UNOPS

TECHNICAL SPECIFICATIONS

For THE CONSTRUCTION OF EMERGENCY SHELTER, CLINIC & LATRINES AT LAC ASSAL IN DJIBOUTI

"ELECTRICAL WORKS"

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Section 1: General Specifications for Electrical Services

1.1 Introduction

A Stand-alone Battery based Solar Roof top mounted Photovoltaic (SPV) Power System consists of SPV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPPT), and Controls & Protections, interconnect cables, Junction boxes, Distribution boxes and switches. PV Array is mounted on a suitable structure. Components and parts used in the SPV power plants including the PV modules, metallic structures, cables, junction box, switches, PCUs etc., should conform to the BIS or IEC or international specifications listed below, wherever such specifications are available and applicable. Solar PV system shall consist of following equipment/components. Solar PV modules consisting of required number of Crystalline PV cells, Mounting structures Junction Boxes, Earthing and lightening protections, IR/UV protected PVC Cables, pipes and accessories.

This section of the Specification deals with the general standards of materials and workmanship and approved methods in connection with the design, manufacture and installation of the electrical services. This section must be read in conjunction with other sections of the Specifications and Drawings and schedules issued herewith. In the instance of reference to more than one standard the stringent of all shall govern.
The Battery based SPV system shall support essential electric equipment and its indicative electrical power requirements and categorizes the following:

(i) Room and service lightings/LED lamps with switches; 24Vdc supply,
(ii) Medical equipment @ Pharmacy (Refrigerator); 24Vdc supply,
(iii) USB Phone charger.

The recommended power system configuration (system voltage) is 24Vdc electricity supply through charge controller.

Except for materials or items or equipment which are specified as being supplied and/or fixed for the works by others, these works shall include the supply, testing and delivery to site, loading, unloading, storage in safe custody, erection, connection, finishing, carrying out preliminary tests at site, commissioning, performance testing and operation for at least one month and putting into service of the whole of the materials, fittings and all cables and conduits necessary for the electrical installation works as specified and scheduled herein and/or indicated on the drawings issued herewith.

Materials and products shall comply with the following:

(i) This Specification

(ii) Balance of Solar PV Systems (BOS): IEC 61215 Crystalline Silicon Terrestrial PV modules poly/mono. IEC 61730 Solar PV module safety qualification requirements. IEC 61701 PV modules to be used in a highly corrosive atmosphere (Coastal area etc,) must qualify Salt Mist corrosion Testing.

(iii) Appropriate British Standard (BS) Specifications and Codes of Practice (CP). Particular mention is made to BS7671: 1992 "Requirements for Electrical Installations" (IEE Wiring Regulations Sixteenth Edition) including all current amendments and the Standards of the International Electro technical Commission (IEC) Publication 364 "Electrical Installations in buildings". EN 12464, IEC 906-1 Socket outlets, IEC 669-1 Switches.

(iv) Appropriate Australian/New Zealand Standards (AS/NZS)

AS/NZS 3000	Wiring Rules
AS/NZS 5033	Installation and Safety requirements for photovoltaic (PV) arrays
AS/NZS 4509.2	Stand-alone Power Systems-Design
AS/NZS 1170.2	Structural design actions-Wind actions
AS/NZS 1768	Lightning Protection
AS/NZS 3008	Electrical Installations-Selection of cables

(v) Government Rules

(vi) Local Authority's Bye-laws and Regulations
(vii) Electricity Supply Authority's requirements
(viii) Fire Prevention Officer's requirements
(ix) Health and Safety at Work regulations

Accredited installers shall comply with the above listed standards where applicable.

The Contractor shall notify the Engineer of any revisions or additions to the foregoing as they are published during the installation of the Works for the Engineer's decision and instructions.

The Contractor shall pay all charges necessary for any Authority's approval of any part of the works.

(a) Prequalification requirement

- The bidder shall fulfill relevant trade license for the assignment to the national by-law and decrees,
- The bidders should submit, with their offer, manufacture authorization, recent test certificates of each items from authorized institution (accredited laboratory),
- The bidders have to provide at least 3 years past experience in similar assignment,
- Subcontracts shall be properly and lawfully signed, and
- Each pages of the relevant offer document shall properly sign and stamped.

(b) Suitability of Materials

Materials and products shall be supplied to suit the temperature and other conditions of use normally expected to apply after the installation is completed, and also to withstand any test specified herein or in any document referred to herein.

(c) Definitions

For This document uses the same terminology as outlined in AS/NZS 5033. Two important definitions are:

a) Where the word "shall" is used, this indicates that a statement is mandatory

b) Where the word "should" is used, this indicates that a statement is a recommendation

The purpose of this Specification:

(i) The definitions given in BS 7671:1992 Requirements for Electrical Installations (IEE Wiring Regulations 16th Edit ion) referred to hereinafter interchangeably as the IEE Wiring Regulations or BS 7671 shall apply.

(ii) The words "weatherproof" and "dust protected" shall have the meanings ascribed to them in BS 2817, definitions 13 and 178 respectively.

(iii) As applied to steel conduits and fittings, the words "protection against corrosion according to class 2" (or to class 4) shall have the following meaning:

Class 2 - Medium protection both inside and outside (e.g. stoving enamel, air drying paint).

Class 4 - Heavy protection both inside and outside (e.g. hot dip zinc coating, sherardizing).

(iv) As applied in cable trunking (steel surface) the words "protection against corrosion according to class 3" shall have the meaning:

Class 3 - Heavy protection both inside and outside (e.g. galvanized steel complying with BS 2989, Class 2A or 2B).

(d) Standardization

For the purpose of this Specification:

The following equipment shall be standardized throughout the installation:

(i) SPV modules

(ii) Solar PV module mounting structure

(iii) Array Junction Box

(iv) Batteries

(v) LV distribution and sub-distribution cabling.

(vi) Distribution boards.

(vii) Wall mounted switch fuses and isolators.

(viii) Socket outlets, spur units, lighting switches etc.

Every item of equipment shall in each of the above groups be of the same make and type unless otherwise specified.

(e) Methods of Fixing

General

The size of bolt or screw used must be the nearest permitted by the diameter of the hole in the equipment to be used.

All bolt or screw holes provided in equipment shall be used and in each, fixing must be secure.

All screws and bolts shall be sherardized.

For fixing in block, brick or concrete, holes of the correct size for screws or bolts shall be neatly drilled with tungsten carbide tipped twist drill to a depth (excluding plaster thickness) equal to the length of plug to be used. The plug length must be correct for the screw. Fixings shall not be made between joints in blockwork or brickwork.

All fixings required to pre-cast concrete wall planks shall be drilled and plugged. Under no circumstances shall "shot fired fixings" be used.

Conduit boxes shall be fixed by two roundhead screws.

Countersunk screws shall only be used where countersunk holes are provided, otherwise the wood screws shall be roundhead and setscrews shall be cheese head. Where holes have to be drilled for fixing, No.10 wood screws shall be the minimum size used. Fixing screws used in conjunction with Class 3 and 4 conduit and trunking shall be stainless steel.

(f) Lightweight Accessories

Fixing to hollow partitions etc. where the hole is bottomless shall be by means of rawl plug screw anchors.

Fixing to supporting metalwork shall be made where possible, by means of setscrews or bolts and nuts of appropriate size for the equipment, holes being drilled to correct size.

Each bolt and setscrew shall be fitted with a plain washer and shake proof washer under the nut. Where it is not possible to fit a nut, a tapped hole shall be provided.

Fixings to structural steelwork shall be to the approval of the Engineer.

(g) Workmanship

All extra low voltage wiring should be performed by a 'competent' person, which is defined by the Australian Standard AS/NZS 4509.1 stand-alone power systems as: "a person who has acquired through training, qualifications, experience or a combination of these, knowledge and skill enabling that person to correctly perform the task required.

All work shall be performed by a licensed electrician.

(h) Training

Providing training to at least two engineers and/or site staff for Operation, Maintenance and Trouble shooting skills.

1.2 Certificates, Applicable Standards and Packing

Products shall be certified or compliant with the offered Specification. Test Certificates shall be submitted from acceptable organization. Organizations accredited to ISO 17025 or equivalent standards shall be acceptable for issuing the component certifications. A maximum measurement of 3% is permitted on all test of compliance.

The supplier provides the most appropriate system integration, components, assembly and packaging that meet the entire system component specifications and the best practices recommendations.

The solar PV system is packed and pre-wired to provide convenient installations at site by a qualified technician. The system is constructed such that users can perform routine maintenance such as replace and repair, also technician can easily perform system diagnostics.

Supply materials must have a type-test certificate from an accredited testing and certification organization and meets or exceeds the technical specifications. Organizations accredited according to ISO 25 or equivalent is acceptable for issuing the component certifications. Accredited testing institute has to put its currently valid approval mark or seal for complying of the standards and shall consist of their relevant information on traceability of solar cells and module as per ISO 9000 standard.

PV Module

The applicable international standard for PV modules is IEC 61215 crystalline silicon terrestrial modules-design qualification and type approval.

Batteries

The applicable international standard for battery is IEC 61427 IEC 2001 Ed.2, secondary cells and batteries for solar photovoltaic Energy systems (PVES)-General requirements and method of test.

Charge Controller

The applicable international standard for Charge Controller and interconnection system equipment for use with distributed energy resources is IEC 62509.

Stand-alone Photovoltaic (PV) systems

The applicable international standard for characteristic parameter of stand-alone photovoltaic (PV) system is IEC61194 (ed.1) Reference by IEC 61215.

Roofing materials

The applicable international standard for roofing material is UL 790 (fire test) of safety.

Panel Board

The applicable international standard for Panel Board or combiner box is UL 1741 Safety.

Fuses

The applicable international standard for Fuses is UL 248 of safety.

1.3 Technical Details of the equipment to supply

Bidders shall strictly follow to comply with the bid technical requirement details of the equipment to be offered.

1.3.1 Balance of System Components

Bidders shall include all required balance system components in their offer, PV module, Battery, Charge Controller, Fittings, Wiring and Cables, Connections, lightning Arrestor and Earthing, etc, that are required to complete the electrical power use from solar system installation. A complete supply shall be included in the offer.

1.3.2 Solar PV Modules Array

The PV module shall be capable of fully charging batteries for one full day of autonomy, to power daily loads indicated in the design. The net output of supplying power shall achieve after all losses incurred in cabling, panels, controllers and the battery bank. Based on a net daily energy to the system the minimum array size of watt peak can be determined. Bidders have to verify this value and present their offer.

The photovoltaic modules shall be warranted to provide their rated output at standard conditions with ±15% for a minimum of 15 years under tropical conditions. Photovoltaic modules of the model offered have to be tested at the ESTI (European Solar Test Installation) or an equivalently qualified institution (such as TUV Rhineland and ASU-PTL) certified according to the international standard IEC-61215.

Cells shall be made of crystalline silicon. Modules have to be famed with marine grade Aluminum with appropriate seals to prevent water and corrosion damage to the active components. The backing of the panel may be glass or other material impermeable to water that is accepted under the applicable international standards.

The modules shall have a separate connection box on its back-side that meets protection class IP65. The terminals must be clearly marked with "+" and +-+ for the corresponding connections. Connections shall be of a screw type with a capacity sufficient to accommodate the recommended size of stranded copper interconnection wire. Connections shall be of the direct wire type; wiring using crimped or soldered connection shall not be used. Connection screws shall include lock washers or other means to prevent loosening due to thermal cycling of the panels.

For the panel model proposed, the bidder shall have to include as a part of the tender response the following information:

- Voc, Isc, Impp, Vmpp, and Wp at standard conditions,
- The relationship between temperature and module output,
- The I-V (current-voltage) curves for 1000 W/m2 solar inputs,
- Physical size and weight,

- Details of the materials used in construction, including the frame, the connection boxes., the backing material and the encapsulation material,
- Number of cells per panel,
- A statement of warranties in effect for the proposed module type shall be provided,

Type: Crystalline silicon – Poly or Mono

Module Efficiency: >=75%

Warranty (Product and Performance): 5 years warranty.

Module frame: Anodized aluminum. Non-corrosive and electrolytically compatible mounting structure.

Mounting structure: Metallic mounting structure. Hot dip Galvanized with 70 microns thickness.

Module minimum rated power: The nominal power of a single PV module shall be >=175Wp.

RF Identification tag for each solar module: must be able to withstand environmental conditions and last the life of solar module and shall be kept inside the module laminate.

RF Identification tag data shall consist of:

a. Name of the manufacturer of PV module
b. Name of the manufacturer of Solar cells
c. Month and year of the manufacture (separately for solar cells and module)
d. Country of origin (separately for solar cells and module)
e. I-V curve for the module
f. Wp, Im, Vm and FF for the module
g. Voc, Isc,
h. Unique serial No and Model No of the module
i. Date and year of obtaining IEC PV module qualification certificate
j. Name of the test lab issuing IEC certificate
k. Other relevant information on traceability of solar cells and module as per ISO 9000 standard.

Power output rating: to be given for standard test conditions (STC). I-V curve of the sample module should be submitted.

The contractor is expected to remove trees if any that could cause shade over the PV panel at any time of the year.

The Panels shall be mounted East-West with a tilt towards the equator (South) equal to the latitude (approximately) twelve degrees (12^0) facing towards the south.

1.3.3 Batteries:

The batteries to be supplied shall be sealed solar battery, maintenance free and deep cycle.

The battery banks shall be able to effectively provide at least for one full day autonomy of the daily load requirement when fully charged. The basic requirements for the battery five years or longer rated service life when the average depth of discharge (DoD) is 20%. Minimum battery terminal voltage is 2 Volts dc. The battery will also be IEC-896-1 compliant. Self-discharge shall not exceed 3% per month.

At an average daily duty cycle of 20% depth of discharge at C10 rate, the battery shall achieve a minimum of 5,000 cycles of operation. Maximum allowable DoD in service shall be 80%. The battery delivered in a dry charged condition. Its shelf life at $30^{o}C$ much be 2 years or more if store in its original packing.

The battery case must be mechanically strong enough to allow being transported and carried by hand over flat land. As a part of the documentation, the conditions required for transport of the cells shall be provided and will include information as to any requirement for maintaining of a specific cell orientation during transport.

Inter-connection cables with the proper connection lugs shall be provided with the batteries. It shall be of the correct type and size.

The following information shall be included with the offer for the battery proposed:

- Columbic and energy efficiency,
- Ampere Hour (AH) capacity at C10 and C100 discharge rate conditions,
- Specific gravity vs cell voltage curves,
- Curves or table for cycle life vs average DoD,
- Physical characteristics including weight dry and wet, height, width, length, connection post dimensions, case material and cell cap type,
- Complete English language manuals for handling, initial charging, installation, operation and inspection,
- Warranty terms and procedures for making warranty claims.

Battery mounting shall be in accordance with applicable internationally recognized practices and adequate electrical safety. Battery mounting shall be in accordance with acceptable international standards.

1.3.4 Charge Controllers

Battery charging will be managed by Maximum Power Point Tracking (MPPT) Charge Controllers. The controller's characteristics and the array configuration shall be matched as to provide the maximum energy delivery to the battery. Due to the harsh environmental conditions at the site and the need for high system reliability, it is required that the rated controller capacity exceed the maximum required capacity in the design by at least 20%. Switching of charge currents have to be controlled from the main switchboard located in the battery house.

Signal indicator shall be included in the controller to show energy flow from the array to the battery charge and discharge level. The device shall have variable speed cooling fans that vary output according to the need for component cooling. Charge controllers shall be supplied with charge and discharge voltage set, which match the battery requirements to ensure adequate protection and cycling. The battery should be protected from deep discharge.

The charge controller shall be able to protect battery over charge, battery undercharge and excessive deep discharge, against reverse polarity of module or battery and reverse polarity of dc load. The controller shall have an indication to users the following:

- The battery is in the charging mode.
- A battery state of charge indicator included on or near the controller of load.
- When the battery condition is:
- Suitable to operate loads
- Energy conservation required
- The controller appropriately labeled such that the user does not have to refer to a manual to understand the existing condition.

Full technical specification for the controller shall be provided in English with offer for each controller model proposed. Complete English language manuals for handling, initial charging, installation, operation and inspection. A statement of warranties in effect must be provided for each controller model proposed.

1.3.5 Solar PV Module Mounting Structure

All array supports, brackets, screws and other metal parts shall be of suitable low-corrosion materials suitable for the lifetime and duty of the system, that do not increase their rates of corrosion when mounted together in an array, and when mounted on the surface of the underlying structure.

This may include techniques to minimize corrosion rates appropriate to the local environment, including but not restricted to methods such as: non-reactive separators between metal surfaces and under screw and bolt heads; and selection of materials with appropriate type and thickness of anti-corrosive coating.

Refer to the manufacturer's guidelines to ensure that the materials introduced are compatible with the roofing.

Any roof penetrations shall be suitably sealed and waterproofed for the expected life of the system.

It is important to allow sufficient clearance to facilitate self-cleaning of the roof to prevent the build-up of leaves and other debris (Refer to roofing manufacturers guidelines.)

If fauna (such as birds, vermin, etc) are a problem in the vicinity of the installation then consideration should be given to how to prevent them gaining access under the array.

Where monocrystalline or polycrystalline modules are used, at least 100mm clearance shall be allowed below the array for cooling by natural ventilation. Insufficient ventilation will result in high operating temperatures for the modules.

The installer shall follow the array frame supplier/manufacturer's recommendations when mounting the array to the roof support structure, to ensure that the array structure still meets AS1170.2 certification.

The PV modules shall be mounted on fixed metallic structures of adequate strength and appropriate design, which can withstand the load of the modules and high wind velocities up to 150 km per hour.

a. The module mounting structure will be designed in such a way that it will occupy minimum space without forfeiting the output from SPV panels & shall be designed to allow easy replacement of any module.

b. The System integrator must ensure proper water proofing in case of any modifications to the roof.

c. Where the PV array cable and conduit passes through steel roof an appropriate collar flashing or dectite shall be installed.

d. Detailed specifications for the mounting structure are given below:

Wind velocity withstanding capacity	150 km / hour
Structure material	Structural materials shall be corrosion resistant and electrolytically compatible with the materials used in the module frame, its fasteners, nuts and bolts. Hot dip galvanized steel with galvanization thickness of min 70 micron or aluminum alloy.
Bolts, nuts, fasteners, panel mounting clamps	Stainless steel SS304
Mounting arrangement for Gable Roofs	Single Shed Roof type
Installation	The structures shall be designed for simple mechanical on-site installation.
Minimum distance between roof edge and mounting structure (Horizontal clearance)	Greater than or equal to 60cm.
Minimum clearance between lowest part of panel and mounting structure (Vertical Clearance)	Shall not be less than 10cm.
Access for panel cleaning and maintenance	All solar panels must be accessible from the top for cleaning and from the bottom for access to the junction box
Panel tilt angle	North-south orientation with a fixed tilt 12 degrees angle (south facing)
Warranty	The structure must have a free replacement warranty for 10 years.

The prospective installer shall specify installation details of the solar PV modules and the support structures with lay-out drawings and array connection diagrams. The work shall be carried out as per the designs approved by concerned authority.

The successful bidder shall provide full design, drawings and technical specifications of the proposed physical design and get prior approval before starting the installation. The details of frame structure construction and physical size, assembly of the rack, solar panel array attachment onto the supporting structure and connection detail on roof structure shall be provided.

1.3.6 Power Control Box Unit

Floor mounted Control Box shall consist of Charge Controller, Bus Bar to and from the battery bank, SPD, relay, LED display, power line from PV array to charge control, dc circuit breaker, power line from charge control to battery bank via dc circuit breaker, power line from charge control to load, dc fuses as per ratings and all the necessary accessories. The Control box is free of dust, vermin, and waterproof and made of cast Aluminum alloy or Powder coated Aluminum. The box shall have lockable door and with door handle. The terminals will be connected to copper bus-bar arrangement of proper sizes. The Control box shall have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Protection shall be IP 65 enclosure and IEC 62208 Hinged door with EPDM rubber gasket to prevent water entry with transparent covers with Surge Protection Device (SPD) class – I/II, DC fuse with holder and string disconnector. It should be placed at 5 feet height or above for ease of accessibility. All fuses shall have DIN rail mountable fuse holders and shall be housed in thermoplastic IP65 enclosure with transparent covers. Suitable markings shall be provided on the bus bar for easy identification and the cable ferrules must be fitted at the cable termination points for identification.

The box shall have two pieces of solid earthing points on either side with an arrangement for sufficient ventilation.

LCD display with light shall be provided with functional bush button to display the following characteristics:

- Total Load [kW]
- Load current A
- Battery capacity [Ahr]
- Battery voltage [V]
- Battery charging current [A]
- Battery temperature
- Input/Output Voltage
- PV Panel Voltage
- Battery Charging coefficient (adjustable)

1.3.7 Array Junction Box

The array junction box is free of dust, vermin, and waterproof and made of Fiber Reinforced Thermo Plastic or cast Aluminum alloy or Powder coated Aluminum. The box shall be out door type. The terminals shall be connected to copper bus-bar arrangement of proper sizes. The array junction boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. Protection shall be IP 65 enclosure and IEC 62208 Hinged door with EPDM rubber gasket to prevent water entry with transparent covers. It should be placed at a place for ease of accessibility. Suitable markings shall be provided on the bus bar for easy identification and the cable ferrules must be fitted at the cable termination points for identification.

1.3.8 DC Distribution Board

- DC Distribution panel to receive the DC output from the array field.
- Shall be surface mounted steel sheet.
- DC DPBs shall have sheet from enclosure of dust and vermin proof conform to IP 65 protection. The bus bars are made of copper of desired size. Suitable capacity MCBs/MCCB shall be provided for controlling the DC power output to the loads along with necessary surge arrestors.

1.3.9 Fuse and Breaker for Protection

Fuse and Circuit breakers shall include to safe users and protect system components from the following:

- Protection against short circuit on installed electric lines and on users load,
- Protection against internal shorts in charge controller or other devices,
- Circuit protection against damage by the high PV open circuit voltage when it is connected to the controller without battery,
- Protection for maintenance and repair technicians.

1.3.10 Luminaries

Lighting shall be screw mounted E27 concentrated Light emitting diodes (LED) 24Vdc providing the proper lumens as shown in the drawing. All lights are to be individually wall mounted switch control, mounting height of the lamp is at 250cm above ground level on pendant fittings with reflector to bring the light more brighter to the point of use or work plane.

Floor mounted type light fittings for examination rooms shall be movable type, adjustable height and adjustable lighting level switch. The lamp shall be LED 24Vdc type, The fitting shall come with socket outlet plug.

Flood lights shall be LED type wall mounted 24Vdc.

At the Practical Completion of the Contract the Contractor shall allow for replacing all defective and burnt out lamps and shall supply 5% of each internal lamps type and rating of lamp installed.

1.3.11 Wiring and Cabling

Stranded and flexible insulated copper wire shall be used. All wiring shall be according to the drawing and should be sized to keep line voltage losses less than 5% and allow the circuit to operate with the rating capacity in safe.

The wiring consists of the electric line installation from:

- PV module to charge controller through circuit protection in distribution box.
- Charge controller to battery.
- Distribution board to house installation.

All exposed wiring shall be in separate and appropriate diameter conduits. No wire joints shall be allowed between distribution board end connections. All connections should be laid in junction boxes and all wiring shall be color coded and labeled.

Polyvinyl Chloride (PVC) or Cross Linked Polyethylene (XLPE) Insulated, Single Wire Armored and PVC Sheathed Cables

This section of the Specification deals with all main, sub-main and sub- circuit wiring specified to be carried out in PVC or XLPE insulated PVC bedded, single wire armored and PVC sheathed overall cable with copper conductors.

(a) **British Standard**

The cables and associated materials shall comply with the following British Standard Specifications, unless otherwise stated:

BS 1442 - Galvanized mild steel wire for armoring cables.

BS 5467 - Specification for cables with thermosetting insulation for electricity supply.

BS 6346 - Specification for PVC Insulated cables for electricity supply.

BS 6360 - Specification for copper conductors in insulated cables and cords.

BS 6746 - Specification for PVC Insulation and sheath of electric cables.

(b) Cable Type

PVC or XLPE insulated power cables shall have copper conductors, PVC sheath, single steel wire armor and PVC sheath overall.

(c) Cable Support System

The cable support system shall be constructed from galvanized cold rolled steel sections. No section shall be smaller than 41mm x 41mm or manufactured in a material of thickness less than 2.7 mm. The support system shall be capable of accepting the cable cleat fixing bolts or studs.

Unless stated otherwise, racks shall be designed to accommodate additional cables to the extent of 20% of those to be installed under this Contract.

The spacing of the racks shall not be greater than that set out in the IEE Wiring Regulations or specified elsewhere in the contract documents.

1.3.11.1 Method of Installation - General

Except where special structures such as cable bridges are required, the whole of the supporting steelwork, racks, trays, cleats, clips etc. shall be supplied by the Contractor.

All cables shall be run with particular regard to neatness of appearance, multiple runs shall be marshalled so that cables entering or leaving the crossover shall be kept to a minimum.

(a) Cable Glands

All cable glands shall be of the correct type and size for the specific application and location.

Cable glands for PVC or XLPE insulated cables shall be of the two-stage type, which grip both the cable sheath and the armouring independently and incorporate an external earthing lug. A PVC shroud shall be used with all cable glands.

(b) Straight Through Joints

Each cable shall be run in one continuous length. No joints will be permitted unless otherwise agreed by the Engineer.

(c) Bending Radii of Cables

Bends in cables shall be as large as possible and in no case shall the bending radii of any cable be such that the cable may suffer damage.

(d) Cleats and Saddles

Cable cleats shall be manufactured in pressure die cast silicon aluminum grade LM6 to BS 1490. Cable cleats shall be manufactured in two identical halves and secured to the support system by two studs or bolts suitable for fixing to the support system.

These shall be provided in vertical and horizontal runs of cables at intervals of not more than 1.2 meters.

Single core cables carrying alternating current for three phase working shall, as far as possible, be arranged in trefoil formation with the cables touching and where departures from the trefoil arrangement cannot be avoided; approved arrangements shall be employed to minimize sheath currents or other undesirable effects.

The cleating arrangements for single core cables shall be of sufficient strength to withstand the forces setup during short circuit conditions.

Where installed on trays, cables not provided with cleats shall be secured by heavy gauge copper or plastic coated clips or saddles at intervals of not more than 1.2m, not more than six cables shall be embraced by one clip, and not more than two layers of cables shall be run on one way.

Where installed on flat surfaces, cables shall be secured by cable cleats at intervals of not more than 1.2 meters.

Every cable shall be securely supported throughout its length and at a point not more than one meter from its termination, and on vertical routes passing through a floor, immediately above the floor.

(e) Cable Identification

Each end of cable shall be provided with an identification label, which shall be lettered to the Engineer's instruction.

Labels shall be permanently attached to the cables in an approved manner, loose tags will not be accepted.

The materials of the labels and fastenings shall be such as to avoid corrosion due to incompatibility of materials and to ensure permanent legibility.

(f) Cables Installed in Service Ducts. Cable Tunnels and Fire Ducts

Where installed in service ducts, cables shall be installed at least 25mm clear of walls and ceilings on cable cleats.

Cable cleats shall be fixed to the galvanized rolled steel cable support system at distances in accordance with IEE Wiring Regulation.

Where cables emerge from a service duct and rise up a wall, a length of suitable sized galvanized steel pipe, bushed at each end shall be threaded over the cable to 450mm above floor level and so positioned as to protect the cable from mechanical damage.

Where cables are detailed to be drawn into ducts, cable pulling eyes shall be used and the cable shall be supported on rollers without sharp edges during drawing operation. All cable ducts shall first be cleared and proved by drawing mandrel of slightly less diameter than the duct immediately before pulling in the cables. Any lubricant used shall have no deleterious effect on the cables.

Where draw-in pits are inserted in the route, they will be of such size that no undue strain caused by bending radii is placed upon the cables. Minimum bending shall be as specified.

Cable rollers shall be used when drawing cables into a pit to ensure that no undue strain is placed on the cables.

After the cable is taken off the drum and flaked, the bending radii shall not be less than those stated for the installation.

After the cable is installed in a duct, the Contractor shall supply and install a suitable purpose made sealing gland assembly within each duct to prevent the ingress of water and to ensure that a complete watertight seal is provided.

(g) Termination of PVC and XLPE Insulated Cables

The method of stripping the sheath, filler and insulation, shall be as recommended by the cable manufacturer, and shall be such that no damage is caused to the insulation or conductor.

Each cable gland shall be fitted in accordance with the manufacturer's recommendations.

1.3.11.2 Elastomer and Polyvinyl Chloride Insulated Cables enclosed in Heavy Gauge Conduit and Metal Trunking

1) General

This section of the Specification deals with main, sub-main and sub-circuit wiring specified to be carried out in VR, EPR, BR, SR and PVC insulated cables drawn into heavy gauge conduit or installed in cable trunking.

Recognized good engineering practice shall be adopted for all conduit runs and no conduit shall be run in such a way as to provide a trap for moisture condensation.

Precautions shall be taken to prevent the ingress of moisture, silt, brick and concrete chippings etc. into the conduit system during and after the installation of same. Hexagonal headed stopping plugs shall be fitted to the ends of all conduit not connected to fixing and outlet boxes. Where condensation has occurred, the conduits shall be thoroughly dried by drawing swabs through it. The inside of all conduits shall be free from burrs or other obstructions.

Where conduits enter the building from outside or in other positions and where in the opinion of the Engineer there may be substantial difference in temperature between different parts of the conduit system, junction boxes shall be inserted into the conduit system and filled with plastic compound to impede the free movement of air in the conduits.

2) Cables

Cables shall be single core, insulated but non-sheathed and shall comply with the following:

BS 6004: Specification for PVC Insulated Cables (Non Armoured) for Electric Power and Lighting.

BS 6007: Specification for Rubber -Insulated Cables for Electric Power and Lighting.

The rated voltage of all cables shall be 600/1000 volts.

Cable joints shall only be made at main switches, distribution boards, ceiling boxes and fixed accessories. No joints shall be made in joint boxes unless the special permission of the Engineer is first obtained.

All phase cables shall be red, yellow or blue, neutral cables black and circuit protective conductors yellow and green. All single pole switches shall be connected in phase cable.

Conduit and cable trunking capacity as set out in the IEE Wiring Regulations shall not be exceeded.

3) Conduits and Fittings

(i) Steel Conduits and Fittings

Steel conduits shall be new, heavy gauge, welded and screwed, enameled or galvanized as specified and shall comply with BS 4568: Part 1. Each length of conduit shall bear a stamp guaranteeing it to be to this standard. The use of conduit less than 20mm diameter shall not be permitted.

All conduit fittings and accessories, including couplers, ordinary clips, saddles, pipe hooks, screwed reducers, stopping plugs, nuts and male and female bushes shall comply with BS 4568 Parts 1 and 2 where applicable.

All screwed couplers, reducers, unions and lock nuts shall be made of malleable iron and all stopping plugs, male and female bushes made of brass. Round locknuts only shall be used on surface work.

(ii) PVC Conduits and Fittings

PVC conduits shall be new, heavy gauge, super high impact as specified and shall comply with BS 4607 and BS 6099. Each length of conduit shall bear a stamp guaranteeing it to be to this standard. The use of conduit less than 20mm diameter shall not be permitted.

All conduit fittings and accessories, including couplers, ordinary clips, saddles, reducers, stopping plugs, male and female bushes, etc. shall comply with BS 4607 and BS 6099 where applicable.

All couplers, reducers, unions, lock nuts, stopping plugs, make and female bushes shall be made of uPVC. Round lock nuts shall be used on surface work.

Solid or Inspection Elbow, Bends, Tee and Inspection Couplings shall not be used.

For wiring purposes all draw-in and inspection boxes must be installed in readily accessible positions as agreed with the Engineer.

Where cables under 6mm^2 are being drawn-in, through boxes shall be used to minimize bending of cables. The heavy duty type fitted with neoprene gaskets shall be used for external work. The inside surface of erected conduit and fittings shall be smooth and free from burrs and other defects.

Where boxes are flush with the ceilings or wall surfaces approved break joint rings shall be provided where necessary to hide the joint.

Underground buried conduits shall have a minimum of 700mm depth from natural ground level.

Excavation for pipe laying shall be carried out only after a full supply of pipes has been made readily available for that section. The bottoms of excavations shall be trimmed and consolidated to the correct levels. Any excavation in excess of the required depth shall be material of the same composition as pipe beds. If the bottom of excavations is not firm, excavation shall be carried to firm level and to approval by the Engineer and filled with material of the same composition as pipe bed. Rock projections, boulders and any hard spots shall be removed and excavations made to true level.

The minimum width of excavations for pipes shall be 600mm for pipes up to 200mm diameter and not less than 600mm greater than the external diameter of the pipe for pipe sizes over 200mm.

The bottom of excavations shall be approved prior to bedding.

Pipes and fittings shall be inspected for damages and defects prior to laying. Any pipes found to be damaged or defective shall be rejected and removed off the site if determined unsuitable for any purpose.

Pipes shall be joined in accordance with the appropriate practice for each type of pipe and strictly following the manufacturers' instructions. Solvent cement to be used for UPVC, PVC, Polyethylene pipe and fitting jointing shall be as recommended by the pipe and fitting manufacturer.

Granular beds and surround shall be graded gravel approved by the Engineer with a maximum size of 20mm free from dust and organic material. The bed shall be placed to the width of the trench, 50mm below pipe and up to 150mm above the crown of pipe or as indicated in drawings.

4) Conduit Joints

Joints in steel conduits shall be made tight by painting the threads just before jointing with an approved aluminum paint to help prevent corrosion and to ensure a high conductivity joint.

Joints in PVC conduits shall be made with specially prepared waterproof adhesives of appropriate types for the joint.

Running joints shall be used only where absolutely necessary; they shall be painted with two coats of the above aluminum paint as soon as they have been tightened.

Conduits crossing expansion joints in the concrete shall be jointed by means of an expansion coupler. The coupler shall be wrapped with waterproof building paper for a distance of 300mm on either side. An inspection box shall be fitted as close as possible on each side of the expansion coupler and a copper protective conductor complying with the IEE Wiring Regulations installed in the conduit between the boxes. The protective conductor shall terminate at each box by means of a M4 brass roundhead tapped onto the bottom of the box and 2 No. flat brass washers.

5) Inspection Boxes

Small standard circular conduit boxes shall be provided and fixed at all junctions and the necessary angles and bends of the conduits.

For surface work boxes of the raised back pattern shall be used.

Conduit boxes mounted outside a building shall have external fixing lugs. Boxes shall be fitted with light steel covers when used internally, overlapping type on flush work, and recessed covers when used externally and in damp situations.

To ensure adequate earth continuity and fitting it is essential that the correct size hole is cut. Holes shall be formed using a hole cutter of approved design. A ring saw cutter must not be used.

No more than two right angle bends or equivalent sets must be made in conduit runs between inspection boxes. On straight runs inspection boxes must be fitted after each second conduit length.

Corners shall be turned by easy bends or sets made cold without altering the section or opening the seams of the conduit. No bend shall have an outside radius of less than three times the external diameter of the conduit. All bends must be machine made.

Where conduits are installed side by side, all off-sets shall be similar and where off-sets are necessary at switch boxes, distribution boards etc. they shall be as short as possible.

Where bending of the conduit causes damage to the paint finish, it shall be made good immediately with high quality matching paint.

Sheet steel adaptable inspection boxes shall be provided and fixed in inspection positions where more than two conduits cross. These boxes shall be 150mm x 150mm x 50mm deep. Where the boxes are fully recessed they shall be provided with 2mm mild steel lids overlapping the boxes 5mm all round.

In damp and external situations, malleable cast iron adaptable boxes shall be used. The boxes shall be provided with neoprene gaskets and malleable cast iron lids secured by four M4 brass roundhead screws. The boxes shall have external fixing lugs.

Boxes shall be fixed with a minimum number of two No.10 round brass screws in plastic wall plugs.

No more than three conduits up to 25mm diameter will be allowed per side on the above adaptable boxes. Where more than three conduits per side occur, proportionally larger boxes shall be used. Deeper boxes shall be provided for conduits larger than 25mm diameter.

Conduits shall be terminated to adaptable boxes, distribution boards, consumer units, switches etc. by means of smooth bore male brass bushes and couplers.

Spanner or purpose made tools shall be used to tighten all conduit fittings. Pliers or toothed wrenches shall not be used.

Where boxes are flush with the ceiling or wall surface approved break joint rings shall be provided where necessary to hide the joint.

6) Flexible Conduit

Where specified, final connection to machines and other items of apparatus shall be with flexible conduit.

The flexible conduit shall consist of a single layer of leaded steel, sheathed with PVC. The flexible conduit shall terminate in couplings with threaded internal sleeve and plastic male bush.

The interconnection between the solid and flexible conduit shall be via a small circular conduit box.

A separate copper protective conductor complying with IEE Wiring Regulations must be included within the conduit and be connected to a brass earthing terminal at each end. Brass washers must be placed above and below the earth wire on the terminals. On no account must a screw securing box lids be used for earthing purposes.

7) Painting Conduits

Conduit and fittings installed behind plaster shall be given one coat of red lead primer immediately after erection.

On concealed installations, in concrete floors and screed where the finish of the conduit fittings is damaged during erection, it shall be made good in the same colour.

Where installed in roof spaces, specified to be in a damp situation, the conduit and fittings shall be given one coat of red primer immediately after fixing.

Galvanized conduit and fittings shall be given one coat of aluminum paint after the installed runs have been inspected by the Engineer.

8) Installation of Conduits

All conduits must be run vertically or horizontally; diagonal runs will not be permitted on walls. Conduits, conduit fittings and equipment shall be fixed by heavy distance saddles fixed not more than 1000mm apart secured by means of 1.75" x No.8 brass countersunk screws, in a plastic wall plug of the correct size.

Conduit installed in concealed positions such as ceiling or floor spaces, shall be fixed by spacer bar saddles, fixed not more than 1000mm apart to the fabric of the building as specified above.

Conduit buried in concrete shall have 40mm depth of cover over its entire length.
Conduit buried in plaster shall have 6mm depth of cover over its entire length.

Conduits which are to be cast in concrete slab shall be laid directly on the upper surface of the shuttering before the concrete is poured. Fixing holes shall not be drilled or otherwise made in the back of the conduit boxes.

A space of 75mm shall be left between adjacent and the like conduits where they are to be covered with concrete.

Conduits installed in chases shall be fixed with corrugated steel clips secured with hardened steel pins at 1200mm centers.

Conduits laid on concrete floor slab or floor and roof beams shall be fixed by means of corrugated steel saddles secured by hardened steel pins at 1200mm centers.

On pre-stressed beams fixings must be into the joints between the beams unless instructed otherwise by the Engineer.

Where conduits, boxes or other fittings are fitted to girders, wrought iron girder clips of approved pattern shall be employed and in no circumstances shall holes be drilled in girders without written instructions from the Engineer.

All conduit outlets installed in concrete or other in-situ construction must be plugged with extreme care to prevent the ingress of foreign matter and the conduit system from becoming blocked during building construction. The Contractor will be held entirely responsible for any additional cost resulting from blockage of conduits due to neglect or lack of attendance.

Female brass bushes shall be screwed on to all free ends of conduit.

Conduit systems shall be electrically and mechanically continuous and watertight after installation. All conduit systems shall be arranged wherever possible to be self-drained to conduit boxes and outlet points. Where necessary, provision shall be made to counteract condensation as directed by the Engineer.

Immediately before wiring, all conduit systems shall be thoroughly swabbed out until dry and clean.

All spare ways in junction boxes etc. left for possible future extensions shall be fitted with brass stopping plugs.

At connection between trunking and apparatus a 4mm paxolin fillet shall be fixed between the two to prevent chafing of cables on metalwork. The cables slot cut in the fillet shall be 5mm smaller all round than the slot cut in the metalwork. As an alternative a standard flanged adaptor or flanged assembly shall be used. Direct attachment of trunking to apparatus will only be permitted if cable entries are provided with smooth bore bushes or grommets and the return edge of the trunking lid is left intact.

Where trunking is used to enclose cables leaving a distribution board the trunking shall be sized to accommodate all cables connected to the board and to leave room for cables that may be connected to spare ways at a future date.

Holes in trunking shall be drilled, cut or punched and all cut edges painted.

Individual pieces of trunking shall be independently supported. On straight runs, fixing shall be at regular intervals not exceeding 1200mm and shall consist of 1.75" X No.10

roundhead black japanned steel screws. Where weatherproof trunking is used, fixing screws shall be brass.

Trunking systems erected outside shall be weatherproof. When installed in damp situations the trunking must be spaced from the wall by means of short tube collars.

Cable supports shall be provided at 900mm intervals in vertical runs. Where afire barrier is required between floors, a cable support shall be provided at floor level and fibre-glass insulation packed between the pins.

Where extra low voltage circuits are contained in the same trunking as mains voltage circuits, cable insulation shall be to mains voltage standards. The cables for each different system shall be laced together to denote the different service and voltage ranges and shall be installed on cable separators fixed at 900mm intervals.

Cable separators shall also be provided when it is specified on the plan that circuits are to be separated and when the space factor exceeds 20%. Cable retaining straps shall be provided above each cover fixing button on a horizontal run of trunking when the cover is on the underside.

The trunking shall be adequately bonded throughout its entire length to comply with IEE Wiring Regulations.

1.4 Switchgear and Distribution Boards

1.4.1 General

This section of the Specification deals with switch gear and distribution boards to be supplied and installed throughout the installation.

British Standard Specification

All fuse switch gear, circuit breakers and contactors etc. shall be of the types outlined, suitable for the fault currents of the system and in accordance with the following British Standard Specifications, unless otherwise specified.

BS 89 Direct acting electrical indicating instruments.

BS 142 Electrical protective relays.

BS 158 Markings and arrangement of switchgear busbars, main connections and small wiring.

BS 159 Bus-bars and Bus-bar connections.

BS 162 Electric Power Switchgear.

BS 1598 Ceramic insulating material for electrical purposes.

BS 1858 Bitumen based filling compounds for electrical purposes.

BS 3858 Binding and identification sleeves for use on electric cables and wires.

BS 3871 Miniature air-break circuit breakers for AC circuits.

BS 3938 Current transformers.

BS 3941 Voltage transformers.

BS 4800 Paint colors for building purposes.

BS 5559 Identification of apparatus terminals and general rules for a uniform system of marking using an alphanumeric notation.

BS 6004 PVC-insulated cables (non-armored) for electric power and lighting.

BS 6321 PVC-insulated cables for switch gear and control gear wiring.

1.4.2 Fault Levels

The switchboards and switchgear shall be designed for the system fault levels to be checked and confirmed by the Contractor throughout the main and sub- distribution networks.

Circuit breakers, switch gear, isolators, contactors, busbars and cable connections shall be suitable for operating at the calculated fault levels.

1.4.3 Fuses

All fuses shall be rated in accordance with BS 88 and shall be to BS rating.

1.4.4 Cable Glands

All cable boxes and glands for the termination of all cabling shall be supplied as necessary by the Contractor.

All cable glands shall be in accordance with this Specification and be suitable for the cables specified.

All cable glands shall be complete with locknut, earth tag and shroud. Terminals shall be marked in a clear and permanent manner.

Entry holes, suitable for the reception of XLPE or PVC/SWA and MICC cables shall be provided in the gland plates.

1.4.5 Labelling

Each outgoing and incoming circuit shall be clearly labelled to indicate the circuit controlled.

Labels shall include black lettering, minimum height 5mm on a white background for general use, and 5mm red letters on a white background for warning labels.

All labels shall be screwed, not glued or fixed by the use of rivets.

Any labelling required inside the panel shall not be by the use of self adhesive PVC strip.

1.5 Fuses and Miniature Circuit Breakers

1.5.1 Fuses Generally

All fuses shall comply with the requirements of BS88 and shall be supplied to suit the rating of the circuits protected in accordance with the requirements of the IEE Wiring Regulations.

1.5.2 Power Fuses

All fuses in distribution switch and fuse gear and fused distribution boards shall be HRC Cartridge Fuses type and category 414AC80 and DC4, arranged vertically and barriers shall be provided between phases. Unless protected by interlocked covers, all live parts shall be fully shrouded.

Type test certificate shall be provided, if required by the Engineer. All cartridge fuses shall be fitted with a device to indicate a blown element. Fuses shall be of the make and type specified and only one make and type shall be used through the installation to ensure discrimination between fuses.

For contactor control gear, the main circuit fuses shall be connected between the isolator and contactor. Each fuse switch and contactor unit shall be supplied with a spare set of fuses and the design of the equipment shall be such that means shall be provided for retaining the spare set of fuses within the fused switch or contactor cubicle compartment.

1.5.3 Control Fuses

Where a control circuit is supplied directly from main power conductors, it shall be protected by HRC power fuses as in power fuses above.

In general, control fuse bases and carriers, of the fully shrouded type having cartridge fuses will be accepted subject to the approval of the Engineer.

The fuse bases and carriers shall be colored as follows, in accordance with clause 42 of BS 162:-

5 amp	Black
15 amp	Light Green
Link	White

Fuses of ratings other than 5 or 15 amp, shall have the rating inscribed on the fuse carrier or label. Such fuses shall be distinguished by approved colorings. Thermo setting self-adhesive labels shall be fitted adjacent to all control fuses and links.

1.5.4 Fuses for Plugs and Spur Units

Fuses for plugs and spur units shall be of the rating of the equipment they protect and shall be to BS 1362 for the 13 amp and ring final circuit accessories or to BS 196 for fuses for industrial ring final circuit accessories.

1.5.5 Miniature Circuit Breakers

All miniature circuit breakers shall be rated to withstand the prospective short circuit currents of the circuits they protect without causing any interference in any other protective devices associated with the distribution system.

At the same time, the design of the circuit breaker shall be such that it will protect the circuit for which it is intended and not cause or allow other protective devices to operate when overload current conditions apply.

Miniature circuit breakers shall be in accordance with BS 3871 : Part 1 and comply with the IEE Wiring Regulations. They shall be capable of interrupting 415 volts, three phase symmetrical faults.

Miniature circuit breakers shall be type C unless otherwise stated.

1.6 Distribution Boards

All distribution boards shall be of the sizes and types specified and shall be in accordance with BS 5486 Part 12 and shall be fitted with miniature circuit breakers. Miniature circuit breakers shall be in accordance with BS 3871 Part 1 except where modified by this Specification. Where distribution boards are specified to be complete with an isolator or switch, the isolator or switch shall be double pole for SP&N distribution boards and four pole for TP&N distribution boards. The isolator or switch shall be integral with the distribution board enclosure.

The enclosure shall comprise a case and door(s) of sheet metal. The type of construction shall be damp and dust protected as specified to BS 5420 classification IP31 as a minimum standard.

Surface mounting shall be office pattern, fitted with cylinder lock. Doors shall be provided with quick release hinges.

Sheet steel used in the construction of the distribution boards shall have a quality of surface finish equal to that of sheet steel to BS 1440 Part 1A HRP or BS 1449 Part 28 GR4/GP.

Sheet steel shall be electro-zinc coated to minimum thickness of 0.009mm and chromate washed.

All door furniture, e.g. locks handles, fasteners etc. shall be chromium plated.

Painted finishes for all steel for use indoors shall have two coats of rust proof primer, then filled as necessary to a smooth finish, then two undercoats applied and the final finish being two coats of epoxy resin paint, the final coat drying to a hard semi-gloss surface.

All bright machined parts shall have a protective treatment applied by the manufacturer before dispatch and this treatment is to be kept intact up to the time of handover unless it has to be removed for installation. If the surface is then exposed after installation, the Contractor shall apply a further protective coating in accordance with the manufacturer's requirements.

Bus-bars shall be rigidly mounted in the same position on all poles relative to their banks of fuses or MCB's and fully shrouded to enable spare ways to be wired whilst the board is live. Busbars shall be copper to BS159.

All incoming terminals shall be fully shrouded and of the pressure clamp or socket type.

Renewable labels in the form of cards in a transparent envelope shall be provided within the enclosure for recording the following information of each circuit:-

- Circuit designation and location served
- Cable size
- Circuit rating

The sequence of identification shall be stated on the label card. The make and type of fuse that discriminates and/or protects the miniature circuit breakers shall be indicated.

If installation of fuses other than the manufacturer stated would not discriminate or protect the miniature circuit breakers, then a label to this effect shall be installed in the distribution board.

External labels shall be fitted in accordance with "nameplates and labels" and shall be brass plates with engraved black letters.

Neutral terminals shall be provided, one for each outgoing phase way, i.e. three neutral terminals for each TP way in positions respective to their phase terminals.

1.7 Lighting Installation

1.7.1 General

The lighting installation shall comply with the previous sections of this Specification in so far as they are applicable.

1.7.2 Wiring for Lighting Circuits

Wiring for lighting circuits shall be carried out on the "loop-in" principle. The "feed" and "neutral" shall be looped at the lighting point using the "three plate" system.

The wiring shall be in cable of the appropriate rating, type and grade in accordance with the IEE Wiring Regulations. The sub-circuits shall be installed and numbered as shown on the design drawings.

The conduit box at each lighting and ceiling switch point shall be provided with an earthing terminal consisting of a 12mm M4 roundhead brass screw and two flat washers fitted to a tapped hole in the box.

To facilitate the connection of the protective conductors a length of 2.5mm2 yellow/green PVC flexible cord fitted to a 5 amp porcelain shrouded brass connector shall be secured to the earthing terminal.

1.7.3 Concealed Conduit Installation

Small circular metal conduit boxes or equivalent "loop-in" boxes shall be provided at each lighting point in which to terminate hard wiring.

Such boxes shall be securely fixed to the structure of the buildings in order to support the weight of the luminaire. Two boxes shall be used for supporting fluorescent luminaires.

Where boxes finish behind surface level the correct size extension ring shall be used to finish level with the ceiling finish.

1.7.4 Surface Conduit Installation

Small circular raised back metal boxes shall be provided and securely fixed at all lighting points. The hard wiring shall be terminated in fixed based porcelain connectors. Heat resisting cables shall be used or heat resisting sleeving applied to PVC sheathed cables and taken into the luminaire from the hard wiring.

1.7.5 Trunking Installation

Where fluorescent luminaires are fixed to channel or trunking they shall be fixed direct on using the trunking manufacturer's fittings/attachments. Hard wiring shall be taken into the luminaires. PVC sheathed cables shall be sheathed with heat resistant sleeving where they are installed within the luminaires.

Runs of trunking shall be supported at equally spaced intervals of not more than 300 mm apart. The two outer suspension points shall be not more than 450mrn from the ends to the run.

Where more than one length of trunking is required to make up a run splice plates shall be used at the joint. Joints shall not be made in the center half portion of a span between suspension points.

An earthing terminal shall be provided in each run of trunking comprising an M4 screw, with two brass flat washers, screwed into a tapped hole in the trunking.

1.7.6 Cleaning of Luminaires

At completion of the Contract the Contractor shall thoroughly clean all luminaires to ensure all dust, grit, building rubbish, etc. is removed from each luminaire.

1.7.7 Switches

Switch boxes shall comply with BS 4662 and shall be fixed by means of two No. 8 round head screws in plastic wall plugs. In external and damp situations brass screws shall be used.

1.8 General Power Installation

1.8.1 General

The general power installation shall comply with other sections of this Specification in so far as they are applicable.

1.8.2 Makes of Accessories and Equipment

The make and finish of accessories and equipment, shall be as indicated in the detailed schedule of equipment.

1.8.3 16 amp Outlets and Spur Units

The socket outlets are generally to be wired in ring circuits. Where radial circuits are to be installed, these shall be indicated on the drawings.

1.8.4 Fixed Equipment

Items of equipment that essentially stand in one position but are moved for cleaning may be specified to be supplied from flush fitting controls. Where this is the case, the control shall be fitted at the height specified and a flush fitting box shall be fixed below the control to allow the flexible cables to be taken to the equipment. The accessories to be used to enable flexible cables to be taken to these boxes shall either be flex outlet plates or a fixed connector block in a conduit box fitted with a strain relief grip.

1.9 Luminaires

1.9.1 British Standards

Components used in the construction of luminaires and the luminaires themselves shall conform to the following British Standards:-

BS 52: 1963:	Bayonet lamp caps, lamp holders and BC adapters
BS 2782: 1975:	Methods of testing plastics
BS 4533:	Electric luminaries (lighting fittings)
BS 4800: 1972:	Paint colours for building purposes

1.10 Earth System (grounding)

1.10.1 General

System earth connection shall be made to:

a) System ground shall be connected: PV array structure, the chassis and any conductive surfaces.

b) Negative terminal of DC line at which of the shortest route.

The installed lightning protection required protecting level A – common lightning risk and the installation of the masts height lay at least 250cm at the two top edge of an array with copper rod ground cable, earth mat, bentonite powder etc. and shall be installed in accordance with international acceptable installation standard for lighting and earth connection. A proper interconnection shall be done between the mast and earth system.

Earth connection shall be:

- By a purpose-made fitting providing earthing or bonding connections for dissimilar metals and fitted to the manufacturer's instructions, or
- by purpose-made washers with serrations or teeth for the connection between the PV module and mounting frame fitted to the manufacturer's instructions, and
- be arranged so that the removal of a single module earth connection will not affect the continuity of the earthing or bonding connections to any other module.
- Self-tapping screws shall not be used. Particular attention shall be paid to mechanical protection and support. Earth cable cannot pass through a steel roof without additional mechanical protection (conduit) and an appropriate collar flashing (e.g. dectite). The same conduit that is used for the PV array cable can also be used for the earth cable. Installation is not subject to lightning.

Main Equipotential Earthing and Bonding

1.10.2 Materials General

All materials used in the earthing network shall be of high conductivity annealed copper of type size and with protective covering manufactured to the appropriate British Standard.

1.10.3 Method of Installation

Non-current-carrying metalwork shall be bonded to extraneous fixed metalwork and the whole of the non-current-carrying metalwork shall be bonded together in accordance with the 16th Edition of the IEE Wiring Regulations.

1.10.4 Bonding of Protective Conductors

All metal pipes or conduits in which the cables have been installed shall be bonded to the main earth point. The joints, metal sheath and armour, if any, of the cable shall not increase the resistance of the protective conductor. Where cables are more than 365 meters in length, the metal sheaths and armour of such cables shall be bonded to earth at intervals of 350 meters.

1.10.5 Earth Tapes

All connections to earth tapes shall be made by means of tinning, sweating and bolting. All connection to fixings of earth tapes to the building shall be by means of 3.5mm thick phosphor bronze or gunmetal saddles and brass screws.

1.10.6 Bonding to Extraneous Metalwork

Metal sinks waste pipes, hot and cold pipes shall be bonded to the nearest socket outlet and/or spur unit by means of a 2.5 sq.mm PVC insulated cable, coloured green/yellow, enclosed within heavy gauge conduit terminating at a low level in a BS 1363 box fitted with a flex outlet plate complete with a solidly mounted earth stud.

From the flex outlet plate a 4 sq.mm FVC insulated cable, coloured green and yellow shall be installed in a neat and tidy manner and be securely bonded to the extraneous metalwork.

1.10.7 Protective Conductors Associated with Flexible Conduits

Where flexible conduits are installed, each shall be provided with a separate earth conductor of 4.0 sq.mm minimum size and shall be connected to the nearest conduit box and the apparatus served by means of tinned copper lugs, brass screws and washers. The protective conductor shall not be installed within the flexible conduit unless otherwise specifically agreed in writing by the Engineer.

1.11 Lightning Protection

1.11.1 General

The lightning protection system shall comply with BS 6651.

1.11.2 Aluminum Tape

Aluminum tape used for roof termination networks and down conductors shall be bare to BS 2898- 1350 and shall have a minimum cross sectional area of 50mm^2.

1.11.3 Copper Tape

Copper tape used for earthing shall be bare and made from high conductivity copper to BS 1432- C101/C103 and shall have a minimum cross sectional area of 50mm^2.

1.11.4 Fixing of Tape Conductors

Conductor tapes shall be fixed to the background using metallic tape clips of the spacer bar type using 1" x no.10 countersunk wood screws and wall plug.

When straight through, cross or tee joints are formed in the tape, square tape clamps shall be used and these shall be fixed to the background as described above for tape conductor clips.

Copper conductor fixing accessories shall be made from high quality copper alloys and aluminium accessories shall be made from high quality aluminium alloys.

No accessory meant for copper conductors shall be used on aluminium conductor and vice-versa.

When aluminium fittings are installed an approved oxide inhibiting compound shall be applied to the connection after it has been made.

At the junction between aluminium down conductors and copper earthing conductors, a bimetallic connector shall be used. The connector shall be firmly fixed to the background using 1" x no.10 countersunk wood screw and wall plug.

1.11.5 Air Termination Network

Their termination network shall be arranged so that no part of the roof is more than 5 meters from an air termination conductor.

1.11.6 Down Conductors

There shall be one down conductor for every 10 meters of the building perimeter at ground level.

Down conductors shall be as evenly spaced, and shall be routed as directly from the air termination network to the earth termination, as the building contour will permit.

The existence of re-entrant loops in the down conductors shall not be permitted, except as allowed by BS 6651.

1.11.7 Earth Termination Network

The earth termination network shall be executed in copper tape and copper clad earth electrodes only.

The connect ion between tape and earth rod shall be made with a proprietary rod to tape clamp of high strength copper alloy body and screw. Commercial brass shall not be used for this purpose. This connection shall be made at least 150mm above the immediate surrounding ground and enclosed in an earth inspection chamber.

The inspection pit and cover shall be made of concrete of internal dimensions 160 x 160mm and minimum depth of 210mm. The top of the pit shall not be below the general surrounding ground.

1.11.8 Earth Resistance

The resistance to earth of the complete lightning protection system measured at any point, shall not exceed 10 ohms.

The resistance of each individual earth shall not exceed ten times the number of down conductors in the complete system.

1.12 Environmental Conditions

The system shall be able to reliably provide full and continuous power under the following conditions:

Ambient Temperature range: 10°C to 55°C
High levels of solar ultraviolet radiation,
High presents of dust,
Presence of insects.

The offered equipment to work reliably in the indicated environmental conditons shall be supported with test evidence document, by the bidder/manufacturer to show its successful operation under similar conditions.

1.13 Protection, Safety and Work Hazards

The installation features of the equipment shall be ensure, there is no significant electrical or physical danger to users due to the design and placement of the system.

Environmental Management

Successful bidder shall be required to minimize the environmental impact of the work by adopting respectful waste management behavior and fulfilling environmental norms. Among others, shall be required to:

- Avoid cutting trees except those that create shading of PV panel array.
- Optimize and reduce wire cut and other waste production,
- Clean wastes after completion of the installation area that arise due to installation.

1.14 Warranty

At the time of contract execution, the contractor must provide warranties and guarantees for the PV installation. Bid respondent shall fully define in its proposal the warranty offered. Bidders must meet warranty requirements with the following:

System Warranty: should any faults arise, this warranty shall be covered for the necessary maintenance or component replacement free of charge for full functionality to be restored within seven working days.

Product Warranty: in addition to the three years warranty, the contractor shall guarantee for the system products based on usual practices as per hereunder:

Components shall be warranted as per hereunder:

- A minimum fifteen years on PV modules
- A minimum five years on Batteries
- A minimum 4000 hours life time on luminaries
- A minimum three years on charge controller
- A minimum ten years on PV mounting structures
- A minimum ten years on battery bed or box and
- A minimum ten years warranty on lightning system and system grounding are required.

Annual energy performance warranty: the bidder shall provide the warranty for the performance of the energy for one year.

1.15 Documentation and Training

Successful bidder shall provide manufacturer's documents of technical specifications, maintenance and operation and users manuals of each component installed.

List of installed components and including spare parts, tools, associated manufacturers literature and warranty claim shall be handover to users of each installed components.

The supplier shall have to prepare and provide user's manual intended for the users. The user's manual should be in local language if possible otherwise in English and French and has to be simple and easy to understand.

The user manual shall consist at least the following:

- Briefing of signal indication on charge control: battery charging, battery low voltage and battery overcharge. The relationship between energy available on a daily basis and sunlight conditions clearly and easily shall be explained.
- Description of disconnect breakers and routine attendance.
- Proper system operation including load limitation; suggested operation, weather condition load management during periods of inclement weather.
- Briefing shutdown procedures in cases of fault.
- User level trouble shooting guide.
- Contact information for warranty claim, maintenance and access to spare parts.

1.16 O & M Manual

The supplier shall provide for components, an operation and maintenance manual to be used by the service technicians. The manual shall be in a language understandable by the technician. The manual include the specific details of installation, operation and maintenance.

- A detailed technical description of the component.
- Instructions and routine maintenance recommendation.
- Trouble shooting guide shall include repairs and diagnostic procedures to eb done by a qualified technician.
- A functional block diagram and electrical line diagram showing the connection and ratings of component.
- A set of blank log sheets for record.
- Contact information for queries and breakdown maintenance service.

The training shall be split into three major components: system installation, system operation and maintenance and demand side management.

The training shall include operating hours, battery discharge, number of appliance operated simultaneously, response to extended periods of cloudy weather etc, explained in detail together with the maintenance requirements for the unit. The bidders shall provide training methodology together with their offer.

1.17 After Sales Services

After sale service shall apply to the solar photovoltaic energy system, including light fittings and main components supplied under this contract. The bidder shall prove and demonstrate that it has the capacity to provide after sales service with capable staff in its bid document with company profile.

1.18 Testing and Commissioning

1.18.1 General

The following inspections and commissioning tests shall be performed:

- Inspection of the supply sets of materials, transportation and delivery condition shall be conducted by Client's or Consultant's technical officers prior to arrival and transportation to the final destination as appropriate carried at the supplier's premises, in Djibouti or beneficiary site.
- Test for proper installation for the main apparatus and the complementary stands, as well as, product commissioning shall be conducted by authorized and responsible parties.
- Inspect all sets of goods and materials incorporated are new, unused, and of the most recent or current models, and check for recent improvements and amendments whether incorporate in design of the supply.

1.18.2 Inspection and Commissioning Tests

As the installation proceeds and on completion of the installation and at the expiration of the maintenance period, the Contractor shall carryout tests in the presence of the Engineer on all sections of the Electrical Services Installation and shall submit six signed copies of the results of the tests to the Engineer, together with six copies of a Completion and Inspection Certificate as required by the IEE Wiring Regulations, Part 7.

Site testing of all systems and components comprising the Contract works shall be carried out in the presence of and to the complete satisfaction of the Engineer, AFTER the Contractor has first satisfied himself that the systems are operating correctly.

The Contractor shall prepare and submit for approval comprehensive commissioning documents prior to commencement of testing.

No section of the installation shall be energized until these tests have been completed.

The Contractor shall provide all certified instruments, equipment, plant, labour and materials necessary for conducting specified site tests and shall be responsible for and prepared to demonstrate the accuracy of all test instruments supplied by him.

All installations, plant and tests must satisfy the requirements of the Factories Act and the requirements of all other interested Authorities and the Contractor shall include for all safety devices, etc. required by such Act or Authority.

Observations shall be made of the operation and performance of the installations and subsequent readjustments made as necessary.

Accurate records of all commissioning and testing shall be kept and results comprehensively reported to the Engineer when the installed system(s) are functioning correctly.

Where it is not possible at the particular time of commissioning and/or demonstration of the plant for full load conditions to be obtained or assimilated, the Contractor shall repeat the requisite operations of the commissioning and demonstrations under such full load conditions (or the reasonable approximation or simulation of such conditions acceptable to the Engineer) at the first opportunity.

The Contractor shall ensure that all equipment and plant under his supply shall be tested at the makers works before dispatch and six copies of test certificates in respect of each test shall be forwarded to the Engineer.

All works tests shall comply with the relevant British Standard Specification or IEC Standard Specification and shall be sufficient to show that equipment will function correctly when installed as part of the Sub-Contract works.

Each item of electrical plant or equipment so tested shall be fitted with a plate giving at least the following information:

- Date of Test
- Individual equipment serial number
- BSS number if any
- Test Voltage
- Operating voltage (if different from test voltage)
- Test current
- Full load current (if different from test current)
- Loading (expressed in kVA) and power factor Phase
- Frequency (expressed in Hz)

The above information shall be included on the test certificate for each item of plant or equipment. This shall also include a description of any particular method of wiring and/or connection with the location of the test and signature of the witness.

The following test results shall be submitted:

a) Continuity of ring final circuit conductors

b) Continuity of protective conductors, including main and supplementary equipotential bonding

c) Earth electrode resistance

d) Insulation resistance

e) Insulation of site-built assemblies

f) Protection by electrical separation

g) Protection by barriers or enclosures during erection

h) Polarity

i) Earth fault loop impedance

j) Operation of residual current devices and fault voltage operated protective devices

k) Each circuit breaker shall be operated manually or electrically 50 times to the satisfaction of the Engineer. Where the circuit breaker is designed for electrical operation at least 10 of these operations shall be made with 80% normal voltage applied to the trip coil in accordance with BS 116: 1952. During this test the trip free feature shall be demonstrated.

1.19 MOUNTING HEIGHTS

Except where otherwise detailed in the drawings or stated in the Bill of Quantities all accessories and fittings shall be fixed at the following heights above finished floor level:

- Distribution boards 1700mm to centerline of board.
- Lighting switches and push buttons 1400mm.
- Sockets (general) 400mm.

Section 2: Particular Specifications for Electrical Services

2.1 General

The electrical materials and works will be selected, erected, inspected and tested in accordance with the following:-

(i) This Specification

(ii) Appropriate British Standard (BS) Specifications and Codes of Practice (CP). (IEE Wiring Regulations Sixteenth Edition) including all current amendments and the standards of International Electro-technical Commission (IEC) Publication 364 "Electrical Installations in buildings".

(iii) Government Rules

(iv) Local Authority's Bye-laws and Regulations

(v) Electricity Supply Authority's requirements

(vi) Fire Prevention Officer's requirements

(vii) Health and Safety at work regulations

The Contractor shall notify the Engineer of any revisions or additions to the foregoing as they are published during the installation of the Works for the Engineer's decision and instructions.

The Contractor shall pay all charges necessary for any Authority's approval of any part of the Works.

The Contractor shall include everything required for the completion of the Works within the installation to ensure continuous operation of all equipment and plant.

The Contractor shall ensure that the installation is compatible with Architectural and Structural details.

The Contractor shall note the requirement for detailed coordinated working drawings showing the location or layout of wiring accessories or particular method of installation.

2.2 Suitability of Materials and Products

Materials and products shall be supplied to suit all conditions of use normally expected to apply after completion of the installation. They should also withstand any tests specified in this Specification or any other documents referred to herein.

Unless otherwise explicitly stated in the contract documents, all materials and equipment incorporated in the Works shall be new and for the purpose intended.

2.3 Lighting Installation

2.3.1 General

The Contractor shall supply, install and connect the complete lighting installation as described herein and indicated on the drawings. All recessed luminaries within suspended ceiling tiles may be supported independently by the ceilings. However, the Contractor must ensure that the arrangements for fixing of the luminaries to be ordered are completely compatible with the ceiling grid type.

Final connection to all luminaries shall be carried out using 2.5mm^2 heat resisting flexible plug-in lighting Luminaries Support Coupler (LSC) system. In the case of luminaries within the suspended ceiling areas, ample lengths of flexible cable shall be provided so that the

luminaries can be moved horizontally a distance of 600mm in any direction from the position shown on the drawing without straining the cable.

The lighting installation shall be carried out using PVC insulated, stranded copper conductor cables, drawn within heavy gauge, high impact PVC conduit.

Separate circuit protective conductors of the same cross sectional area as the phase conductors shall be provided.

Lighting circuits shall be wired in 1.5mm^2 or 2.5 mm^2 cables as indicated on the drawings.

No cable size smaller than 1.5mm^2 shall be used for the lighting installation.

The lighting installation shall be flush/concealed with conduits concealed within suspended ceiling voids or buried as necessary within walls, floors and other building finishes.

The Contractor shall ensure that all conduits, cables etc. installed are clear of any thermal or other insulation which may be provided within ceiling voids, etc.

Wiring shall be carried out in loop-in system and no cable junctions or terminations will be permitted in inaccessible locations.

Lighting cables shall be drawn within conduits specifically provided for the purpose and sha1l not be drawn within conduits provided for other services or vice versa.

The Contractor shall prepare detailed working drawings of the installation indicating the exact positioning and routing of all conduits, trunkings, luminaires etc. and submitted to the Architect for approval prior to commencement of installation.

Low voltage luminaires installed within the bar area of the restaurant on the first floor are to be supplied via a remote wire wound transformer of the multi-outlet type rated at 225VA enabling a maximum of four 50 watt luminaires to be connected to it. The transformer shall be measured as one luminaire point and the short connections to the luminaires measured separately.

The Contractor shall ensure that the transformer and associated cabling are installed to the manufacturer's specifications.

The modular luminaires in the meeting room on the first floor shall be suspended at 500mm below ceiling level by methods recommended by the manufacturer.

The spherical pendant luminaires mounted in the void shall be mounted to form a spiral with the first numerically identified luminaire suspended with the lower side of the sphere at 500 mm below the mounting ceiling level. The subsequent luminaires shall be mounted with their lower side progressively 500 mm below the one above it.

2.3.4 Lighting Switches

Lighting switches for the control of luminaires shall be suitable for flush mounting with overlapping white plastic front plates, single or multi-gang as indicated on the drawings.

2.4 16 Amp Socket Outlets

General purpose socket outlets, unless otherwise specified, shall be of 16 ampere capacity, single pole and of rectangular pin type to BS 1363/1947 with a white plastic front plate and integral switches. They shall be mounted in rectangular galvanised steel boxes single or multi-gang as necessary with at least one adjustable lug.

Socket outlets for mounting onto the skirting trunking shall be of a type suitable for that purpose and shall be provided with all necessary proprietary accessories. No local improvising shall be accepted.

2.4.1 Wiring

The installation shall be carried out using PVC insulated single core cables having stranded copper conductors enclosed in heavy gauge high impact PVC conduit and steel cable trunking. Separate circuit protective conductors (c.p.c.) of the same cross sectional area as phase conductors shall also be provided and installed for each circuit. Where the phase conductors are wired in a ring, the c.p.c. conductors shall also be wired in a ring.

All 16 amp socket circuits shall be wired using 2.5mm^2 cables or other size as indicated on the drawings.

No cable size smaller than 2.5mm^2 shall be used for any power installation.

The power circuits shall be a flush or concealed installation with conduits concealed within suspended ceiling voids or buried as necessary within walls, floors and other building finishes. On the second to the tenth floor open space areas the cables shall be laid in the skirting trunking fixed on the surface of the walls at skirting level and in under floor threshold units where the trunking crosses an opening such as a door.

The Contractor shall ensure that all cabling, conduits, trunking etc. installed are clear of any thermal or other insulation which may be provided within the ceiling and floor voids, risers etc.

Power circuits shall be contained within the conduits or trunking compartment specifically provided for the purpose and shall not be installed within conduits or trunking compartments provided for other services or vice versa.

Detailed working installation drawings shall be prepared by the Contractor indicating the exact positioning and routing of all conduits, trunking etc.

These drawings shall be submitted by the Contractor to the Architect for approval prior to commencement of the installation.

2.5 Earthing and Bonding

The entire cable, trunking, conduit and cable tray installation, together with the sheathed and earthing conductors of cables shall be electrically bonded to earth.

All main, sub-main and final distribution boards, plant and equipment shall be bonded to earth in an approved manner by solid copper conductors secured by means of substantial bonding clamps.

The Contractor shall bond, in all locations, all extraneous conductive parts of the installation including sinks, basins, waste pipes, hot and cold water pipes and all general items of mechanical services plant. The bonding shall be carried out using green/yellow PVC insulated single core conductors.

All steel accessories boxes for light switches, socket outlets etc. shall be bonded to earth by connecting the brass earth terminal at the back of the box solidly to the circuit protective conductor.

All bonding installations shall be carried out in a neat and unobtrusive manner to the satisfaction of the Engineer.

2.6 Lightning Protection

The lightning protection system shall consist of an air terminal network, down conductors, earth termination network and bonding to prevent side flashing.

2.6.1 Air Termination Network

The air termination network shall consist of bare aluminium conductor tape which forms a network mesh of not more than 20m by 10m as shown on the drawing. The tape shall be 30mm x 3mm thick.

All tape intersections or connections shall be carried out with connectors which are compatible with the tape material. All fixings of tapes to the building shall be by means of tape clips of cast gun metal upper and lower sections with countersunk brass screws.

2.6. 2 Down Conductors

Down conductors shall be installed to provide a low impedance path from the air termination network to the earth termination network, to allow the lightning current to be safely conducted to earth.

The down conductors shall be of bare aluminium conductor tape of dimensions 30mm x 3mm and shall be fixed in like manner as the air termination network conductors. The aluminium conductor tapes shall terminate onto a test clamp at a height of 1.5m from ground level from where a copper tape will lead into the ground termination.

Down conductors systems shall take the most direct route from the air termination network to the earth termination network. The routes chosen shall be such as to avoid side-flashing.

Re-entrant lops shall not be permitted in the conductor except where the length of the conductor forming the loop does not exceed eight times the width of the open side of the loop as recommended in BS 6651. The routing of conductors inside the structure shall not be permitted.

2.6.3 Earth Termination Network

The earth termination network shall consist of high conductivity annealed bare copper conductor tape of dimensions 30mm x 3mm from the test clamps installed at 1.5m above ground level and terminating onto earth rods driven into the ground.

The copper tape to earth rod connection shall be via a rod to tape clamp of cast gun metal body and phosphor bronze bolt. The connection shall be made above the surrounding soil in the inspection chamber to facilitate visual inspection.

The earth rods shall be of the extensible type made from pure electrolytic copper of minimum thickness 0.25m, molecularly bonded onto low carbon steel cores with high tensile strength. The threads shall be rolled onto the rod with a uniform layer of copper. The coupling shall be of silicon and aluminum bronze, counter-bored and shall completely cover the threads on the rods. The rods shall be 1500mm x 16mm diameter and driven to a depth of 4.5m.

The whole earthing assembly shall be enclosed in a concrete earth inspection chamber of 400mm x 400mm internal dimensions complete with a concrete cover.

2.6.4 Bonding

The Contractor shall bond all exposed metal work on or around the structure to the lightning protection system to avoid side-flashing. All such bonding shall be carried out using factory made accessories.

2.7 USB outlet Mobile Charger Unit

Supply and Install separate unit 10W Solar Panel Charger with two pieces of 5V USB ports for cell phone. The unit shall have built-in battery with minimum capacity of 17Ahr and 24Vdc. There shall be separate Solar panel with minimum of 30Wp & 24Vdc capacity. The USB ports shall have capability to read MP3 files and the unit has 24Vdc LED light lamps with output interface.

The unit shall have the following features:

- Battery capacity indicator on real time
- Load indicator
- Charging
- Float charging and
- Overloading

The unit shall also have the following protection:

- All round reverse connected protection
- Reverse charging protection
- Over charge protection
- Over load protection
- Fuses to prevent short circuit of battery

The work shall include locally made lockable and well painted Rack for the Unit and the Solar panel made of metal RHS and angle iron. The Rack for the solar panel shall fixed over the roof and the rack for the unit shall be fixed over the wall.

2.8 The following Spares shall be included in the Bill of Quantities

SPARES:

Required to maintain immediate spares stocks stored at the service center for the number and type of system.

S.No.	Item Techincal Descriptions	Unit	Qty
1	Battery interconnects	Pcs	12
2	Fuse 175/200A dc	Pcs	2
3	ACB 175/200A 24V dc system	Pcs	2
4	ACB 16A-2Poles	Pcs	2
5	ACB 10A-2Poles	Pcs	2
6	LED light fitting wih lamp of 12W, 24V dc	Pcs	10

Special Tools required

S.No.	Item Techincal Descriptions	Unit	Qty
1	Digital Multi-meter	Pcs	1
2	Screw driver (Star and flat)	Set	1
3	Test light (digital and analogue)	Pcs	2
4	Wrench	Set	1
5	Variable Wrench	Pcs	1
6	Long and Short Nose Pliers and Cutter.	Pcs	3
7	Set of Spanner (8-20)	Set	1
8	Allen key.	Set	1
9	Pack of Dust/Waste cleaning material for module.	Set	1