FAT.

The Contractor shall submit a FAT report no later than ten (10) days after completion of each FAT. The FAT report shall include data as recorded, including valid calibration certificates (dating back no more than twelve (12) months for temporarily installed performance test instrumentation, unless a more restrictive validity period is imposed by the applicable reference standards), and at least, the following information:

- The type of test, applicable test procedure and test standards;
- The date and time of each test, including the start and completion time of the test;
- A description of conditions under which the test was conducted;
- A summary of the quality control procedures, instrumentation used and instrument; calibration instructions from the Original Equipment Manufacturer (OEM), historical and up-to-date calibration certificates;
- A summary of test results;
- A comparison of test results to relevant contractual values where applicable;
- The conclusion from test results, including whether the acceptance criteria were met; and,
- The identification of any abnormal conditions presents during the test period.

Upon successful completion of each FAT in accordance with the Employer, a Factory Certificate shall be provided. The successful completion of all FAT shall be a condition precedent for the issuance of the Taking Over.

16.9.3.1 Transformers Factory Acceptance Tests

For power and earthing transformers, the Contractor shall provide evidence of type tests for transformers of similar rating and construction as specified in SANS 60076, including:

- Temperature-rise type test (SANS 60076-2);

- Dielectric type tests (SANS 60076-3);
- Determination of sound level (SANS 60076-10) for each method of cooling for which a guaranteed sound level is specified;
- Measurement of the power drawn by the cooling fan and cooling liquid pump motors; and
- Measurement of no-load loss and current additionally at 90 % and 110 % of rated voltage.

In the absence of satisfactory certification, type tests shall be carried out by the Contractor.

Evidence of a short-circuit withstand test as per SANS 60076-1 11.1.4 and SANS 60076-5 or a rated short-time neutral current withstand test as per SANS 60076-6 (for earthing transformers) shall be available for transformers of similar rating and construction as specified in SANS 60076:2011. Otherwise, demonstration of the transformer's thermal ability to withstand short circuit and the ability to withstand the dynamic effects of short circuit is required either by test or by calculation and design and manufacture considerations.

The following routine tests are required in the factory for all transformers to be supplied:

- Voltage ratio & Vector Group Verification;
  - SANS 60076-1: Power Transformers - Part 1 (Clause 11.3)
- Winding Resistance test I;
  - SANS 60076-1: Power Transformers - Part 1 (Clause 11.2)
- Insulation resistance test;
  - SANS 60076-1: Power Transformers - Part 1 General (Clause 11.1.2.2)
- No-Load Test and magnetising current;
  - SANS 60076-1: Power Transformers - Part 1 General (Clause 11.5)
- Short Circuit Impedance and Load losses;
  - SANS 60076-5: Power Transformers - Part 5 Ability to withstand short circuit
  - SANS 60076-20: Power Transformers – Part 20 Energy Efficiency
- Leak testing with pressure for liquid-immersed transformers (tightness test);
  - SANS 60076-1: Power Transformers - Part 1 General (Clause 11.8)
- Applied Voltage Test (AV);
  - SANS 60076-3: Power Transformers - Part 3 Insulation levels, dielectric tests and external clearances (Clause 11)
- Line terminal AC withstand voltage test (LTAC);
  - SANS 60076-3: Power Transformers - Part 3 Insulation levels, dielectric tests and external clearances (Clause 12)
- Induced voltage test with partial discharge measurement IVPD;
  - SANS 60076-3: Power Transformers - Part 3 Insulation levels, dielectric tests and external clearances (Clause 11)
- Capacitance windings-to-earth and between windings and Dissipation Factor (Tan δ);
  - SANS 60076-1: Power Transformers – Part 1 General
- Measurement of dissolved gasses in dielectric liquid from each separate oil compartment except diverter switch compartment;
  - Before all tests
  - After temperature rise ONAF test
  - After temperature rise ONAN test

  - After impulse test
  - After all electrical tests

- Ratio and Polarity Test of internal CTs;
  - SANS 61869-2: Instrument Transformers - Part 2: Additional requirements for current transformers
- Operation of on-load tap changer;
  - SANS 60076-1: Clause 11.7
- Wiring 2 kV insulation test;
  - SANS 60076-3: Power Transformers - Part 3 (Clause 9)
- Bushings;
  - SANS 60137 Insulated bushings for alternating voltages above 1000 V
- Tests applied to devices with alarm and tripping contacts;
  - NRS 054 Clause 5.3
- Gas and oil actuated relay tests;
  - NRS 054 Clause 5.5
- Digital thermometers;
  - NRS 054 Clause 5.6
- Dimensions, general assembly, painting and documentation.

Special tests will be quoted and offered by the Contractor as part of optional and additional tests to be carried out in the factory. The Employer will decide later the final special tests to be carried out, as follows:

- No-load current harmonics measurement;
  - SANS 60076-1: Power Transformers–- Part 1 General (Clause 11.5)
- Lightning impulse and switching impulse withstand test, full wave and chopped wave;
  - SANS 60076-3: Power Transformers–- Part 3 (Insulation levels, dielectric tests, and external clearances).
  - SANS 60076-4: Power Transformers–- Part 4 (Guide to lightning impulse and switching impulse testing–- Power transformers and reactors)
- Induced overvoltage withstands test IVW;
  - SANS 60076-3: Power Transformers–- Part 3 Insulation levels, dielectric tests, and external clearances (Clause 11)
- Zero sequence impedance test;
  - SANS 60076-1: Power Transformers – Part 1 General
- SFRA;
  - SANS 60076-18 Measurement of frequency response
- Temperature Rise (ONAN, ONAF). Infrared images to be taken of the main tank and to be included in the test report. DGA samples to be taken before, during and after Temperature rise test.
  - SANS 60076-2: Power Transformers–- Part 2 Temperature rise for liquid-immersed transformers.

16.9.3.2 HV and MV switchgear

HV and MV switchgear shall be factory tested as per SANS 62271 "Standards for high voltage switchgear and control gear".

A certificate from an internationally reputable independent third party shall be made available to demonstrate that all equipment (and its component parts) has been fully type tested in accordance with the appropriate SANS/IEC Standards and the specified ratings. In the absence of satisfactory evidence, type tests shall be carried out by the Contractor. Type tests shall not be repeated; however, valid Type Test report & Certificates for offered switchgear shall be provided.

Each switchgear system shall be routine tested, in accordance with SANS 62271 "Standards for high voltage switchgear and controlgear".

16.9.3.3 MV cables

MV cables shall be factory tested as per SANS 60502-4.

A certificate from an independent third party shall be made available to demonstrate that MV cables have been fully type tested in accordance with the appropriate SANS/IEC Standards and the specified ratings. In the absence of satisfactory evidence, type tests shall be carried out by the Contractor. Type test shall not be repeated, however valid Type Test report & Certificates for offered switchgear shall be provided.

Routine tests shall be carried out on each type of manufactured cable. The number of lengths can only be reduced if accepted by the Employer according to the agreed quality control procedures. The routine tests shall include but not necessarily be limited to:

- Non-electrical tests (radial dimensions, thickness of insulation, embossing and marking);
- Hot set test of insulation;
- AC high voltage test and/or spark test;
- Conductor resistance;
- Insulation resistance;
- Capacitance test measurement (for MV cables);
- Partial discharge test (for MV cables); and,
- DC test on outer sheath (for MV cables).

16.9.4 Site Acceptance Tests

As far as applicable, the Contractor will carry out site acceptance testing for all Materials. Where materials can be tested on-Site, the Contractor shall not incorporate materials into the Work until site acceptance testing has been carried out. On arrival at the Site, and during the performance of the Work, all items of materials shall be inspected and tested by the Contractor as appropriate to ensure there is no delay in construction, installation, and commissioning arising from defects, damage and / or deterioration of parts. The Employer has the right to review the material reception report from the Contractor.

Materials reception and warehouse management procedure shall be issued by the Contractor as part of the Quality Plans. As a minimum criterion for all mechanical and electrical equipment received on-site, the following shall be checked:

- Identification and traceability data is provided;
- Equipment certifications and type test certificates are provided; and,
- Visual inspection shall be performed including packaging being undamaged.

16.9.5 Inspection And Tests During Construction

The inspection and testing activities shall be performed in a logical and sequential manner, including the division of the Plant into different systems and sub-system, which shall undergo different quality control levels allowing for all items identified during the initial quality control levels to be traced through the entire quality control and testing process until they have all been completed as per the Contractor's Scope of Work.

During the construction and erection period, the Contractor shall undertake all installation checks, preliminary mechanical and electrical checks, proving the integrity of all connections (mechanical and electrical), safety systems and verification that all plant is functionally complete.

Throughout construction, all incomplete work and deficiencies shall be recorded in a punch list, which latest version (i.e., only non-rectified items) shall be included in the TOP documentation.

Inspection and tests during construction shall include and not limited to the following:

- Trenching;
- Road works;
- Fence works;
- Foundations;
- AC & DC and control cabling;
- AC & DC boards and switchgear;
- Power and earthing transformers;
- Circuit Breakers;
- Current transformers;
- Voltage transformers;
- Disconnector and earthing switches;
- Surge arrestors;
- SCADA system/RTU & telecommunication panels;
- Security system;
- Firefighting system;
- Earthing system;
- Lightening protection system; and,
- MV switchboards and RMUs.

In performing the inspection and tests during Construction, the Contractor must verify that all systems and components of the Plant comply with the Contract, and that all equipment has been installed according to their manufacturer'' installation manuals and guidelines.

For the avoidance of doubt, the tests during Construction shall not require any connection to the grid.

Successful completion of these tests together with the delivery to the Employer of the associated test reports or checklists is a requirement for the achievement of the Mechanical Completion milestone.

16.9.5.1 Trenches

The Contractor shall check the compliance of the following items with the civil works drawing:

- Trench routing/alignment; and,
- Position of the trench drainage traps.

The Contractor shall check the compliance of the following items with the trench drawing:

- Depth;
- Length;
- Width;
- Thickness of the bottom sand layer;
  Diameter, position and colour of the sleeves;

- Thickness of the top sand layer;
- Quality and composition of the backfill material;
- Presence, position, and colour of the warning net; and,

- Presence, type of material and size of the earth cable.

The Contractor shall check the correct installation:

- Sleeves have not been damaged; and,
- Connection between sleeves is fully tightened.

16.9.5.2 Roads

The Contractor shall check the compliance of the roads alignment with the civil works drawing. Further, the Contractor shall check the compliance of the following items with the civil works technical specification:

- Length, width and thickness of the roads;
- Presence and type of the geotextile layer (if applicable);
- Size of the material (gravel, stones…); and,
- Completion of compaction.

16.9.5.3 Fences

The Contractor shall check the compliance of the following items with the fence technical specification:

- Type of fence;
- Dimensions of the fence;
- Mesh size;
- Thickness of the galvanisation on fence poles; and,
- Colour.

The Contractor shall check on the whole length of the fence:

- The fence has been founded and installed according to the drawing;
- The fence is not damaged;
- The fence is installed vertically correctly;
- Proper distance maintained between the ground level and the bottom of the fence;
- Distance between earth rods is correct;
- Depths of driving in of the earth rods is correct;
- Quantity of concrete on the rods foundations by a visual inspection;
- The gates have been installed vertically correctly;
- The opening/closing of the gates is correct; and,
- The locking/unlocking of the gates is correct.

16.9.5.4 Foundations

The Contractor shall check the compliance of the following foundation items with the drawings:

- Position;
- Length;
- Width;
- Depth;
- Thickness; and,
- Presence, type of material and size of the earth conductors.

For the respective concrete foundations:

- Compliance of the rebar framework with the bending schedules;
- Rebar specified minimum cover afforded to base and edge of foundation excavations;
- Quality of concrete through a visual inspection; and,
- Concrete cube test results.

16.9.5.5 DC wiring

With respect to DC wiring, the Contractor shall:

- Verify cable identification is in place and correct for identification and durability;
- Verify condition of cable;
- Verify cables are landed and lugs are torqued to appropriate value in accordance with manufacturer's data;
- Verify that all electrical safety certificates have been issued by the relevant authority;
- Verify that all cabling is installed as per design with service loops and cable protection conduits as a UV barrier;
- Cabling must not be exposed to the sun directly;
- Verify that all the cables are fastened at regular intervals and that no sharp edges prevail which may damage the cables; and,
- Verify that all cable transitions (e.g., above ground to below ground, etc.) are appropriately fastened using weather resistant jointing elements which are also rodent barriers for prevention of egress into the cable conduits.

16.9.5.6 Cabling

For the AC cabling, both LV and MV cables, the Contractor shall:

- Compare cable type data with drawings and specifications;
- Verify cable identification is in place and correct for identification and durability;
- Verify condition of cable; and,
- Verify cables are landed and bolted connections torqued to the appropriate value(s) in accordance with manufacturer's data.

16.9.5.7 AC boards and switchgear

With respect to commissioning tests for AC boards and switchgear, the Contractor shall:

- Inspect AC cabling and switches and verify that types, sizes and lengths are in accordance with the Agreement requirements and are correctly labelled and in line with respective diagrams;
- Verify lightning protection measures, if applicable;
- Verify voltage rating;
- Verify protection device setting and suitability; and,
- Verify compliance to requirements and standards.

16.9.5.8 Power and Earthing Transformers

Contractor shall execute the following actions and checks, where devices are installed and/or where applicable:

- Visual inspection;
- Check correct earthing;
- Check tightening torque of bolted connections after completion of all tests;
- Check oil leakages;
- Check oil level;
- Check of protection devices operation;
  Check of alarms and trip initiation (oil level, Buchholz, temperature, overpressure valve); and,
- Check (non) saturation of dehumidifying crystals and oil bath level.

16.9.5.9 Current Transformers

The Contractor shall check the compliance of the following items:

- Visual inspection including corrosion and alignment;

- Check unused secondary windings are short circuited and earthed;
- Check earthing;
- Completeness of installation and cleanliness of insulators;
- SF6 pressure or oil level;
- Check connections;
- Check ratios and data sheet parameters;

16.9.5.10 Voltage Transformers

The Contractor shall check the compliance of the following items:

- Visual inspection including corrosion and alignment;
- Check unused secondary windings are open circuited and earthed in one end;
- Check earthing;
- Check tightening of bolts;
- Completeness of installation and cleanliness of insulators;
- Oil level;
- Check connections; and,
- Check ratios and data sheet parameters.

16.9.5.11 Disconnector and Earthing Switches

The Contractor shall check the compliance of the following items:

- Check grounding;
- Check tightening of bolts;
- Completeness of installation and cleanliness of insulators;
- Check alignment and mechanical operation; and,
- Verify lubrication of main contacts and moving parts.

16.9.5.12 Surge Arrestors

The Contractor shall check the compliance of the following items:

- Check grounding of supports;
- Check grounding of dischargers;
- Check grounding of counter;
- Check tightening of bolts; and,
- Completeness of installation and cleanliness of insulators.

16.9.5.13 Earthing

The Contractor shall check the compliance of the following items with the earth grid drawing or calculation note:

- Position of the earth conductors and rods;
- Dimensions and type of material of the earth conductors and rods;
- Welding of the earth conductors and rods together, through a visual inspection; and,
- Verification of earth bond between structures and earth grid through current injection.

16.9.5.14 Security system

The Contractor shall check the compliance of the following items with the anti-intrusion drawings:

- Position of the CCTV cameras and perimeter floodlights which are integrated in the IDS functionality as described in the Employer's Requirements;
- Mounting height of the cameras & floodlights support poles;
- Installation of the IDS along the full length of the perimeter fence (mounted on fence and buried along the outer boundary of the fence);
- Installation of the IDS across the full length of the gates;
- Installation of the intrusion/detection system on/off switch;

- Installation of magnetic contact switches at all perimeter gates and key entrances in the PV Plant; and,
- Ensure there are no blind spots.

The Contractor shall check the compliance of the following items with the anti-intrusion technical specification:

- Type and performance of the cameras; and,
- Type of IDS for the perimeter fence.

16.9.5.15 PV Plant SCADA system

With respect to commissioning tests for the SCADA system, the Contractor shall:

- Verify compliance to requirements and standards;
- Verify accuracy classes are within requirements and inspect calibration certificates; and,
- Verify that all electricity meters (input and output) and corresponding secondary circuits connections are sealed.

16.9.6 Tests On Completion

The Plant shall be commissioned and tested in compliance with the Employer's Requirements, internationally recognised codes and standards, and the current best commissioning practice of solar PV plants. The Tests on Completion shall include but is not limited to the following:

- Pre-Commissioning (Cold Commissioning);
  - Visual inspection – Functional tests.
  - Electrical safety tests.
- Grid Code Compliance test;
- Commissioning (Hot Commissioning):
  - Transformer Commissioning (HV/MV, MV/LV transformers)
  - Security System Commissioning.
  - Commissioning of Components and Systems (MV circuit breakers, Current transformers, Voltage transformers, MV disconnectors, Surge arrestors, Power transformers, MV cables, MV switchgear, Auxiliary transformers, AC &DC panels, Battery chargers & rectifiers, Protection devices, Fire alarm system, Lighting system, Diesel generator & other systems).

16.9.6.1 Personnel

The Contractor shall procure the services of an Authorised Person (OEM Approved) during testing and commissioning of the PV Plant for all switching, linking, safety testing, and earthing operations.

16.9.6.2 Pre-Commissioning (Cold Commissioning)

The Pre-commissioning shall include, but is not limited to, the following:

- Visual inspection;
- Functional tests; and,
- Electrical safety tests.

The minimum required information is to be provided prior to commencement of the pre-commissioning tests, which shall include, but not be limited to, the following:

- Rated component capacity (DC and AC);
- Detailed design pack consisting of the following:
  - Up to date SLD of the facility;

- Specification of overvoltage protection devices (current and voltage rating). Location, type and rating of overvoltage protection devices should be specified;
- Details of all all LV, MV, and HV cables used in the substations on Site. This includes cable type, size, OEM, and length;
- A SLD detailing all earthing, lightning protection system, and details of the surge protection devices installed; and,
- A SLD detailing the AC isolators and over current protection devices, location, type, and rating.

16.9.6.3 Visual Inspection

The envisaged scope of the visual inspection will consist of, but is not limited to, the following:

- The Plant is free from any defect other than minor defects that do not exceed one (1%) of the Contract price, excluding those defects that have an adverse effect on the safety, operation, and performance of the Plant;
- The component has been installed and wired in accordance with the approved design and good practice, relevant codes, and OEM guidelines;
- Review the selection and usage of materials and proper installations appropriate with the environment in which the component is to be utilised;
- The state of readiness of the installation and of the setting of all protection and signalling equipment;
- The availability of electrical drawings, safety manuals and usage handbooks, and factory test reports or quality test reports from manufacturer, when applicable;
- Spare parts available on Site;
- Labelling, marking and identification of cables, fuses, panels cubicles etc.; and,
- Adequate protection afforded from live parts.

Visual checks are applicable on all the components that form part of the Plant, and shall include as a minimum the following parts:

- Foundations;
- Trenches, cabling, electrical boxes and protection devices;
- Monitoring System including any UPS;
- LV installation, including protection equipment;
- MV installation, including transformers and protection equipment;
- Interconnection Facilities;
- Security system;
- Grid connection line tower and assembly system;
- Equipment labelling in agreement with plans; and,
- Health and safety signage.

In addition to the aforementioned, the visual inspection shall verify the installation of the system components comply with the designs. This includes a review of the following:

- Durable, easily legible labels and markings;
- Durable, easily legible safety signs in accordance with local laws, regulations, and standards;
- Rating of components;
- Number of components;
- Distances, heights, and positions of components and systems in accordance with OEM guidelines and national standards;
- Verify sizing of cables, wires, and busbars are in accordance with the design; and,
- Tightening torque of bolts.

16.9.6.4 Functional Test

The two substations shall be subject to functional tests which shall include confirmation that components operate within the expected parameters as well as respond correctly to transient conditions.

16.9.6.5 Power and earthing transformers

- Power transformers shall be commissioned by the transformer manufacturer or an authorized representative of the transformer manufacturer using the transformer manufacturer's specified procedures. Commissioning reports shall be issued in a format provided by the manufacturer.

SCADA system and security system

- Verification of the security system;
- Verification of all communication cable signals;
- Obtain attenuation measurement records on all optical fibres.
- Test communications with all panels;
- Verify format and handling of acquired data set;
- Check threshold alarm settings;
- Inspect UPS operation and correct dimensioning;
- Inspect the Site communication systems–- broadband cable distribution and GSM;
- Control of remote system access and data downloading; and,
- System is ready for on-load commissioning.

16.9.6.6 Electrical Safety Tests

The electrical safety tests shall include but not be limited to, the following:

16.9.6.7 LV system

- Low-voltage DC and AC cables shall be tested for insulation resistance in accordance with IEC/SANS 60364, IEC 60364-6, and SANS 60364-7-712;
- Continuity testing of all DC and LV AC cable;
- Verify the polarity and voltage rating of cables;
- LV protections and switchgear functional tests; and,
- Verification of (no) hot spots in electrical connections.

16.9.6.8 MV system

- MV protections and switchgear tests;
- Verification of (no) hot spots in electrical connections;
- Perform and record conductor continuity testing;
- Perform and record insulation resistance testing;
- Perform dielectric strength withstand testing;
- Perform VLF voltage withstand testing; and,
- Perform partial discharge testing.

16.9.6.9 Power and earthing transformers

- Insulation check (with measurement of insulation resistance) (primary to secondary – primary to earth – secondary to earth);
- Measurement of voltage ratio at each tap setting and vector group;
- Measurement of no-load losses and current;
- Measurement of short circuit impedance and load losses;
- Measurement of winding resistance at each tap setting;
- AC voltage withstand test;
- Tan delta tests performed on all bushings with test taps;
- Test tap changer manual and electrical operation;

- Dielectric tests;
- Functional tests (feedings and auxiliary circuits, ventilators, cooling fans, oil pumps);
- SFRA; and,
- No-load test (when applicable).

16.9.6.10 Current transformers

- Measurement of winding resistance;
- Ratio and Polarity Test;
- Turns ratio test;
- Check saturation curves of protection cores; and,
- Verification by injection of primary current.

16.9.6.11 Voltage transformers

- Measurement of winding resistance;
- Check voltage ratio; and,
- Verification by injection of voltage to the primary.

16.9.6.12 Disconnector and Earthing Switches

- Check setting of limit switches;
- Check interlocking between earthing and disconnector;
- Perform electrical operations;
- Perform mechanical operations;
- Functional tests; and,
- Measure resistance of main contacts.

16.9.6.13 Surge Arrestors

- Measure insulation resistance;
- Register number of discharges recorded by the counter before activation; and,
- Measure residual resistance before activation.

16.9.6.14 Earthing

The Contractor shall supply to the Employer the results of all tests associated with the earthing system, including without limitation the results of:

- Earth resistance tests for each isolated PCU;
- Earth conductor continuity tests and resistance tests; and,
- Electrical continuity of the Project earthing (all metallic and electrical equipment).

Full compliance with relevant local standards shall be verified by way of current injection tests and step and touch voltage measurements and analysis.

The earth grid shall be tested at the Solar Plant Substation, the Eskom Switching Station as well RWB Lethabo Substation.

Validation tests shall be undertaken, including:

- Resistance and continuity tests of the earth grid;
- An ‘off-frequency’ current injection test to determine the impedance and earth potential rise of the complete earthing system;
- Voltage gradient tests to determine the extent of earth potential rise contours; and,
- Step, touch, and transfer potential measurements throughout the Project to determine the performance of the installed earthing system under simulated fault conditions.

16.9.6.15 Grid Code Compliance Tests

It is the Contractor’s obligation to ensure that the design and installation of the Plant are in compliance with all applicable requirements and regulatory approvals, including national grid code requirements

(Latest revision of Grid Connection Code for Renewable Power Plants (RPPs) connected to the electricity Transmission System (TS) or the Distribution System (DS) in South Africa, Version 3.1/January 2022, as may be amended from time to time) and Eskom requirements (e.g. Eskom Standard for the Interconnection of Embedded Generation (240-61268576)). The responsibility is on the Contractor to support and drive all required permitting applications and the application process for grid interconnection and compliance in relation to the PV Plant and related Grid Connection system.

The Contractor will ensure all required hardware that is to be specified to allow for grid interconnection is included in its scope. All required SLD's and layouts will be submitted as part of the design package in support of the grid interconnection application.

The results of the electrical grid tests shall be presented in a manner that will be acceptable to the Grid Operator and the Employer.

16.9.6.16 Commissioning (Hot Commissioning)

16.9.6.17 General

For safety reasons, Hot Commissioning activities shall only start when the earthing system commissioning has been completed and the results accepted by the Employer. The commissioning tests are performed to determine and verify the proper operation of all component parts, subsystems, and systems constituting the works and of the Project in its entirety.

The Commissioning shall include, but is not limited to, the following:

- Transformer commissioning;
- SCADA system and monitoring system commissioning test;
- Security system commissioning tests;
- Protection systems/settings, in accordance with the agreed design and the requirements of the power interconnection system; and,
- Connection facilities commissioning.

The equipment shall be tested and commissioned using OEM approved procedures and trained personnel.

16.9.6.18 Transformer Commissioning

Transformers (HV/MV – MV/LV – MV/MV – LV/LV transformers) shall be commissioned by the transformer manufacturer or an authorized representative of the transformer manufacturer using the transformer manufacturer's specified procedures.

Commissioning reports shall be issued in a format provided by the transformer manufacturer.

The commissioning engineer shall execute at least the following tests and checks, where devices are installed and/or where applicable:

- Visual inspection;
- Check correct grounding;
- Check tightening torque of bolted connections;
- Insulation check (with measurement of insulation resistance) (primary to secondary – primary to earth – secondary to earth); Measurement of turns ratio and vector group;
- Measurement of no-load losses and current;
- Measurement of short circuit impedance and load losses;
- Measurement of winding resistance;
- AC voltage withstand test;
- Test tap changer;
- Check oil leakages;
- Check oil level;
- Check overpressure valve;

- Check of protection devices;
- Check of alarms (oil level, Buchholz, temperature);
- Check saturation of dehumidifying crystals;
- Dielectric tests;
- Functional tests; and,
- No-load test (when applicable).

Where power transformers have been transported to Site and contain accelerometers:

- The Contractor shall extract and assess (only after final positioning) the accelerometer data for compliance to all applicable Laws and Standards and manufacturers specifications;
- The accelerometer data shall be provided to the Employer within 1 day of it becoming available to the Contractor;
- The accelerometers should be designed to record individual shocks greater than 1G; and,
- In instances where transformers are transported by sea additional devices should be installed to summate the number of lesser shocks exceeding 0.7G.

All tests shall be executed according to SANS 60076, SANS 60270, IEC 60156, and all other applicable Laws and Standards.

16.9.6.19 SCADA System and Monitoring System Commissioning Tests

The SCADA system and monitoring system shall be commissioned according to manufacturer specifications and industry best practice. Tests shall verify the correct operation of the SCADA system and meters, while verifying the correct data input logging from breakers and other components monitored by the system. The SCADA system shall be fully accessible remotely.

Every instrument required for the measurement of data shall have been previously calibrated and certified by third party experts. Calibration certificates shall be provided for the instruments at the time of test. The costs involved in preparation of calibration certificates shall be borne by the Contractor.

Prior to the Provisional Acceptance tests, every test instrument required for the measurement of test data shall be checked and recalibrated if necessary. This test shall verify that the data collected is correctly received by the SCADA system and can be used to produce any required performance or operation reports. Each row of data shall report the exact date and time in a suitable format.

The Employer shall review the calibration certificates of each sensor and all related documentation like certifications and installation manuals.

Formal approval and acceptance from the System Operator as to the correct interfacing of the SCADA system with their systems is required for Taking Over. All FO cable installations are to be compliant with SANS 10340-1/2 Standards.

16.9.6.20 Security System Commissioning Test

Security system equipment shall be commissioned, tested, and calibrated by a certified installer of the equipment manufacturer using the manufacturer's specified procedures.

Security system testing shall include testing of all operating modes and alarm conditions, including testing of:

- Cameras and dome cameras;
- Infrared sensors / projectors;
- Lights;
- Sirens; and,
- Reaction time of security company.

A security system commissioning protocol or report shall be provided by the Contractor to the Employer.

16.9.6.21 Connection Facilities Commissioning

All tests prescribed by the manufacturers shall be executed in accordance with the prescriptions contained in the respective installation and commissioning manuals. The following list of tests shall be complied with by the Contractor whenever manufacturers' tests are less restrictive than what is presented below.

HV Switchgear

- Check correct mounting and fixing;
- Check correct grounding;
- Verify correct setting of protections;
- Functional tests;
- Check SF6 gas pressure and humidity level;
- Measure insulation resistance; and,
- Perform dielectric tests.

MV Circuit Breakers

- Check grounding;
- Completeness of installation and cleanliness of insulators;
- Gas[26] pressure;
- Functional tests;
- Tests for verifying opening / closing time;
- Measurement of power absorption of the coils; and,
- Measurement of resistance of the main contacts.

Current Transformers

- Check grounding;
- Completeness of installation and cleanliness of insulators;
- Gas[27] pressure or oil level;
- Check connections;
- Check ratios and data sheet parameters;
- Turn ratio test; and,
- Verification by injection of current to the primary.

Voltage Transformers

- Check grounding;
- Check tightening of bolts;
- Completeness of installation and cleanliness of insulators;
- Oil level; and,
- Check ratios and data sheet parameters.

MV Disconnectors

- Check grounding;
- Check tightening of bolts;
- Completeness of installation and cleanliness of insulators;
- Verify greasing of main contacts and moving parts;
- Check setting of limit switches;

[26] MV Primary distribution equipment to be AIS with vacuum switchgear. MV Secondary distribution equipment to be SF6-free GIS technology.
[27] MV Primary distribution equipment to be AIS with vacuum switchgear. MV Secondary distribution equipment to be SF6-free GIS technology.

- Check interlocking between earthing and disconnector;
- Perform electrical operations;
- Perform mechanical operations;
- Functional tests; and,
- Measure resistance of main contacts;

Surge Dischargers

- Check grounding of supports;
- Check grounding of dischargers;
- Check grounding of counter;
- Check tightening of bolts;
- Completeness of installation and cleanliness of insulators;
- Measure insulation resistance;
- Register number of discharges recorded by the counter before activation; and,
- Measure residual resistance before activation;

MV Cables

- Check clamping;
- Check correct positioning and orientation of toroid CTs;
- Check grounding of shields;
- Dielectric test according to Laws and Standards; and
- Check compliance to SANS 1339.

AC and DC Panels

- Check correct mounting and fixing;
- Check correct grounding;
- Verify correct setting of protections; and,
- Functional tests.

Battery Chargers and Rectifiers

- Check correct mounting and fixing;
- Check correct grounding;
- Check correct installation of battery units;
- Check levels of liquids (if applicable);
- Check seal and filler caps (if applicable);
- Check proper functioning of HVAC system in the battery room;
- Check feeding voltage and phase sequence;
- Check output voltage (Facility and battery side);
- Check polarity; and,
- Check alarms and signals.

Protection Devices

- Check correct mounting and fixing;
- Check correct grounding;
- Check feeding voltage;
- Verify correctness of settings;
- Functional tests; and,
- Check rational and correct tripping of protections, including discrimination.

Fire Alarms, Lightning Protection System, Diesel Generator, and Other Systems

- Check correct mounting and fixing;
- Check correct grounding;

- Verify correct setting of protections; and,
- Functional tests.

Overhead line

- Check setting out during construction of foundations;
- Check clearances;
- Check transmission pole alignment and fixing;
- Check structures assemblies, ties, clamps, conductor attachment;
- Check labelling;
- Check transmission pole footing resistance; and
- Check phasing.

17 O&M HANDOVER

The following set of requirements pertain to the O&M handover process to take place between the Contractor and the Employer's chosen O&M staff, who may be internal staff or a third-party O&M Contractor, following the completion of the Defects Liability Period. While certain requirements have been addressed previously in the Employer's Requirements, such as O&M documentation, they are repeated here for completion. In case of any conflict in requirements, the more restrictive requirement(s) shall apply. In the case where the Employer decides to appoint an independent O&M Contractor, all references to the Employer in this section (section 17) shall apply to the independent O&M Contractor as well.

17.1 Transfer of documentation

The Contractor shall provide the Employer with a complete set of all relevant documentation required to run the Plant in a safe, effective, and efficient manner. All documentation shall be provided in an appropriate file format.

The Contractor shall provide the Employer with all Plant operational data to date. This includes maintenance reports, hourly energy production data from each inverter and meter, hourly irradiation data, any force majeure events or other of significant impact which have occurred and the results/reports from all measurement tests conducted, including commissioning test results and reports.

17.2 Transfer of contracts

The Contractor shall provide the Employer with copies of all existing Project contracts with external parties, subcontractors etc. for review.

All existing and valid Project contracts shall be transferred to the Employer. Should any contract require termination for any reason, the Contractor shall be responsible for securing a suitable replacement contractor prior to acceptance by the Employer.

17.3 Monitoring and communication systems

Sufficient time and attention shall be allowed for the transfer of the monitoring and communication systems. This shall cover aspects such as password transfer, proprietary PLC code, SCADA system (GUI) operation, VPN access etc.

17.4 Site Access

The Contractor shall allow the Employer sufficient time and access to the Site and Site facilities. This shall allow the Employer to conduct the necessary (detailed) technical inspections to familiarise themselves with the Project prior to handover of O&M duties. The inspections shall include the following checks as a minimum: health and safety (of field personnel during Plant operation), As-Built design (correctness of drawings with installed/constructed Works across entire Plant), existing Plant PR prior to O&M Contract signature, discuss/verify details of O&M reports received with Contractor staff on Site, (spare parts) warehouse inspection including existing inventory levels and visual inspection of PV modules.

17.5 Handover report

Following the onsite inspections, the Contractor shall prepare a technical handover report containing a description of the Plant's operating history to date. The report shall focus on the various Plant components and include a punch list of any outstanding issues still to be addressed, a (check)list of all documents provided to the Employer, recommendations for future O&M, commentary on the current condition of the (spare parts) warehouse, special storage conditions (temperature, humidity etc.) for certain spare parts items, the current spare parts inventory, and any proposed changes to the (minimum) list of spare parts to meet contractual obligations.

17.6 TRAINING

The Contractor shall provide the Employer with a suitable training program as part of the handover process which shall include the following:

- HSE and security training. The Contractor shall explain and demonstrate all related HSE and security related aspects of the Plant to the Employer. This shall include a demonstration of key systems and procedures e.g., a fire emergency, breach of Site security etc. The training will provide the Employer the chance to identify any shortcomings in existing Site HSE and security procedures or unidentified hazards on Site and propose and implement changes/new procedures if necessary. All changes proposed and/or implemented shall be communicated to the Employer.
- O&M manual and procedures. The Contractor shall ensure that the Employer’s team are suitably trained in the O&M manual and all related procedures for the Plant. The Employer shall have the option to propose changes to the O&M manual and procedures based on industry best practice. If accepted, the O&M manual and procedure shall be updated to incorporate such changes.

17.7 O&M HANDOVER TRANSITION PERIOD

The transition period during which O&M handover takes place between the Contractor and the Employer shall not be less than six (6) months. At the end of the transition period, a final handover report shall be compiled by the Contractor and issued to the Employer. This report shall include the final punch list and any additional information relating to the Site which is relevant for the future O&M of the Plant.

ANNEXURE A. ACRONYMS AND DEFINITIONS

Item	Description
AC	Alternating Current
ACB	Air Circuit Breaker
AKZ system	The Plant Designation System AKZ ((Anlagenkennzeichnungssystem) is a predecessor system for identifying plants, systems, sub-systems, and equipment items for plant operating companies. It is the existing system utilised at Lethabo Power Station.
AN	Air Natural
Applicable Laws, Codes and Standards	Where applicable for the carrying out of the Works and as amended from time to time: (a) statutes and ordinances (including regulations enacted under those statutes); (b) national, regional, provincial, state, municipal, or local laws and by laws) judgments and orders of courts of competent jurisdiction. (d) rules, regulations, and orders issued by government agencies, authorities, and other regulatory bodies) all regulatory approvals, permits, licenses, permissions, approvals, and authorisations.
Authorities	Official person or institution that has power, permission or right to act.
BECW	Bare Earth Copper Wire
BESS	Battery Energy Storage System
BMS	Building Management System
BoM	Bill of Materials
CB	Circuit Breaker
CBR	California Bearing Ratio
CCR	Central Control Room
CCTV	Closed-Circuit Television
CE Marking	CE marking indicates that a product has been assessed by the manufacturer and deemed to meet the European Union (EU) safety, health and environmental protection requirements. It is required for products manufactured anywhere in the world that are then marketed in the EU.
CEO	Chief Executive Officer
CFD	Computational Fluid Dynamics
C&I	Control and Instrumentation
COD	Commercial Operations Date
Commencement Date	Means the date on which the Contractor is to commence the performance of the Works according to the respective Notice to Proceed and the Contract, provided by the Employer and delivered to the Contractor.
Contract	Means the terms and conditions, exhibits and written amendments, modifications, supplement and change orders for the agreement between the Contractor and the Employer for the Works.
Contracted Capacity	Total installed capacity according to the number of the PV modules to be installed by the contractor and their rated power at STC conditions, and nominal power of the PV inverters at power factor 1 and operational temperature of 50 degrees.
Contractor	Main EPC company to be engaged for the Works.
Contractor's Documents	Documents prepared by the Contractor as part of the Works including calculations, digital files, computer programs and other software, drawings, manuals, models, specifications, and other documents of a technical nature.
CPE	Collective Protections Equipment
CPU	Central Processing Unit
CV	Curriculum Vitae
DAF	Dynamic Amplification Factor

Item	Description
Date of Completion	Date on which the Contractor is expected to achieve Provisional Acceptance according to the Contract.
DC	Direct Current
Defects Liability Period	Means the period to be stated within the Contract starting on Provisional Acceptance, when the Contractor is liability to remedy any damage or defect on the Works.
Design Lifetime	Number of years or which the PV Plant shall be able to operate, equal to 25 years.
DMS	Document Management System
DNO	Distribution Network Operator
DNP	Defect Notification Period
DRCS	Design Review Comment Sheet
DS	Distribution System
EA	Environment Authorisation
ECC	Environmental Clearance Certificate
EIA	Environmental Impact Assessment
EL	Electroluminescence Test
Emergency Plan	Project plan document that must describe the system of procedures to organize and supervise the safe and orderly movement of people in case evacuation from a danger zone
EMPr	Environmental Management Programme
Employer	Eskom
EN	European Standards
Environmental and Social Management Plan	Project plan document that must describe the implementation and management of environmental and social impacts mitigation and enhancement measures during the executions of the Works
EPC	Engineering, Procurement and Construction
EPs	Equator Principles
ESS	Energy Storage System
ETA	Estimated Time of Arrival
Excavation Management Plan	Project plan document that must describe the procedures and of health and safety risks associated with all types of excavation work
EYA	Energy Yield Assessment
FAT	Factory Acceptance Test
FAC	Final Acceptance Certificate
FEM	Finite Element Materials (analysis)
FIC	Field Inspection Checklist
FO	fibre optic
FQC	Final Product Quality Control
FSOU	Free State Operating Unit
FTP	File Transfer Protocol
GHI	Global Horizontal Irradiation (W/m^2)
GII	Global Inclined Irradiation (W/m^2)
Good Industry Practice	means the exercise of degree of skill, diligence, prudence, efficiency, foresight, and timeliness which could be reasonably expected from a reputable and experienced EPC company.
GPS	Global Positioning System
Grid Code	means, as applicable, any code(s) in respect of electricity distribution or transmission system.
Grid Operator	Eskom
Guaranteed Availability	Minimum level of availability required during the contractual period defined according to the Contract.

Item	Description
Guaranteed PR	Minimum level of performance ratio required during the contractual period defined according to the Contract.
GUI	Graphical User Interface
HAZOP	Hazard and Operability study
HDPE	High Density Polyethylene
HMI	Human-Machine Interface
HSE	Health, Safety and the Environment
HV	High Voltage
HV Contractor	Main company to be engaged for the HV works according to the Project battery limits under section 3.2.
HVAC	Heating Ventilation and Air Conditioning
HVRT	High Voltage Ride Through
IACS	Integrated Access Control System
IBC	International Building Code
ICS	Integrated Control System
IDMT	Inverse definite minimum time relay
IDS	Intrusion Detection System
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IFC	International Finance Corporation
Inspection and Test Plans	Contractor plan that collects all the inspections and tests to be carried out in the entire project for quality assurance purposed.
International Standards	Technical standard developed by one or more international organizations outside of South Africa.
I/O	Input/Output
IP	Ingress Protection
IP	Internet Protocol
IPQC	In Process Quality Control
IPS	Intrusion Prevention System
IQC	Incoming material Quality Control
IR	Infrared
ISO	International Organization for Standardization
IT	Information Technology
ITP	Inspection Test Plan
IVPD	Induced Voltage Partial Discharge
KKS	The Plant Designation System KKS (Kraftwerk-Kennzeichen-System) is a system for identifying plants, systems, subsystems, equipment items, electrical and C&I cabinets, as well as buildings and rooms at a power plant.
KPI	Key Performance Indicator
LAN	Local Area Network
LCOE	Levelized cost of energy
LED	Light emitting diode
LEMP	Lightning Electromagnetic Pulse
LeTID	Light and elevated-Temperature Induced Degradation
LID	Light Induced Degradation
LV	Low Voltage
LVRT	Low Voltage Ride Through
M&E	Mechanical and Electrical systems
Main Equipment	means the PV modules, Inverters, Mounting Structures (including Trackers) and the MV stations (including transformers and switchgears).

Item	Description
Main Right Unit	Factory assembled; metal enclosed set of switchgear used at the load connection points of the central stations.
MAMSL	Meters above mean sea level
Maximum AC Capacity	The maximum AC capacity as per the Table 1 to be considered for the Plant.
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MDL	Master Document List
MET	Ministry and Environment and Tourism
MPPT	Maximum Power Point Tracking
MSDS	Material Safety Data Sheets
MV	Medium Voltage
National Law	Laws that exist “within” the country of South Africa.
National Standards	Technical standard developed by one or more South African organizations.
NEC	Neutral Earthing Compensator
NECRT	Neutral Earthing Compensators, Resistors, and auxiliary Transformer.
NER	Neutral Earthing Resistor
NFPA	National Fire Protection Association
NVR	Network Video Recorder
O&M	Operation and Maintenance
O&M Contractor	Contractor responsible for the O&M of the Plant
OEM	Original Equipment Manufacturer
OHL	Overhead Line
ONAF	Oil Natural Air Forced
ONAN	Oil Natural Air Natural
OQC	Outgoing Quality Control
ORHVS	Operating Rules for High Voltage Systems
OT	Operational Technology
PA	Public Address
PCC	Power Control Centre
PCU	Power Control Unit
PERC	Passivated emitter rear cell
PID	Potential Induced Degradation
Plant	The Solar PV Plant located at the Site, including all components thereof and related facilities.
PLC	Programmable Logic Controller
PoA	Plane of Array
POC	Point Of Connection
POE	Powered Over Ethernet
POT	Pull Out Test
PPC	Power Plant Controller
PPE	Personal Protective Equipment
PR	Performance Ratio
Project	The PV power Plant, facilities and associated grid connection infrastructures to the point of interconnection with the electricity transmission system, the access road and the site facilities.
Project Agreements	the terms and conditions between two parties to enter into a business partnership focusing on a particular aspect related to the Project, such as the Power Purchase Agreement, Distribution Agreements, Site Lease Agreements, Independent Engineer Agreement, etc.

Item	Description
Project Approvals	Means all consents, permits, clearances, authorisations, rulings, exemptions, registrations, filings, decisions, licenses, required to be issued by or made with any Authority in connection with the performance of the Works.
Project Documents	Existing documentation related to permitting, preliminary design and other relevant information for the Project, provided by the Employer to the Contractor.
Project Manager	Contractor professional in the specific field, having the responsibility of the planning, procurement and execution of a defined scope.
Provisional Acceptance	Employer´s conditional acceptance of the Works subject to further performance testing and remedy of defects by the Contractor during the DNP
Prudent Industry Standards	Practices, methods, acts and equipment approved by a significant portion of the renewable energy electric generation industry operating in South Africa in prudent electrical operations that, at a particular time, in the exercise of reasonable judgment in light of the facts known or that reasonably should have been known at the time a decision was made, would reasonably have been expected to accomplish the desired result in a manner consistent with the Applicable Laws, Permits, Codes and Standards, and equipment manufacturer’s recommendations, in each case, followed in the solar power industry and such regard to reliability, safety, environmental protection, efficiency, economy, and expedition.
PTW	Permit to work
PTZ	Pan-tilt-zoom
PV	Photovoltaic
PUC	Point of Utility Connection
PVSyst	Project Design-modelling tool to estimate PV plant production
PVC	Polyvinyl chloride
QA/QC	Quality assurance / Quality control
RAID	Redundant Arrays of Independent Disks
RETEC	Renewable Energy Technical Evaluation Committee
RfP	Request for Proposals
RGB	Red, Green, Blue
Risk Assessments	Identification and analysis of potential events that may negatively impact individuals, assets, and/or the environment.
RMS	Root Mean Square
RMU	Ring Main Unit
RTU	Remote Terminal Unit
SACPCMP	South African Council for the Project and Construction Management Professions
SANBI	South African National Biodiversity Institute
SANS	South African National Standard
SAT	Site Acceptance Tests
SCADA (system)	Supervisory control and data acquisition
SCADA (system) HMI	SCADA (system) Human Machine Interface
Scope of Works	List of activities and responsibilities to be performed by the Contractor under the Contract.
SD&L	Supplier Development and Localisation
SE	Substation
SET	Intermediate Substations
SFRA	Sweep Frequency Response Analysis
SI	International System of Units
Site Manager	Construction Contractor manager or site agent responsible for the day-to-day on site.
Site/Sites	The location where the Plant and respective interconnections to the substations will be constructed

Item	Description
SLD	Single Line Diagram
Standards	National Standards and International Standards
STC	Standard Test Conditions
SFTP	SSH File Transfer Protocol
STP	Shielded twisted pair
Subcontractor	means a contractor executing part of the Works on Site on behalf of the Contractor
TOP	Transfer of Package
Traffic Management Plan	Project plan document that must include all aspects related to traffic management procedures associated with the transport routes to Site and internal roads and traffic management
Testing and Commissioning Plan	Project plan document that must include all those aspects related to the commissioning and start-up activities required.
THD	Total Harmonic Distortion
TMY	Typical Meteorological Year
TS	Transmission System
UGL	Under-ground Line
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
UV	Ultraviolet radiation
VLF	Very Low Frequency
VoIP	Voice over Internet Protocol
VRLA	Valve-regulated lead acid
V_{oc}	Open circuit Voltage
VPN	Virtual Private Network
WAN	Wide Area Network
Warranty Period	Period during which the Contractor shall remain liable for repair or replacement of any defective part of the Works performed under the Contract.
Waste Management Plan	Project plan document that must include all those aspects related to the storage, production, transport and treatment of waste produced in the workplace.
WB	World Bank
WEEE	waste of electric and electronic equipment
Work Schedule	means the schedule od fates in chich the contractor is required to achieve certain state of completion of the Works.
Works	Means the obligations, duties and responsibilities required to be performed by the Contractor according to the Contractor Scope of Works
XLPE	Cross-linked polyethylene

ANNEXURE B. TECHNICAL STANDARDS AND REGULATIONS

All Standards referenced here shall be the latest edition with applicable addenda and code cases in effect on the date of the Contract, unless specially stated otherwise. Application of subsequent addenda and code cases published both before and after that date are subject to agreement between the Employer and the Contractor. National standards shall be preceded from equivalent international standards such as EN, IEC or ISO.

B.1 General

Act No. 45 of 1965	Atmospheric Pollution Prevention Act (No. 45 of 1965)
Act No. 107 of 1998	National Environmental Protection Act (No. 107 of 1998)
Act No. 36 of 1998	National Water Act (No. 36 of 1998)
Act No. 39 of 2004	National Environmental Management Air Quality Act (No. 39 of 2004)
ASTM B117-19	Standard Practice for Operating Salt Spray (Fog) Apparatus
EN 842	Safety of machinery - Visual danger signals - General requirements, design and testing
IEC 60068-2-68	Environmental testing - Part 2-68: Tests - Test L: Dust and sand
IEC 60068-2-78	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state
IEC 60617	Graphical symbols for diagrams
IEC 60721-1	Classification of environmental conditions Part 1: Environmental parameters and their severities.
IEC 61082	Preparation of documents used in electrotechnology
IEC 61882	Hazard and operability studies (HAZOP studies) - Application guide
IEC TS 62738	Ground-mounted photovoltaic power plants - Design guidelines and recommendations
IEEE 1547	Standard for Interconnecting Distributed Resources with Electric Power Systems
IEEE 2030.5	Smart Energy Profile 2.0 for DER integration
ISO 2859-2	Sampling procedures for inspection by attributes - Part 2: Sampling plans indexed by limiting quality (LQ) for isolated lot inspection
ISO 9000	Quality management systems - Fundamentals and vocabulary (ISO 9000:2015)
ISO 9001	Quality management systems - Requirements
ISO 14001	Environmental management systems - Requirements with guidance for use
ISO/IEC 31010	Risk Management – Risk assessment techniques
ISO 45001	Occupational health and safety management systems - Requirements with guidance for use
ISO 55000	Asset management - Overview, principles and terminology
NFPA 241	Standard for Safeguarding Construction, Alteration, and Demolition Operations
NRS 048	Electricity Supply - Quality of Supply
NRS 097-1	Code of Practice for the interconnection of embedded generation to electricity distribution networks: Part 1 MV and HV
NRS 097-2-1	Grid Interconnection of Embedded Generation: Part 2 Small-scale embedded generation – Section 1: Utility interface
NRS 097-2-3	Grid Interconnection of Embedded Generation: Part 2 – Section 3: Simplified utility connection criteria for low-voltage connected generators
OHS Act (Act 85 of 1993)	Occupational Health Safety Act (Act 85 of 1993)

SANS 2859-1	Sampling procedures for inspection by attributes - Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection
SANS 9227	Corrosion tests in artificial atmospheres - Salt spray tests
SANS 9712	Non-destructive testing - Qualification and certification of personnel
SANS 10400	Buildings Regulation South Africa Equipment (including oculars) for eye, face and neck protection against non-ionizing radiation arising during welding and similar operations - Welding helmets, hand shields, goggles, and welding spectacles.
SANS 10400-P	Buildings Regulation South Africa Part P: Drainage
SANS 12100	Safety of machinery – General principles for design – Risk assessment and risk reduction
SANS 17020	Conformity assessment — Requirements for the operation of various types of bodies performing inspection
SANS 17025	General requirements for the competence of testing and calibration laboratories
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 61936-1	Power installations exceeding 1 kV a.c. - Part 1: Common rules
SANS 62305	Protection against lightning – all parts
SANS 62305-2	Protection against lightning Part 2: Risk management.
SANS 62561	Lightning Protection System Components (LPSC) – all parts
SANS 62561-2	Lightning Protection System Components (LPSC) – Part 2: Requirements for conductors and earth electrodes.
SANS 62561-7	Lightning Protection System Components (LPSC) - Part 7: Requirements for earthing enhancing components.
SANS 61936-1	Power installations exceeding 1 kV a.c. - Part 1: Common rules
SANS 62305	Protection against lightning – all parts
SANS 62305-2	Protection against lightning Part 2: Risk management.

B.2 PV MODULES AND INVERTERS

ASTM E2481-12	Standard Test Method for Hot Spot Protection Testing of Photovoltaic Modules
ASTM D2765	Standard Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics
EN 50380	Datasheet and nameplate information for photovoltaic modules
EN 50524	Data sheet and name plate for photovoltaic inverters
EN 50530	Overall efficiency of grid connected photovoltaic inverters
IEC 60068-2-68	Environmental testing - Part 2-68: Tests - Test L: Dust and sand
IEC 60068-2-78	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state
IEC 60364-4-41	Low voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock
IEC 60364-4-42	Low-voltage electrical installations - Part 4-42: Protection for safety - Protection against thermal effects
IEC 60364-4-43	Low-voltage electrical installations - Part 4-43: Protection for safety - Protection against overcurrent
IEC 60364-4-44	Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances
IEC 60891	Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics
IEC 60904	Photovoltaic devices - all parts

IEC 60904-1	Photovoltaic devices - Part 1: Measurement of photovoltaic current-voltage characteristics
IEC 60904-13	Photovoltaic devices - Part 13: Electroluminescence of photovoltaic models
IEC 61215-1	Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements
IEC 61215-1-1	Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules
IEC 61215-2	Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 2: Test procedures
IEC 61683	Photovoltaic systems - Power conditioners – Procedure for measuring efficiency
IEC 61701	Photovoltaic (PV) modules - Salt mist corrosion testing
IEC 61727	Photovoltaic (PV) systems – Characteristics of the utility interface
IEC 61829	Crystalline silicon photovoltaic (PV) array – On-site measurement of I-V characteristics
IEC 61853-1	Photovoltaic (PV) module performance testing and energy rating - Part 1: Irradiance and temperature performance measurements and power rating
IEC 61853-2	Photovoltaic (PV) module performance testing and energy rating - Part 2: Spectral responsivity, incidence angle and module operating temperature measurements
IEC 62093	Photovoltaic system power conversion equipment – Design qualification and type approval.
IEC 62108	Concentrator photovoltaic (CPV) modules and assemblies – Design qualification and type approval
IEC 62116	Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures
IEC 62446-1	Photovoltaic (PV) systems - Requirements for testing, documentation, and maintenance - Part 1: Grid connected systems - Documentation, commissioning tests and inspection
IEC 62548	Photovoltaic (PV) arrays - Design requirements
IEC 62716	Photovoltaic (PV) modules - Ammonia corrosion testing
IEC 62759-1	Photovoltaic (PV) modules - Transportation testing - Part 1: Transportation and shipping of module package units
IEC 62790	Junction boxes for photovoltaic modules – Safety requirements and tests
IEC 62891	Maximum power point tracking efficiency of grid connected photovoltaic inverters
IEC TS 60904-1-2	Photovoltaic devices - Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices
IEC TS 62446-3	Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 3: Photovoltaic modules and plants - Outdoor infrared thermography
IEC TS 62782	Photovoltaic (PV) modules - Cyclic (dynamic) mechanical load testing
IEC TS 62804-1	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon
IEC TS 63126	Guidelines for qualifying PV modules, components, and materials for operation at high temperatures
ISO 9000	Quality management systems - Fundamentals and vocabulary (ISO 9000:2015)
ISO 14001	Environmental management systems - Requirements with guidance for use
ISO 45001	Occupational health and safety management systems - Requirements with guidance for use
SANS 60364-7-712	Low-voltage electrical installations - Part 7: Requirements for special installations or locations - Section 712: Solar photovoltaic (PV) power supply systems
SANS 60529	Degrees of protection provided by enclosures (IP Code)

SANS 61140	Protection against electric shock - Common aspects for installations and equipment
SANS 61204	Low-voltage power supplies, d.c. output – all parts
SANS 61215	Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval.
SANS 61646	Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval
SANS 61724-1	Photovoltaic system performance - Part 1: Monitoring
SANS 61730-1	Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction
SANS 61730-2	Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing
SANS 62109-1	Safety of power converters for use in photovoltaic power systems – Part 1: General requirements
SANS 62109-2	Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters
SANS 62852	Connectors for DC-application in photovoltaic systems - Safety requirements and tests
SANS 62930	Electric cables for photovoltaic systems with a voltage rating of 1,5 kV DC. Equivalent to EN 50618
UL 1741	Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources
UL 2703	Standard for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels.
UL 3703	Standard for Solar Trackers

B.3 MOUNTING STRUCTURE

BS EN 10346	Continuously hot-dip coated steel flat products for cold forming - Technical delivery conditions
DIN 65151	Dynamic testing of the locking characteristics of fasteners under transverse loading conditions (vibration test)
EN 1991-1-4	Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions
EN 1991-1-6	Eurocode 1: Actions on structures - Part 1-6: General actions - Actions during execution
EN 1993-1-1	Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buildings
EN 1993-1-3	Eurocode 3: Design of steel structures - Part 1-3: General rules - Supplementary rules for cold-formed members and sheeting
EN 1993-1-5	Eurocode 3 - Design of steel structures - Part 1-5: Plated structural elements
EN 1993-1-8	Eurocode 3: Design of steel structures - Part 1-8: Design of joints
EN 1993-1-9	Eurocode 3: Design of steel structures - Part 1-9: Fatigue
EN 1993-1-10	Eurocode 3: Design of steel structures - Part 1-10: Material toughness and through-thickness properties
EN 1993-5	Eurocode 3. Design of steel structures - Part 5: Piling
EN 1994-1-1	Eurocode 4: Design of composite steel and concrete structures – Part 1-1: General rules for rules for buildings
EN 1997-1	Eurocode 7: Geotechnical design - Part 1: General rules.
EN 1997-2	Eurocode 7: Geotechnical design - Part 2: Geotechnical design Ground investigation and testing
EN 1999-1-1	Eurocode 9: Design of aluminium structures – Part 1-1: General structural rules
EN 10025	Hot rolled products of structural steels - all parts

EN 13438	Paints and varnishes - Powder organic coatings for hot dip galvanised or sherardised steel products for construction purposes
EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
IEC 62817	Photovoltaic systems - Design qualification of solar trackers
IEC TS 62727	Photovoltaic systems – Specification for solar trackers
ISO 3549	Zinc dust pigments for paints — Specifications and test methods
ISO 16163	Continuously hot-dipped coated steel sheet products – Dimensional and shape tolerances.
SANS 920	Steel bars for concrete reinforcement
SANS 12944	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - all parts
SANS 121	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
SANS 8501-1	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.
SANS 10162-4	Structural use of steel - Part 4: The design of cold-formed stainless steel structural members
SANS 14713-1	Zinc coatings - Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 1: General principles of design and corrosion resistance
SANS 14713-2	Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 2 Hot Dip galvanising
UL 2703	Standard for Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat-Plate Photovoltaic Modules and Panels.
UL 3703	Standard for Solar Trackers

B.4 ELECTRICAL

ANSI/IEEE Standard C37.2	Standard Electrical Power System Device Function Numbers, Acronyms and Contact Designations
BS 10257-2	Zinc or zinc alloy coated non-alloy steel wire for armouring either power cables or telecommunication cables. Submarine cables
BS 7430	Code of Practice for Protective Earthing of Electrical Installations
BS 88	Low-Voltage Fuses
EN 13601	Copper and copper alloys - Copper rod, bar and wire for general electrical purposes
EN 50178	Electronic equipment for use in power installations
EN 50181	Plug-in type bushings above 1 kV up to 52 kV and from 250 A to 2,50 kA for equipment other than liquid filled transformers.
EN 50393	Test methods and requirements for accessories for use on distribution cables of rated voltage 0,6/1,0 (1,2) kV
EN 50395	Electrical test methods for low voltage energy cables
EN 50522	Earthing of power installations exceeding 1 kV a.c.
EN 50618	Electric cables for photovoltaic systems
EN 50655-1	Electric cables - Accessories - Material characterization - Part 1: Fingerprinting for resinous compounds
EN 50655-2	Electric cables - Accessories - Material characterization - Part 3: Fingerprinting for cold shrinkable components for low and medium voltage applications up to 20,8/36 (42) kV

EN 50655-3	Electric cables - Accessories - Material characterization - Part 2: Fingerprinting for heat shrinkable components for low and medium voltage applications up to 20,8/36 (42) kV
EN 187200	Harmonized system of quality assessment for electronic components - Sectional Specification: Optical cables to be used along electrical power lines (OCEPL).
ENA Engineering Recommendation EREC S34	A Guide for Assessing the Rise of Earth Potential at Electrical Installations
ENA Technical Specification 41-24	Guidelines for the Design, Installation, Testing and Maintenance of Main Earthing Systems in Substations
IEC 60085	Electrical insulation. Thermal evaluation and designation
IEC 60156	Insulating liquids – Determination of the breakdown voltage at power frequency – Test method
IEC 60183	Guide to Selection of High-Voltage Cables
IEC 60189	Low-frequency cables and wires with PVC insulation and PVC sheath - Part 1: General test and measuring methods
IEC 60216-2	Electrical insulating materials - Thermal endurance properties -- Part 2: Determination of thermal endurance properties of electrical insulating materials - Choice of test criteria
IEC 60228	Conductors of insulated cables
IEC 60230	Impulse Testing on Cables and its Accessories
IEC 60255-1	Measuring relays and protection equipment – Part 1: Common requirements
IEC 60255-27	Measuring relays and protection equipment – Part 27: Product safety requirements
IEC 60296	Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear
IEC 60364	Low voltage electrical installations - all parts
IEC 60364-4-41	Low voltage electrical installations - Part 4-41: Protection for saf4ty - Protection against electric shock
IEC 60364-4-42	Low-voltage electrical installations - Part 4-42: Protection for safety - Protection against thermal effects
IEC 60364-4-43	Low-voltage electrical installations - Part 4-43: Protection for safety - Protection against overcurrent
IEC 60364-4-44	Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances
IEC 60364-6	Low voltage electrical installations - Part 6: Verification
IEC 60423	Conduit systems for cable management - Outside diameters of conduits for electrical installations and threads for conduits and fittings
IEC 60502-2	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) – Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)
IEC 60507	Artificial pollution tests on HV insulators to be used AC systems
IEC 60567	Oil-filled electrical equipment and for the analysis of free and dissolved gases
IEC 60599	Mineral oil-filled electrical equipment in service - Guidance on the interpretation of dissolved and free gases analysis
IEC 60652	Overhead line structures – loading tests
IEC 60664	Insulation coordination for equipment within low-voltage supply systems – all parts.
IEC 60695-2-11	Fire hazard testing - Part 2-11: Glowing/hot-wire based test methods - Glow-wire flammability test method for end-products (GWEPT)
IEC 60695-2-12	Fire hazard testing -- Part 2-12: Glowing/hot-wire based test methods - Glow-wire flammability index (GWFI) test method for materials
IEC 60865	Short-circuit currents – Calculation of effects
IEC 60871	Shunt capacitors for AC power systems having a rated voltage above 1000 V
IEC 60885-3	Partial discharge tests

IEC 60898-1	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 1: Circuit-breakers for a.c. operation
IEC 60898-2	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations -- Part 2: Circuit-breakers for a.c. and d.c. operation
IEC 60898-3	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 3: Circuit-breakers for DC operation
IEC 60949	Calculation of thermally permissible short-circuit currents, taking into account non-adiabatic heating effects
IEC 61000-3-6	Electromagnetic compatibility (EMC) – Part 3-6: Limits – Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems
IEC 61000-3-7	Electromagnetic compatibility (EMC) – Part 3-7: Limits – Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems
IEC 61181	Mineral oil-filled electrical equipment. Application of dissolved gas analysis (DGA) to factory tests on electrical equipment
IEC 61238-1-1	Compression and mechanical connectors for power cables - Part 1-1: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages up to 1 kV (Um = 1,2 kV) tested on non-insulated conductors
IEC 61238-1-2	Compression and mechanical connectors for power cables - Part 1-2: Test methods and requirements for insulation piercing connectors for power cables for rated voltages up to 1 kV (Um = 1,2 kV) tested on insulated conductors
IEC 61238-1-3	Compression and mechanical connectors for power cables - Part 1-3: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages above 1 kV (Um = 1,2 kV) up to 36 kV (Um = 42 kV) tested on non-insulated conductors
IEC 61243-5	Live working – Voltage detectors – Part 5: Voltage detecting systems (VDS)
IEC 61309	Classification of insulating liquids
IEC 61443	Short-circuit temperature limits of electric cables with rated voltages above 30 kV (Um = 36 kV)
IEC 61810-2	Electromechanical elementary relays - Part 2: Reliability
IEC 62040-5-3	Uninterruptible power systems (UPS) - Part 5-3: DC output UPS - Performance and test requirements
IEC 62423	Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses
IEC TR 60616	Terminal and tapping markings for power transformers
IEC TR 62271-310	High-voltage switchgear and controlgear - Part 310: Electrical endurance testing for circuit-breakers above a rated voltage of 52 kV
IEEE 80	Guide for Safety in AC Substation Grounding
IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Ground System
IEEE 524	Installation of Overhead Transmission Line Conductors
IEEE 665	Standard for Generating Station Grounding
IEEE 980	Guide for containment and control of oil spills in substations
IEEE 1052	Guide for the Specification of Transmission Static Synchronous Compensator (STATCOM) Systems
IEEE 1301	Guide for the Functional Specification of Transmission Static Var Compensators
IEEE 1303	Guide for Static Var Compensator Field Tests
IEEE 1584	Guide for Performing Arc Flash Hazard Calculations
IEEE 2778	IEEE Guide for Solar Power Plant Grounding for Personnel Protection
IEEE C57	Standard Terminology for Power and Distribution Transformers
IEEE C57-104	Guide for the interpretation of gases Generated in Oil- Immersed Transformers
IEEE C57-106	Guide for acceptance and Maintenance of Insulating Mineral Oil in Electrical Equipment

IEEE C57-130	Guide for the Use of Dissolved Gas Analysis Applied to factory Temperature Rise Tests for the Evaluation of Mineral Oil-Immersed Transformers and Reactors
IEEE C57-152	Guide for Diagnostic Field Testing of Fluid-Filled Power Transformer, Regulators and Reactors
IEEE C62.11	Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV)
IEEE P81	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System
ISO 9772	Cellular plastics — Determination of horizontal burning characteristics of small specimens subjected to a small flame
ISO 9773	Plastics — Determination of burning behaviour of thin flexible vertical specimens in contact with a small-flame ignition source.
ITU-T G.651	Characteristics of a 50/125 micro metre multi-mode graded index optical fibre cable.
ITU-T G.652	Characteristics of a single mode optical fibre cable
ITU-T G.653	Characteristics of a dispersion-shifted single-mode optical fibre and cable
ITU-T G.654	Characteristics of a cut-off shifted single-mode optical fibre and defined as the amount of time that cable
ITU-T G.655	Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable
NESC Rule 011A2	National Electric Safety Code Section 11. Protective arrangements in electric supply stations
NEMA TR-1	Transformers, Step Voltage Regulators and Reactors (for audible noise level)
NFPA 70E	Standard for Electrical Safety in the Workplace
NRS 054	Rationalized User Specification – Power Transformers.
SANS 168	Plugs and socket outlets for household and similar purposes
SANS 555	Fluids for electrotechnical applications ‐ all parts
SANS 725	IEEE guide for safety in a.c. substation grounding
SANS 1019	Standard voltages, currents and insulation levels for electricity supply
SANS 1339	Electric cables – Cross-linked polyethylene (XLPE) insulated cables for rated voltages 3.8/6.6 kV to 19/33 kV.
SANS 1411	Materials of insulated electric cables and flexible cords – all parts
SANS 1507	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – all parts
SANS 1874	Switchgear - Metal-enclosed ring main units for rated a.c. voltages above 1 kV and up to and including 36 kV.
SANS 1973-1	Low-voltage switchgear and controlgear ASSEMBLIES Part 1: Type-tested ASSEMBLIES with stated deviations and a rated short-circuit withstand strength above 10 kA.
SANS 1973-3	Low-voltage switchgear and controlgear ASSEMBLIES Part 3: Safety of ASSEMBLIES with a rated prospective short-circuit current of up to and including 10 kA.
SANS 6282	Test methods for bare conductors and conductors of insulated electric cable – all parts
SANS 6283	Test methods for armouring of insulated electric cables
SANS 6284	Test methods for cross-linked polyethylene (XLPE) insulated electric cables – all parts
SANS 10142-1	Code of Practice for the Wiring of Premises – Part 1: Low Voltage Installations
SANS 10142-2	The wiring of premises Part 2: Medium-voltage installations above 1 kV a.c. not exceeding 22 kV a.c. and up to and including 3 MVA installed capacity
SANS 10198	The selection, handling, and installation of electric power cables of rating not exceeding 33 kV – all parts
SANS 10200	Neutral earthing in medium voltage industrial power systems.
SANS 10280-1	Overhead power lines for conditions prevailing in South Africa Part 1: Safety
SANS 10292	Earthing of low-voltage (LV) distribution systems

SANS 10340-1	Installation of telecommunications cables - Part 1: Fibre optic cables in buildings
SANS 10340-2	Installation of telecommunications cables - Part 2: Outdoor fibre optic cables
SANS 60034-1	Rotating electrical machines – Part 1: Rating and performance
SANS 60034-3	Rotating electrical machines – Part 3: Specific requirements for synchronous generators driven by steam turbines or combustion gas turbines
SANS 60071-1	Insulation co-ordination – Part 1: Definitions, principles and rules
SANS 60071-2	Insulation co-ordination – Part 2: Application guidelines
SANS 60076	Power transformers – All parts
SANS 60076-1	Power transformers – Part 1: General
SANS 60076-2	Power transformers – Part 2: Temperature rise for liquid-immersed transformers
SANS 60076-3	Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air
SANS 60076-4	Power transformers – Part 4: Guide to lightning impulse and switching impulse testing - Power transformers and reactors
SANS 60076-5	Power transformers – Part 5: Ability to withstand short circuit.
SANS 60076-6	Power Transformers – Part 6: Reactors
SANS 60076-10	Power transformers – Part 10: Determination of sound levels
SANS 60076-11	Power transformers – Part 11: Dry-type transformers
SANS 60076-18	Power transformers – Part 18: Measurement of frequency response
SANS 60076-20	Power transformers – Part 20: Energy efficiency
SANS 60099-4	Surge arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems
SANS 60099-5	Surge arresters - Part 5: Selection and application recommendations
SANS 60137	Insulated bushings for alternating voltages above 1000 V
SANS 60214	Tap Changers – all parts
SANS 60227	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – all parts
SANS 60255-118-1	Measuring relays and protection equipment - Part 118-1: Synchrophasor for power systems - Measurements
SANS 60255-121	Measuring relays and protection equipment - Part 121: Functional requirements for distance protection
SANS 60255-127	Measuring relays and protection equipment - Part 127: Functional requirements for over/under voltage protection
SANS 60255-181	Measuring relays and protection equipment - Part 181: Functional requirements for frequency protection
SANS 60269-1	Low-voltage fuses - Part 1: General requirements
SANS 60269-2	Low-voltage fuses - Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) - Examples of standardized systems of fuses A to K
SANS 60269-6	Low-voltage fuses - Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems
SANS 60270	High-voltage test techniques – Partial discharge measurements
SANS 60282-2	High-voltage fuses - Part 2: Expulsion fuses
SANS 60287-1-1	Electric cables - Calculation of the current rating - Part 1-1: Current rating equations (100% load factor) and calculation of losses – General
SANS 60287-2-1	Electric cables - Calculation of the current rating - Part 2-1: Thermal resistance - Calculation of thermal resistance
SANS 60287-3-2	Electric cables - Calculation of the current rating - Part 3-2: Sections on operating conditions - Economic optimization of power cable size
SANS 60309-1	Plugs, socket-outlets and couplers for industrial purposes - Part 1: General requirements
SANS 60331	Tests for electric cables under fire conditions – all parts

SANS 60332-1	Tests on electric and optical fibre cables under fire conditions Part 1: Test for vertical flame propagation for a single insulated wire or cable – all parts
SANS 60332-3	Tests on electric and optical fibre cables under fire conditions Part 3: Test for vertical flame spread of vertically mounted bunched wires or cables
SANS 60364-7-712	Low-voltage electrical installations - Part 7: Requirements for special installations or locations - Section 712: Solar photovoltaic (PV) power supply systems
SANS 60479	Effects of current on human beings and livestock ‐ all parts
SANS 60502-4	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 4: Test requirements on accessories for cables with rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)
SANS 60730-1	Automatic electrical controls Part 1: General requirements
SANS 60754-1	Test on gases evolved during combustion of materials from cables - Part 1: Determination of the halogen acid gas content
SANS 60754-2	Test on gases evolved during combustion of materials from cables - Part 2: Determination of acidity (by pH measurement) and conductivity
SANS 60793-1-1	Optical Fibres – Part 1-1: Measurement methods and test procedures – General and guidance
SANS 60793-2	Optical fibres – Part 2: Product specifications - General
SANS 60794-1-1	Optical fibres cables - Part 1-1: Generic specification – General
SANS 60794-1-2	Optical fibres cables - Part 1-2: Generic specification - Basic optical cable test procedures
SANS 60794-2	Optical Fibre Cables – Part 2: Indoor cables – Sectional specification
SANS 60811 all parts	Insulating and sheathing materials of electric and optical cables - Common test methods (all parts).
SANS 60811-504	Electric and optical fibre cables - Test methods for non-metallic materials - Part 504: Mechanical tests - Bending tests at low temperature for insulation and sheaths
SANS 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – all parts
SANS 60826	Overhead transmission lines – Design Criteria
SANS 60840	Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) - Test methods and requirements
SANS 60853-1	Calculation of the cyclic and emergency current rating of cables - Part 1: Cyclic rating factor for cables up to and including 18/30 (36) kV
SANS 60853-2	Calculation of the cyclic and emergency current rating of cables - Part 2: Cyclic rating of cables greater than 18/30 (36) kV and emergency ratings for cables of all voltages
SANS 60947	Low-voltage switchgear and controlgear – all parts
SANS 60947-1	Low-voltage switchgear and controlgear -- Part 1: General rules
SANS 60947-2	Low voltage switchgear and controlgear – Part 2: Circuit Breakers
SANS 60947-3	Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors, and fuse-combination units
SANS 60947-4-1	Low-voltage switchgear and controlgear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
SANS 60947-5-1	Low voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechnical control circuit devices
SANS 60947-5-3	Low-voltage switchgear and controlgear - Part 5-3: Control circuit devices and switching elements - Requirements for proximity devices with defined behaviour under fault conditions (PDDB)
SANS 60947-7-2	Low voltage switchgear and controlgear – Part 7-2: Ancillary Equipment
SANS 61000-2-5	Electromagnetic compatibility (EMC) Part 2-5: Environment - Description and classification of electromagnetic environments

SANS 61000-3-12	Electromagnetic compatibility (EMC) – Part 3-12: Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase
SANS 61000-4-5	Electromagnetic compatibility (EMC) Part 4-5: Testing and measurement techniques - Surge immunity test
SANS 61000-4-9	Electromagnetic compatibility (EMC) Part 4-9: Testing and measurement techniques - Pulse magnetic field immunity test
SANS 61000-6-1	Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial, and light-industrial environments
SANS 61089	Round wire concentric lay overhead electrical stranded conductors
SANS 61284	Overhead lines – Requirements and tests for spacers
SANS 61854	Overhead lines – Requirements and tests for fittings
SANS 61897	Overhead lines – Requirements and test for Aeolian vibration dampers
SANS 61000-6-2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
SANS 61000-6-3	Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for equipment in residential, commercial, and light-industrial environments
SANS 61000-6-4	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments
SANS 61008-1	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules
SANS 61010-1	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements
SANS 61034-1/2	Measurement of smoke density of cables burning under defined conditions – Part 1 & 2
SANS 61073-1	Fibre optic interconnecting devices and passive components - Mechanical splices and fusion splice protectors for optical fibres and cables – Part 1: Generic
SANS 61084-1	Cable trunking systems and cable ducting systems for electrical installations. Part 1: General requirements.
SANS 61140	Protection against electric shock – Common aspects for installations and equipment
SANS 61204	Low-voltage power supplies, d.c. output – all parts
SANS 61238-1	Compression and mechanical connectors for power cables for rated voltages up to 30 kV - Part 1: Test methods and requirements.
SANS 61300	Fibre optic interconnecting devices and passive components - Basic test and measurement procedures – all parts
SANS 61386-1	Conduit systems for cable management -- Part 1: General requirements.
SANS 61386-24	Conduit systems for cable management -- Part 24: Particular requirements - Conduit systems buried underground
SANS 61439	Low-voltage switchgear and controlgear assemblies – all parts
SANS 61442	Test methods for accessories for power cables with rated voltages from 6 kV (Um = 7,2 kV) up to 36 kV (Um = 42 kV)
SANS 61557	Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring, or monitoring of protective measures – all parts
SANS 61643-11	Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods
SANS 61643-12	Low-voltage surge protective devices - Part 12: Surge protective devices connected to low-voltage power systems - Selection and application principles
SANS 61869-1	Instrument transformers - Part 1: General requirements
SANS 61869-2	Instrument transformers - Part 2: Additional requirements for current transformers
SANS 61869-3	Instrument transformers - Part 3: Additional requirements for inductive voltage transformers
SANS 62040-1	Uninterruptible power systems (UPS) - Part 1: Safety requirements

SANS 62040-2	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements
SANS 62040-3	Uninterruptible power systems (UPS) - Part 3: Method of specifying the performance and test requirements
SANS 62040-4	Uninterruptible power systems (UPS) - Part 4: Environmental aspects - Requirements and reporting
SANS 62053-21	Electricity metering equipment - Particular requirements - Part 21: Static meters for AC active energy (classes 0.5, 1 and 2)
SANS 62067	Power cables with extruded insulation and their accessories for rated voltages above 150 kV (Um = 170 kV) up to 500 kV (Um = 550 kV) - Test methods and requirements
SANS 62103	Electronic equipment for use in power installations
SANS 62208	Empty enclosures for low-voltage switchgear and control gear assemblies - General requirements.
SANS 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
SANS 62271	High-voltage switchgear and controlgear – all parts
SANS 62271-102	High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches
SANS 62271-200	High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
SANS 62271-202	High-voltage switchgear and controlgear – Part 202: High-voltage/low-voltage prefabricated substation
SANS 62444	Cable glands for electrical installations
SANS 62477-1	Safety requirements for power electronic converter systems and equipment – Part 1: General
SANS 62619	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications
SANS 62930	Electric cables for photovoltaic systems with a voltage rating of 1,5 kV DC. Equivalent to EN 50618
UL 94	Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
UL 1973	UL Standard for Safety Batteries for Use in Stationary and Motive Auxiliary Power Applications
UNE 21123-1	Industrial cables of rated voltage 0,6/1 kV. Part 1: PVC insulated and sheathed cables.
UNE 21428-1	Three-phase oil-immersed distribution transformers 50 Hz, from 25 kVA to 3 150 kVA with highest voltage for equipment not exceeding 36 kV – Part 1: General requirements.

B.5 CIVIL

ASCE 07-10	Minimum Design Loads for Buildings and Other Structures
ASCE 10-97	Design of Latticed Steel Transmission Structures
BS EN 1011	Parts 1 and 2: Galvanised sheeting and welding
BS-EN 1708-1	Welding - Basic welded joint details in steel - Part 1: Pressurized components
DIN 50929-3	Corrosion of metals – Part 3: Buried and underwater pipelines and structural components standard shall be followed
EHE-28	Aggregates technical specifications for mortar and concrete
EHE-29	Other cement components. Additions and additives.
EHE-30	Concrete technical specifications.
EHE-84	Concrete strength control

EN 196-3	Methods of testing cement - Part 3: Determination of setting times and soundness
EN 197-1	Cement - Part 1: Composition, specifications, and conformity criteria for common cements
EN 1744-1	Tests for chemical properties of aggregates - Part 1: Chemical analysis
EN 10025	Hot rolled products of structural steels - all parts
EN 10080	Steel for the reinforcement of concrete - Weldable reinforcing steel - General
EN 12201-2	Plastics piping systems for water supply, and for drainage and sewerage under pressure - Polyethylene (PE) - Part 2: Pipes
EN 12350-1	Testing fresh concrete - Part 1: Sampling and common apparatus
EN 12350-2	Testing fresh concrete - Part 2: Slump test
EN 12390-1/2/3	Testing hardened concrete - All parts
EN ISO 14171	Welding consumables. Solid wire electrodes, tubular cored electrodes, and electrode/flux combinations for submerged arc welding of non-alloy and fine grain steels - Classification
IEEE 665	Standard for Generating Station Grounding
IEEE Std. 81	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System
ISO 10240	Internal and/or external protective coatings for steel tubes. specification for hot dip galvanized coatings applied in automatic plants.
ISO 15630-1	Steel for the reinforcement and prestressing of concrete - Test methods - Part 1: Reinforcing bars, rods, and wire
SANS 121	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
SANS 920	Steel bars for concrete reinforcement
SANS 1200	Standardised Specification for Civil Engineering
SANS 1215	Concrete Masonry Units
SANS 2001	Construction Works Specification
SANS 3834 Part 1 to 6	Quality requirements for fusion welding of metallic materials
SANS 6520 Part 1 & 2	Welding and allied processes - Classification of geometric imperfections in metallic materials
SANS 10100	The structural use of concrete – all parts
SANS 10109	Concrete floors – all parts
SANS 10160	Basis of structural design and actions for buildings and industrial structures – all parts
SANS 10160-3	Basis of structural design and actions for buildings and industrial structures Part 3: Wind actions
SANS 10160-4	Basis of structural design and actions for buildings and industrial structures Part 4: Seismic actions and general requirements for buildings
SANS 10160-5	Basis of structural design and actions for buildings and industrial structures – Part 5: Basis for geotechnical design and actions
SANS 10162-4	Structural use of steel Part 4: The design of cold-formed stainless steel structural members
SANS 10238	Welding and thermal cutting processes – Health and safety
SANS 10280-1	Overhead power lines for conditions prevailing in South Africa - Part 1: Safety
SANS 10313	Protection against lightning - Physical damage to structures and life hazard
SANS 10400	Buildings Regulation South Africa
SANS 10400-P	Buildings Regulation South Africa Part P: Drainage
SANS 12944	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - all parts
SANS 14713-1	Zinc coatings - Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 1: General principles of design and corrosion resistance

SANS 14713-2	Guidelines and recommendations for the protection against corrosion of iron and steel in structures - Part 2 Hot Dip galvanising
SANS 15609 Part 1 to 5	Specification and qualification of welding procedures for metallic materials - Welding procedure specification
SANS 15614 Part 1 to 13	Specification and qualification of welding procedures for metallic materials - Welding procedure test
SANS 17660 Part 1 & 2	Welding-welding of reinforcing steel
UNE 7050-1/2/3/4/5	Test sieves and test sieving - All parts
UNE 80243	Cement test methods. Chemical analysis. Determination of free calcium oxide. Ethylenglycol method.

B.6 SCADA AND SECURITY SYSTEMS

ASTM G217	Standard guide for evaluating Uncertainty in Calibration and Field Measurements of Broadband Irradiance with Pyranometers and Pyrheliometers
BS EN 54	Fire detection and fire alarm systems
BS 5839-1	Fire detection and fire alarm systems for buildings – Code of practice for design, installation, commissioning, and maintenance in non-domestic premises
DIN VDE 0126-1-1	Automatic disconnection device between a generator and the public low-voltage grid
EN 50131-1	Alarm systems - Intrusion and hold-up systems - Part 1: System requirements
EN 50131-6	Alarm systems - Intrusion and hold-up systems - Part 6: Power supplies
EN 50136-1	Alarm transmission systems and equipment Part 1: General requirements for alarm transmission systems
EN 50173-1	Information technology - Generic cabling systems - Part 1: General requirements
EN 50174-1	Information technology - Cabling installation - Part 1: Installation specification and quality assurance
EN 50174-2	Information technology - Cabling installation - Part 2: Installation planning and practices inside buildings
EN 50174-3	Information technology - Cabling installation - Part 3: Installation planning and practices outside buildings
EN 50518-1	Monitoring and alarm receiving centre - Part 1: Location and construction requirements
EN 50518-2	Monitoring and alarm receiving centre - Part 2: Technical requirements
IEC 60870-5-101	Telecontrol equipment and systems - Part 5-101: Transmission protocols - Companion standard for basic telecontrol tasks
IEC 60870-5-104	Telecontrol equipment and systems - Part 5-104: Transmission protocols - Network access for IEC 60870-5-101 using standard transport profiles
IEC 62351	Power systems management and associated information exchange - Data and communications security
IEC 62676-4	Video surveillance systems for use in security applications - Part 4: Application guidelines
IEC 62443-4-2	Security for industrial automation and control systems - Part 4-2: Technical security requirements for IACS components.
ISO/IEC 27019	Information technology - Security techniques - Information security controls for the energy utility industry
ISO/IEC 27001	Information technology - Security techniques - Information security management systems - Requirements
ISO/IEC 27002	Information technology - Security techniques - Code of practice for information security controls
ISO 9060	Specification and classification of instruments for measuring hemispherical solar and direct solar radiation

ISO 9846	Solar energy – Calibration of a pyranometer using a pyrheliometer
ISO 9847	Calibration of field pyranometers by comparison to a reference pyranometer
ISO 27032	Information technology - Security techniques – Guidelines for cybersecurity
SANS 10340-1	Installation of telecommunications cables - Part 1: Fibre optic cables in buildings
SANS 10340-2	Installation of telecommunications cables - Part 2: Outdoor fibre optic cables
SANS 60751	Industrial platinum resistance thermometers and platinum temperature sensors
SANS 61850-7	Communication networks and systems for power utility automation - all parts
SANS 61850-7:420	Communication networks and systems for power utility automation Part 7-420: Basic communication structure - Distributed energy resources logical nodes
SANS 62443	Industrial communication networks - IT security for networks and systems - All parts

B.7 Fire fighting Protection equipment & practice

EN 1363-1	Fire resistance tests - Part 1: General requirements
EN 1363-2	Fire resistance tests - Part 2: Alternative and additional procedures
NFPA 10	Standard for Portable Fire Extinguishers
NFPA 850	Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations
IEC 60695-2-11	Fire hazard testing - Part 2-11: Glowing/hot-wire based test methods - Glow-wire flammability test method for end-products (GWEPT)
IEC 60695-2-12	Fire hazard testing -- Part 2-12: Glowing/hot-wire based test methods - Glow-wire flammability index (GWFI) test method for materials
SANS 10105-1	The use and control of fire-fighting equipment Part 1: Portable and wheeled (mobile) fire extinguishers
SANS 10139	Code of practice for design, installation, commissioning and maintenance of fire detection and alarm systems in non-domestic premises
SANS 1475-1	The production of reconditioned fire-fighting equipment Part 1: Portable and wheeled (mobile) rechargeable fire extinguishers
SANS 1910	Portable refillable fire extinguishers
SANS 7240-16	Fire detection and alarm systems - Part 16: Sound system control and indicating equipment
SANS 7240-19	Fire detection and alarm systems - Part 19: Design, installation, commissioning and service of sound systems for emergency purposes
SANS 60695-11-20	Fire hazard testing – Part 11-20: Test flames – 500 W flame horizontal and vertical test methods

B.8 Eskom Standards

240-100183119	Standard for Fences in Eskom Transmission Substation
240-03022021	IT HIGH LEVEL DESIGN FOR Lethabo SOLAR PV SITE
240-100183119	Standard for Fences in Eskom Transmission Substation
240-101712128	Standard for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings
240-102547991	General Technical Specification for HVAC Systems Standard
240-105020315	Standard for Low Pressure Valves
240-105200800	Water Accounting and Management Framework Standard
240-105478209	High Voltage Single Phase Power Voltage Transformers Standard.

240-106192541	Chemistry Standard for Auxiliary Cooling Water Systems Standard
240-106365693	Standard for the External Corrosion Protection of Plant, Equipment and Associated Piping with Coatings
240-109589380	Direct Lightning Stroke Protection of Substations
240-113163905	LED Floodlights for Distribution Substation Applications
240-114967625	Operating Regulations for High Voltage Systems
240-120804300	Standard for the Labelling of Electrical Equipment within Eskom Wires Networks
240-123801640	Standard for Low Pressure Pipelines
240-123919938	Legionella Control and Management in Water Systems
240-125383428	Building Line Restrictions, Servitude Widths, Line Separations and Clearances from Power Lines
240-126210656	LED Street lighting for Eskom Properties
240-129686484	Power Plant C&I Level of Automation Guideline
240-134369472	Substation Earth Grid Design standard
240-139282493	Standard for Security Lighting for Eskom Applications
240-145581571	Standard for the Identification of the Contents of Pipelines and vessels
240-150642762	Generation Plant Safety Regulations
240-150139783	Cloud Standard
240-170000918	Standard for the Design for Maintenance Vehicle Access in and Around Substations
240-52599753	Workspace standard
240-54937439	Fire Assessment Standard
240-55410927	Cyber Security Standard for Operational Technology
240-55714363	Generation PS Lighting and Small Power Installation Standard
240-56062765	Inductive Voltage Transformers Eskom Specific Requirements up to 132 kV.
240-56062864	Current Transformers Eskom Specific Requirements for Voltages up to 132kV in Accordance with NRS 029 Standard
240-56063756	Outdoor circuit breakers for systems with nominal voltages from 6.6 kV up to and including 765 kV
240-56063815	High Voltage Outdoor Disconnectors and Earthing Switches Standard
240-56227443	Requirements for Control and Power Cables for Power Stations Standard
240-56227516	LV Switchgear and Control Gear Assemblies and Associated Equipment for Voltage up to and including 1000V AC and 1500V DC Standard
240-56227573	Air-Insulated Withdrawable AC Metal-Enclosed Switchgear and Control Gear for Rated Voltages above 1kV up to and including 52kV
240-56227589	List of Approved Electronic Devices to be used on Eskom Power Stations Standard
240-56355466	Alarm Management System Guideline Rev 2
240-56355541	C&I Computer & Equipment Rooms Civil and General Building Requirements Guideline
240-56355728	Human Machine Interface Design Requirements Standard
240-56355754	Field Equipment Installation Standard
240-56355731	Environmental Conditions for Process Control Equipment Used at Power Stations Standards
240-56355789	Flow Measurement Systems Installation Standard
240-56355808	Ergonomic Design of Power Station Control Suites Guideline
240-56355815	Field Instrument Installation Standard: Junction Boxes and Cable Termination
240-56355843	Pressure Management Systems Installation Standard
240-56355855	Temperature Management Systems Installation Standard
240-56356396	Earthing and Lightning Protection Standard

240-56359083	Metering and Measurement Systems for Power Stations in Generation
240-56364444	Standard for the metering of electrical energy and demand
240-56364535	Architectural technical specification for structures and other buildings
240-56364542	Standard for reinforced concrete foundations and structures
240-56364545	Structural design and engineering standard
240-56737448	Fire Detection and Life Safety Design Standard
240-57648848	Specification for Combined Three-Phase Neutral Electro-Magnetic Couplers with Neutral Earthing Resistors and Auxiliary Transformers (NECRT's)
240-60777474	Susp and Strain assemblies HV Lines
240-61268576	Standard for the Interconnection of Embedded Generation
240-62581162	Generation energy management and data acquisition System (EMDAS) Standard
240-62629353	Specification for Plant labelling standard
240-64720986	Emergency Preparedness Public Address System Standard
240-68973110	Specification for Power Transformers rated for 1.25 MVA and above and highest voltage of 2.2 kV or above
240-70164623	Eskom Design Guideline for HVAC in the Eskom Coal Fired Power Stations
240-75540566	Specification for Station Class Metal Oxide Surge Arresters
240-75658628	Standard for AC/DC Distribution Units
240-75880946	Earthing Standard
240-75883378	Specification for Steel Pole Overhead Line Supports
240-75883830	Steel Grades and Welding Requirements for Steelwork and Overhead Line Hardware Components
240-76368574	High Security Mesh Fencing
240-78980848	Specification for non-lethal energized perimeter detection system (NLEPS) for protection of Eskom installations and its subsidiaries.
240-79669677	Demilitarised Zone (DMZ) Designs for Operational Technology
240-82332407	Generation Fixed Pattern Gas Insulated Metal-Enclosed Indoor Primary Switchgear and Controlgear Specification for Rated Voltages above 1kV up to and including 52kV
240-82332463	Data and Information Security in Power Plant Operations Standard
240-84418186	Eskom Road Specification Manual
240-85549846	Standard for design of drainage and sewerage infrastructure
240-86738968	Specification for integrated security alarms system for protection of Eskom installations and its substations
240-89147446	Instrument Piping for Coal Fired Power Plants Standards
240-90353855	Design Standard for TeleProtection Systems
240-91190304	Specification for CCTV Surveillance with Intruder Detection
240-98155879	Vibration Dampers for Single Conductor Sub-Transmission Line
240-106628253	Standard for Welding Requirements on Eskom Plant
240-102220945	Specification for integrated access control system (IACS) for Eskom sites
240-170000098	Security Public Address Systems for Substations and Telecoms High Sites
32-373	Information Security – IT/OT and Third Party Remote Access Standard
32-438	Information Security Systems Classification Standard
375-172742	Lethabo Solar PV Facility Employer's Requirements
375-172743	Lethabo Solar PV Plant Quality Specification
375-172744	OHS requirements for Lethabo 75MW Solar PV project

ANNEXURE C. LETHABO PV SWITCHING STATION AND OVERHEAD LINE TO RWB LETHABO POWER STATION

ANNEXURE D. LETHABO SOLAR ENERGY FACILITY NETWORK DIAGRAM