No.: 32/645/2017-SPV Division
Ministry of New and Renewable Energy
Government of India
***

Block No.14, CGO Complex,
Lodhi Road, New Delhi-11003

Date: 15.09.2022

Office Memorandum

Subject: Comments/ suggestions on Quality Control Manual for Solar Water Pumps – reg

Ministry is implementing the PM-KUSUM scheme, which inter-alia includes installation of 20 Lakh standalone solar water pumps. These pumps are to be installed as per Guidelines of the PM-KUSUM Scheme and the specifications issued by the Ministry.

2. To ensure quality of installation and a structured mechanism for monitoring of installations, Ministry proposes to bring out a quality control manual for solar water pumps. Draft manual prepared is enclosed herewith for comments of stakeholders.

3. It is requested that comments/suggestions may please be sent in the format given below, in word file, to shobhit.srivastava@nic.in by **30th September 2022**.

S. No.	*Section No./ Para No./ Page No.*	*Existing provision*	*Comment/ Suggested modification*	*Justification*

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(Shobhit Srivastava)
Scientist-D

To

All Stakeholders

DRAFT QUALITY CONTROL MANUAL

FOR

SOLAR PV WATER PUMPNG SYSTEM

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1.Objective

The Quality Control manual for Solar PV Water Pumping System is to serve as a guide to ensure quality of the solar water pumping system installed, including its components, under the Schemes of the Ministry of New & Renewable Energy. It also enumerates stakeholders' responsibilities and provides a structured approach in assessing the quality of installations under such schemes. The Quality control mechanism and inspection procedures can check the efficiency of the system and serve as a tool for optimisation.

2.Solar PV Water Pumping System

2.1 Overview

The Standalone Solar PV Water Pumping system operates the Surface (Mono-set) / Submersible pumpsets through collected photovoltaic energy as opposed to grid electricity or diesel run water pumps. The electricity generated by Solar Photovoltaic system can be utilised to operate the Pumpset to lift water from shallow wells, ponds, canals or Tube wells with SPV Pump Controllers and other electrical accessories as intermediaries.

In Solar PV water pumping system, the DC power generated from SPV panel can either be utilised directly by the pump in case of DC pumpset or can be converted to AC for operating AC pumpset. Depending upon the Head and discharge requirement of the site, the system can be designed as per the specifications.

2.2. Definition of Technical parameters

i. **Photovoltaic (PV) System**: Converts irradiance (solar power) from the sun into electricity
ii. **Solar Array (or PV Array):** A configuration of solar panels arranged and wired together to output power as a single unit
iii. **Solar Irradiance:** The power per unit area received from the sun
iv. **Array orientation:** The array should be oriented towards the south in Northern hemisphere
v. **Tilt Angle:** The inclined angle of the solar panels relative to the horizontal.
vi. **Short Circuit Current (I_{sc}):** Short Circuit Current is the maximum current produced by a solar cell and is measured in Ampere (A).
vii. **Open Circuit Voltage (V_{OC}):** Open circuit voltage is the maximum voltage that the cell can produce under open-circuit conditions. It is measured in volt (V). The value of V_{OC} depends on cell technology and the operating temperature of the cell.
viii. **Maximum Power Point (MPP):** Maximum power point represents the maximum power that a solar cell can produce at the STC (Standard Testing Conditions). It is measured in W_P. Other than STC, the solar cell has MPP at different values of radiance and cell operating temperature. The cell can operate at different current and voltage combinations. But it can only produce maximum power at a particular voltage and current combination.

$$PM = I_{mp} \times V_{mp}$$

ix. **Current at Maximum Power Point:** It represents the current which the solar cell will produce when operating at the maximum Power Point. It is denoted by $I_{mp;}$ its value is always less than the short circuit current (I_{SC}). It is measured in ampere (A).

x. **Voltage at Maximum Power Point:** It represents the voltage that the solar cell will produce when operating at the maximum Power Point. It is denoted by V_{mp} and its value is always less than the open-circuit voltage (V_{OC}). It is measured in volts (V).

xi. **Fill Factor (FF):** It represents the area covered by $I_{mp} – V_{mp}$ rectangle with the area covered by $I_{SC} – V_{OC}$ rectangle. The fill factor represents the squareness of the I – V curve. It is represented in terms of the percentage (%), the higher the fill factor in percent the better is the cell.

- $FF = [MPP/ (I_{SC} \times V_{OC})] \times 100$

xii. **Efficiency (η):** The efficiency of the Solar cell refers to the percentage of input solar irradiance got converted to electrical power. The solar irradiance is measured in W/m^2. Therefore, to calculate efficiency multiply Solar irradiance by area of the cell. The efficiency can be calculated as follows:

$$\eta = [\text{Electric power } (W_p) / (\text{Solar irradiance} \times \text{Area})] \times 100$$

xiii. **Temperature Co-efficient:** The photovoltaic (PV) temperature coefficient of power indicates dependency of solar out power with cell temperature, meaning the surface temperature of the PV array. The output power of solar panel will decrease with increase in temperature. Hence, the value will be prefixed by a negative sign.

xiv. **Maximum Power Point Tracker (MPPT):** MPPT is an algorithm that is included in the pump controller used for extracting maximum available power from SPV array under a given condition. The voltage at which SPV array can produce maximum power is called 'maximum power point' voltage (or peak power voltage).

xv. **TDH:** Total Dynamic Head is the total elevation lift (including friction loss) required in the water supply system

xvi. **Static Water Depth:** It is the depth of water level below the ground level when the pump is not in operation.

xvii. **Draw-Down:** It is the elevation difference between the depth of static water level and the consistent standing water level in tube well during operation of pump set.

xviii. **Submergence:** It is the minimum height of water level after drawdown above the pump suction casing.

xix. **Manometric Suction Lift:** Manometric suction lift is the vacuum gauge/suction manometer reading in meter of water column when pump (Surface Mono-set) operates at suction lift.

xx. **Static Suction Lift:** Static suction lift/head is the vertical distance between sump water level and center of pump (Surface Mono-set) inlet.

xxi. **Daily Water Output:** It is the total water output on a clear sunny day with three times tracking SPV panel, under the “Average Daily Solar Radiation” condition of 7.15 KWh / m2 on the surface of SPV array.

2.3 System Components

i. PV Modules

PV Modules convert sunlight directly into DC electricity. Solar cells (which are normally made of crystalline, or amorphous silicon or other semiconductor compounds like Cadmium Telluride-CdTe and Copper Indium Gallium Selenide-(CIGS) are connected in series and encapsulated in a PV module. PV modules are rated for a particular power capacity at standard testing conditions (STC), which is also indicated on its label. The label will also contain details like V_{oc}, V_{mp}, I_{oc}, I_{mp} and temperature coefficient.

ii. Strings and Arrays

A number of PV modules connected in series is entitled a string. A string is designed such that it provides an output voltage in a range that is compatible with the solar Pump controller input voltage range. Strings are then connected in parallel in a PV plant to accomplish the desired DC capacity. When a number of strings are connected in parallel, it forms an array. Module in a string (i.e., in series) add up the voltage, and modules in an array (i.e., in parallel) add up the current.

iii. DC Cables

DC cables are used to carry DC current from the PV modules right up to the controller. The DC cable should be sized to carry the required current (along with necessary safety margins) and also limit the voltage drop (i.e., resistance losses). They are sized to carry the required current and also limit the voltage drop.

iv. DC Isolators

DC Isolators are required to disconnect the PV modules and strings from the rest of the PV system in cases of faults, fire, or repair. DC isolators are mandated globally; they should be clearly labelled and easily accessible.

v. SPV Pump Controller

SPV pump Controller are among the most critical components of the Solar PV water pumping system that not only perform power-related functions but are also responsible for the intelligence of the PV system. For protection from environmental factors, the controller should be rated for appropriate Ingress Protection (IP).

The major functions of the Pump Controller are to:

- Extract maximum power from the PV modules through MPPT for maximizing the water discharge
- Convert DC power into AC power (In case of AC Pumpset).
- Synchronize the pumpset with the frequency and voltage generated from PV string.
- Ensure protection of the solar powered pumpset against Dry running, open circuit, Output short circuit, under voltage and reverse polarity.

vi. AC Cables

AC Cables carry the AC power of the PV system from the Pump controller output to the pumpset in case of AC motor, which is typically at the ground and hence has to be carefully chosen critically to ensure safety as well as minimize power loss. While copper or aluminium cables can be used, it is highly recommended to use armoured cables. AC cabling practices are common in India, and suitable standards and certifications should be adhered to.

vii. Module Mounting Structure

Module Mounting Structures (MMS) are used to secure the PV modules in particular orientation to harness maximum sunlight. MMS are designed keeping several structural considerations such as:

- Load (weight) of the PV system
- Typical and maximum wind loads at that particular location (Designed load is generally taken as 150 km/ hr)
- Seismic zone safety factors
- Other considerations such as saline or corrosive environments

Most of the physical considerations are governed by Indian Standards. PV modules are often mounted at a tilt angle equal to that of the latitude of the location.

viii. Lighting Arrestors

While it is desired to protect all PV systems from lightning, It is highly recommended for PV systems to have dedicated lightning arrestors rather than depending on foreign rods and structures at greater heights that might exist at the time of installation.

ix. Earth Pits

Earth Pits used in solar PV systems are the same as conventional earth pits used for electrical installations. Separate earthing has to be provided for Lightening arrestor.

x. Motor-Pump Set

The Motor-pump set consists of the pump and the driving motor (AC/DC) or Surface Mono set. The pump works on the principle of transferring kinetic energy of impeller to the water thereby lifting the water to the required head. The head and discharge requirement of the site is the selection criteria for the pump set and SPV system. Based on the water source, appropriate pumpset type can be selected.

2.4 Principle of Working

The Solar Water Pumping System helps in utilising solar power for lifting water from an open well or bore well. The SPV water pumping system mainly consists of three major components. These are the pumpset, solar PV modules with mounting structure and the Pump controller. The solar panels convert solar energy into electricity in DC form (Direct Current). The DC electrical energy can be directly utilised for operating DC pumpset without any conversion or it can be converted into AC (using inverter) through pump controller. The Pump controller synchronises the pumpset operation

based on the frequency and voltage generation from the SPV panel. The electricity generation will be altered according to the sun shine hours and cloud cover.

3.Three Tier Quality Control Mechanism

3.1 Overview of Methodology

In order to ensure quality of Solar PV Water Pumping Systems, a three tier Quality Control Mechanism (QCM) has been developed. This three tier QCM is mandatory for systems installed under MNRE Schemes. These can also be used by stakeholders to ensure quality and performance of the Solar PV Water Pumping Systems installed beyond MNRE Schemes.

QCM needs participation of Vendor, State Implementing Agency (SIA), Third Party Inspecting Agency and MNRE.

a) **Vendor** supplies solar modules, pump controller, Pumpset and Balance of System (BOS) to the consumer. The Vendor is responsible for site inspection, feasibility analysis, design, engineering, civil works, supply, erection, testing, commission, operation and maintenance of the Solar PV Water Pumping System.
b) **State Implementing Agency (SIA)** are the designated implementation agencies for the Schemes of MNRE in specific State / Union Territory. SIAs implement, oversee and monitor installation and performance of Solar PV Water Pumping projects across the State.
c) **Third Party Inspecting Agency (TPIA)** is a firm or an individual expert engaged by MNRE for various services related to inspection, verification, progress monitoring, evaluation etc., of the Solar PV Water Pumping projects under various stages of pre-dispatch, installation and post-commissioning.

A matrix of all the three tiers with the stakeholders and the activities (in a typical Solar PV Water Pumping System) falling under each tier is provided below.

TIER I		
Project Cycle/ Stakeholders	**Pre-Dispatch**	**Post-installation**
State Implementation Agency (Utility/SNAs)	Pre-Dispatch Inspection for Modules, Controller, pumpset and BOQs ***(Annexure I)***	Post installation inspection ***(Annexure II)***
TIER II		
Third Party Inspection Agency	Applicable based on the term of engagement between MNRE and TPA as per the inspection report ***(Annexure I)***	Post installation inspection on sampling basis based on the terms of engagement between MNRE and TPA as per the inspection report ***(Annexure II)***
TIER III		
MNRE / Authorised institute by MNRE	Optional and random sampling basis as per the inspection report ***(Annexure I)***	On random sampling basis as per the inspection report ***(Annexure II)***

Table 1:Three Tier Quality Control mechanism

The basic framework of the three tier QCM is provided below.

(i) TIER-I

Under the Tier-I, the activities related to monitoring and assessing the quality control will be implemented by State Implementing Agency from their own quality control team resources or designated institutions authorised by SIA as applicable. These stakeholders may use formats of inspection or modify the templates (as per state regulations) as required to ensure quality of supplied materials from the Vendors and workmanship as per the Standards approved by MNRE. The empanelled Vendors will ensure the quality of the supplied materials from their respective suppliers in the supply chain of Solar PV Water Pumping System.

State Implementation Agency (SIA) shall be responsible for first tier Quality Control Mechanism (QCM). SIA/designated institutions authorised by SIA shall be responsible for the following: -

- Check acceptance tests/test reports of all materials of all empaneled vendors at vendors' site / warehouse as per Drawings / Technical Specifications as approved by MNRE and other applicable / prevalent Standards at the pre-dispatch stage
- Shall inspect 100% of Solar PV water Pumping System installations in its coverage area after its installation
- Shall inspect Solar PV Water Pumping Systems on random sampling basis or inputs from the remote monitoring systems, in its coverage area during the first five years of Operation & Maintenance

Quality Assurance shall be undertaken in the following areas of the project implementation: -

- Quality of material/equipment being supplied at pre-dispatch stage.
- Quality of works in the field.

(ii) TIER-II

Third Party Inspection Agency (TPIA) engaged by MNRE shall be responsible for second tier Quality Control Mechanism (QCM) on a random sampling basis.

TPIAs could be engaged typically by MNRE based on their availability of internal resources. The detailed Terms & Condition of the activity to be carried out by the TPIA would be elaborated at the time of engagement.

(iii) TIER-III

MNRE will be responsible for third tier Quality Control Mechanism. MNRE officials or any authorised Institutions designated by MNRE shall conduct quality checks during Pre-Dispatch and Post Installation levels. The frequency of inspection shall be as and when decided by MNRE. MNRE shall be responsible for the following: -

- MNRE shall randomly inspect vendors empaneled by SIAs in every State at vendors' site / warehouse / Manufacturing facility.
- MNRE shall review test records for major materials like Solar PV module, Pump controller, Module Mounting structure, Pumpset etc. as per the MNRE Specifications on a random sampling basis as and when required by MNRE
- MNRE shall inspect Solar PV water Pumping system installations implemented under the Central Financial Assistance in each state to assess the quality of the installations and its performance on random sampling basis.

4. Quality Control Mechanism

Quality Control Mechanism (Guidelines)

These guidelines can serve as a tool for assessing the quality of materials being used in the Solar PV water pumping system. The Vendor can use this as a check during material procurement. The chapter also provides guidance over the Mechanism to be followed during transportation, storage and installation of the components of Solar PV Water Pumping System.

Quality Control Mechanism at Manufacturing level

4.1. Solar PV Modules

4.1.1. Modules must qualify to IS/IEC 61730 Part I and II for safety qualification testing

4.1.2. Modules supplied with the SPV water pumping systems shall have certificate as per IS 14286/IEC 61215 specifications or equivalent National or International/ Standards. Lab certified STC performance data supplied with the modules shall not be more than one year old.

4.1.3. Modules must qualify to IEC TS 62804-1:2015 for the detection of potential-induced degradation - Part 1: Crystalline silicon (Mandatory in case the SPV array Open Circuit voltage is more than 600 V DC)

4.1.4. In case the SPV water pumping systems are intended for use in coastal areas the solar modules must qualify to IEC TS 61701:2011 for salt mist corrosion test.

4.1.5. The name plate shall conform the IS 14286/IEC 61215.

4.1.6. The power output of individual PV modules used in the PV array, under STC, should be a minimum of 300 Wp or as prescribed by MNRE through amendments/ Orders, with adequate provision for measurement tolerances.

4.1.7. The minimum module efficiency should be minimum 16 percent and fill factor shall be more than 70 percent

4.1.8. Module to Module wattage mismatch in the SPV array mismatch shall be within ± 3 percent.

4.1.9. The PV modules shall be equipped with IP 67 or better protection level junction box with minimum 3 numbers of bypass diodes of appropriate rating and appropriately sized output power cable of symmetric length with MC4 or equivalent solar connectors.

4.1.10. Frame of module should be made up of anodized aluminum and should have proper earthing point mark on the panel.

4.1.11. PV modules must be tested and approved by one of the NABL accredited and BIS approved test centers.

4.1.12. The RFID must be inside of module lamination. The module laminate, but must be able to withstand harsh environmental conditions must retrieve all the bare minimum parameters

4.1.13. Other details as per IS/IEC 61730-1 clause 11 should be provided at appropriate place

4.1.14. The PV Modules must be warranted for output wattage, which should not be less than 90% of the rated wattage at the end of 10 years and 80% of the rated wattage at the end of 25 years.

4.2. SPV Pump Controller

4.2.1. The pump controller should be certified as per IS 16221(Part 2)

4.2.2. Controller Power Capacity should be at-least equal to Solar Panels Power Capacity (Wp) and not Pump Capacity. Example: For 5HP pumps, the pump capacity will be 3750W as per MNRE Specs, the solar panel capacity will be at-least 4800Wp the controller capacity should match to the solar panel capacity.

4.2.3. Maximum Power Point Tracker (MPPT) shall be integrated in the controller to maximize energy drawn from the array. Should track power only and not Voltage at Maximum power point

4.2.4. The SPV Controller must have IP (65) protection or shall be housed in a cabinet having at least IP (65) protection.

4.2.5. A DC switch as per IS/IEC 60947-1 suitable for switching dc power ON and OFF shall be provided in the SPV Pump Controller.

4.2.6. Controller shall be integrated with Remote Monitoring System with GSM/GPRS and Geo tagging. GSM/ GPRS Charges to be included in the Costing till the end of Warranty period of the Pump set

4.2.7. The GPRS Module should have a horizontal accuracy of 10metre

4.2.8. The RMS should be provided with complaint management system

4.2.9. The RMS have provision for at least two Analog and Digital inputs with 0.1% accuracy to address the requirement of local sensors connectivity if required

4.2.10. The RMS portal should have details like ratings, Serial Number, Make, Model Number of Pump, Panel and Controller, IMEI number (of communication module) and ICCID (of SIM)

4.2.11. The RMS should allow the user to remotely operate the pump and should be supported with complaint management system.

4.2.12. All the Pump Controller should contain the following clear and indelible Marking Label & Warning Label as per IS16221 Part II, clause 5.

4.2.13. Customer care details should be clearly pasted on the controller

4.2.14. The LCD screen of the Controller should display the following parameters when connected in the system

- Pump status
- Array Input DC Voltage
- Array Input DC current
- DC/AC output Current & voltage
- Power
- Drive frequency
- Real time energy generation daily
- Water output
- water flow rate
- Running hours daily and cumulative

4.2.15. Adequate protections shall be provided in the SPV Controller to protect the solar powered pump set against the following:

a) Dry running;
b) Open circuit;
c) Output short circuit;
d) Under voltage;
e) Reverse polarity;

f) The controller should detect motor jam and unjam automatically

4.3. Surge Protection Device

4.3.1. For SPDs IEC 63227 and its updated versions or amendments should be followed.

4.3.2. At the DC Input side of the controller, it should have protection from an External Surge Protection Device of Type-2 or higher (i.e., Type-1) in accordance with the IEC 61643-31.

4.3.3. If the distance between the SPD and the controller to be protected is greater than 10 m, then SPD according to IEC 63227 should be applied.

4.3.4. The rated voltage of SPDs on the DC side depends on the type of protective circuit and the magnitude of the maximum operating voltage of the PV modules.

4.4. Cables

4.4.1. All cables used shall be as per IS 694 or IS 9968(Part 1)

4.4.2. Suitable size of cable shall be used in sufficient length for inter-connection between the SPV array to SPV Controller and the SPV Controller to solar powered pump set. Selection of the cable shall be as per IS 14536.

4.4.3. Cables should be flexible and should have good resistance to heat, cold, water, oil, abrasion etc.

4.4.4. The size of each type of AC cable selected shall be based on minimum voltage drop. However, the maximum drop shall be limited to 3%.

4.5. Module Mounting Structures and Tracking System

4.5.1. The raw material used and process for manufacturing of module mounting structure including welding of joints should conform to applicable IS 822.

4.5.2. The module mounting structure should be hot dip galvanized according to IS 4759. Zinc content in working area of the hot dip galvanizing bath should not be less than 99.5% by mass. The thickness of the zinc coating should be minimum of 80 microns.

4.5.3. The general hardware for structure fitment should be either SS 304 or 8.8 grade. Modules should be locked with antitheft bolts of SS 304 Grade.

4.5.4. Welding should be as per IS 822 and the grade of welding wire used should be of ER70S-6.

4.5.5. In order to make structure rigid, the gap between Telescopic pattern supports should be minimal, further, for bearing of center load of whole structure only pins should be used instead of threaded bolts.

4.5.6. To enhance the performance of SPV water pumping systems arrangement for seasonal tilt angle adjustment and three times manual tracking in a day should be provided.

4.5.7. Details of Module Mounting Structure and its specifications for pumps of capacity 1HP and above attached at ***Annexure-III***

4.5.8. These are indicative of minimum standards and an Implementing Agency may specify higher standards which shall be certified by recognized structural engineering department of any IIT/NIT or IISC.

4.5.9. The metallic structures should be of adequate strength and appropriate design, which can withstand load of modules and high wind velocities up to 150 km per hour. The site-specific seismic load shall also be considered as a selection criterion.

4.5.10. The Module Mounting Structure shall be designed in such a way that easy replacement of any PV module is allowed.

4.5.11. The mounting structure shall support for simple mechanical and electrical installation.

4.5.12. Welding of structure shall not be allowed on site.

4.6. Motor-Pump Set

4.6.1. The SPV water pumping systems may use any of the following types of motor pump sets in the range of 1HP (0.75kW) to 25HP (18.75kW):

a) Surface mounted motor-pump set
b) Submersible motor-pump set.
c) Any other type of the motor pump set after approval from Ministry.

4.6.2. The motors of the pump set may be of the following types: -

a) AC Induction Motor.
b) DC Motor (PMSM/BLDC/SRM)

4.6.3. The AC motor-pump set shall be tested independently for hydraulic and electrical performance as per the relevant IS specification including following test

a) Constructional requirements/features
b) General requirements
c) Design features
d) Insulation resistance test
e) High voltage test
f) Leakage current test

4.6.4. The Pumpset should be supported with Third Party Type Test Report.

4.6.5. In case of the DC motor-pump set for (a), (b), (c) declaration will be given by the vendor and for (d), (e), (f) the relevant clause of IS 9283:2013 will be followed for testing until BIS notifies the Standard about it. Once the Standard gets released then it will be effective for DC motor-pump set from its Date of notification.

4.6.6. As per IEC 61683, Total Harmonic Distortion (THD) for Voltage and Current should be less than 3 % at the Motor Terminal over the entire radiation profile and in order to achieve this, measures such as use of the choke coil (du/dt Filter) etc. can be adopted.

4.6.7. The suction/ delivery pipe shall be of HDPE or uPVC column pipes of appropriate size, electric cables, floating assembly, civil work and other fittings required to install the Motor Pump set. In case of HDPE pipes the minimum pressure rating of 8 kg/sqcm-PE100 grade for pumps up to 3 HP, 10 kg/sqcm-PE100 grade for 5 HP pumps and further higher minimum pressure rating for above 5 HP as appropriate shall be used.

4.6.8. The pump and all external parts of motor used in submersible pump which are in contact with water, should be of stainless steel of grade 304 or higher as required. Further for submersible pumps used in coastal areas or bores with higher salinity, preferably, SS316 or higher grade may be used.

4.6.9. Flat/Round cables insulated and sheathed with suitable polymer as per IS 694 shall be used.

4.6.10. The motor should have provision for earthing as per IS 3043.

4.6.11. The direction of rotation should be clearly marked.

4.6.12. The motor-pump set should have a 5 years warranty and therefore, it is essential that the construction of the motor and pump should be made using parts which have a much higher durability and do not need replacement or corrode for at least 5 years of operation after installation.

4.6.13. The motor pump-set and Controller used in SPV Water Pumping Systems shall be securely marked with the following parameters declared by the manufacturer:

Motor Pump-set

- Manufacturer's name, logo or trade-mark;
- Model, size and SI No of pump-set (To be engraved/laser marked on the motor frame);
- Motor Rating (kW / HP);
- Total head, m, at the guaranteed duty point;
- Capacity (LPD) at guaranteed head;
- Operating head range, m;
- Maximum Current (A);
- Voltage Range (V) and;
- Type - AC or DC Pump set; &
- Photo Voltaic (PV) Array Rating in Watts peak (Wp)
- Country of origin

Note: -In addition, a metal name plate containing the above details shall be fixed on the module mounting structure for the information of user.

Controller

- Manufacturer's name, logo or trade-mark;
- Model Number;
- Serial Number;
- Voltage Range;

- Power Range in kW for Controller; and
- Current rating (A)
- Country of origin

4.6.27. Under the "Average Daily Solar Radiation" condition of 7.15 KWh / sq.m. on the surface of PV array (i.e., coplanar with the PV Modules), the minimum water output from a Solar PV Water Pumping System at different "Total Dynamic Heads" should be as specified in the ***Annexure IV***. The actual duration of pumping of water on a particular day and the quantity of water pumped could vary depending on the solar intensity, location, season, etc.

4.6.28. Testing of Solar PV Water Pumping Systems shall be done as per procedure specified by the MNRE

4.6.29. Solar Photo Voltaic Water Pumping Systems shall be guaranteed by the manufacturer against the defects in material and workmanship under normal use and service for a period of at least 60 months from the date of commissioning.

4.6.30. Sufficient spares for trouble free operation during the Warrantee period should be made available as and when required

5. Quality Control Plan during installation

5.1. General Safety Guidelines

Before starting installation work, identify all personal health and safety risks related to the project site. After identifying all possible risks, suggest the ways to mitigate the risks so that they are corrected before proceeding with the installation and commissioning work.

A wrong safety assessment will impact the installation schedule and could result in serious injury to the installer and other personnel in the vicinity.

Risk involve during PV system installation are:

- Electrocution - When the wiring of the PV modules in series creates a solar array with a DC voltage,it reaches a “deadly” voltage (≥120 V DC);
- Injuries from lifting and installing structure & controller;
- Injuries from falling objects;
- Exposure to the Sun;
- Insect bites – some insect may be poisonous;
- Cuts and bumps;
- Thermal burns;

Personal safety resources:

- A work partner (never work alone);
- Safety plan & first-aid kit;
- An understanding of safety practices, equipment and emergency procedures;
- Safety helmet & eye protection;
- Proper measuring equipment: electrical & dimensional;
- Appropriate safety harnesses;
- Tape, wire nuts or cable connectors to protect cable terminals;
- Fire extinguisher;
- Suitable labels on all equipment, wiring, etc

Electrical Safety

Major causes for these fatal accidents are snapping of conductor, contact with live wire/ equipment, leakage current, defective tools and apparatus, negligence on safety measures and inadequate maintenance of electrical wiring.

In a SPV water pumping system, multiple numbers of PV modules are connected in series, producing a DC voltage and conversion of AC voltage in case of AC pumpsets. Therefore, in the event of any fault or leakage, any metallic part of a solar PVsystem can potentially cause electric hazards in the form of shock, arcing and fire. Hence only certified electricians trained in solar PV installation are to be engaged to install, operate and maintain electrical components and equipment in a Solar PV water pumping system.

The following procedures must be followed by the PV system installers and supervisors:

i. Ensure all personnel safety resources are available and in good condition;
ii. Check all electrical measurement equipment for function and accuracy;
iii. Check the existing earthing system at the project site using the earth resistance tester;
iv. Make sure there are no uninsulated electrical cables passing through the installation area;
v. Cordon off the working area during installation;
vi. Do not presume that everything is connected and working as designed;
vii. Do not trust switches to operate perfectly and do not “believe” schematics;
viii. Always “test before you touch” to establish whether circuits are live or not;
ix. Ensure that the earthing structure is completed and tested before fixing the modules;
x. Do Not connect the module in series while fixing the modules on the structure;
xi. Strings should be connected only when the system is ready for commissioning;
xii. Ensure that no exposed DC cables are lying on the ground;
xiii. Ensure that the string cable joints are not exposed and soaked in water;
xiv. Tighten the string cable joints (MC4 or equivalent) using appropriate tools and NOT by hand;
xv. All DC/ AC cables must be protected from any possible physical damage.

Fire safety

A SPV water pumping system consists of several modules, connected in series which produces DC voltage ranging from 150V to 600V. With such a range of DC voltage, it is very easy for an electric arc tobe established and hence subsequent fire as a result of loose connections or short-circuit in the system. Fire ina PV system primarily results from poor installation, wrong system design, underrated cables, loose connection, poor O&M, incorrect or faulty equipment, and most importantly, damaged DC cables as a result of mechanical stress, action of animals or vermin.

***Note**: -PV module is a current limiting device and fuses installed in the strings are sized based on current at peak solar irradiance. Since solar radiation level is normally at lower level than the peak value, fuses are not likely to operate under short-circuit conditions. In such case a short circuit fault in the system may be unnoticed and unattended.*

5.2. Solar PV Water Pumping System Installation Procedure

Before starting the installation process, the installer must go through all installation documents and verify the quantity and availability of listed equipment, accessories, and tools for installation and commissioning of the solar PV water pumping system. Verification of the quantity and availability must be done before starting the installation procedure to minimize the risk of project delay or an incomplete job due to non-availability or shortage of the equipment, accessories and tools. The installation and commissioning procedures for SPV Water Pumping System are presented in twelve steps. These steps are to be followed in sequence.

Step 1: Site Assessment

Step 2: Installation of PV array mounting structure

Step 3: Installation and testing of Mounting Structure Earthing System

Step 4: Installation of PV modules

Step 5: Earthing of PV Module Frames

Step 6: DC cabling

Step 7: Installation of Pump Controller

Step 8: Pump Controller to Pumpset cabling

Step 9: Pumpset installation

Step 10: Installation of Lightning arrester

Step 11: Pre-commissioning tests

Step 12: Commissioning the system

Preparation for Installation

In addition to the system components, the following are common tools used in Solar PV water pumping system installation:

- Flashlights
- Mirrors
- Magnifying glass
- Tape measures
- Compasses
- Levels
- Protractors
- Solar Shading Calculators
- Voltmeters
- Ammeters
- Watt & Watt-hour meter
- Power quality equalizers
- Multimeters
- Calculator
- Wire stripper
- Impact drivers
- Utility Knife
- Screwdrivers
- Hammers
- Pliers
- Hardhats
- Safety glasses
- Safety gloves
- Safety shoes

Step-1 Site Assessment

An initial visit to the site is a critical step in the system installation process. It serves to confirm feasibility of the installation and aids in planning of the system installation. In carrying out the site visit, the following factors need to be checked/confirmed/assessed:

1. Shadow free Space availability
2. Site layout
3. Shadow analysis
4. Site orientation
5. Assess the Borewell details including the distance between array location & borewell, depth of bore well, depth of pumpset installation, Soil condition, etc.
6. Assess the wind velocity at the site and confirm with the structure stability

Factors to be considered for SPV array location

Firstly, the position of the array needs to be determined. Solar panels produce the most electricity when they are perpendicular to the sun. Since the sun moves all day, it is not practical to keep moving the panel all day to keep it perpendicular to the sun (unless a tracking system is used but it is expensive). The performance of the array is influenced by:

1. Shading

When a solar panel is shaded in whole or part, for example, by tree branches and or a building, it captures less energy from the sun thus its performance is reduced. Less voltage and current

will be produced. This is because most solar cells are connected in series such that if one of the cells is not producing some energy, the output will be reduced. Even minor shading can result in significant loss of energy.

Seasonal cloud patterns, local shading and environmental factors need to be taken into consideration when orienting the array. In the tropics shading could vary due to the sun being in both north and south parts of the sky at different times of the year. If available, it is best to use a solar survey instrument that clearly shows where shading will occur at different times of the year

Note: -

Shading does not only lead to lower generation but can also damage the PV modules over a period of time

2. Orientation

Solar panels should be installed south facing in the Northern hemisphere and north facing in the Southern hemisphere. Since India is in the Northern hemisphere, Solar panels will be installed always- South facing in our country. The directions North-South may be found with the help of Magnetic Compass.

3. Tilt

Maximum performance can be achieved on tilting the photovoltaic array towards the sun. Adjustment of the tilt angle can be done in both tracking and non-tracking system where the optimum tilt angle is determined by the location (latitude)

Tasks to be performed during site survey:

Must have tools for site survey:

- Personal protective equipment (as applicable to site condition)
- A Solar Pathfinder or Sun eye to identify / determine shadow free area
- A compass to record direction (Mobile app is available)
- A measuring tape/ digital distance meter to measure distance
- An angle measuring equipment (Mobile app is available)
- A notebook
- A working partner (Never survey a site alone)

1) Determine PV array location:

a) Carry out shadow analysis to find the area which is free from shadow in all days of the year. Objects that come in the path of the incident solar rays any time during the day, will cast shadows and hence reduce the solar generation. A taller object located in the east direction would cast shadows during morning and a taller object located on the west direction would cast shadows during the afternoon. When multiple rows are placed, one row can cast shadow on the other if not properly placed. Highly accurate and user-friendly tools are available for conducting shadow analysis that can assess the requirement.

b) Ensure that the PV array will have safe access for maintenance and fire safety

c) Ensure that PV array has ample space for air cooling

d) Ensure that modules are protected from theft and vandalism

e) Ensure that PV array is nearer to the Pumpset

2) Determine suitable location for Controller and other electrical equipment:

a) Location of Pump controller should be such that it is accessible for operation

b) Minimum distance from the PV array to reduce losses

c) The controller location should have protection from environment factors

d) Controller should be installed in such a place where there is enough space for cross ventilation, heat dissipation and maintenance.

3) Identify cabling routes and therefore calculate the required cable run distances:

Determine cable routes and hence cable length based on array location, controller location and location of Pumpset. Minimum distance between solar array & controller and controller & Pumpset is preferred.

Follow the steps below:

a) Verify the location of equipment and routing of the cable at the site and measure cable length and compare with the drawing / design documents prepared by the installer;

b) Determine the length of conduit or cable tray required for the installation

Step- 2 Installation of PV array mounting structure

It is very common for PV array mounting structures to be conceptualised and designed primarily to enhance energy generation considering area specific tilt angle and use of tracking facility etc. Apart from the strength and wind loading capacity, a mounting structure must ensure that the PV array receives optimum solar radiation and reduces temperatures loss by

allowing enough air circulation. It is also important to ensure that factors such as structure design, placement, orientation, tilt and shading are aligned with the electrical string design.

Points to remember

i. The steel structure will be hot dip galvanised and the aluminium structure will be anodized. These coatings protect the structure from corrosion. Do not drill, weld or cut the structure at the site. This will damage thecoating and corrosion will be accelerated.

ii. Ideal orientation of a fixed PV Array should face towards true south (in northern hemisphere)

iii. The area under the solar modules should be accessible for maintenance of the solar modules and for control of the growth of vegetation under the array.

iv. The tilt angle is mainly determined by the latitude of the location

v. Foundation should be as per the site condition, based on the properties of soil. Foundation can be done either with the help of 'J Bolt' (refer IS 5624 for foundation hardware) or direct pilling, it should be decided as per the site and relevant IS i.e., IS 6403 / 456 / 4091 / 875 should be referred for foundation design.

vi. The Design of foundation should be such that the safe Bearing Capacity of Soil (as obtained at site) is not exceeded. The work includes necessary excavation, concreting, curing, piling (if necessary), back filling, shoring, shuttering etc.

vii. The foundations should be designed considering the weight and distribution of the structure and assembly and a wind speed of 150 km per hour.

viii. Seismic factors for the site have to be considered while making the design of the foundation.

ix. The foundation design for different MMS has been attached in ***Annexure V***

x. In areas of sandy soil, foundation should be protected against tilt

xi. In case of more than one array, the spacing should be such that the shadow of one array doesn't fall on the other.

Procedures for Installation of Mounting Structure

1. Check the direction using compass
2. Mark the reference points on ground for column erection along east west direction so that the panels are oriented towards south.

3. Dig pit along the marked points with dimensions as per the Annexure V
4. The foundation design for the columns should be as per the diagram attached in the Annexure V.
5. Place the reinforcing steel as per the foundation design
6. Fill the pit with concrete mixture whose composition should be as per M20 standard. Water used should be of clean and clear water with suitability for drinking purpose. The mixture should be well mixed for a minimum period of 2 minutes and uniformity should be ensured. While pouring concrete mix, care should be taken that the concrete is devoid of air pockets. Sufficient curing time shall be provided for the concrete.
7. Bolt the main column to the foundation and assemble the structure. At each and every stage, ensure the perpendicularity of the column using plum bob.
8. Ensure the column-to-column distance and level of the columns are as per the requirement
9. Assemble and fasten the structure.

Step- 3 Installation and testing of mounting structure earthing system

After installation of module mounting structure, the next step is to provide a continuous equipotential bond between mounting structure and module frames.

Following procedures to be followed:

1. Verify the earthing conductor routing plan
2. Prepare earth terminal bar / conductor, lugs, clamps, earthing rod and earth pit
3. Ensure all module frames and each part of mounting structure are electrically bonded
4. Use proper WEEB for bonding
5. Find the best location for earthing pit where soil is wet and resistivity is least
6. Attach the earthing terminal bar /wire with earthing rod
7. Connect terminal bar to structure
8. Ensure all the connections are neat and tight
9. Test earthing continuity and resistance of earth electrode after installation
10. Follow the same procedure for earthing pump-set and Pump controller

Procedure for measurement of earthing continuity and earth electrode resistance using earth resistance tester (Megger) – Follow in sequence

1. Short the P1 and E1 terminal of the Earth resistance tester;
2. Connect the electrode under test to E1 terminal of earth resistance tester;
3. Using a hammer, dig an electrode at a distance (D) of minimum 30 meter from the test Electrode;
4. Connect this electrode to E2 terminal of earth resistance tester;
5. Using a hammer, dig another electrode in between both the electrodes at 50% of D;
6. Connect this electrode to P2 of the terminal;
7. Take reading by rotating the handle of Earth resistance tester or press push button;
8. Repeat the above procedure by changing the location of middle electrode to 40% and 60% of D;
9. To get the resistance of electrode, take mean of these three readings.

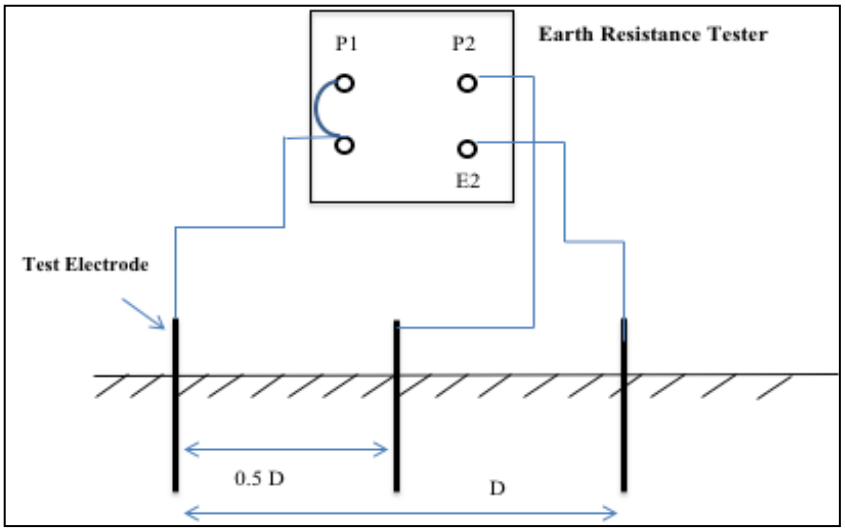


Figure 1: Illustration for Earth Electrode resistance testing

Position of Middle Electrode	Measured Electrode Resistance (ohm)
50% of D	
40% of D	
60% of D	
Mean	

Table 2:Table format to record the earthing resistance

Note: -Desired electrode resistance is around 1 Ohm and it must be lower than 5 Ohms.

Step-4 Installation of PV modules

Handling and Packaging:

a) Solar modules should be stacked, packed and transported vertically and separators should be placed between each module. Horizontal stacking should be avoided.
b) If due to unavoidable reasons, the modules are required to be stacked horizontally, introduction of a good buffer material between each module and around the modules is necessary to reduce potential damage. Also, additional protection is to be added to the four corners of each module and not more than six modules should be packed in one box.

Important to Note:

Solar modules should be stacked, packed and transported vertically. Horizontal stacking of the modules causes stress on the modules at the bottom and can lead to micro-cracks that will not be detected by naked eyes. Even if the separators are used, they are not strong and wide enough to sufficiently separate the modules from each other, thus the upper layers of the stack cause weight stress towards the lower layers that leads to micro- cracks in the cells.

Loading, transport and unloading:

a) Modules may damage externally or internally, causing micro cracks while loading, transport and unloading. Any external damage or breakage is visible but internal damage to cells is not visible by naked eye and therefore precaution during loading, transportation and unloading should not be underestimated if there is no visible damage to the modules.
b) To avoid breakage and micro-cracks during loading, transportation and unloading of modules, the modules must be packaged properly even if the distance of travel is short. Rough handling during loading and unloading and walking on the package must be avoided. While carrying the modules in a truck on a bumpy road, the speed of the truck must be controlled and kept at minimum to avoid vibration and jerking.
c) PV modules should be unpacked in the vertical manner by two persons. Also, care should be taken to avoid falling over of one module onto the other inside the packaging box.
d) Do NOT use a knife to cut the zip-ties, instead, use wire cutting pliers

Storage of PV modules:

a) Similar to packaging, solar modules should be stacked, packed and stored vertically and separators should be placed between each module.
b) Horizontal stacking and storing should be avoided.

Mounting

a) Solar modules should be attached to the array structure using the mounting holes provided by the solar module manufacturer
b) The mounting of the PV modules should allow for the expansion and contraction of the PV modules due to temperature changes under the expected operating conditions.
c) Where modules are installed in such a way that a junction box is mounted to the side or at the bottom of the module, care must be taken to ensure this is permitted by the manufacturer.
d) The Solar module frame must be electrically isolated from the steel using a layer of non-conductive material.
e) Stainless steel screws, washers and nuts should always be used to fasten solar modules to the array frame.

Things to be noted

- Use of insulated tools and gloves while working with modules;
- Do not step on the PV module as this will damage to the solar cells inside the module;
- Ensure electrical connectors are well protected from ingression of water and dust;
- Do not install/ handle PV modules under gusty winds and if there is rain;

Step - 5 Earthing of PV Module Frames

i. After physical installation, PV module frames are to be bonded together and connected to main earthing conductor of the mounting structure.

ii. The earthing conductor must be properly fastened to the module frame to ensure good electrical contact.

iii. PV module frames have anodised coating which is an aluminium oxide and it works as insulation. Therefore, appropriate means should to be employed, which will crash the aluminium oxide coating and establish electrical bond between PV module frames and the structure. Manufacturers may provide specifically marked connections points without insulation so as to ensure proper connection.

iv. The earth/grounding cable can be insulated unsheathed cable. If exposed to direct sunlight the cable shall have a UV coated physical barrier to prevent exposure to direct sunlight.

v. The earth/grounding cable should be installed in parallel with and in close proximity to the PV array cables (both positive and negative) and the pump controller cables until connected to an earth rod connected in the ground.

After physical installation and establishment of earthing bond of the frames, PV modules are connected in series electrically to form a string.

Series Connection of Solar Panels

a) For increased voltage requirement, solar panels should be connected in series.
b) Solar panels shall be connected in series as per the voltage requirement of the pumpset. The maximum number of solar panels that can be connected in series can be fixed such that the sum of the V_{oc} of the solar panels should not exceed the Voltage rating of the controller. In this case, current remains the same.

Note: The Solar panels connected in series should be identical in all specifications

Parallel Connection of Solar Panels

a) For increased current requirement, solar panels should be connected in parallel.
b) The strings containing serial connected solar panels can be connected in parallel to match the current requirement of the pumpset. The summation of the current should not exceed the current rating of the controller.

Note: The Strings connected in parallel should have same number of Solar Panels

Precautions to be taken while wiring modules:

i. Only a trained and qualified installer should perform all wiring;
ii. Use stainless steel clamp or UV protected cable tie to fix cables;
iii. DO NOT connect all the module in series to avoid high DC voltage;
iv. Final connection will be done when the system is ready for commissioning;
v. Ensure electrical connectors are well protected against corrosion and soiling;
vi. Ensure that connectors are corrosion free, cleaned with absolutely no gaps between the contacts;
vii. DO NOT allow any inflammable liquids/gases near installation area.

Note: - While connecting modules, each string should have one MC4 disconnected until all wiring to the controller has been completed. This is to ensure that no one is working on live dangerous DC voltage.

Procedure for module wiring or stringing:

1. Review the DC cable wiring diagram;
2. Review module interconnection (string or series) diagram;

3. Check that there isn't any bare cable in module wire;
4. Connect DC cable connector (MC4 or equivalent) properly;
5. Connect number of modules in series in accordance with the wiring diagram provided;
6. Attach the cables with cable tie wraps to the module frame and/or rails;
7. Ensure minimum looping in cable;
8. Ensure NO cable is hanging loose;
9. Label the terminals with "+" and "-" sign using cable tag.

Note: -

(1) Always verify the voltage and polarity of each individual string before making a parallel connection. Electrical and electronic components can be irreparably damaged if an array string is connected in reverse polarity to another.

(2) Minimize the area of conductive loops to reduce the magnitude of lightening-induced overvoltage

(3) Maintain correct cable routing

Step - 6 DC cabling

It is important to minimise voltage drop loss in the cables for a desired performance of solar PV systems. Ensure that aggregate voltage drop in all DC cables is less than 3% as recommended by IEC 62548 PV array design requirements.

When wiring the array frame and the cable to the pump controller, following points to be noted:

i. Cables should be protected from Mechanical damage & it should not lie on the ground without any enclosure or conduit.
ii. All conduits exposed to sunlight should be UV treated
iii. Connections should be ensured for tightness and protected against moisture entry.
iv. The cables should be enclosed inside a PVC conduit of IS standard or black drip pipe used for covering panel wiring and which should be buried in the ground by 1 foot
v. In areas of fauna existence, cable protection measures should take into account the possible damage caused by fauna.

Step – 7 Installation of Pump Controller

Points to remember

i. Temperature is detrimental for controller operation. It is recommended to position the controller in a secured place such that it gets protected from direct sunlight and other extreme weather events.
ii. Adequate insulation shall be provided to controller from thermal, electrical and mechanical loads/ shocks.
iii. Controller should be vertically mounted.
iv. Proper ventilation should be ensured.

Procedures to follow:

1. Read controller installation and operation manual carefully;
2. Ensure that there is adequate ventilation for the controller
3. Ensure that no direct sunlight falls on the controller;
4. Ensure that the controller is nearer to the array and not to the pumpset
5. Mount the controller with accessories provided by the manufacturer
6. Openings in the controller should be properly sealed to restrict vermin entry at the same time ventilation should not be affected
7. Install the earthing connection as per controller installation manual;
8. Tighten the cable glands using appropriate tools.
9. Connect the DC cable from array to the controller through MCB.
10. Connect the AC cable from the pumpset at the appropriated gland once the pumpset is installed.
11. All connections should be done with proper lugs.

Step – 8 AC cabling

The next step is to install cable connection from Pump controller to Pumpset.Ensure that total voltage drop in all cables is less than 3% according to IS 14536.

Points to be noted:

1. Suitable size of cable shall be used in sufficient length for inter-connection between the SPV array to SPV Controller and the SPV Controller to solar powered pump set. Selection of the cable shall be as per IS 14536.

2. The cable should run through a PVC conduit of suitable size buried in the ground at a depth of 1 foot
3. The connection to a surface water pump shall be with the connectors provided by the manufacturer.
4. The cable connected to a submersible pump shall be suitable for installation in water.
5. It shall not be used to support the weight of the submersible pumpset.
6. The connection to the pump motor shall use the waterproof connectors provided by the manufacturer.
7. The pump cable should be tied to the pump's discharge water pipe (sometimes called the rising main)

Step – 9 Pumpset installation

For Submersible Pumpset

Pre-installation Checks

- Ensure that the inner diameter of the borewell is more than that of the pumpset diameter.
- Rough spots or sharp edges on the top lip of the borewell casing should be smoothed out to prevent damage to the power cables.
- The power cables and lifting rope shall be clamped to the discharge pipe at specific interval.
- **Water Filling** of Water Filled Type Submersible Motor. The motor has to be filled with clear, cold fresh water only

Procedure:

i. Remove the drain plugs provided at the top of the motor.
ii. Fill the motor completely with clear water.
iii. Check and remove the air bubbles if any and then fill the loss of volume
iv. Fix the drain plugs securely so that zero water leakage is ensured

- **Motor and Pump Coupling**:

i. Erect a supporting clamp / Tripod stand.
ii. Suspend the pump for coupling with the motor.
iii. Clean the motor and pump seating surface before it is coupled.
iv. Lift and lower the pump on the motor so that the pump shaft with coupling is inserted onto the motor shaft.
v. Tighten all the nuts equally and firmly. Also refer the manufacturers operating manual

for any other type of couplings and procedures.

vi. Check the coupling for free movement.

vii. Fixing of the cable guard and strainer is recommended.

- **Lowering the Pumpset**:

i. Flush the bore well before lowering.

ii. Align the pumpset carefully with the borewell casing.

iii. Lower the pump slowly without forcing.

iv. Check valves shall be installed at appropriate length of the discharge line to prevent the water travelling back to pump.

v. Pumpset should be lowered below the drawdown level but it should not rest on the borewell bottom.

- **Cable Joining Procedure**:

The cable joint can be made as follows:

i. Check for the damage in the motor and drop cables.
ii. Strip and trim off the insulation for a specified length and indent the conductors.
iii. Tape the joints so that air space is eliminated and joint is securely protected against water seepage.
iv. Check the insulation of the joint using megger.

- Earth the cables as per IS 3043 and make electrical connections between pumpset and Controller

For Mono-set

The following factors come into play in the installation of a pump:

a) The pumpset location shall be selected such that the suction lift ca be minimized and ensure that the lift is within the permissible level.
b) Raising slope shall be maintained in the suction pipe so that air pockets and unprime risks can be avoided.
c) The pumpset shall be placed in a well-ventilated pump house for heat dissipation and easy accessibility

Points to remember

i. Check the insulation resistance using megger
ii. It is recommended to install the Mono-set on concrete foundation.

iii. Connect the suction and discharge pipes of size recommended by the manufacturer. Shorter Suction pipeline will reduce the frictional head loss
iv. Eccentric reducer is preferred and control valve is not advisable on suction side
v. Large radius air tight smooth curved joints shall be preferred for uniform flow and reduced friction loss.
vi. Check the squareness of the pipe joints.
vii. Provide support and anchor to the pipings independent of the pump, so that the pump casing will be free of strain.
viii. Foot valve with wider mouth and larger area of openings is preferred
ix. Properly connect the foot valve at the end of the suction and it should not rest at the bottom of the sump.
x. Avoid air lock through foot valve by ensuring minimum water level in the sump.
xi. Earth the Mono-set using the provision provided as per IS3043.
xii. Ensure proper electrical connection between Pump controller and Mono-set.

Step-10 Grounding and Lightning Arrestor installation

The purpose of grounding any electrical system is to prevent unwanted currents from flowing (especially through people) and possibly causing equipment damage, personal injury, or death. Lightning, natural and man-made ground faults, and line surges can cause high voltages to exist in an otherwise low-voltage system. Proper grounding, along with over current protection, limits the possible damage that a ground fault can cause.

i. The Earthing shall be done in accordance with the IS 3043 including its amendments and updated versions.
ii. The Earthing system should be designed in such a way that it should able to restrict the potential of each conductor according to the level of insulation applied and magnitude of the current conducted through human body should be less than the value that can cause ventricular fibrillation of heart.
iii. Before proceeding for the installation of the pumps one-time line diagram of the electrical connections along with the earthing connection for Solar Water Pumping System should be submitted for each capacity of surface/submersible and AC/DC type of the pumps to the State Implementing Agency.
iv. Earth connections shall be done such that they are visible for inspection and all the earth electrode can easily be tested at any point of time.
v. It is recommended to keep the value of resistance of earth electrode less than 5 ohms.
vi. All the materials, fittings etc. used for doing earthing shall conform to the Indian standard, wherever exists.

vii. The actual value of soil resistivity should be considered while designing the earthing system at site and for reference, selection criteria of the site, for any type of soil treatment to improve earth electrode resistance, etc. the IS 3043 shall be referred.

viii. The electrode material should be selected according to the corrosivity of the soil in which it is used, for the relation between resistivity and corrosivity of the soil and method to safeguard conductor against the excessive corrosion the IS 3043 shall be referred.

ix. It is recommended for selection of type and installation of the earth electrode the provisions of the IS 3043 should be considered. However, the pipe or rod type earth electrode is preferable.

x. In case of the two-earth electrode or more the separation among them should be twice the length of the electrode driven in the ground. Except in special conditions (for e.g.- where the soil is hard to dig out), a number of electrodes in parallel are to be preferred to a single long electrode.

xi. The provisions given in the IS 3043 should be considered while selecting or connecting the earthing/protective/grounding conductor from the components to the earth pit.

xii. Separate earthing conductor shall be provided for controller, pumpset and SPV array etc. for its connection to the earthing pit and it should be continuous in nature for electrical conductivity. However, in no case, even for the earthing of light current equipment (for example, high voltage testing equipment), should the cross-sectional area of the earthing lead be less than 6 mm2.

xiii. For the maintenance of the earth electrode and measurement of the Earth electrode resistance the provisions of IS 3043 shall be referred.

xiv. Motor shall have suitable provision for earthing to facilitate earthing of the motor as per IS 3043 at the time of installation. In case GI pipes are used for the purpose of earthing the motor, earthing connection may be made to the discharge pipe clamps. However, in case of HDPE/PVC pipes, a separate metallic cable from the motor to the control panel shall be provided and earthing given as if four-core cable is used, the fourth core not connected to the terminals can be used for earthing.

xv. Lightning protection shall be provided as per IEC 62305 and IEC 63227 standard including its amendments and updated versions.

xvi. An external lightning Rod, whose height should be more than the highest point in the system with lightning protection system (LPS) designed to comply with class III or higher shall be installed as based on the requirement of the site which in turn depend upon the area-specific lightning activity, etc. parameters.

xvii. Arrangement and positioning of the separate air-termination systems can be determined using different methods given in the IEC 62305-3. While determining position following points to be considered such as: -

a) The structure to be protected is fully located within the protected volume provided by the air-termination system.
b) There should be separation distance between the air-termination system and PV power supply system to prevent dangerous sparking against parts of the PV power supply system in case of the direct lightning. The separation distances determined in accordance with IEC 62305-3 & IEC 63227 shall preferably be maintained.
c) The possibility of the PV modules being shadowed by air-termination systems shall be taken into account and distance from the PV modules can be calculated using the IEC 63227.

xviii. A separate earth electrode is required for the dispersion of the lightning current into the ground with suitably low value of the earthing resistance i.e. less than 5 ohm. And the minimum length (l_1) of vertical earth electrodes for lightning protection level III or higher shall be determined according to the IEC 62305-3.

xix. The cross section of the metal sub-structures used for the connection of the lightning arrestor to earth electrode should be no less than 16 mm^2 Cu or 25 mm^2 Al or GI of equivalent current carrying capacity should be used, which will also depend upon the class of the Lightning protection system.

Points to remember while handling Lightning arrester

i. On receipt of the unit, inspect the structure for any visible damage
ii. Lightning arrestor should be preferably stored indoors
iii. The arrestor should be handled only in upright position
iv. The line terminal connection should be made without giving an excessive strain to the arrester.
v. Perpendicularity of the arrestor should be maintained and ensure that the lugs rest solidly on the mounting surface.
vi. Tighten the bolts firmly.

Step - 11 Pre-commissioning tests

After completion of installation process, a pre-commissioning test has to be performed. Conducting a pre-commissioning test is very important to ensure there are no wrong connections in the system.

The Procedure for pre-commissioning test is as follows:

1. Make sure all the components of the systems are tested for the desired performance and protection in case of any fault as per the specification of the MNRE and relevant IS/IEC standard. Further, also ensure that the insulation testing of AC and DC cables is done to prevent any leakage of the current.

2. Ensure that the PV arrays (string or strings) are in segments
3. Make sure that DC switch isolators is in the 'OFF' position.
4. Ensure that the controller is turned OFF.
5. Measure and confirm that no voltage is present across any string.
6. Measure and confirm that no voltage is present on the output side of the controller.
7. Check continuity of cables and complete the array cabling.
8. Confirm that the polarity of each of the array connections is correct.
9. Measure and record the open circuit voltage of each string as shown in the table below.
10. Measure irradiance, ambient temperature and cell temperature at the same time.
11. Observe variation between effective (string) voltage and measured (string) voltage.
12. Measure and record the open circuit voltage (V_{OC}) at the input to the Controller.
13. Check the polarity and continuity between the PV array and the controller
14. Check the continuity between the controller and the pumpset.
15. Measure the resistance of the earth system.

Table 3: Format of Table to record String Voltage

Format of table to record string voltage:

String No.	Irradiance (W/m^2)	Ambient Temp (^oC)	Cell Temp (^oC)	V_{OC} Effective (V)	V_{OC} Measured (V)	Variation of V_{OC} (%)	Acceptable (Yes/ No)
String 1							
String 2							
String 3							

Step-12 Commissioning the system

When the conductors and connections are acceptable and the system has successfully passed the pre-commissioning testing, then it's time to commission the system.

Commission the system as follows:

(1) Refer to the controller's system manual and follow the start-up procedure

(2) Measure the DC input voltage and confirm that it is within the operating limits of the controller

(3) Measure the output voltage of the controller and ensure that pumpset is operating at rated

current

(4) Check the discharge of the pumpset.

(5) Check the parameters in the LCD screen of the controller and ensure that they are aligned with the system rating and on-site measurement.

5.3. Measuring Equipment

I. I-V Tester

I-V tester is a highly effective tool to check for deterioration in performance of the system. It can be used to identify and locate module or wiring issues and compare power generation performance against previous performance data or product warranty data. I-V curve measurements can also highlight the effect of partial or uniform shading and demonstrate the improvement in performance after module cleaning.

II. Thermography Camera

IR imaging is done to determine the causes of power deficiencies in several components of the PV plant. O&M personnel can use a number of diagnostic procedures. Thermal imaging of all the PV plant components like PV modules, array junction boxes, Pump controller, and cables is used to identify faults in the system that may not be visually identified.

III. Clamp Meter

A clamp meter is an electrical testing tool that combines current sensor with a basic digital multimeter. The clamps measure current and the probes measure voltage. Having a hinged clamp jaw integrated into an electrical meter allows consumers to simply clamp around wire, cables and other conductors at any point in the electrical system and measure its current, without disconnecting it. It measures AC & DC voltage, AC current, continuity, resistance, and with some models, DC current, temperature, capacitance, frequency and more. Typically, they measure to the nearest tenth of a unit making them perfect for electrical work.

IV. Pyranometer

An instrument for measuring the intensity of solar irradiance, normally used to measure global irradiance on a horizontal plane. Pyranometers are generally high precision, high-cost instruments using thermal sensors in a glass dome. The dome on a pyranometer acts as a radiation filter that blocks thermal radiation. The working principle of the pyranometer mainly depends on the difference in temperature measurement between two surfaces like dark and clear. The solar radiation can be absorbed by the black surface on the thermopile whereas the clear surface reproduces it, so less heat can be absorbed. The thermopile plays a key role in measuring the difference in temperature. The potential difference formed

within the thermopile is due to the gradient of temperature between the two surfaces. These are used to measure the sum of solar radiation.

V. Multimeter

A Digital Multimeter is a measuring instrument which can measure several parameters of an electric circuit. The standard measurements it performs is mentioned described in this section.

The parts of the multimeter include:

- Display screen: The screen displays the numerical value of the parameter being measured
- Selection knob: A multimeter performs many tasks like reading voltage, current and resistance. The selection knob allows the user to select the required task.
- Port: There are two ports on the front of the unit. One is the mAVΩ port which allows the measurement of all the three units: current up to 200 mA, voltage, and resistance. Various types of digital multimeter are commonly used to measure the output of the PV module and string as well as to test controller and other circuits.

VI. Megger

The Megger test is a method of testing making use of an insulation tester resistance meter that will help to verify the condition of electrical insulation**.** Insulation resistance quality of an electrical system degrades with time, environment condition i.e., temperature, humidity, moisture and dust particles. It also gets impacted negatively due to the presence of electrical and mechanical stress, so it's become very necessary to check the IR (Insulation resistance) of equipment at a constant regular interval to avoid any measure fatal or electrical shock.

The IR gives a measure of the enduring power of an insulator to bear the service voltage without any current leakage path. It gives an idea of an insulator's condition mainly in the Motor part of the Pump-set.

VII. Earth resistance meter

The purpose of earthing is to minimize the effect of transient voltage that occurred due to a strike of lightning. The method of testing considers three points of ground contacts, 1) an earth electrode, 2) a current probe 3) a voltage probe. Hence the analog/digital earth tester injects current into the tower footing earth electrode under test. An alternating current (I) is passed through the outer electrode, the voltage is measured by the inner electrode (P) at an intermediary point between the inner and outer electrodes. The current flows from the earth to the remote current probe and returns to the tester. As the current

flow, a voltage drop takes place. This voltage drop is proportional to the amount of current flow and the resistance of the earth electrode.

VIII. Anemometer

The wind load on the solar panel and mounting structure can be assessed using Anemometer. It uses an electrically animated hot piece of wire similar to the thread in an out-of-date light bulb past which the wind blows. As the wire chills, its electrical confrontation changes can be measured to figure out the amount of cooling and the wind speed.

IX. Vernier Caliper

Vernier calliper can be used to measure the thickness of the mounting structure to check whether the structure is in concurrence with the specifications

6.Routine Maintenance and Preventive Maintenance

a) The Vendor should provide 5 years comprehensive maintenance of the Solar Photovoltaic Water pumping system set, which shall include corrective maintenance as well as routine service visits during guarantee period.

b) CMC shall be in line with scheme guidelines and its amendment (if any). Apart from the monitoring, regular periodical maintenance of system has to be done. The report has to be maintained in a prescribed format containing Month, Inspection Date, Action taken against the Defects found in the System and along with signatures of both service Engineer and the farmer/ beneficiary. Maintenance report in digital form to be sent to Scheme implementing agency (SIA) and also uploaded on portal of SIA whenever such portal or mobile app is made available.

c) The deputed personnel shall be in a position to check and test all the equipment regularly, so that preventive actions, if any, could be taken well in advance to save any equipment from damage.

d) Normal and preventive maintenance of the Solar Photovoltaic Water pumping systems such as cleaning of module surface, tightening of all electrical connections, changing of tilt angle of module mounting structure, cleaning & greasing of motor pump sets, changing filters etc. are also the duties of the deputed personnel during maintenance visits.

e) During operation and maintenance period of the Solar Photovoltaic Water Pumping Systems, if there is any loss or damage of any component due to miss management or miss handling or due to any other reasons pertaining to the deputed personnel by empaneled vendor, what-so-ever, the supplier shall be responsible for immediate replacement or rectification. The damaged component may be repaired or replaced by new component.

f) The maintenance shall include replacement of any component irrespective of whether the defect was a manufacturing defect or due to wear and tear

g) An Operation and Maintenance Manual, in English and the local language, should be provided with the solar PV pumping system. The Manual should have information about solar energy, photovoltaic, modules, DC/AC motor pump set, tracking system, mounting structures, electronics and switches. It should also have clear instructions about mounting of PV module, DO's and DONT's and on regular maintenance and Trouble Shooting of the pumping system. Helpline number and Name and address of the Service Centre and contact number of authorized representatives to be contacted in case of failure or complaint should also be provided. A warranty card for the modules and the motor pump set should also be provided to the beneficiary.

Monitoring of installed pumps should be carried out to check whether the system is performing as per the specifications. Vendor shall check the components of the system as follows:

6.1. PV Array

i. Check the PV array/panel mounting to make sure that it is strong and well attached. If it is broken or loose, repair it.
ii. Check that the glass is not broken. If it is, the PV array/panel will have to be replaced.
iii. Check the connection box to make sure that the wires are tight and the water seals are not damaged.
iv. Check the Hot spots using Thermo graphic Camera
v. Check whether there are any shade problems due to vegetation or new building. If there are, make arrangements for removing the vegetation or moving the panels to a shade-free place.
vi. Check the cleaning schedule as dust is detrimental for solar panel performance. Water used for cleaning should be clean and should be free of salt
vii. Check the Voltage and Current of the solar panel using Multimeter and Clamp meter as follows:

- Connect the Positive and negative terminal of the string to the Multimeter and measure the V_{oc} of the string and compare with the expected cumulative voltage of the modules connected in the string.
- Use clamp meter to measure the current of the string and compare with the short circuit current (I_{sc}) of the module connected in the string.

6.2. Mounting Structure

i. Visually inspect the components of the structure are in correct position
ii. Check for damages in the foundation
iii. The straightness of the column should be assured using plum bob.

Usage of plum bob:

Fix the magnetic reel box of the plum bob on the top of the column and check whether the distance between the plum bob and the column is uniform.

iv. Ventilation below the structure should be ensured and check for uncontrolled plant growth if any.
v. Check for the corrosion in any parts of the structure
vi. Check whether all the clamps are tightened.
vii. Check the area between the arrays for accessibility

6.3. Wires

i. Check the wire covering (insulating sheath) for cracks or breaks. If the insulation is damaged, replace the wire.

ii. If someone has changed the wiring since the last check, make sure that it is the correct size, that it has suitable insulation, that the connections are properly made and that it is fastened securely in its new place.

iii. Check the connections for corrosion and tightness.

iv. Check that the junction box of the solar panel is still firmly attached. If it is not, attach it correctly.

v. **Conduct Insulation and continuity Test:** Insulation values of the cable should be assessed periodically using Megger. If sudden fall in insulation resistance value of conductor is observed, repair or replace the defective cable. Continuity of wire can be checked using Clamp meter with probe adjusted for continuity mark

vi. The following types of faults should be checked using Megger:

- **Open circuit fault** is the fault due to break in the conductor of the cable, which can be analysed using megger. For this, the conductors of the 3-core cable at the far end are shorted and earthed, and then use megger to measure the resistance between the conductor and earth. If the megger indicates zero resistance, there is no break in the conductor. In case of infinite resistance reading in megger, the conductor is broken.
- If two conductors of a multi-core cable come in contact with each other, **short circuit fault** will occur. In such a fault, if megger is used to check the resistance between any of the two conductors, it will read zero resistance. The same should be repeated for other conductors, by taking two at a time.
- **Earth or ground fault** occur when the conductor of the cable comes in contact with the earth. In such a fault, the megger will read zero resistance when one of the terminals of the megger is connected to the conductor and other to the earth. Repeat the same for other conductors.

6.4. Pump Controller

i. Turn on Pump controller and check that it is working properly.

ii. Check the controller is well ventilated and protected from direct sunshine.

iii. Check the earthing and motor wire connections.

iv. Check that Controller is mounted securely. If loose or incorrectly mounted, attach them securely.

v. Clean all exposed parts of controller. Clean light bulbs.

vi. Use Multimeter to check the internal circuits of the controller

vii. Check whether the enclosure provide protection against the entry of reptiles like lizard, etc

6.5. Pumpset

Check for the following conditions:

i. Check the resistance of the motor coil using Megger by connecting one of the Megger terminals to motor cable and the other to the ground. High value resistance indicates the good condition of the Motor coil.

ii. Check the discharge from the pumpset. Following can be reasons for lesser discharge.
   a) Pumpset may not be completely submerged in water (for submersible pumpset)
   b) Operational system head is more than the rated head
   c) Choking of strainer/impeller/pipes – Take the pumpset out of the Borewell and clean or replace the parts
   d) Leakage in pipe line – Fix the leakage in the pipe line
   e) In case of zero discharge, check for the electrical connection and coupling damage
   f) For Mono-set, in addition to the above points, check and replace the foot valve; prime the pumpset.

iii. Check the current of the Pumpset using clamp meter. Excessive current can be due to the following reasons:
   a) Rubbing of rotating parts and stationary parts.
   b) Defective cable

iv. Check the excessive vibration of the pumpset if any and the reason can be as follows. The reasons can be same for Pump seizure.
   a) Improper alignment and corresponding bends in shaft
   b) Dry running of pump
   c) Foreign bodies lodged in Impeller
   d) Improper resting of pumpset in the borewell
   e) Bearing worn out
   f) Air or gas inclusion in water
   g) Reverse rotation
   h) In case of Mono-set, cavitation due to high static head can also be a reason. Reduce the suction lift of the pumpset.

v. Check the presence of sand particles in pumped water. Take the pumpset out of the borewell and check for the wearing of parts. Presence of sand may wear out the pumpset parts.

vi. Take the pumpset out of bore well and replace the defective parts.

vii. Check for the cable joints for proper insulation

6.6. Maintenance of Earth Electrodes and Lightning Arrestor

i. Periodically check the resistance of the earthing electrode and maintain records and the method can be opted as given in the Step-3 of installation.

ii. Visually inspect the earth electrode connection.

iii. Ensure the moisture content in the ground surrounding the earth pit.

Lightning Arrestor

i. Visually inspect the LA for any sign of overheating at connecting points.
ii. Clean the insulator of LA with dry cloth and check flash mark, surface cracks etc.
iii. Check for LA burst or puncture. If so, replace with the new LA.
iv. Check the earthing resistance of the Lightning arrestor earthing.

Annexure I

Pre-Dispatch Inspection

Basic Details

S. No	Details Required	Response
1.	Date Of Inspection	….....
2.	Name of the Supplier/Contractor	….....
3.	Supplier's Inspection Call No.	….....
4.	Place of inspection: Address?	Godown/OEM; .....
5.	Work order no. and date	….....
6.	Order Quantity (pls specify ?)	….....
7.	Name of District and quantity	….....
8.	Inspection Order Call No.	….....
9.	Name of Inspecting Officers	….....
10	Offered quantity for Inspection.	….....

Solar PV Panel

Components/Characteristics	Type of check	Acceptance norm	Response by inspection officer	Remark; If any?
Visual Checks: -				
Make (Logo) & Model No. of PV module	Visual	As per ALMM given by MNRE	….....	
Unique Serial No. of each model	Visual		….....	
Whether reference module (Specific Sr. No.) has valid calibration certificate which is traceable to NABL lab ?	Visual	Valid certificate should be present.	Yes/No; IF yes specify the S.No.-	
IEC Test certificate detail	Visual	Lab should be NABL accredited.	Name of the lab….....; Test Report Number …....; Sr. No of the pump….....; S.No. of the motor….....	
Name of the Manufacturer of Solar cells	Visual		….....	
Month and year of the manufacture (separately for solar cells and module)	Visual		….....	
Country of origin (separately for solar cells and module)	Visual		….....	
Date and year of obtaining IEC PV module qualification certificate	Visual		….....	

Certificate regarding Made in India Cell and Modules (From Manufacturers)	Visual		….....	
Maximum peak power (Pm)	Visual	As per MNRE specifications it should be greater than 300Wp.	….....	
Open circuit Voltage (Voc)	Visual		….....	
Short circuit current (Isc)	Visual		….....	
Maximum peak Voltage (Vmp)	Visual		….....	
Maximum peak Current (Imp)	Visual		….....	
Power tolerance	Visual	As per MNRE specifications	….....	
Maximum system voltage	Visual		….....	
Fire Rating Class	Visual		….....	
Maximum Series Fuse Rating	Visual		….....	
Safety Instruction	Visual		….....	
Size of Module & Weight	Visual		….....	
Is module frame and glass free from scratches?	Visual	No scratches	Yes/No; If yes Please specify.	
Excessive or Uneven Glue marks Glue Marks on Glass present?	Visual	No traces of uneven glue	Yes/No	
Gap between frame and Glass due to poor sealing present?	Visual	Proper finish	Yes/No	
Bubbles or Dirt Marks present in the module?	Visual	Proper Clean	Yes/No	
Whether the module is free from cracks?	Visual	No crack	Yes/No; If NO please specify.	
Nameplate Type (Waterproof Sticker or Metal plated or else, specify)	Visual	As per MNRE specifications	….....	

RF Identification tag of good quality for each solar module is provided with the module? And its location.	Visual	RFID Tag should be present inside the lamination and able to withstand harsh environment.	Yes/No	
Junction box having IP67 or higher rating with minimum of 3 (three) numbers of bypass diodes of appropriate rating, provided?	Visual	JB with IP rating 67 or above and bypass diode should be present	Yes/No	
Is the module frame is made up of corrosion resistant, electrically resistant anodized aluminium.	Visual	Frame of module should be made up of anodized aluminium.	Yes/No	
Whether the earthing connection spot is properly marked on the frame of the module for its earthing.	Visual	Proper earthing point is present on the panel for doing its earthing.	Yes/No	

Check whether the RFID reader is able to retrieve all the bare minimum (as per IEC Requirement) parameters as per the name plate data of the module?	Visual	It should retrieve all the bare minimum parameters which are necessary.	Yes/No	
Whether the report of the EL image of modules is available?	Visual	There should be no defects present in the cells of module	Yes/No	
TEST/Measurement: -				
Unique Serial No. of each panel	Visual		….....	
Whether reference module (Specific Sr. No.) has valid calibration certificate which is traceable to NABL lab?	Visual		Yes/No	
Ambient Temperature	Measurement		….....	
Temperature of Module	Measurement		….....	
Air mass	Measurement		….....	
Incident Irradiance (W/m2)	Measurement		….....	
(Length (mm) X Width (mm))	Measurement		….....	
Total Area of Solar Panel	Measurement		….....	
Reference module power rating (Pmp – W)	Measurement		….....	
Reading of sun simulator of reference module (Pmp- W)	Measurement		….....	
Difference between claim reference module rating - Reading of sun simulator of reference module in watt	Measurement	As per MNRE specification	….....	

P max	Measurement	As per MNRE specification	….....	
Vmp	Measurement		….....	
Imp	Measurement		….....	
Voc	Measurement		….....	
Isc	Measurement		….....	
% Mod.Effi.	Measurement	As per MNRE specification	….....	
% Fill Factor	Measurement	As per MNRE specification	….....	
Temperature coefficient				
I-V Curve of the module	Measurement	It should be according to the reference module.	….....	
Mismatch Factor	Measurement	As per MNRE specification		

Module mounting Structure

Component/Characteristics	Type of check	Reference Documents	Acceptance norm	Response by inspection officer	Remarks. If any by inspecting officer.
Visual: -					
Is the Raw material Test Certificate available	Visual		Valid certificates	YES/No	
Is Welding of the items is as per standard	Visual	IS 822- Procedure code for the inspection of welds; and check the welding as per the Visual inspection on the page number 11-12.	Welding should be as per IS 822 and the grade of welding wire used should be of ER70S-6.	Yes/No	
Is there is a certificate regarding the grade of the welding wire used is ER70S-6.	Visual		Valid certificate or document which confirms the use of the welding wire.	Yes/No	
Is ISI mark for the IS 4759 available on the all items of the 51properly51.	Visual	Certificate/ISI mark	Valid certificate /ISI marks present on the all items of structure.	Yes/No	
Is certificate available for use of SS 304 grade in the Anti-theft bolts.	Visual	Certificate	Valid certificate	Yes/No	

Is certificate available regarding the use general hardware for the structure fitment is of the either Stainless steel (SS) then its grade should be 304 or higher, whereas in case of the carbon steel the grade should be 8.8 or higher.	Visual	Certificate	Valid certificate which states that if SS is used than the grade should be 304 or higher whereas in case of the carbon steel the grade should be 8.8 or higher.	Yes/No	
Measurement/Test:-					
Is structure and dimension of the items is as per approved drawings given in MNRE specification or approved by IIT, NIT, IISC, CSIR-SERC and Certified Structural Engineer	Visual/Measurement	Approved drawing	Structure and dimension of the items should be as per the approved drawings given in MNRE Specification or approved by IIT, NIT, IISC.	Yes/No; If No Please specify the item or structure. **Centre Shaft: -** Outer Diameter: -…..... Thickness: -..... Baseplate Thickness, If any?..... Length: -..... **Rafters Type:** - SHS/RHS **Purlin Thickness: -**	
Thickness of the zinc coating in all the items of structure: - Front Leg, Rear Leg, Rafter, Purlin, Connecting Bracket, SQ Bracket, Bracing, Base Plate	Measurement	As per IS 4759/ASTM A123/approved drawings	minimum 80micron	For each item 10 readings are taken. (1) ……. (2) ……. (3) ……..(4) ……..(5)……..(6)……..(7)……..(8)……..(9)……..(10)…….. Unit is in micron	
Is Adhesion of the zinc coating is proper	Hammer impression	As per IS 2629:1985	No removal or lifting of the coating in areas between hammer impression.	Yes/No	
Remarks: -					
Any other observation: -					

Pump-Set

Components/Characteristics	Type of check	Reference Documents	Acceptance norm	Response by inspection officer	Remarks; If any?
Visual: -					
Make (Logo) & Model No. and S.No. of pump.	Visual				
Make (Logo) & Model No. and S.No. of Motor.	Visual				
Type of pump and rating	Visual			Surface/Submersible (oil filled)/Submersible (Water filled) ….....HP	
Operation of the motor	Visual			AC/DC	
Is there any defect present on the surface of Casing/Cover (pump & motor).	Visual		Surface should be free from any kind of defect etc.	Yes/No; If Yes Please Specify.	
Is there is any defect present on the Impeller & Guide vane	Visual		should be free from any kind of defects	Yes/No	
Certificate regarding the use of Stainless Steel 304 grade Parts in Pumps	Visual		Certificate stating that SS 304 is used.	Yes/No	
Is Physical condition of Shaft & Shaft sleeve being acceptable	Visual		should be free from any kind of defects	Yes/No	
Is the rotation of the shaft being along the true axis of rotation.	Visual		Shaft should rotate along the true axis of rotation should not be deviated.	Yes/No	
Is valid certificate of Hydro Test of Submersible pump being available	Visual	Standards: IS 8034 clause 9	Valid test report which states that Pressurization of pump is done to 1.5times the maximum pressure for 2 minutes	Yes/No	

Declaration by the manufacture about the use of the imported parts.	Visual			….....	
Certificate regrading Made in India of Pump	Visual			Acceptable/Unacceptable	
Which type of material used for the pipe along with pressure ratings.	Visual	MNRE specification	HDPE and uPVC and pressure rating according to the rating of the pump. In case of HDPE pipes the minimum pressure rating of 8 kg/sqcm-PE100 grade for pumps up to 3 HP, 10 kg/sqcm-PE100 grade for 5 HP pumps and further higher minimum pressure rating for above 5 HP as appropriate shall be used.	…....;….....	
Is valid Warranty certificates and calibration certificates being available	Visual		certificates should be valid.	Yes/No	
Is controller being IP protected?	Visual	MNRE specification	Certificate against IP protection and rating should be at least IP65.	Yes/No; If yes specify IP rating	
Is third Party **Type Test** Report available	Visual	Third party type test report.	Type test reports as per IS: 9283	Yes/No	
List of the parameter available on the LCD Screen of controller	Visual		All the parameter should be available on the LCD screen	Pump status: Running/Standstill	
				Array Input DC Voltage: YES/NO	
				Array Input DC current: YES/NO	

				DC/AC output Current & voltage: YES/NO	
				Power: YES/NO	
				Drive frequency: YES/NO	
				Real time energy generation daily: YES/NO	
				Water output: YES/NO	
				water flow rate: YES/NO	
				Running hours daily and cumulative: YES/NO	
				Any other than above Please specify:	
Randomly check the serial no present physically on pump, motor and controller and match it with the S. No. present in the lot list and also with the S.NO. Present on the warranty card.	Visual		Serial No. given in the list and card should match with the physically available one's.	Matching/Unmatching	
Is there is any surface defect on the controller	Visual		Free from any surface defect.	Yes/No; If yes specify	
Is controller having provision of remote monitoring of inverter data through sim card/Bluetooth	Visual			Yes/No	
Is required website/mobile app platform, where the user (Consumer) can access the data, provided.	Visual			Yes/No	

Is all data of controller made available for implementing agency for monitoring by giving web access?	Visual			Yes/No	
Is GPS Module with less than 10-meter horizontal accuracy is available in the system.	Visual	Mobile application	The Geo location where the GPS device is kept should be accurate on the mobile application	Yes/No	
Is under the live status in RMS it must indicate whether the pump is in running condition or standstill?	Visual			Yes/No	
List of the parameter available on the RMS portal	Visual		All the parameter should be available on the RMS portal	Pump status: Running/Standstill	
				Array Input DC Voltage: YES/NO	
				Array Input DC current: YES/NO	
				DC/AC output Current & voltage: YES/NO	
				Power: YES/NO	
				Drive frequency: YES/NO	
				Real time energy generation daily: YES/NO	
				Water output: YES/NO	
				water flow rate: YES/NO	
				Graph representation	
				Running hours daily and cumulative: YES/NO	
				Any other than above Please specify:	

Is Data pushed on Event/Notification: such as when pump on, pump off, protection operated etc.	Visual				
Is Declaration from the vendor that there is a provision for data backup of 1year available in the controller.	Visual			Yes/No	
Is any Faults related to Pump Operation, Solar generation, Controller/Drive faults like overload, dry run, short circuit, etc. is available on the RMS.	Visual			Yes/No	
Is complaint management system provided in the remote monitoring system.	Visual			Yes/No	
Is Declaration from the vendor is available which states that RMS have provision for at least two Analog and Digital inputs with 0.1% accuracy to address the requirement of local sensors connectivity if required?	Visual			Yes/No	
Is RMS have provision to give remote on/Off command to pump through farmer mobile app. And in case, farmer do not have a smart	Visual			Yes/No	

phone, farmer shall be able to on-off pump thru SMS/missed call.					
Is the certificate available for the overload test, dry run, undervoltage, over temperature, high voltage test.	Visual		Valid certificates	Yes/No	
Measurement					
Type, size, length of cable used for motor	Visual/Measurement	As per IS 9283/ IS 694	As per the standard based on the rating of the pump.	…. core/….mm2/…....m	
Controller Input Current	Measurement			….....	
Motor Input Current	Measurement			….....	
MPPT voltage range					
Controller Output Current	Measurement			….....	
Is Protection Checks for reverse polarity, short circuit, working properly.	Test		All protection checks should work.	Yes/No	
Is Controller being able to detect motor jam and unjam automatically	Test		Controller should detect the jam and able to unjam it.	Yes/No	
Dimension of the controller box; -Height, Width, Depth, Wall thickness, body thickness	Measurement		H-500mm; W-450mm; D-250mm; body wall thickness is about 2mm	….....mm; mm, mm; mm; .....mm	

Annexure II

Post Installation Inspection

General Information

Detail of farm where Solar Pump is to be installed:	**Response given by the inspector**
Name of the beneficiary	
Name of the vendor who installed the system	
Land Survey number	
Work Order No.	
Latitude & Longitude	
Water Required	
Irrigation Area	
Village/Taluka/District	
HP of Solar Pump Demanded	
SPV Capacity installed in kWp	
Total Head in meters (suction + Delivery)	
Installed Pump Type (AC/DC)	
Installed Pump Sub Type (Submersible Pump (Water filled Motor) / Submersible (Oil filled Motor)/Surface Pump)	
Date of Registration	
Farmer's Contribution Amount and date of payment	
Date of installation of Solar Water Pump	
Is User manual and warranty card handed over to customer in local language?	Yes/NO
Is USPC Installed?	Yes/NO

Solar PV array

Safety: -Personal Protective Equipment		
Helmet		
Gloves		
Glasses		
Safety shoes		
Instruments to be carried along for the inspection		
Multimeter		
meter tape		
IR Thermal Camera		
clamp meter		
inclinometer		
megger		
Checklist	**Response of the inspecting officer**	**Remarks, If any**
Manufacture's Name of PV panels		
Capacity (Wp) of each PV module		
No. of PV Modules	….....Also specify series…..... & Parallel….....	
Serial number of each module		
Total PV Capacity (Wp) of the array		
Declared maximum peak Voltage (Vmp) of each module		
Declared maximum peak Current (Imp) of each module		
Declared Maximum voltage of the system		
Fire Rating Class		
Maximum Series Fuse Rating		
Whether RFID tag is pasted or not? Location	Yes/NO;	

Nameplate Type (Waterproof Sticker or Metal plated or else, specify)		
Any physical defect present in the Modules/Array?	YES/NO, If Yes? Please Specify.	
Is module frame made up of corrosion resistant, electrically resistant anodized aluminium.	YES/NO	
Whether the earthing connection spot is properly marked on the frame of the module for its earthing.	YES/NO	
Is PV Modules electrical connections being tight and secure?	YES/NO	
Is Module to Module wattage mismatch in the SPV array mismatch shall be within ± 3 percent?	YES/NO	

Solar Pump Controller

Safety: -Personal Protective Equipment		
Helmet		
Gloves		
Glasses		
Safety shoes		
Instruments to be carried along for the inspection		
Multimeter		
clamp meter		
	Response by inspecting officer	**Remark; If any?**
Checklist		
Power Range in kW for Controller		
Current rating (A)		
Type of Controller	AC/DC	

Rating of pump for which controller is suitable for?		
Check for any physical damage to controller? If yes, Please Specify		
Is controller is mounted on the separate angles?	Yes/NO	
Is cable for controller to motor connection run through PVC pipe and 1 foot inside the ground?	Yes/NO	
IS Customer care information striker pasted on controller for OM related issue?	Yes/NO	
Is open Circuit Protection working?	Yes/NO	
Is Short Circuit Protection working?	Yes/NO	
Is Reverse Polarity Protection working?	Yes/NO	
Is SPV Controller have IP (65) protection or housed in a cabinet having at least IP (65) protection?	Yes/NO	
Is suitable size of cable used in sufficient length for inter-connection between the SPV array to SPV Controller and the SPV Controller to solar powered pump set?	Yes/NO; If yes? Please mention Size and length.	
IS SIM card of suitable Internet service provider having sufficient Signal Strength for communication is provided?	Yes/NO	
Is controller having provision of remote monitoring of inverter data through sim card	Yes/NO	
Whether website/mobile app platform, where the user (Consumer) can access the data, provided/explained to consumer?	Yes/NO	
Is all data of controller made available for implementing agency for monitoring by giving web access?	Yes/NO	
List the values of the parameter available on the RMS portal	Pump On/Off status	
	Array Input DC Voltage:	
	Array Input DC current:	
	DC/AC output Current & voltage:	
	Power:	
	Drive frequency:	

	Real time energy generation daily:	
	Water output:	
	water flow rate:	
	Running hours daily and cumulative:	
	Any other than above Please specify:.....	
Is Data pushed on Event/Notification: such as when pump on, pump off, protection operated etc.	Yes/No	
Check for periodically data updation on the RMS portal after the default interval of at most 15 minutes. For this the readings at the portal can be viewed with the 15mins time gap.	Satisfactory/Unsatisfactory.	
Is Real time latitude and longitude should be captured with an accuracy of less than 10-meter horizontal accuracy.		
Is any Faults related to Pump Operation, Solar generation, Controller/Drive faults like overload, dry run, short circuit, etc. is available on the RMS.	Yes/NO	
Are the details such as name, agriculture details, service No. Contact Details, etc. is 63captured?	Yes/NO	
Are the ratings, Serial Number, Make, Model Number of Pump, Panel and Controller, IMEI number (of communication module) and ICCID (of SIM) is available at RMS portal?	Yes/NO	
Is complaint management system 63provided in the remote monitoring system.	Yes/NO	
Is RMS have provision for at least two Analog and Digital inputs with 0.1% accuracy to address the requirement of local sensors connectivity if required by SIA/Consumer?	Yes/NO	
Is RMS have provision to give remote on/Off command to pump through farmer mobile app. And in case, farmer do not have a smart phone, farmer shall be able to on-off pump thru SMS/missed call.	Yes/NO	
The value of various parameters presents on the controller screen	Pump On/Off status	

	Array Input DC Voltage:	
	Array Input DC current:	
	DC/AC output Current & voltage:	
	Power:	
	Drive frequency:	
	Real time energy generation daily:	
	Water output:	
	water flow rate:	
	Running hours daily and cumulative:	
	Any other than above Please specify:	

Module Mounting Structure

Instruments to be carried along for the inspection		
Measuring Tap		
Torque Wrench		
Vernier calliper		
Spirit level		
Compass		
Checklist	**Response of the inspecting officer**	**Remark; If any?**
Is SBC (Soil bearing capacity) lab test available: -	YES/NO	

Is Validated foundation drawing and design along with its calculation, as per Safe bearing capacity of site available?	Yes/No	
Is foundation hardware being as per IS 5624?	Yes/No; If No then which standard is used (IS 6403 / 456 / 4091 / 875)	
Is the Foundation Block size/Pile cap Size being as per the approved drawing	Yes/No? If no Please specify	
Is nature of soil being sandy?	Yes/No. If yes, then is the anti-tilt protection is provided in the foundation?	
Is all hardware are properly tightened.	Yes/No	
All Anti-theft Nuts.	Broken/Not Broken	
Is the square type of Washer used in all tightened nut and bolts	Yes/No	
Module facing direction: -		
Is Structure Assembly level being vertical, it should not be tilted?	Yes/NO	
Is Structure Alignment being free from any defect?	Yes/NO	
Is Surface finish free from defect?	Yes/NO	
Is Ground clearance should be maintained as per drawing:	Yes/No	
Is shadow free area available?	Yes/No	
Three times daily tracking	Manual/Automatic/Not present.	
Seasonal Tracking	Manual/Automatic/Not present.	
Whether the proper gap is 65provided in between the module as per structure drawing	Yes/No	
Is alignment of all PV module being in level?	Yes/NO	
Is it certified that All Nut bolts, Panel Mounting clamps fasteners are of stainless steel of Garde SS 304?	Yes/No	
Is fencing Provided?	Yes/NO	

Pump Assembly

Safety: -Personal Protective Equipment		
Helmet		
Gloves		
Glasses		
Safety shoes		
Checklist	**Response by inspecting officer**	**Remark; If any.**
Pump make/Model No./Serial No.		
Motor make/Model No./Serial No.		
Depth to which the pump has been lowered in the Borewell (in case of submersible pump)		
Flushing of bore well before I & C	Yes/No; if yes then Date?	
Dynamic Head		
Types of pipes used for suction and delivery.	uPVC/HDPE	
Size of pipe for suction and Delivery		
Length of pipe used in meter.		
Pressure rating of the pipe.		
Has the pump run in the direction of rotation specified by the arrow on metal label of pump	YES/NO	
Is adequate length of insulation is removed so that multi-core cable joints can be visually separated with crimped connectors and Rubber sleeve needs to cover the crimped connector for additional protection with electrical protective tape on it.	YES/NO	
Is ISI mark present on cable along with its cross section?	Yes/No	
Is rain cover fixing for surface pump present?	Yes/NO	

Electrical Connections

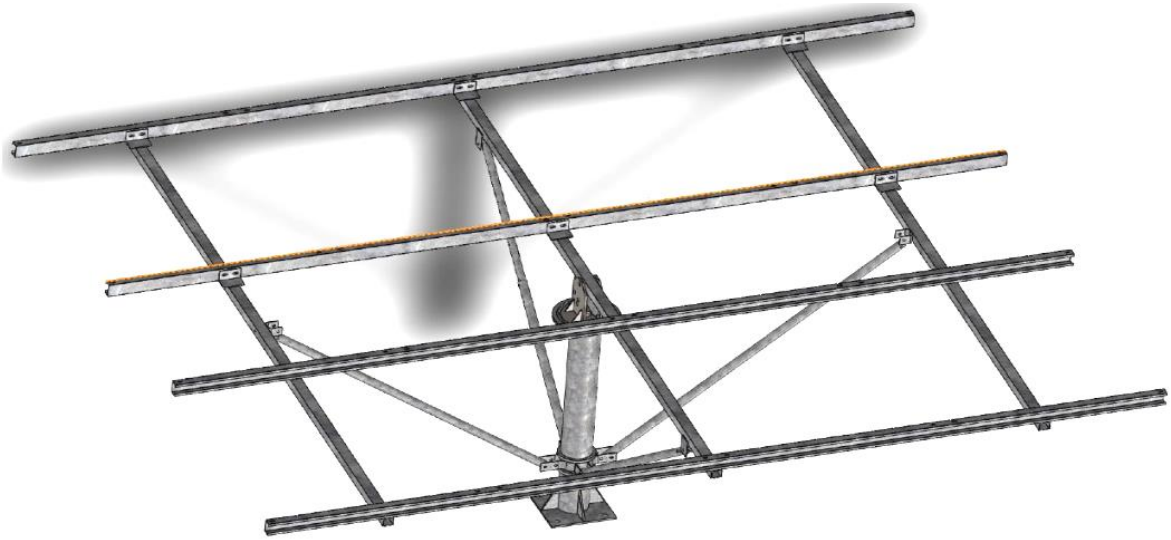
Safety: -Personal Protective Equipment		
Helmet		
Gloves		
Glasses		
Safety shoes		
Instruments to be carried along for the inspection		
Megger		
clamp meter		
Multimeter		
electrical tape		
thread		
Checklist	**Response by inspecting officer**	**Remark; If any.**
No. of Earthing provided		
Earth resistance value of all the pits		
Is the value of earth resistance of all the pits is less than 5ohm	Yes/NO	
In case of multiple earth pits	Connected/Independent	
LA Pipe height and Size of GI strip/Cable used for connection to ground:-		
Is in case of uPVC/HDPE pipes used as discharge pipe, a separate non-corrosive, low resistance conductor from motor earth terminal to control panel earth terminal shall be provided for earthing?	Yes/NO	
Is Connections of earthing 67properly done?	Yes/NO	
Is PV module wiring routing properly with UV rated cable tie?	Yes/NO	

Is chemical Earthing done as per IS-3043?	Yes/NO	
Is PVC conduit pipe of suitable size ISI make or black drip pipe used for covering panel wiring and which is buried in the ground by 1 foot?	Yes/NO	
Is Electrical continuity of PV module is maintained?	Yes/NO	
Is LA positioning behind structure & height greater than highest structure peak	Yes/NO	
Is Array connection to controller done through JB/MCB?	Yes/NO	
Is Polarity correct in connection?	Yes/NO	
Is proper lugs used for the connection of the wire?	Yes/NO	
Is there any loose wire or connection available?	Yes/NO; If yes please specify	

Annexure-III

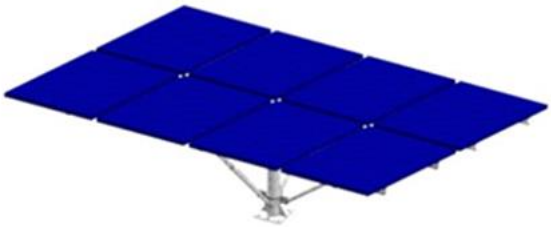
Specifications for Dual Axis Manual Tracking Type

Module Mounting Structure (MMS) for Solar Water Pumping System



4 Module MMS

6 Module MMS



8 Module MMS

10 Module MMS

A-1 Standard MMS for 4, 6, 8 and 10 solar modules have been specified. These standard MMS may be used in combinations for different capacities of solar water pumping systems as follows:

1. Standard MMS of 4 Modules for 1 HP
2. Standard MMS of 6 Modules for 2 HP
3. Standard MMS of 10 Modules or Combination of standard MMS of 4 Modules and standard MMS 6 Modules for 3 HP
4. Combination of two standard MMS of 8 Modules or combination of standard MMS of 10 Modules and standard MMS 6 Modules for 5 HP
5. Combination of three standard MMS of 8 Modules or combination of two standard MMS of 10 Modules and one standard MMS 6 Modules for 7.5 HP

and so on….

A- 2 Specifications of main parts used in MMS are given below:

A-2.1 Centre Shaft

Centre shaft used in structure shall be of :

a) For 4, 6 and 8 Modules structure - minimum 139 OD with minimum thickness of 4 mm with base plate minimum 10 mm thickness if used and foundation hardware shall be as per IS 5624.
b) For 10 Modules structure - minimum 165 OD with minimum thickness of 4 mm with base plate minimum 20 mm thickness if used and foundation hardware shall be as per IS 5624.

For system without base plate i.e., direct pilling is shall be as per the site condition based on the properties of Soil and refer (IS 6403 / 456 / 4091 / 875) for foundation design.

A-2.2Rafters

The Main and secondary rafter used in structure shall be of either SHS & RHS pipe sections.

A-2.3Purlin

Mounting Purlins used in the structure shall be made of Cold form steel section as per IS 1079 with minimum thickness of 2 mm.

A-2.4 Provision for Seasonal Tilt

In one structure at least four telescopic supports (three may be used in MMS for 4 modules) either round hollow sections or square hollow section to be provided to support the mounting structure.

A-2.5 Provision for Daily Tracking

Provision for Daily tracking shall be provided by the way of providing min. 8 mm thick metal sheet with precision cut grooves.

A-2.6 Module Locking System

Modules shall be locked with antitheft bolts of SS 304 Grade.

A-2.7General Hardware for Structure Fitment

Either SS 304 or 8.8 grade hardware shall be used for fitment.

A-2.8Hot Dip Galvanizing

All structure parts shall be hot dip galvanized according to IS 4759.

A-2.9Tolerance for Fabrication

Tolerance for fabrication of steel structure shall as per IS 7215.

A-2.10Welding

Welding shall be done as per IS: - 822 & grade of welding wire shall be (ER70S-6).

A-2.11 Raw Material Test Certificates (MTC)

MTC of all types of raw material used in dual axis manual tracking type MMS as per appropriate Indian Standard shall be submitted along with dispatch documents.

A-2.12 Square washer to be used for all the nut-bolts arrangement.

A-2.13 Tests to be performed on Dual Axis Manual Tracking Type MMS for Solar Water Pumping System.

A-2.13.1 For ascertaining proper welding of structure part following shall be referred.

a) Weld wire grade shall be of grade **(ER 70 S - 6);** and

b) D.P. Test (Pin Hole / Crack) **(IS 822)**

A-2.13.2 For ascertaining hot dip galvanizing of fabricated structure following shall be referred: -

a)Min coating required shall be as per IS 4759.

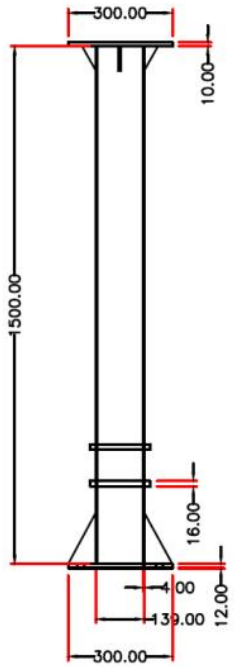
b) Testing of galvanized material.

c) PREECE Test (CuSO4 Dip Test) **(IS 2633)**

d) Mass of Zinc **(IS 6745 or IS 4759)**

e) Adhesion Test **(IS 2629)**

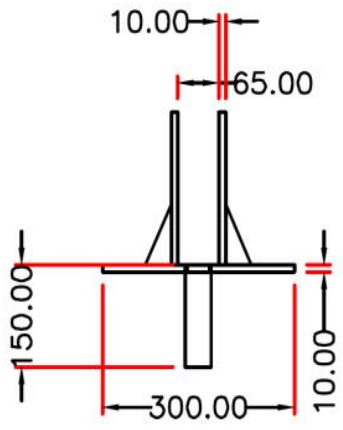
Part1 – Mail Column

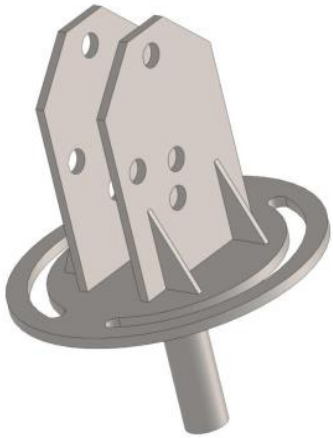


Notes: -

1. All Dimensions are in mm.
2. Main Column material grade should be YST - 240 as per: -IS: 1161 / 1239 & E250 as per: - IS: 1079 / 2062.

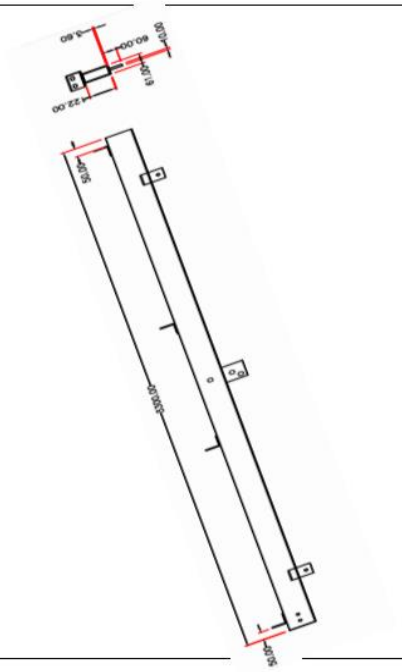
Part 2 – Top Plate



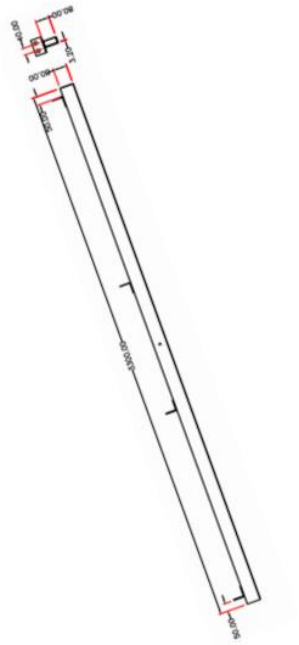


Notes: -

1. All Dimensions are in mm.
2. Top Plate material grade should be YST - 240 as per: -IS: 1161 / 1239 & E250 as per: - IS: 1079 / 2062.

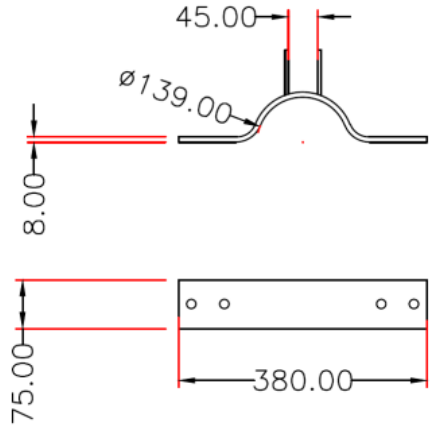
Part 3 – Main Tube	
	

Notes: -
1. All Dimensions are in mm.
2. Main Tube material grade should be YST - 240 as per: -IS: 1161 / 1239 & E250 as per: - IS: 1079 / 2062.

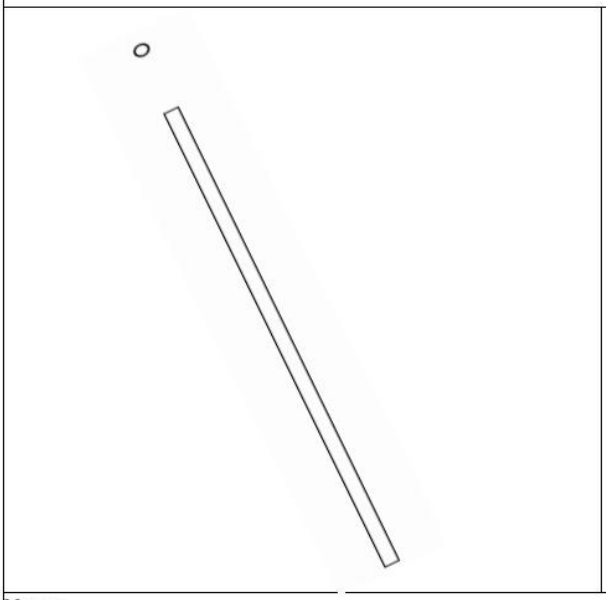
Part 4 – Side Tube	
	

Notes: -
1. All Dimensions are in mm.
2. Side Tube material grade should be YST - 240 as per: -IS: 1161 / 1239 & E250 as per: - IS: 1079 / 2062.

Part 5 – Purlin	
	
Notes: - 1. All Dimensions are in mm. 2. Mounting Purlin material grade should be E250 as per: - IS: 1079 / 2062 & IS: 811.	

Part 6 – Clamp with Blade	
	
Notes: - 1. All Dimensions are in mm. 2. Clamp with Blade material grade should be as per: - IS: 1079 & E250 as per: - IS: 2062.	

Part 7 – Supporting Pipes



Notes: -

1. All Dimensions are in mm.
2. Supporting Pipes material grade should be YST - 240 as per: -IS: 1161 / 1239 & E250 as per: - IS: 1079 / 2062.

Main Parts of MMS for Solar Water Pumping System

SR. NO.	PART NAME	CROSS SECTION DETAIL	LENGTH (MM)	QUANTITY PER SET
1.	**MAIN POLE**			
	4, 6 and 8 Modules	139 OD	1500	1
	10 Modules	165 OD	1500	1
2.	**TOP PLATE (Common for all)**	300 OD	--	1
3.	**CLAMP WITH BLADE**			
	4, 6 and 8 Modules (for 139 OD pole)	75X8	380	2
	10 Modules (for 165 OD pole)	75X8	380	2
4.	**SUPPORTING PIPES**			
	4, 6 and 8 Modules	41 OD & 33 OD	--	6
	10 Modules	41 OD & 33 OD	--	8
5.	**MAIN TUBE**			
	4 and 6 Modules	60X60X3.6	3300	1
	8 and 10 Modules	122X61X3.6	3300	1
6.	**SIDE TUBE**			
	4 and 6 Modules	50X50X3.6	3300	2
	8 and 10 Modules	80X40X3.2	3300	2

7.	**MOUNTING PURLIN**			
	4 Modules	80X50X15X2	2050	4
	6 Modules	80X50X15X2	3100	4
	8 Modules	80X50X15X2	4150	4
	10 Modules	100X50X15X2	5200	4

Annexure IV

Indicative Technical Specifications of Shallow Well (Surface) Solar Pumping Systems with D.C. Motor Pump Set with Brushless.

Description	Model-1	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8	Model-9	Model-10	Model-11	Model-12	Model-13
PV array (Wp)	900	1800	2700	2700	4800	4800	4800	6750	6750	6750	9000	9000	9000
Motor Pump-set capacity (HP)	1	2	3	3	5	5	5	7.5	7.5	7.5	10	10	10
Shut Off Dynamic Head (meters)	12	12	12	25	12	25	45	12	25	45	12	25	45
Water output * (Liters per day)	99000 (from a total head of 10 meters)	198000 (from a total head of 10 meters)	297000 (from a total head of 10 meters)	148500 (from a total head of 20 meters)	528000 (from a total head of 10 meters)	264000 (from a total head of 20 meters)	182400 (from a total head of 30 meters)	742500 (from a total head of 10 meters)	371250 (from a total head of 20 meters)	256500 (from a total head of 30 meters)	990000 (from a total head of 10 meters)	495000 (from a total head of 20 meters)	342000 (from a total head of 30 meters)

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e., Performance Requirements) specified earlier.
3. If submersible pumps are used in lieu of surface pumps, the water output must match that of the surface pumps as specified in this table.

Indicative Technical Specifications of Shallow Well (Surface) Pumping Systems with D.C. Motor Pump Set with Brushless.

Description	**Model-14**	**Model-15**	**Model-16**	**Model-17**	**Model-18**	**Model-19**	**Model-20**	**Model-21**	**Model-22**	**Model-23**	**Model-24**	**Model-25**	**Model-26**
PV array (Wp)	11250	11250	11250	11250	13500	13500	13500	13500	15750	15750	15750	18000	18000
Motor Pump-set capacity (HP)	12.5	12.5	12.5	12.5	15	15	15	15	17.5	17.5	17.5	20	20
Shut Off Dynamic Head (meters)	12	25	45	70	25	45	70	100	45	70	100	45	70
Water output * (Liters per day)	1237500 (from a total head of 10 meters)	618750 (from a total head of 20 meters)	427500 (from a total head of 30 meters)	258750 (from a total head of 50 meters)	742500 (from a total head of 20 meters)	513000 (from a total head of 30 meters)	310500 (from a total head of 50 meters)	202500 (from a total head of 70 meters)	598500 (from a total head of 30 meters)	362250 (from a total head of 50 meters)	236250 (from a total head of 70 meters)	684000 (from a total head of 30 meters)	414000 (from a total head of 50 meters)

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e. Performance Requirements) specified earlier.
3. If surface pumps are used in lieu of submersible pumps, the water output must match that of the submersible pumps as specified in this table

Indicative Technical Specifications of Shallow Well (Surface) Pumping Systems with D.C. Motor Pump Set with Brushless.

Description	**Model-27**	**Model-28**	**Model-29**	**Model-30**	**Model-31**	**Model-32**	**Model-33**	**Model-34**
PV array (Wp)	18000	18000	20250	20250	20250	22500	22500	22500
Motor Pump-set capacity (HP)	20	20	22.5	22.5	22.5	25	25	25
Shut Off Dynamic Head (meters)	100	150	70	100	150	70	100	150
Water output * (Liters per day)	270000 (from a total head of 70 meters)	189000 (from a total head of 100 meters)	465750 (from a total head of 50 meters)	303750 (from a total head of 70 meters)	212625 (from a total head of 100 meters)	517500 (from a total head of 50 meters)	337500 (from a total head of 70 meters)	236250 (from a total head of 100 meters)

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e. Performance Requirements) specified earlier.
3. If surface pumps are used in lieu of submersible pumps, the water output must match that of the submersible pumps as specified in this table

Indicative Technical Specifications of Solar Deep well (submersible) Pumping Systems with D.C. Motor Pump Set with Brushless.

Description	**Model-1**	**Model-2**	**Model-3**	**Model-4**	**Model-5**	**Model-6**	**Model-7**	**Model-8**	**Model-9**	**Model-10**	**Model-11**	**Model-12**	**Model-13**	**Model-14**
PV array (Wp)	1200	1800	3000	3000	3000	4800	4800	4800	6750	6750	6750	9000	9000	9000
Motor Pump-set capacity (HP)	1	2	3	3	3	5	5	5	7.5	7.5	7.5	10	10	10
Shut Off Dynamic Head (meters)	45	45	45	70	100	70	100	150	70	100	150	70	100	150
Water output * (Liters per day)	45600 (from a total head of 30 meters)	68400 (from a total head of 30 meters)	114000 (from a total head of 30 meters)	69000 (from a total head of 50 meters)	45000 (from a total head of 70 meters)	110400 (from a total head of 50 meters)	72000 (from a total head of 70 meters)	50400 (from a total head of 100 meters)	155250 (from a total head of 50 meters)	101250 (from a total head of 70 meters)	70875 (from a total head of 100 meters)	207000 (from a total head of 50 meters)	135000 (from a total head of 70 meters)	94500 (from a total head of 100 meters)

*Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e. Performance Requirements) specified earlier.
3. If submersible pumps are used in lieu of surface pumps, the water output must match that of the surface pumps as specified in this table.

Indicative Technical Specifications of Solar Deep well (submersible) Pumping Systems with D.C. Motor Pump Set with Brushless.

Description	**Model-15**	**Model-16**	**Model-17**	**Model-18**	**Model-19**	**Model-20**	**Model-21**	**Model-22**	**Model-23**	**Model-24**	**Model-25**	**Model-26**	**Model-27**	**Model-28**
PV array (Wp)	11250	11250	11250	11250	13500	13500	13500	13500	15750	15750	15750	15750	18000	18000
Motor Pump-set capacity (HP)	12.5	12.5	12.5	12.5	15	15	15	15	17.5	17.5	17.5	17.5	20	20
Shut Off Dynamic Head (meters)	100	150	180	225	100	150	180	225	100	150	180	225	150	180
Water output * (Liters per day)	168750 (from a total head of 70 meters)	118125 (from a total head of 100 meters)	106875 (from a total head of 120 meters)	84375 (from a total head of 150 meters)	202500 (from a total head of 70 meters)	141750 (from a total head of 100 meters)	128250 (from a total head of 120 meters)	101250 (from a total head of 150 meters)	236250 (from a total head of 70 meters)	165375 (from a total head of 100 meters)	149625 (from a total head of 120 meters)	118125 (from a total head of 150 meters)	189000 (from a total head of 100 meters)	171000 (from a total head of 120 meters)

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e. Performance Requirements) specified earlier.
3. If submersible pumps are used in lieu of surface pumps, the water output must match that of the surface pumps as specified in this table.

Indicative Technical Specifications of Solar Deep well (submersible) Pumping Systems with D.C. Motor Pump Set with Brushless.

Description	**Model-29**	**Model-30**	**Model-31**	**Model-32**	**Model-33**	**Model-34**	**Model-35**	**Model-36**	**Model-37**	**Model-38**	**Model-39**
PV array (Wp)	18000	18000	20250	20250	20250	20250	20250	22500	22500	22500	22500
Motor Pump-set capacity (HP)	20	20	22.5	22.5	22.5	22.5	22.5	25	25	25	25
Shut Off Dynamic Head (meters)	225	300	150	180	225	300	375	180	225	300	375
Water output * (Liters per day)	135000 (from a total head of 150 meters)	99000 (from a total head of 200 meters)	212625 (from a total head of 100 meters)	192375 (from a total head of 120 meters)	151875 (from a total head of 150 meters)	111375 (from a total head of 200 meters)	91125 (from a total head of 250 meters)	213750 (from a total head of 120 meters)	168750 (from a total head of 150 meters)	123750 (from a total head of 200 meters)	101250 (from a total head of 250 meters)

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the “Average Daily Solar Radiation” condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e. Performance Requirements) specified earlier.
3. If submersible pumps are used in lieu of surface pumps, the water output must match that of the surface pumps as specified in this table.

Indicative Technical Specifications of Shallow Well (Surface) Solar Pumping Systems with A.C. Induction Motor Pump Set

Description	**Model-**	**Model-2**	**Model-3**	**Model-4**	**Model-5**	**Model-6**	**Model-7**	**Model-8**	**Model-9**	**Model-10**	**Model-11**	**Model-12**	**Model-13**
PV array (Wp)	900	1800	2700	2700	4800	4800	4800	6750	6750	6750	9000	9000	9000
Motor Pump-set capacity (HP)	1	2	3	3	5	5	5	7.5	7.5	7.5	10	10	10
Shut Off Dynamic Head (meters)	12	12	12	25	12	25	45	12	25	45	12	25	45
Water output * (Liters per day)	89100 (from a total head of 10 meters)	178200 (from a total head of 10 meters)	267300 (from a total head of 10 meters)	132300 (from a total head of 20 meters)	475200 (from a total head of 10 meters)	235200 (from a total head of 20 meters)	168000 (from a total head of 30 meters)	668250 (from a total head of 10 meters)	330750 (from a total head of 20 meters)	236250 (from a total head of 30 meters)	891000 (from a total head of 10 meters)	441000 (from a total head of 20 meters)	315000 (from a total head of 30 meters)

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4. (i.e. Performance Requirements) specified earlier.

3. If submersible pumps are used in lieu of surface pumps, the water output must match that of the surface pumps as specified in this table.

Indicative Technical Specifications of Shallow Well (Surface) Solar Pumping Systems with A.C. Induction Motor Pump Set

Description	**Model-14**	**Model-15**	**Model-16**	**Model-17**	**Model-18**	**Model-19**	**Model-20**	**Model-21**	**Model-22**	**Model-23**	**Model-24**	**Model-25**	**Model-26**
PV array (Wp)	11250	11250	11250	11250	13500	13500	13500	13500	15750	15750	15750	18000	18000
Motor Pump-set capacity (HP)	12.5	12.5	12.5	12.5	15	15	15	15	17.5	17.5	17.5	20	20
Shut Off Dynamic Head (meters)	12	25	45	70	25	45	70	100	45	70	100	45	70
Water output * (Liters per day)	11,13,750 (from a total head of 10 meters)	5,51,250 (from a total head of 20 meters)	3,93,750 (from a total head of 30 meters)	2,36,250 (from a total head of 50 meters)	6,61,500 (from a total head of 20 meters)	4,72,500 (from a total head of 30 meters)	2,83,500 (from a total head of 50 meters)	1,89,000 (from a total head of 70 meters)	5,51,250 (from a total head of 30 meters)	3,30,750 (from a total head of 50 meters)	2,20,500 (from a total head of 70 meters)	6,30,000 (from a total head of 30 meters)	3,78,000 (from a total head of 50 meters)

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e. Performance Requirements) specified earlier.
3. If submersible pumps are used in lieu of surface pumps, the water output must match that of the surface pumps as specified in this table.

Indicative Technical Specifications of Shallow Well (Surface) Solar Pumping Systems with A.C. Induction Motor Pump Set

Description	**Model-27**	**Model-28**	**Model-29**	**Model-30**	**Model-31**	**Model-32**	**Model-33**	**Model-34**
PV array (Wp)	18000	18000	20250	20250	20250	22500	22500	22500
Motor Pump-set capacity (HP)	20	20	22.5	22.5	22.5	25	25	25
Shut Off Dynamic Head (meters)	100	150	70	100	150	70	100	150
Water output * (Liters per day)	2,52,000 (from a total head of 70 meters)	1,62,000 (from a total head of 100 meters)	4,25,250 (from a total head of 50 meters)	2,83,500 (from a total head of 70 meters)	1,82,250 (from a total head of 100 meters)	4,72,500 (from a total head of 50 meters)	3,15,000 (from a total head of 70 meters)	2,02,500 (from a total head of 100 meters)

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e. Performance Requirements) specified earlier.
3. If submersible pumps are used in lieu of surface pumps, the water output must match that of the surface pumps as specified in this table.

Indicative Technical Specifications of Solar Deep well (submersible) Pumping Systems with A.C. Induction Motor Pump Set

Description	**Model-1**	**Model-2**	**Model-3**	**Model-4**	**Model-5**	**Model-6**	**Model-7**	**Model-8**	**Model-9**	**Model-10**	**Model-11**	**Model-12**	**Model-13**	**Model-14**
PV array (Wp)	1200	1800	3000	3000	3000	4800	4800	4800	6750	6750	6750	9000	9000	9000
Motor Pump-set capacity (HP)	1	2	3	3	3	5	5	5	7.5	7.5	7.5	10	10	10
Shut Off Dynamic Head (meters)	45	45	45	70	100	70	100	150	70	100	150	70	100	150
Water output * (Liters per day)	42000 (from a total head of 30 meters)	63000 (from a total head of 30 meters)	105000 (from a total head of 30 meters)	63000 (from a total head of 50 meters)	42000 (from a total head of 70 meters)	100800 (from a total head of 50 meters)	67200 (from a total head of 70 meters)	43200 (from a total head of 100 meters)	141750 (from a total head of 50 meters)	94500 (from a total head of 70 meters)	60750 (from a total head of 100 meters)	189000 (from a total head of 50 meters)	126000 (from a total head of 70 meters)	81000 (from a total head of 100 meters)

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the "Average Daily Solar Radiation" condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e. Performance Requirements) specified earlier.
3. If submersible pumps are used in lieu of surface pumps, the water output must match that of the surface pumps as specified in this table.

Indicative Technical Specifications of Solar Deep well (submersible) Pumping Systems with A.C. Induction Motor Pump Set

Description	**Model-15**	**Model-16**	**Model-17**	**Model-18**	**Model-19**	**Model-20**	**Model-21**	**Model-22**	**Model-23**	**Model-24**	**Model-25**	**Model-26**	**Model-27**	**Model-28**
PV array (Wp)	11250	11250	11250	11250	13500	13500	13500	13500	15750	15750	15750	15750	18000	18000
Motor Pump-set capacity (HP)	12.5	12.5	12.5	12.5	15	15	15	15	17.5	17.5	17.5	17.5	20	20
Shut Off Dynamic Head (meters)	100	150	180	225	100	150	180	225	100	150	180	225	150	180
Water output * (Liters per day)	157500 (from a total head of 70 meters)	101250 (from a total head of 100 meters)	95625 (from a total head of 120 meters)	75375 (from a total head of 150 meters)	189000 (from a total head of 70 meters)	121500 (from a total head of 100 meters)	114750 (from a total head of 120 meters)	90450 (from a total head of 150 meters)	220500 (from a total head of 70 meters)	141750 (from a total head of 100 meters)	133875 (from a total head of 120 meters)	105525 (from a total head of 150 meters)	162000 (from a total head of 100 meters)	153000 (from a total head of 120 meters)

* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the “Average Daily Solar Radiation” condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

Notes:

1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e. Performance Requirements) specified earlier.
3. If submersible pumps are used in lieu of surface pumps, the water output must match that of the surface pumps as specified in this table.

Indicative Technical Specifications of Solar Deep well (submersible) Pumping Systems with A.C. Induction Motor Pump Set

Description	**Model-29**	**Model-30**	**Model-31**	**Model-32**	**Model-33**	**Model-34**	**Model-35**	**Model-36**	**Model-37**	**Model-38**	**Model-39**
PV array (Wp)	18000	18000	20250	20250	20250	20250	20250	22500	22500	22500	22500
Motor Pump-set capacity (HP)	20	20	22.5	22.5	22.5	22.5	22.5	25	25	25	25
Shut Off Dynamic Head (meters)	225	300	150	180	225	300	375	180	225	300	375
Water output * (Liters per day)	120600 (from a total head of 150 meters)	90000 (from a total head of 200 meters)	182250 (from a total head of 100 meters)	172125 (from a total head of 120 meters)	135675 (from a total head of 150 meters)	101250 (from a total head of 200 meters)	81000 (from a total head of 250 meters)	191250 (from a total head of 120 meters)	150750 (from a total head of 150 meters)	112500 (from a total head of 200 meters)	90000 (from a total head of 250 meters)

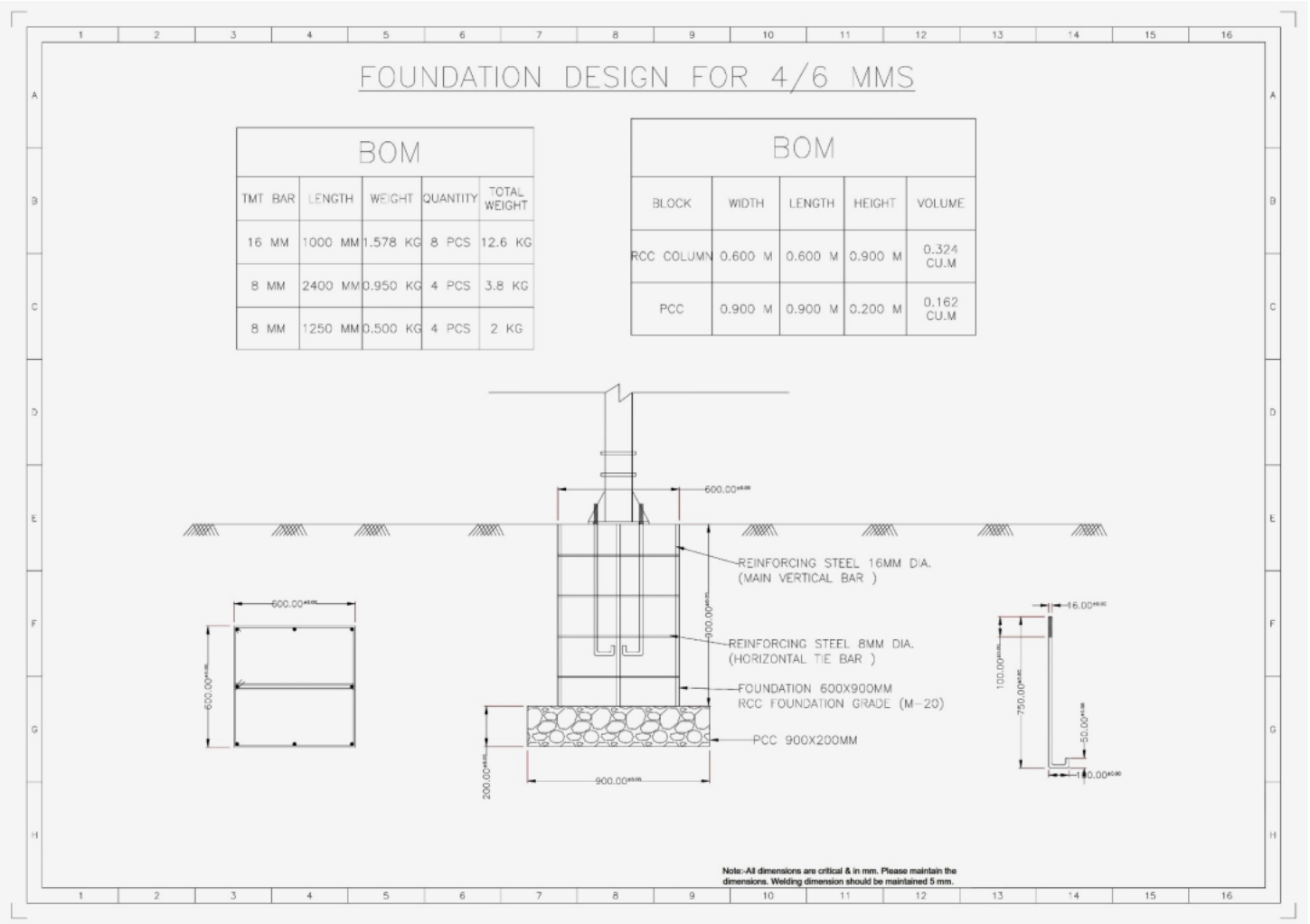
* Water output figures are on a clear sunny day with three times tracking of SPV panel, under the “Average Daily Solar Radiation” condition of 7.15 kWh/ sq.m. on the surface of PV array (i.e. coplanar with the PV Modules).

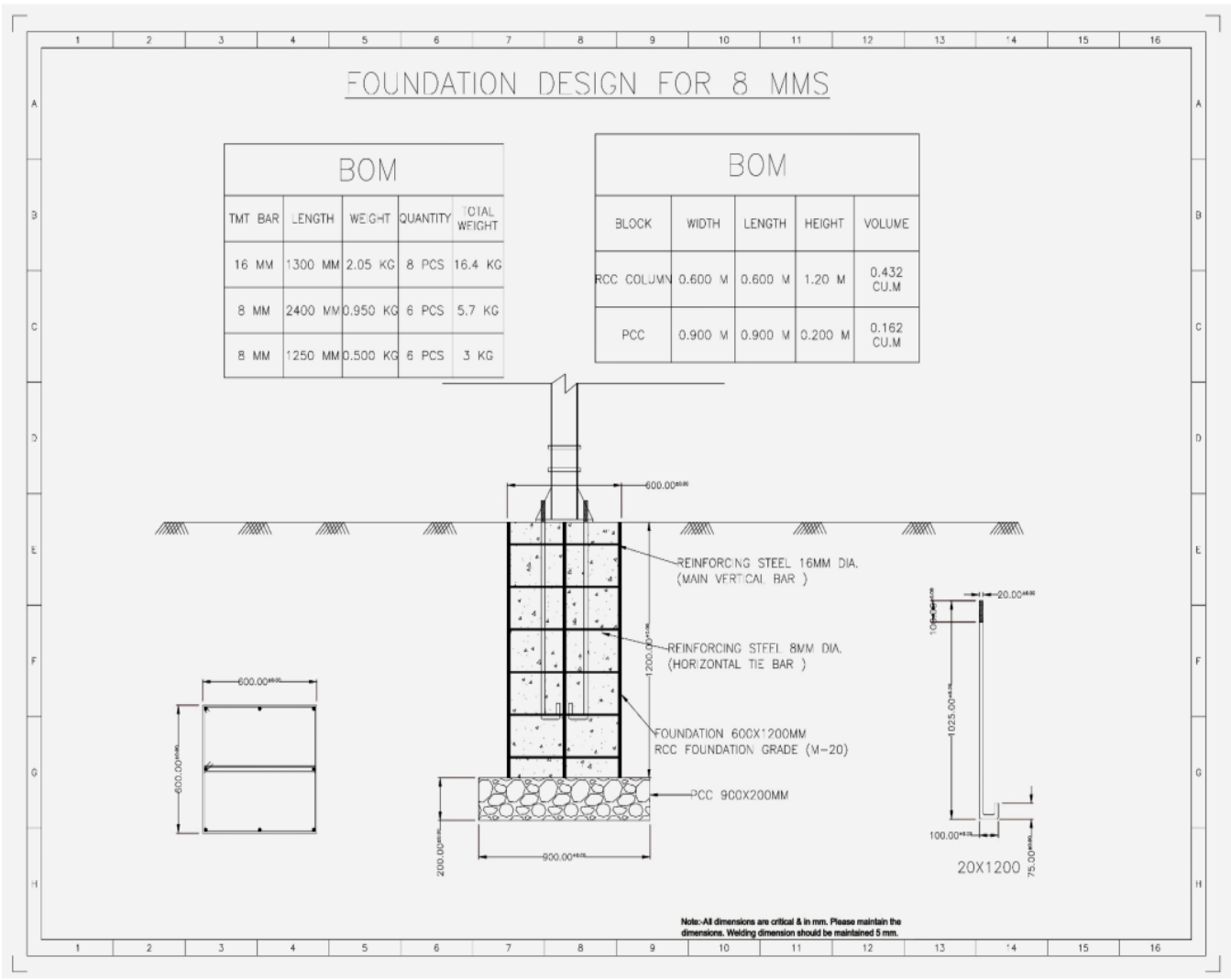
Notes:

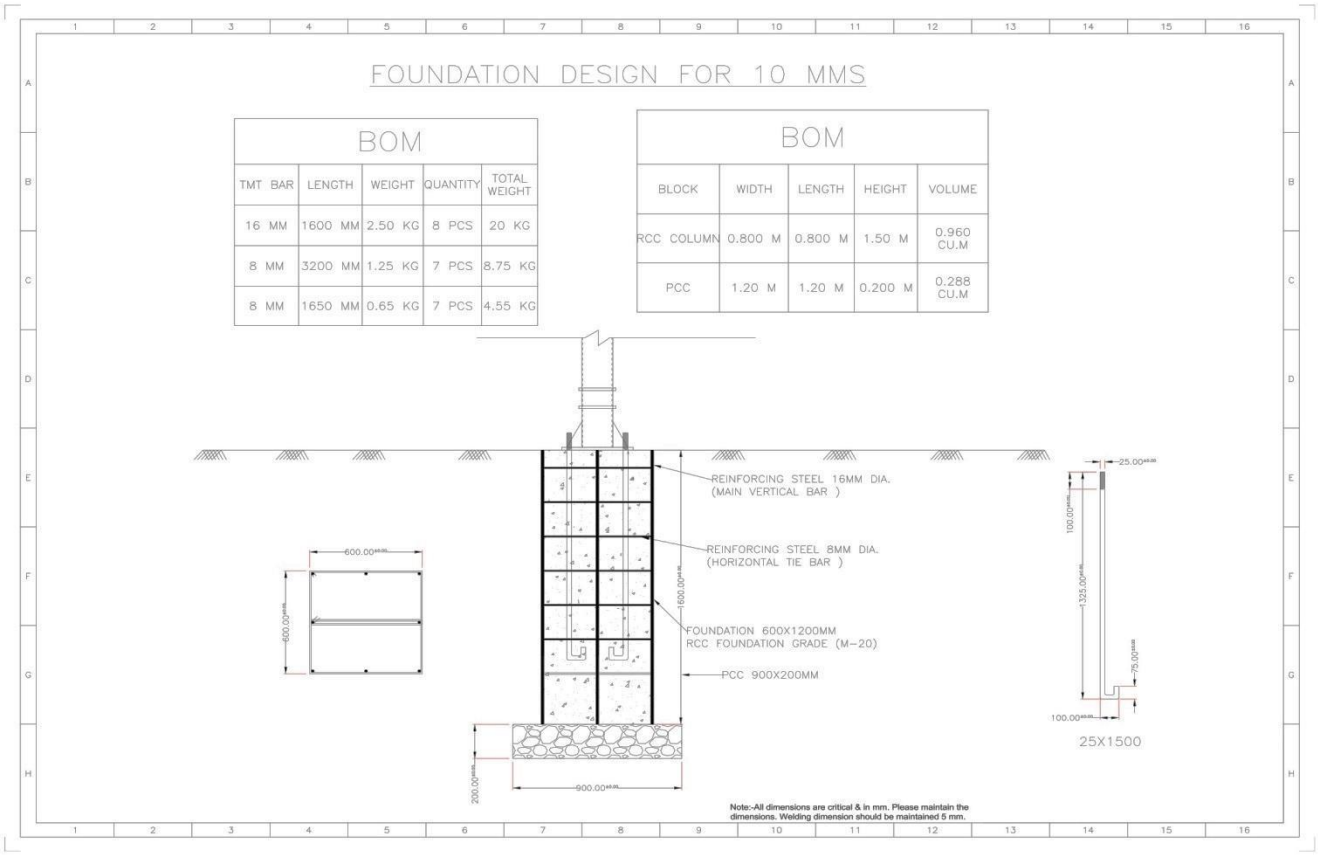
1. Suction head, if applicable, minimum 7 meters.
2. For higher or lower head / PV capacity, or in between various models; water output could be decided as per the clause 4 (i.e. Performance Requirements) specified earlier.
3. If submersible pumps are used in lieu of surface pumps, the water output must match that of the surface pumps as specified in this table.

Annexure V

Foundation design




FOUNDATION DESIGN FOR 8 MMS
BOM
TMT BAR | LENGTH | WEIGHT | QUANTITY | TOTAL WEIGHT
16 MM | 1300 MM | 2.05 KG | 8 PCS | 16.4 KG
8 MM | 2400 MM | 0.950 KG | 6 PCS | 5.7 KG
8 MM | 1250 MM | 0.500 KG | 6 PCS | 3 KG
BOM
BLOCK | WIDTH | LENGTH | HEIGHT | VOLUME
RCC COLUMN | 0.600 M | 0.600 M | 1.20 M | 0.432 CU.M
PCC | 0.900 M | 0.900 M | 0.200 M | 0.162 CU.M
600.00
REINFORCING STEEL 16MM DIA.
(MAIN VERTICAL BAR)
REINFORCING STEEL 8MM DIA.
(HORIZONTAL TIE BAR)
1200.00
FOUNDATION 600X1200MM
RCC FOUNDATION GRADE (M-20)
PCC 900X200MM
200.00
900.00
20.00
1025.00
100.00
75.00
20X1200
Note:-All dimensions are critical & in mm. Please maintain the dimensions. Welding dimension should be maintained 5 mm.


FOUNDATION DESIGN FOR 10 MMS
BOM
TMT BAR | LENGTH | WEIGHT | QUANTITY | TOTAL WEIGHT
16 MM | 1600 MM | 2.50 KG | 8 PCS | 20 KG
8 MM | 3200 MM | 1.25 KG | 7 PCS | 8.75 KG
8 MM | 1650 MM | 0.65 KG | 7 PCS | 4.55 KG
BOM
BLOCK | WIDTH | LENGTH | HEIGHT | VOLUME
RCC COLUMN | 0.800 M | 0.800 M | 1.50 M | 0.960 CU.M
PCC | 1.20 M | 1.20 M | 0.200 M | 0.288 CU.M
REINFORCING STEEL 16MM DIA. (MAIN VERTICAL BAR)
REINFORCING STEEL 8MM DIA. (HORIZONTAL TIE BAR)
FOUNDATION 600X1200MM RCC FOUNDATION GRADE (M-20)
PCC 900X200MM
600.00
600.00
1600.00
200.00
900.00
25.00
100.00
1325.00
75.00
100.00
25X1500
Note:-All dimensions are critical & in mm. Please maintain the dimensions. Welding dimension should be maintained 5 mm.

LIST OF REFERRED INDIAN STANDARDS

456:2000	Plain and reinforced concrete - Code of practice (Fourth Revision)
811:1987	Specification for cold formed light gauge structural steel sections (Second Revision)
822:1970	Code of procedure for inspection of welds
IS 875 : Part 1 : 1987	Code of practice for design loads (Other Than Earthquake) for buildings and structures: Part 1 dead loads - Unit weights of building materials and stored materials (Second Revision)
694:2010	Polyvinyl Chloride Insulated Unsheathed--And Sheathed Cables/cords With Rigid And-Flexible Conductor for Rated Voltages-Up to annd including 450/750 V
1079:2017	Hot rolled carbon steel sheet, plate and strip - Specification (Seventh Revision)
1161:2014	Steel tubes for structural purposes - Specification (Fifth Revision)
1239 (Part 1):2004	Steel tubes, tubulars and other wrought steel fittings - Specification: Part 1 steel tubes (Sixth Revision)
2062:2011	Hot rolled medium and high tensile structural steel - Specification (Seventh Revision)
2629:1985	Recommended practice for hot-dip galvanizing of iron and steel (First Revision)
2633:1986	Method for testing uniformity of coating on zinc coated articles (Second Revision)
3043:1987	Code of Practice for Earthing
4091:1979	Code of practice for design and construction of foundations for transmission line towers and poles (First Revision)
4759:1996	Hot - Dip zinc coatings on structural steel and other allied products - Specification (Third Revision)
5120:1977 5624:1993	Technical requirements for rotodynamic special purpose pumps (First revision) Foundation bolts - Specification (First Revision)
6403:1981	Code of practice for determination of bearing capacity of shallow foundations
6745:1972	Methods for determination of mass of zinc coating on zinc coated iron and steel articles
7215:1974	Tolerances for fabrication of steel structures
8034:2018	Submersible pump sets - Specification (third revision)

9079:2018	Monoset pumps for clear, cold water for agricultural and water supply purposes - Specification (third revision)
9283:2013	Motors for submersible pump sets
9968 (Part 1):1988	Specification for elastomer insulated cables: Part 1 for working voltages up to and including 1100 volts (First Revision)
14220:2018	Open well submersible pump sets - Specification (first revision)
14536:2018	Selection, installation, operation and maintenance of submersible pumpset - Code of practice (First Revision)
IS/IEC 61701: 2011	Salt mist corrosion testing of photovoltaic (PV) modules First Revision
IS 17210 (Part 1): 2019 IEC TS 62804-1: 2015	Photovoltaic (PV) Modules — Test Methods for the Detection of Potential-Induced Degradation Part 1 Crystalline Silicon
IS/IEC 60034-1:2004	Rotating Electrical Machines ─ Part 1 Rating and Performance
IS/IEC 61683:1999	Photovoltaic System-Power Conditioners — Procedure for Measuring Efficiency
IEC 62253:2011	Photovoltaic Pumping Systems – Design qualification and performance measurements
IS 14286 : 2010 /IEC 61215 : 2005	Crystalline Silicon Terrestrial Photovoltaic (Photo Voltaic (PV)) modules - Design Qualification And Type Approval (First Revision)
IS/IEC 61730-1 : 2004	Photovoltaic (Photo Voltaic (PV)) Module Safety Qualification Part 1 Requirements for Construction
IS/IEC 61730-2 : 2004	Photovoltaic (Photo Voltaic (PV)) Module Safety Qualification Part 2 Requirements for Testing
IEC 60068-2-6:2007	Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)
IEC 60068-2-30:2005	Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 + 12h cycle)
IS 16221 (Part-2)	Safety of Power Converters for use in Solar Photovoltaic Power Systems
IEC 62305-1/2/3/4	Lightning Protection
IEC 63227	Lightning and Surge Voltage Protection for photovoltaic (PV) power supply systems
IEC 61643-31	Low-voltage surge protective devices
IS/IEC 60947: PART 1: 2007	Low - Voltage switchgear and control gear: Part 1 general rules (First Revision)

Documents Referred:

i. Alternative Energy Production Centre,2014, Training Manual on Solar PV Pumping System.

ii. Asian Development Bank,2014, Handbook for Rooftop Solar Development in Asia

iii. Gujarat Urja Vikas Nigam Limited,2021, Rooftop Solar PV Inspection Handbook.

iv. Energy Market Authority, Handbook for Solar Photovoltaic Systems.

v. GERMI,2018, Best Practices in Operation and Maintenance of Rooftop Solar PV Systems in India.

vi. Global Sustainable Energy Solutions, Standards Operating Procedure for Installation of Small Rooftop solar PV Plants.

vii. Solar Power Europe,2020, Operation & Maintenance Best Practices Guidelines / India Edition

viii. UNICEF, Solar Powered Water Systems Design and Installation Guide.

ix. World bank Group, Ministry of New & Renewable Energy, State Bank of India,2019, Standard Operating Procedure for Installation of Grid Connected Rooftop Solar Photovoltaic Systems-A handbook for Engineers & Developers.