Section-4 Technical specifications

SPECIFICATION FOR SOLAR PHOTOVOLTAIC WATER PUMPING SYSTEMS

1. SCOPE

These specification covers design qualifications and performance specifications for Centrifugal Solar Photo Voltaic (SPV) Water Pumping Systems 02, 03 & 05 HP suitable for bore-well, open well, water reservoir, water stream, etc., and specifiesthe minimum standards to be followed under MNRE Schemes.

2. TERMINOLOGY

In addition to the terminology specified in **3** of IS 5120 and IEC 62253 as suggested by MNRE, the following shall also apply.

- **2.1. Static Water Depth** It is the depth of water level below the ground level when the pump is not in operation.
- **2.2. 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.
- **2.3. Submergence** It is the minimum height of water level after drawdown above the pumpsuction casing.
- **2.4. Manometric Suction Lift** Manometric suction lift is the vacuum gauge/suction manometer reading in meter of water column when pump operates at suction lift.
- **2.5. Static Suction Lift** Static suction lift/head is the vertical distance between sump water level and center of pump inlet.
- 2.6. 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 (i.e. coplanar with the SPV Modules).
- **2.7. Wire to Water Efficiency** It is the combined system efficiency of SPV Converter/Controller with Inbuilt MPPT mechanism, Pump set and piping.
- 2.8. Pump Controller Pump Controller converts the DC voltage of the SPV array into a suitable DC or AC, single or multi-phase power and may also include equipment for MPPT, remote monitoring, and protection devices.

2.9. 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).

3. CONSTRUCTIONAL FEATURES

3.1 General

3.1.1.3.1.1 SPV Water Pumping System set uses the irradiance available through SPV array. The SPV array produces DC power, which can be utilized to drive a DC or an AC pump set using pump controller.

3.2 A SPV Water Pumping system typically consists of:

3.2.1 Motor Pump Set see 3.4.

3.2.2 SPV Controller

Note: Some controllers are inbuilt in the motors

S.No.	Requirement	Specifications				
1.	Controller Power Capacity to drive the Pump	Controller Power Capacity should be at-least equal to Solar Panels Power Capacity (Wp), not Pump Capacity. Example: For 5HP pumps, thepump capacity will be 3750W as per MNRE Specs, the solar panel capacity will be at-least 4800 Wp the controller capacity should match to the solar panel capacity.				
2.	Point Tracking (MMPT)	Should track power only and not Voltage at Maximum power point				
3.	Enclosure	The Controller must have IP65 protection or must be housed in acabinet having at least IP65 protection with Suitable (IP65) or above class - cable glands, outside connectors & other related accessories.				
4.	Isolator Switch	Should be between Solar panels and controller				
5.	RMS (GSM/GPRS connectivity)	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				

Specifications of Controller/Drive for Solar Water PumpingSystems

For IS 16221 (Part-2) as suggested by MNRE certification of the SPV pump controller the latest qualitycontrol order released by MNRE regarding IS 16221 (Part-2) as suggested by MNRE must be followed. The detailed Specification of RMS is attached as Annexure IV.

3.3 Solar Photo Voltaic (SPV) Array

3.3.1 SPV arrays contains specified number of same capacities, type and specification modules connected in series or parallel to obtain the required voltage or current output. The SPV water pumping system should be operated with a PV array minimum capacity in the range of **1800 Wp to 4800 Wp**, measured under Standard Test Conditions (STC). Sufficient number of modules in series and parallel could be used to obtain the required voltage or current output. The poweroutput of individual PV modules used in the PV array, under STC, should be a minimum of 300 Watts peak of 02 HP, minimum 320 Watts peak for 03 & 05 HP pumps and 535 Watts peak and above Mono PERC Solar modules can also be use for 05 HP Pumps with adequate provision for measurement tolerances. Use of PV modules with higher power output is preferred. Only DCR modules shall be used in the project.

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

3.3.3 Modules must qualify to IS/IEC 61730 Part I and II as suggested by MNRE for safety qualification testing.

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

3.3.5 Modules must qualify to IEC TS 62804-1:2015 as suggested by MNRE for the detection of potential-induced degradation - Part 1: Crystalline silicon (Mandatory in case the SPV array Open Circuit voltageis more than 600 V DC)

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

3.3.7 The name plate shall conform the IS 14286/IEC 61215 as suggested by MNRE.

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

3.3.9 Any array capacity above the minimum array wattage requirement as specified in these specifications for various models of solar pumping systems is allowed.

3.3.10 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.

3.3.11 The RFID tag shall be placed on the SPV Modules inside the glass laminate.

3.4 Motor-Pump Set

- **3.4.1** The SPV water pumping systems may use any of the following types of motor pump sets:
 - a) Surface mounted motor-pump set
 - b) Submersible motor-pump set.
 - c) Any other type of the motor pump set after approval from Ministry.

3.4.2 Motor

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

- a) AC Induction Motor.
- b) DC Motor (PMSM/BLDC/SRM)
- **3.4.3** The "Motor-Pump Set" should have a capacity in the range of 02, 03 & 05 HP and should have the following features:
 - a) The closed coupled or mono block DC/ AC centrifugal motor pump set with appropriate mechanical seals which ensures zero leakage.
 - b) The motor of the capacity ranging from 02, 03 & 05HP should be AC/DC. The suction and delivery head will depend on the site-specific condition of the field.
 - c) Submersible pumps could also be used according to the dynamic head of the site atwhich the pump is to be used.
- **3.4.4** 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, stainless steelof grade 316 or higher grade may be used.
- **3.4.5** As per IEC 61683 as suggested by MNRE, 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.
- **3.4.6** 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 forpumps up to 3 HP, 10 kg/sqcm-PE100 grade for 5 HP pumps and further higher minimum pressure rating for 5 HP as appropriate shall be used.

3.5 Module Mounting Structures and Tracking System

3.5.1 MMS as per drawings (which is given as Annexure "V"-A₁ to A₅₄) should be installed along with the hot dipped galvanized (minimum 80 microns) array support structure for mounting of SPV modules at site. The panel frame structure should be capable of withstanding a minimum wind load of 150 Km per hour, after grouting and installation. MMS should be sturdy & designed to assist SPV Modules to render maximum discharge. The hardware (fasteners) used for installation of SPV Modules & MMS should be of suitable Stainless Steel SS 304 grade or Hot dipped galvanized 8.8 grade. Each MMS should be grouted on pedestals & Foundation as per drawings. Each module should be fastened using four theft proof nut bolt. Module Mounting Structure including foundation bolt, other nut & bolt, steel nut & bolts, washer, theft proof nut &

bolts, clamps for holding controller etc. for 06 nos. & 09 nos. modules shall be as per drawing and specification attached in tender document.

- i. Module Mounting Structures should have theft proof arrangements with the use of GI Steel C-channel along with the array support structure for locking arrangement of SPV modules for protecting them from theft. Its size should be with reference to the specifications of the SPV modules such that modules can comfortably slide in the channel while installation. It should not hide any portion of the photovoltaic circuit encapsulated in the lamination of the SPV module, there by un-affecting the efficiency & rating of the SPV modules. Anti-Theft Nut Bolts of SS-304 (with washers) must be used for better theft proofing along with "C" Channel MMS.
- **ii.** To enhance the performance of SPV irrigation pumping systems arrangement for seasonal tilt angle adjustment and three times manual tracking in a day should be provided. In order to make structure rigid, the gap between Telescopic pattern supports should be minimal, further, for bearing of centre load of whole structure only pins should be used instead of threaded bolts.
- iii. The general hardware for structure fitment should be either Stainless Steel **SS 304** grade or Hot dipped galvanized 8.8 grade. Modules should be locked with antitheft bolts of SS 304 Grade. Foundation should be as per drawing attached.

3.6 SPV Controller

3.6.1 Maximum Power Point Tracker (MPPT) shall be included to optimally use the poweravailable from the SPV array and maximize the water discharge.

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

- **3.6.3** Adequate protections shall be provided in the SPV Controller to protect the solar poweredpump set against the following:
 - a) Dry running;
 - b) Open circuit;
 - c) Output short circuit;
 - d) Under voltage;
 - e) Reverse polarity;

3.6.4 A DC switch as per IS/IEC 60947-1 as suggested by MNRE suitable for switching dc power ON and OFF shallbe provided in the SPV Pump Controller.

3.6.5 All cables used shall be as per IS 694 or IS 9968(Part 1) as suggested by MNRE. 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 as suggested by MNRE.

3.6.6 The various parameters should be present on the SPV Pump Controller display/screen such as:- Pump On/Off status, Array Input DC Voltage, DC/AC output Current & voltage, operating frequency, Latest RMS Lat, Latest RMS Long, Pump Capacity (HP), PV Module Capacity (KW), Pump Status, Current Generation (kW), Today Solar Generation (kWh), Total Solar Generation (kWh), Today Runs Hours (Hrs.), Total Pump Run Hours (Hrs.), Today Water Discharged (Liters), Total Water Discharged (Liters), Peak Power (kW) supplied by the controller to Motor-Pump Set.

3.7 Protections

The system should be provided with all necessary protections like earthing, Lightning, and Surge Protection etc., as described below:

3.7.1 Earthing and Lightning Protection

- 1) The Earthing shall be done in accordance with the IS 3043 including its amendments and updated versions.
- 2) The Earthing system should be designed in such a way that its 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.
- 3) 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.
- 4) It is recommended to keep the value of resistance of earth electrode less than 5 ohms.
- 5) All the materials, fittings etc. used for doing earthing shall conform to the Indian standard, wherever exists.
- 6) 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 as suggested by MNRE shall be referred.
- 7) 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 as suggested by MNRE shall be referred.
- 8) It is recommended for selection of type and installation of the earth electrode the provisions of the IS 3043 as suggested by MNRE should be considered. However, the pipe or rod type earth electrode is preferable.
- 9) 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.

- 10) The provisions given in the IS 3043 as suggested by MNRE should be considered while selecting or connecting the earthing/protective/grounding conductor from the components to the earth pit.
- 11) Separate earthing conductor shall be provided for controller, pump, motor 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.
- 12) For the maintenance of the earth electrode and measurement of the Earth electrode resistance the provisions of IS 3043 as suggested by MNRE shall be referred.
- 13) Motor shall have suitable provision for earthing to facilitate earthing of the motor as per IS 3043 as suggested by MNRE 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/UPVC 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.
- 14) Lightning protection shall be provided as per IEC 62305 as suggested by MNRE and IEC 63227 as suggested by MNRE standard includingits amendments and updated versions.
- 15) 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.
- 16) Arrangement and positioning of the separate air-termination systems can be determined using different methods given in the IEC 62305-3 as suggested by MNRE. 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 as suggested by MNRE & IEC 63227 as suggested by MNRE 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 calculated using the IEC 63227 as suggested by MNRE.
- 17) 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 (l₁) of vertical earth electrodes for lightning protection level III or higher shall be determined according to the IEC 62305-3 as suggested by MNRE.
- 18) 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 mm² Cu or 25 mm² Al or GI of equivalent

current carrying capacity should be used, which will also depend upon the class of the Lightning protection system.

19) The earth pits given with the SWPS {i.e. Earth pit(s) for the BoS system (other than LA) and Earth Pit for LA} should be made equipotential bonded to each other.

3.7.2 Surge Protection Device

- 1) For SPDs IEC 63227 as suggested by MNRE and its updated versions or amendments should be followed.
- 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 as suggested by MNRE.
- 3) If the distance between the SPD and the inverter to be protected is greater than 10 m, then SPD according to IEC 63227 as suggested by MNRE should be applied.
- 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.

3.8 Use of indigenous components

It will be mandatory to use indigenously manufactured solar modules with indigenous mono/ multi crystalline silicon solar cells. Further, the motor-pump-set, controller and balance of system should also be manufactured indigenously. The vendor has to declare the list of imported components used in the solar water pumping system.

4. PERFORMANCE REQUIREMENTS

4.1 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 PVWater Pumping System at different "Total Dynamic Heads" should be as specified below:

For D.C. Motor Pump Set:

- (i) 110 liters of water per watt peak of PV array, from a Total Dynamic Head of 10 meter (Suction head, if applicable, minimum of 7 meter static suction lift corrected for atmospheric pressure and water temperature) and with the shut off head being at least 12 meter.
- (ii) 55 liters of water per watt peak of PV array, from a Total Dynamic Head of 20 meter (Suction head, if applicable, minimum of 7-meter static suction lift corrected for atmospheric pressure and water temperature) and with the shut off head being at least 25 meter.
- (iii) 38 liters of water per watt peak of PV array, from a Total Dynamic Head of 30 meters (Suction head, if applicable, minimum of 7-meter static suction lift corrected

for atmospheric pressure and water temperature) and the shut off head being at least45 meter.

- (iv) 23 liters of water per watt peak of PV array, from a Total Dynamic Head of 50 meter (Suction head, if applicable, minimum of 7-meter static suction lift corrected for atmospheric pressure and water temperature) and the shut off head being at least 70 meter.
- (v) 15 liters of water per watt peak of PV array, from a Total Dynamic Head of 70 meters (Suction head, if applicable, minimum of 7-meter static suction lift corrected for atmospheric pressure and water temperature) and the shut off head being at least 100 meter.
- (vi) 10.5 liters of water per watt peak of PV array, from a Total Dynamic Head of 100 meters (Suction head, if applicable, minimum of 7-meter static suction lift corrected for atmospheric pressure and water temperature) and the shut off head being at least 150 meter.

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.

Indicative performance specifications for the Shallow and Deep well SPV Water Pumping Systems are given in the Annexure II.

For A.C. Induction Motor Pump Set:

- i) 99 liters of water per watt peak of PV array, from a Total Dynamic Head of 10 meter (Suction head, if applicable, minimum of 7-meter static suction lift corrected for atmospheric pressure and water temperature) and with the shut off head being at least 12 meter.
- 49 liters of water per watt peak of PV array, from a Total Dynamic Head of 20 meter (Suction head, if applicable, minimum of 7-meter static suction lift corrected for atmospheric pressure and water temperature) and with the shut off head being at least 25 meter.
- iii) 35 liters of water per watt peak of PV array, from a Total Dynamic Head of 30 meter (Suction head, if applicable, minimum of 7-meter static suction lift corrected for atmospheric pressure and water temperature) and the shut off head being at least 45 meter.
- iv) 21 liters of water per watt peak of PV array, from a Total Dynamic Head of 50 meter (Suction head, if applicable, minimum of 7-meter static suction lift corrected for atmospheric pressure and water temperature) and the shut off head being at least 70 meter.
- v) 14 liters of water per watt peak of PV array, from a Total Dynamic Head of 70 meter (Suction head, if applicable, minimum of 7-meter static suction lift corrected for atmospheric pressure and water temperature) and the shut off head being at least 100 meter.
- vi) 9 liters of water per watt peak of PV array, from a Total Dynamic Head of 100 meter (Suction head, if applicable, minimum of 7-meter static suction lift corrected for

atmospheric pressure and water temperature) and the shut off head being at least 150 meter.

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. Indicative performance specifications for the Shallow and Deep well SPV Water Pumping Systems are given in the Annexure III.

5. TESTS FOR HYDRAULIC AND ELECTRICAL PERFORMANCE OF PUMPSET

5.1 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

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 as suggested by MNRE 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.

5.2 Testing of SPV Water Pumping Systems shall be done as per procedure specified by theMNRE.

6. GUARANTEE OF PERFORMANCE

- **6.1** The SPV Water Pumping Systems shall be guaranteed for their performance of the nominal volume rate of flow and the nominal head at the guaranteed duty point as specified in 7.1 under the "Average Daily Solar Radiation" condition of 7.15 KWh/m² on the surface of SPV array (i.e. coplanar with the Photo Voltaic (PV) Modules). 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.
- **6.2** 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.
- **6.3** Sufficient spares for trouble free operation during the Warrantee period should be made available as and when required

7. MARKING AND PARAMETERS TO BE DECLARED BY THEMANUFACTURER

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

7.1.1 Motor Pump-set

- a) Manufacturer's name, logo or trade-mark;
- b) Model, size and SI No of pump-set(To be engraved/laser marked on the motorframe);
- c) Motor Rating (kW / HP);
- d) Total head, m, at the guaranteed duty point;
- e) Capacity (LPD) at guaranteed head;
- f) Operating head range, m;
- g) Maximum Current (A);
- j) Voltage Range (V) and;
- k) Type AC or DC Pump set; &
- 1) Photo Voltaic (PV) Array Rating in Watts peak (W_p)
- m) 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.

7.1.2 Controller

- a) Manufacturer's name, logo or trade-mark;
- b) Model Number;
- c) Serial Number;
- d) Voltage Range;
- e) Power Range in kW for Controller; and
- f) Current rating (A)
- g) Country of origin

8. OPERATION AND MAINTENANCE MANUAL

8.1 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 solarenergy, 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 representative 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.

9. COMPREHENSIVE OPERATION AND MAINTENANCE

- i. The Contractor 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.
- ii. 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 CREDA and also uploaded on portal of CREDA whenever suchportal or mobile app is made available.
- iii. The deputed personnel shall be in a position to check and test all the equipments regularly, so that preventive actions, if any, could be taken well in advance to save any equipment from damage.
- iv. 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.
- v. 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.
- vi. The maintenance shall include replacement of any component irrespective of whether the defect was a manufacturing defect or due to wear and tear.

LIST OF REFERRED INDIAN STANDARDS

(as Suggested by MNRE)

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 UnsheathedAnd Sheathed Cables/cords					
	With Rigid And-Flexible Conductor For Rated Voltages-Up To And 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	Steel tubes, tubulars and other wrought steel fittings - Specification: Part 1 steel tubes					
1):2004	(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	Technical requirements for rotodynamic special purpose pumps (First					
	revision)					
5624:1993	Foundation holts - Specification (First Devicion)					
6403:1981	Foundation bolts - Specification (First Revision) 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)					
8034.2018	Submersible pump sets - Specification (unite Tevision)					
9079:2018	Monoset pumps for clear, cold water for agricultural and water					
2010	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 pump set - Code					
	ofpractice (First Revision)					
IS/IEC 61701 : 2011	Salt mist corrosion testing of photovoltaic (PV) modules					
	First Revision					
IS 17210 (Part 1) : 2019 IEC	Photovoltaic (PV) Modules — Test Methods for the Detection of Potential-Induced					
TS 62804-1 : 2015	Degradation Part 1 Crystalline Silicon					
IS/IEC 60034-1:2004	Rotating Electrical Machines – Part 1 Rating and Performance					
10 / EC <1 <02 1000						
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 :	Crystalline Silicon Terrestrial Photovoltaic (Photo Voltaic (PV)) modules - Design					
2005	Qualification And Type Approval (First Revision)					

	Photovoltaic (Photo Voltaic (PV)) Module Safety Qualification Part 1 Requirements for Construction
	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)
	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 controlgear: Part 1 general rules (First Revision)
IS xxxxxx (Doc No MED/20/13071)	Solar Photovoltaic Water Pumping Systems — Testing Procedure Guidelines

ANNEXURE – II

Description	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
PV array (Wp)	1800	2700	2700	4800	4800	4800
Motor Pump- setcapacity (HP)	2	3	3	5	5	5
Shut Off Dynamic Head (meters)	12	12	25	12	25	45
Water output * (Liters perday)	198000 (from a total headof 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)

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

* 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).

- 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.

Description	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8
PV array (Wp)	1800	3000	3000	3000	4800	4800	4800
Motor Pump- set capacity (HP)	2	3	3	3	5	5	5
Shut Off Dynamic Head (meters)	45	45	70	100	70	100	150
Water output * (Liters per day)	68400 (from a total head of 30 meters)	114000 (from a total head of 30 meters)	69000 (from a total headof 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)

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

* 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).

*

- 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 – III

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

Description	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7
PV array (Wp)	1800	2700	2700	4800	4800	4800
Motor Pump- setcapacity (HP)	2	3	3	5	5	5
Shut Off Dynamic Head (meters)	12	12	25	12	25	45
Water output * (Liters perday)	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)

* 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).

- 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.

Description	Model-2	Model-3	Model-4	Model-5	Model-6	Model-7	Model-8
PV array (Wp)	1800	3000	3000	3000	4800	4800	4800
Motor Pump- set capacity (HP)	2	3	3	3	5	5	5
Shut Off Dynamic Head (meters)	45	45	70	100	70	100	150
Water output * (Liters per day)	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)

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

* 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).

- 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.

REMOTE MONITORING SYSTEM(RMS)

- a. Solar System Performance: DC Voltage, DC current, AC output Current, Power, Drive frequency, Energy, etc.
- b. Pump Performance: Running Hours, Water Discharge (Output), etc.
- c. RMS Performance: %Device Connectivity, %Data Availability, etc.
- d. Geo Location: Real time latitude and longitude should be captured with an accuracy of less than 10m horizontal. This is required to ensure that system is not moved from its original location.
- e. Events and Notifications: Faults related to Pump Operation, Solar generation, Controller/Drive faults like overload, dry run, short circuit, etc.
- f. Consumer Management: Name, Agriculture details, Service No. Contact Details, etc.
- g. Asset Management: Ratings, Serial Number, Make, Model Number of Pump, Panel and Controller, Geo Location, IMEInumber (of communication module) and ICCID (of SIM).
- h. Complaint and Ticket Management Complaint management system is a part of centralized monitoring software platform.
- i. Consumer Mobile Application: Generation, Running Hours, Water Discharge, Complaint logging, etc.

Note: MNRE will provide the support for the development of the Mobile App for the PM-KUSUM scheme.

- 1. Communication Architecture should be (to be seen from tender documents) as mentioned below.
 - a. Communication Connectivity:
 - i. **Pump Controller Connectivity:** Communication between RMS and Pump Controller should be on UART/RS485MODBUS RTU protocol to ensure interoperability irrespective of make and manufacturer.
 - ii. **Remote Connectivity:** RMS of SWPS should be using GSM/GPRS/2G/3G/4G cellular connectivity.
 - iii. **Local Connectivity:** Ethernet/Bluetooth/Wi-Fi connectivity to configure parameters, notifications, communication interval, set points etc. or to retrieve locally stored data
 - iv. Sensor Connectivity: RMS should 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 for applications such as irradiation, flow meter for water discharge, moisture sensor for micro-irrigation, etc.

As mentioned in specifications, Analog and digital sensor inputs will be required for integration of flow meter for water discharge, moisture sensor for micro irrigation, level sensor for overhead tank water storage etc. Only provision for Analog and digital inputs with 0.1% accuracy of Full-Scale Range is required. Sensors will not be in scope of bidder.

- v. RMS should have provision to give various modes of operations which are as follows:
 - i. Remote Mode: Pump can be made ON/Off using the Mobile App or in case, farmer do not have a smartphone, farmer shall be able to on-off pump thru SMS/missed call.
 - ii. Auto Mode: Pump can ON/Off automatically using the sensor data which are installed in the field bythe beneficiary. (Cost of sensors will be worn by the beneficiary)
 - iii. Timer Mode: Pump controller shall operate pump as per configured schedule using mobile application

i.e. daily start time and running hours of pump.

iv. Manual Mode: - Pump can be made to run into manual mode from field.

To save ground water, provision for remote operation is required so that farmer can switch on and off remotely.

b. Communication Modes:

- i. Push Data on Event/Notification: such as pump on, pump off, protection operated, etc.
- ii. Push Data Periodically: important parameters of solar pump (as mentioned above) should be pushed to central server onconfigurable interval.
 Default interval should be of 15 minutes. However, if required, it should be possible to configure the periodic intervalin multiple of 1 minute starting from 1 minute and up to 15 minutes. Further, in case of any abnormalities orevent, RMS should push on event immediately.
- iii. Command on Demand: It should be possible to send commands via GSM or GPRS to RMS either to control pump operations or to update configuration.
- **c.** Communication Protocol: RMS should provide data on MQTT protocol to establish communication with thousands of systems.

d. Security:

- i. Communication between RMS and Server should be secured and encrypted using TLS/SSL/X.509 certificate etc.
- ii. As a part of IoT protocol, Authentication and Authorization should be implemented using token/password mechanism
- e. Message Format: RMS should provide data in a JSON message format as per requirement of implementing agency.

f. Data Storage: In case of unavailability of cellular network, RMS should store data locally and on availability of network it shouldpush data to central Server. Local data storage should be possible for one year in case of unavailability of cellular network. RMUsshould have configuration update over the Air of multiple parameters such as IP, APN, Data logging Interval, Set Points etc. is essential. Software updating should be possible with 2G and even without the presence of SD card. Software updating process and/or failure to update software shouldn't disrupt pumping operations.

RMS should be connected to the Solar Energy Data Management Platform of the implementing Agency.

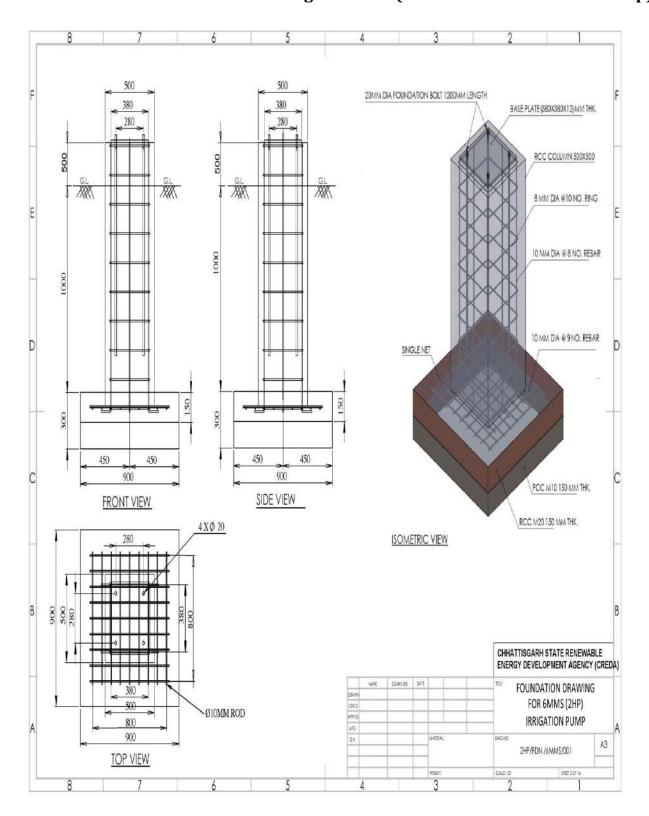
g. RMUs should have configuration update over the Air of multiple parameters such as IP, APN, Data logging Interval, Set Points etc.is essential. Software to be updated through "Programming over the air" on SIA server. Software updating process and/or failure to update software shouldn't disrupt pumping operations.

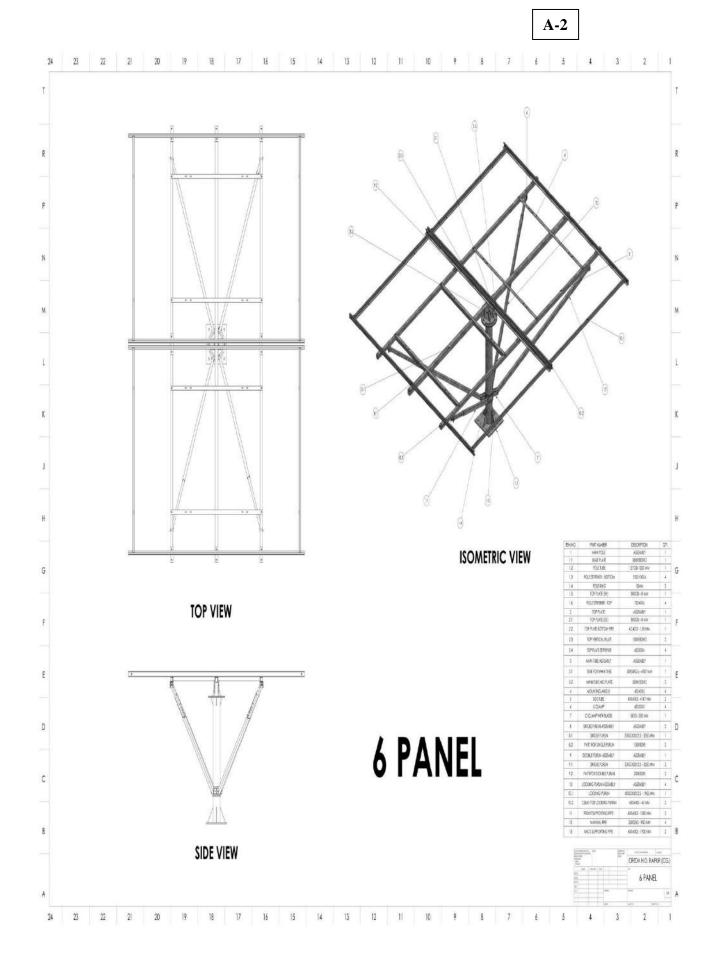
Manufacturer should consider Programming Over the Air (POTA) instead of Firmware Over the Air (FOTA) toupdate co

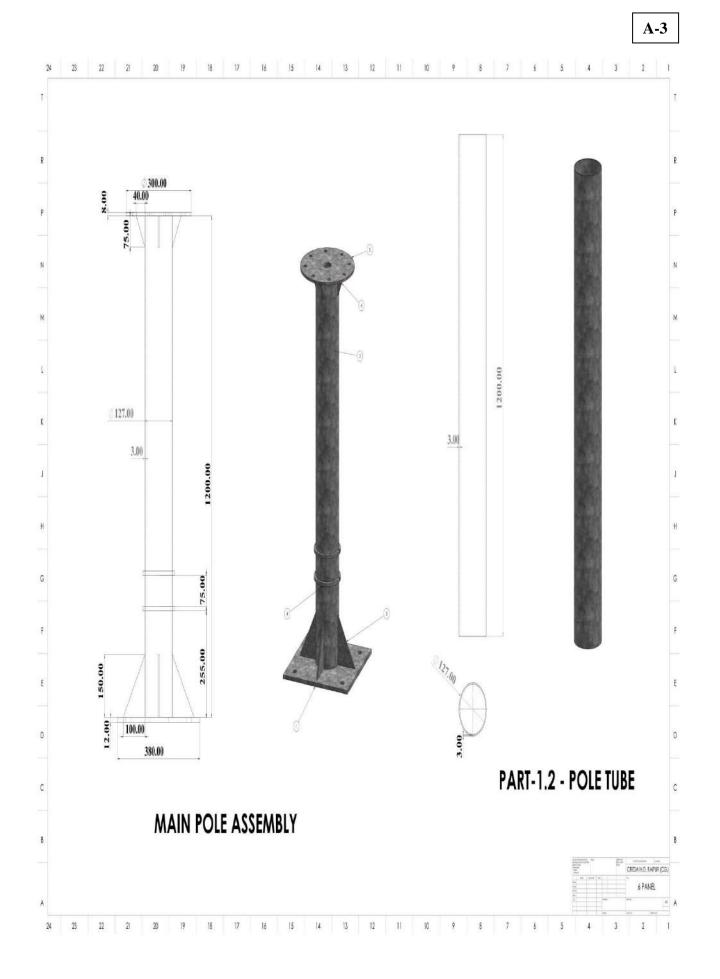
A-1

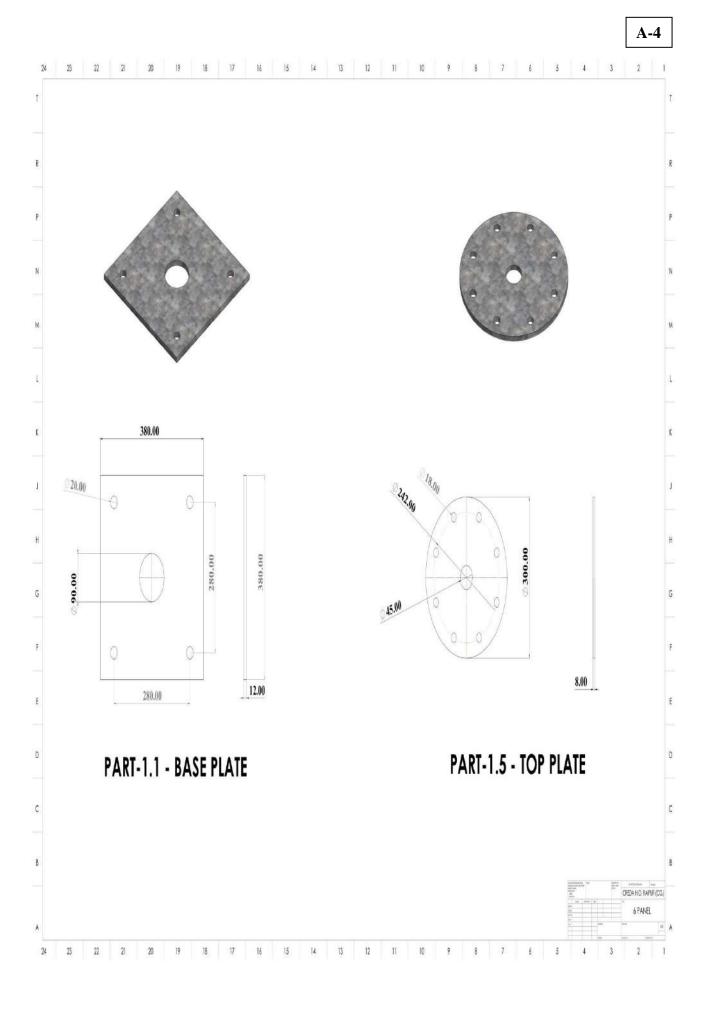
Complete Drawing of Module Mounting Structure & Civil Works

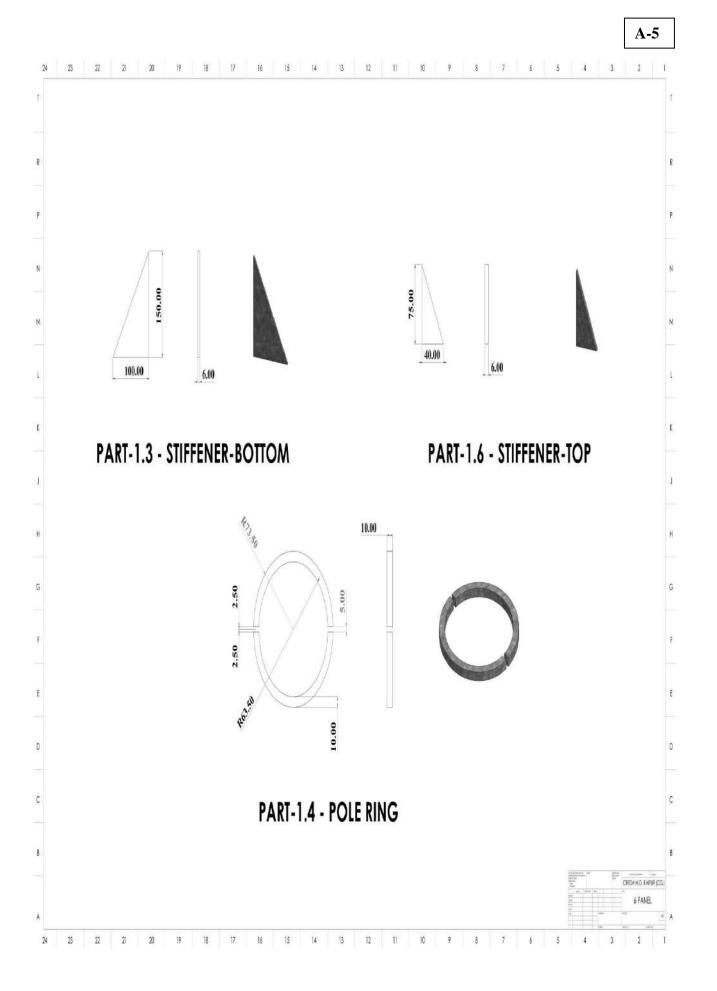
(Shall be applicable only on approval from MNRE) Foundation & MMS Drawings of 02 HP (06 NOs. Module of min 320 Wp)

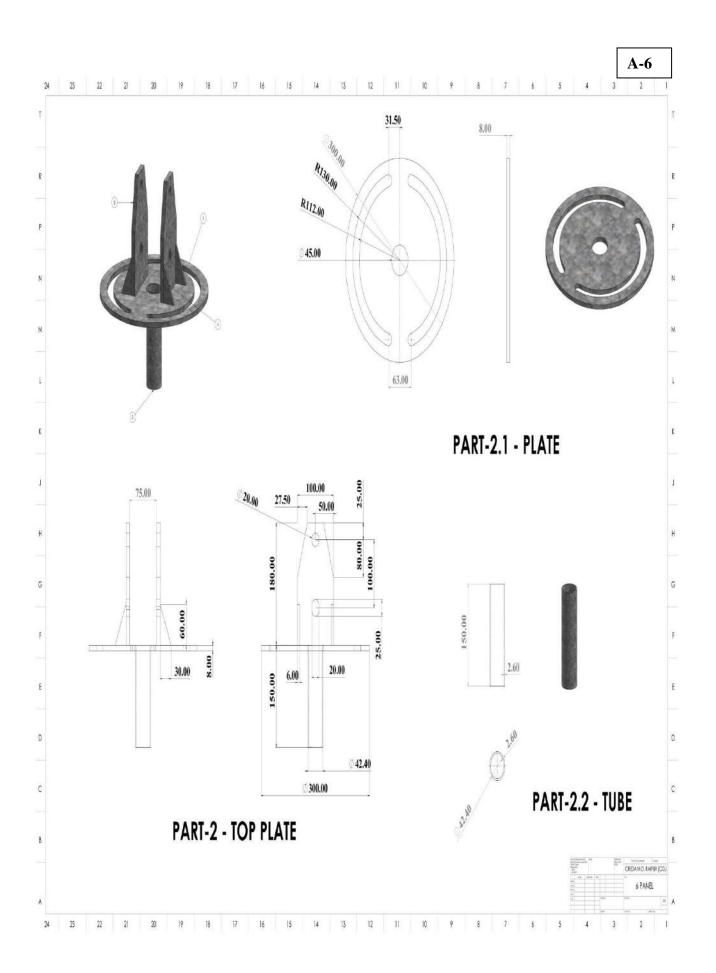


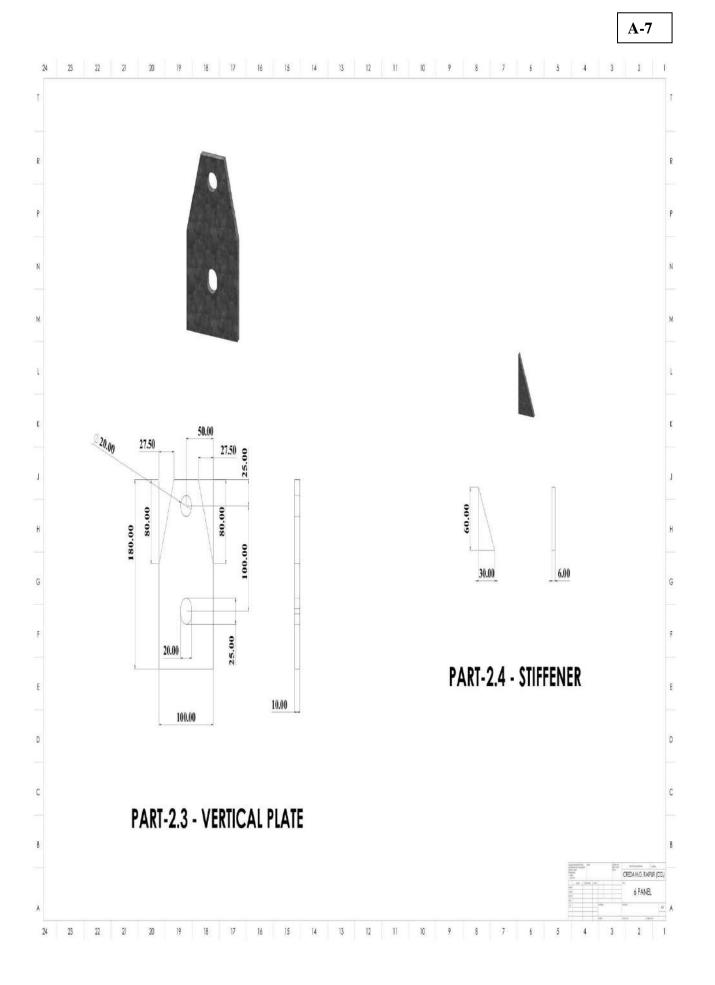


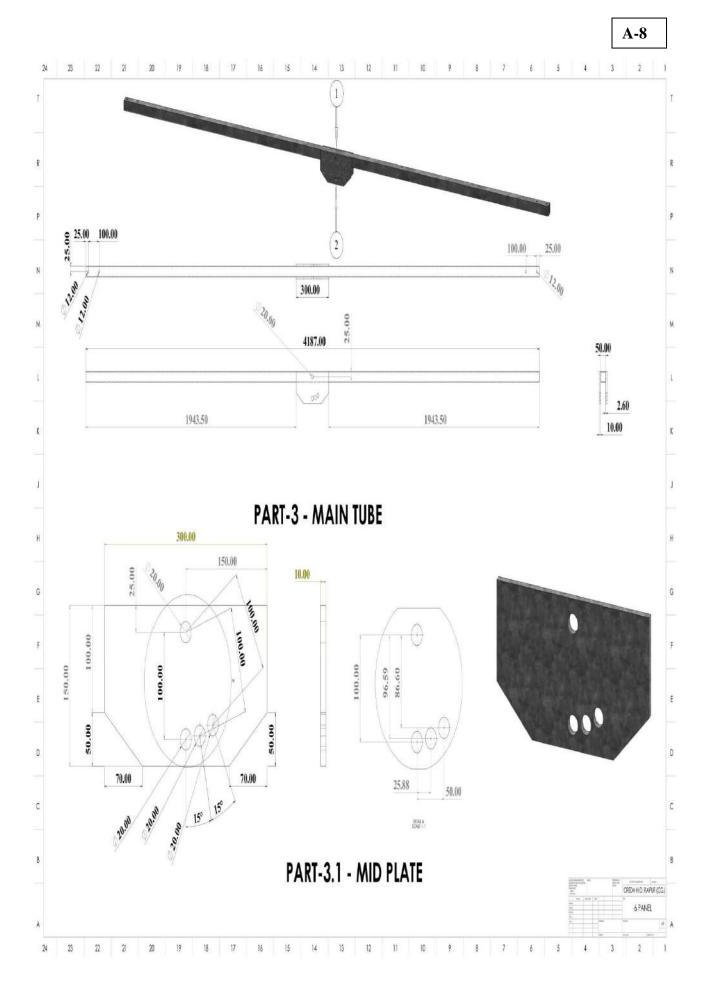


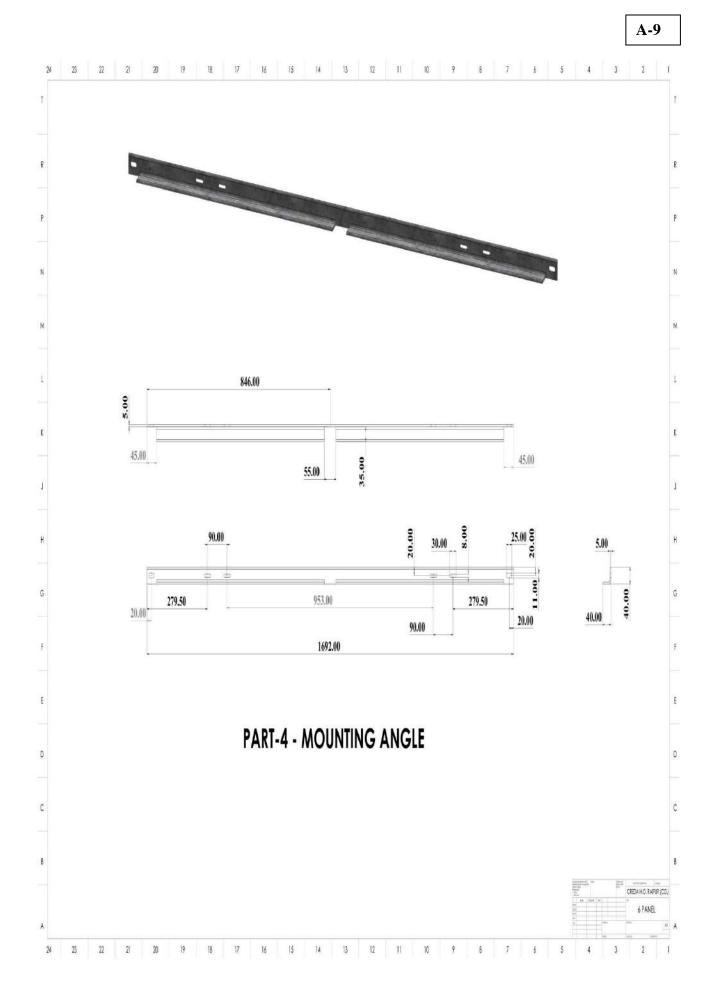


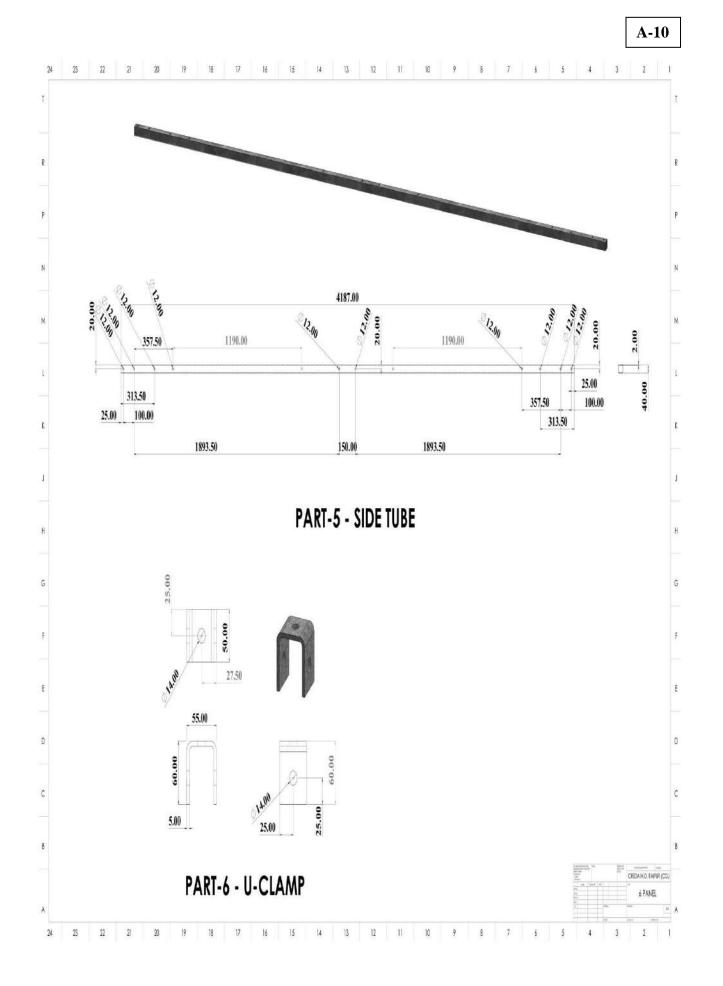


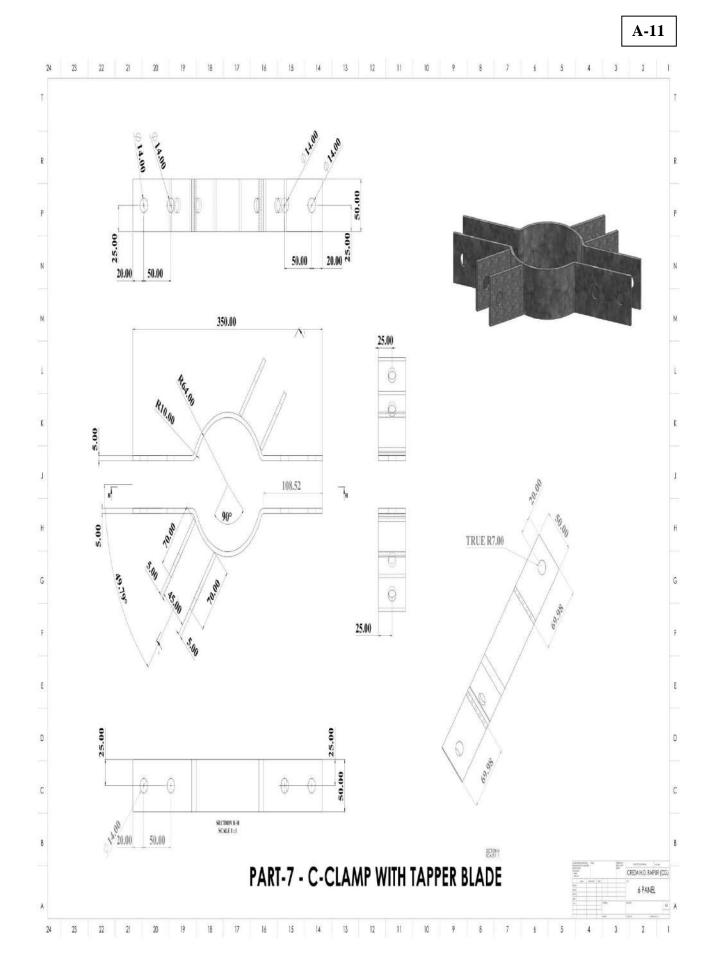


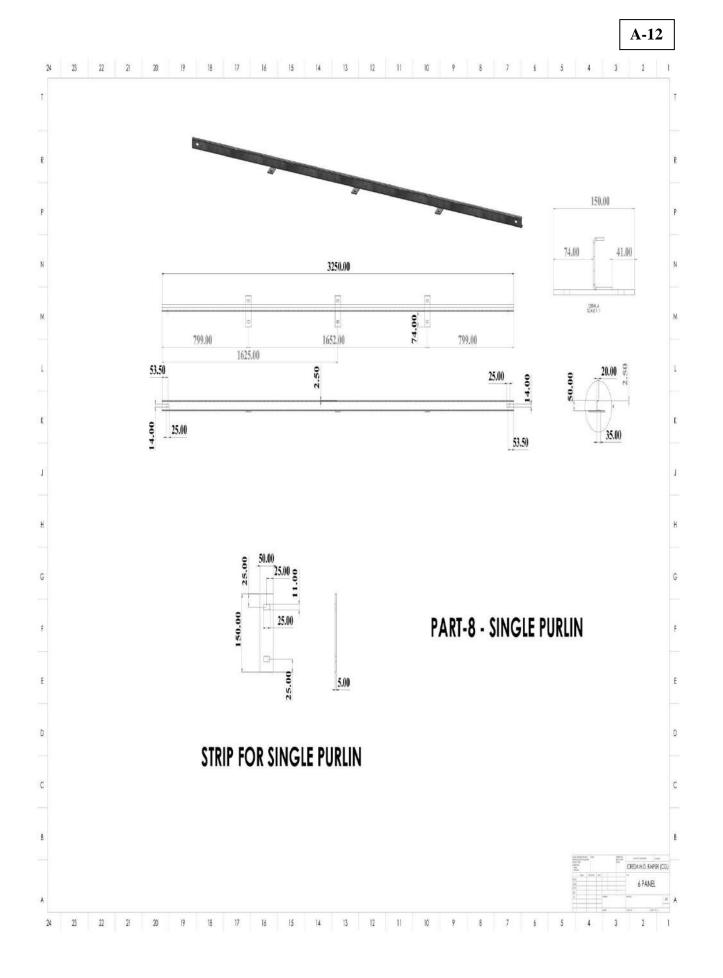


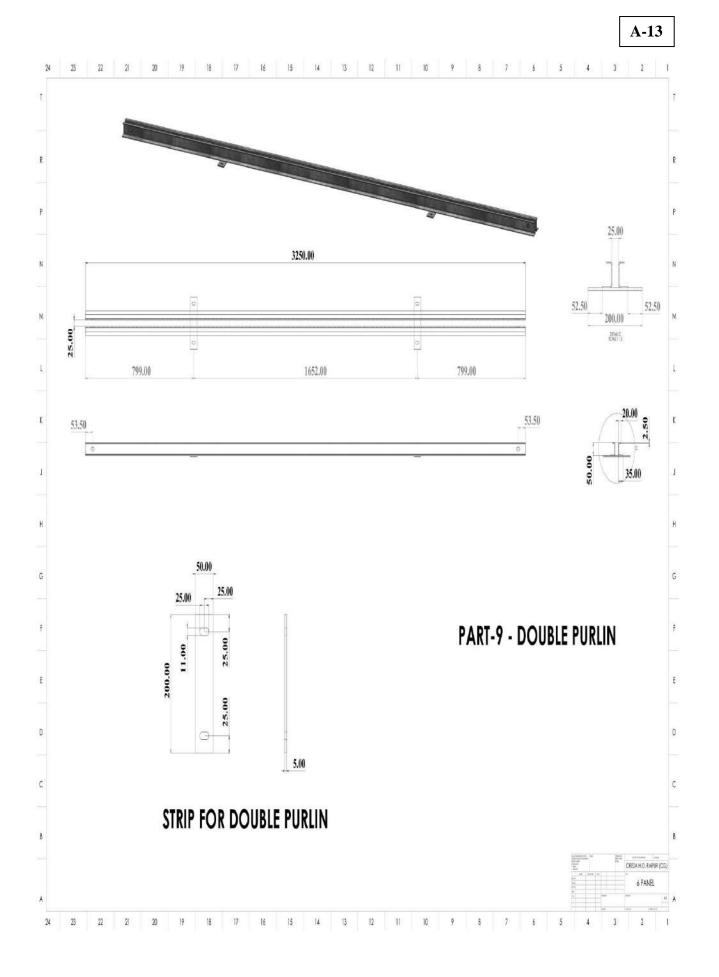


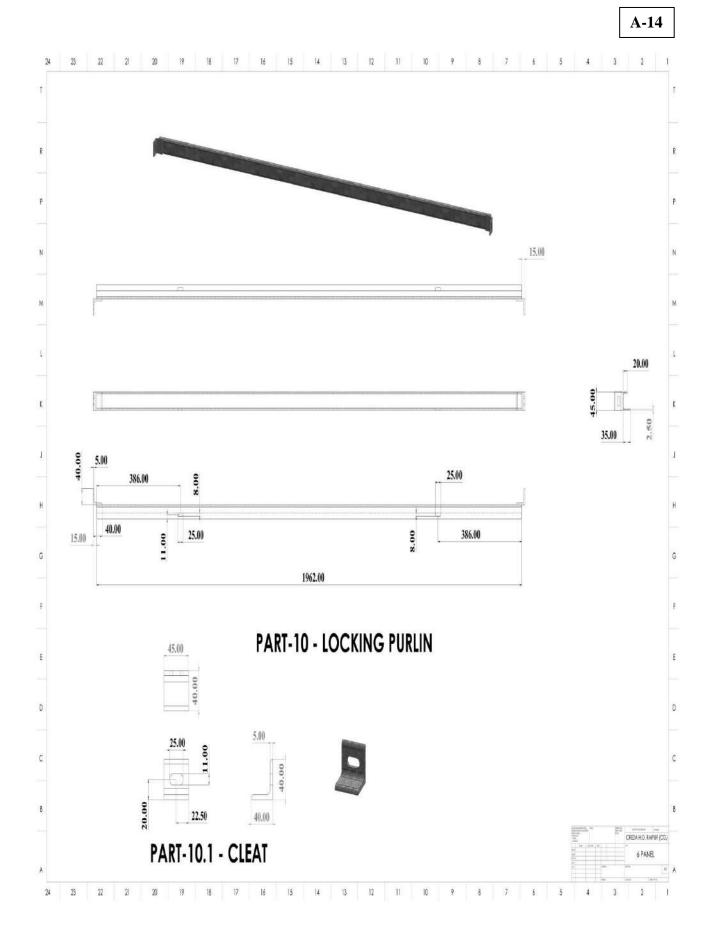


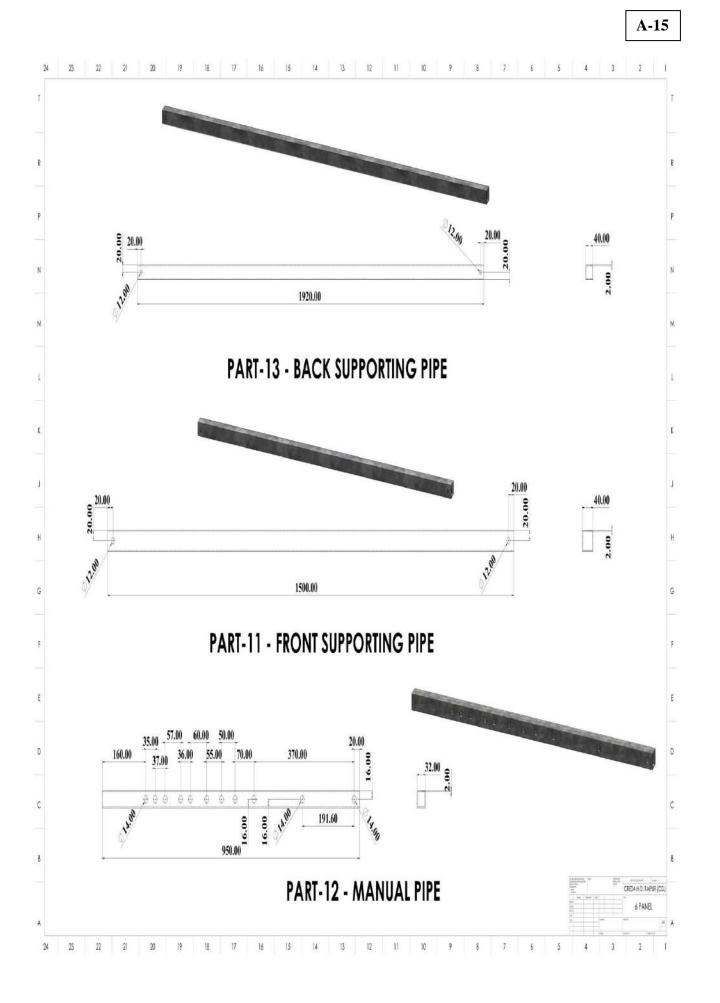


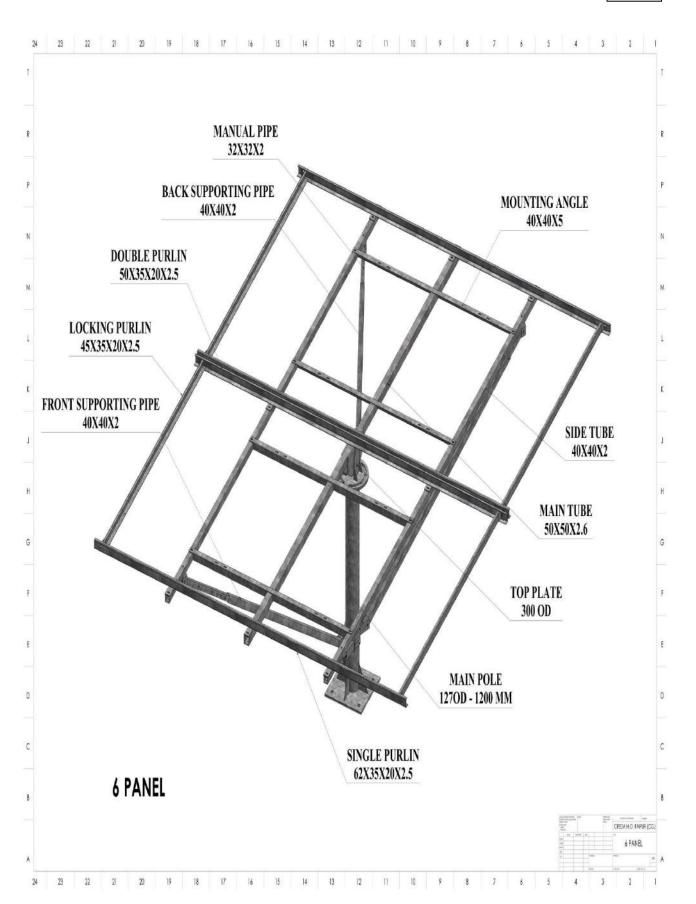


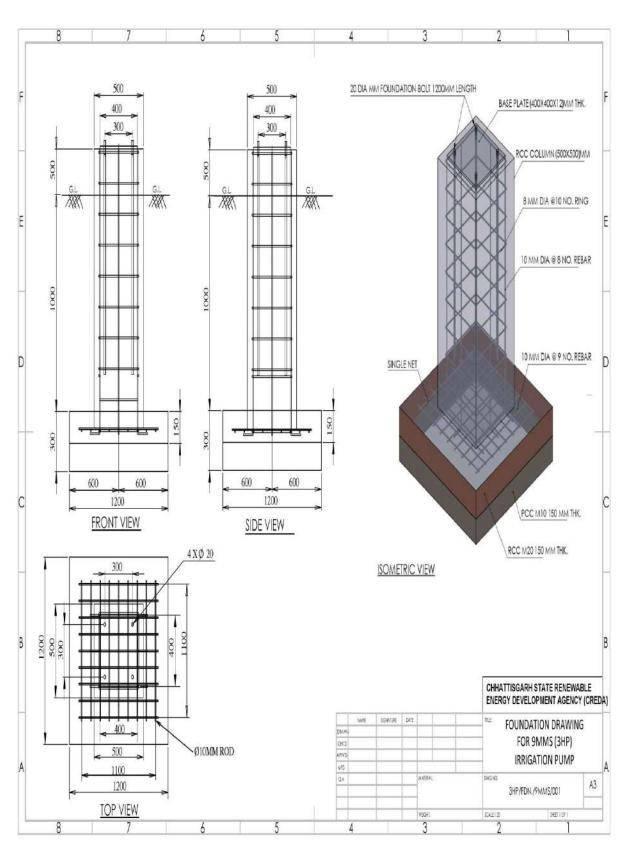




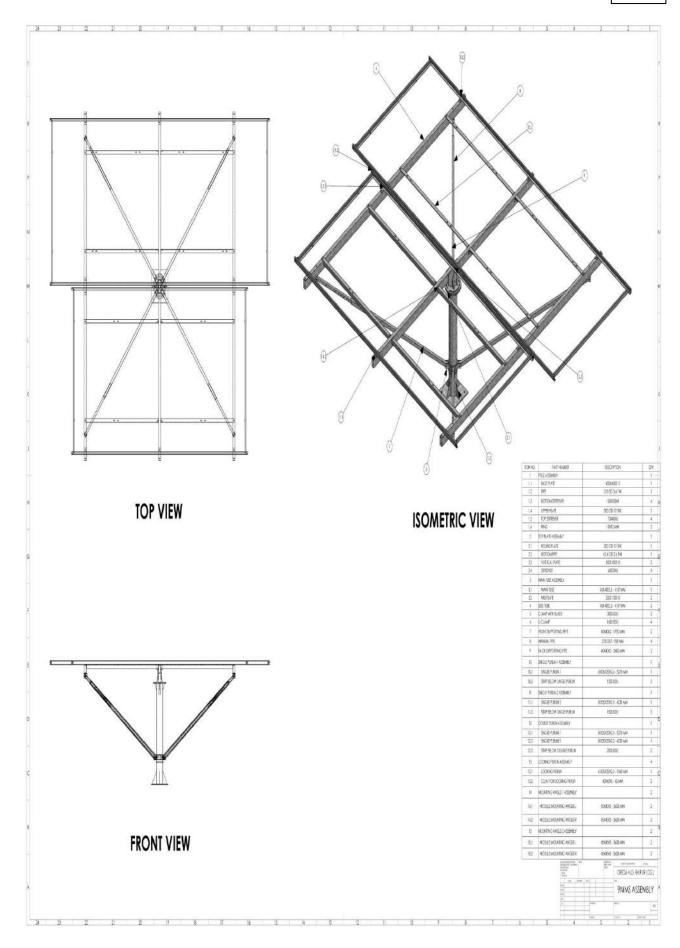




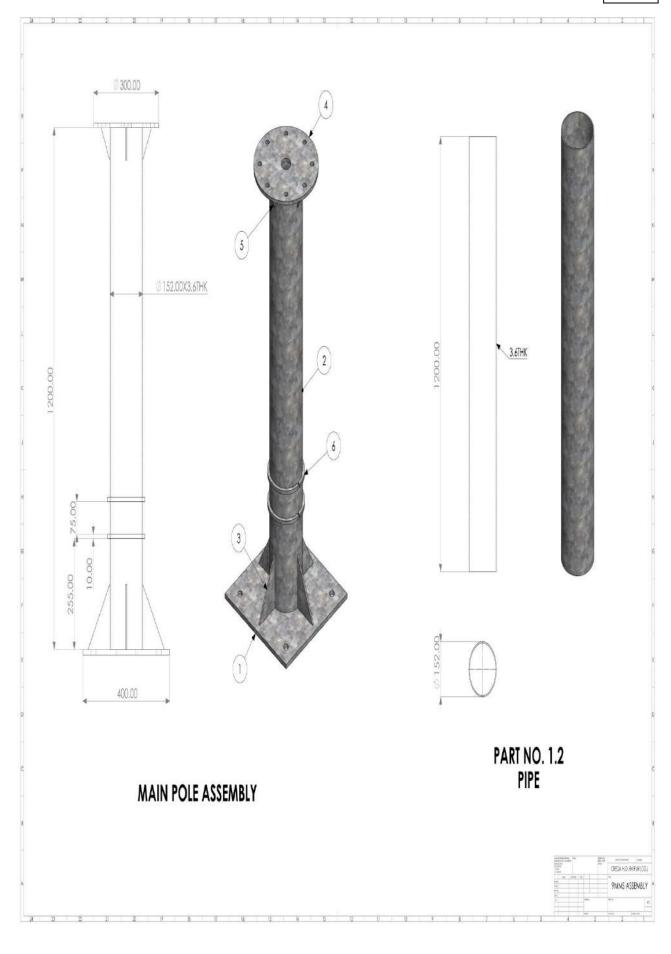




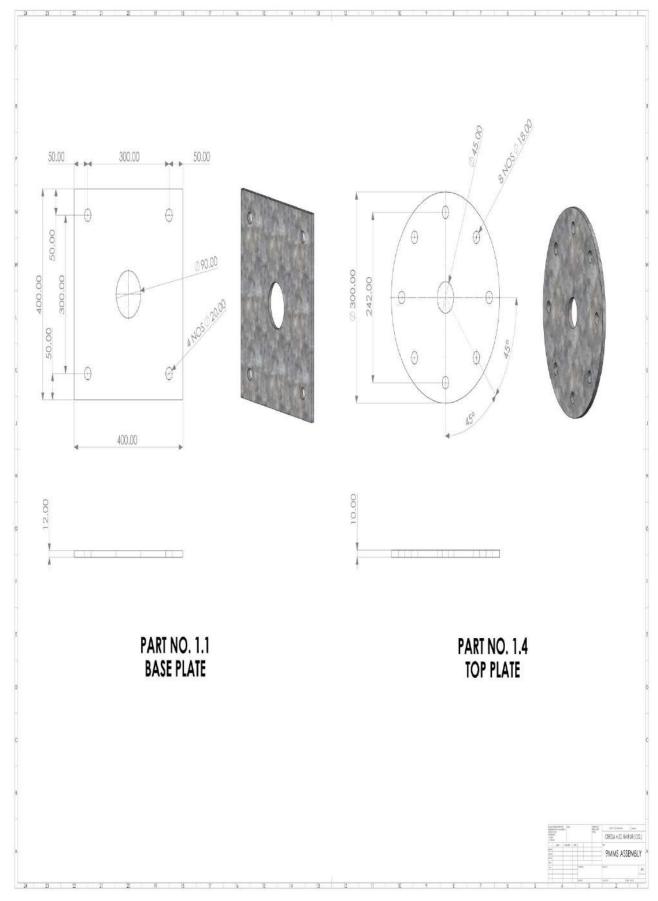
Foundation & MMS Drawings of 03 HP (09 NOs. Module of min 320 Wp)

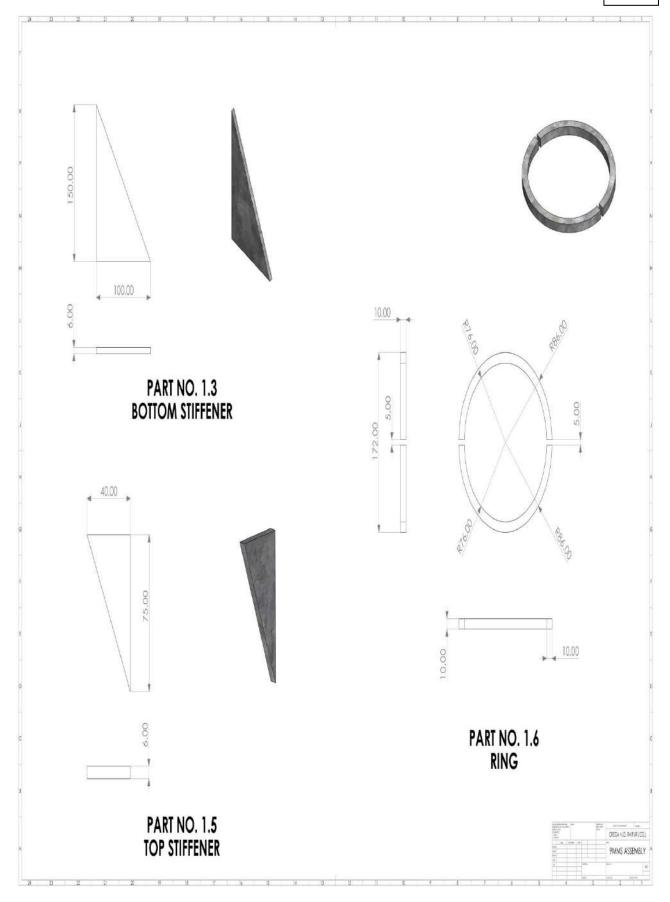




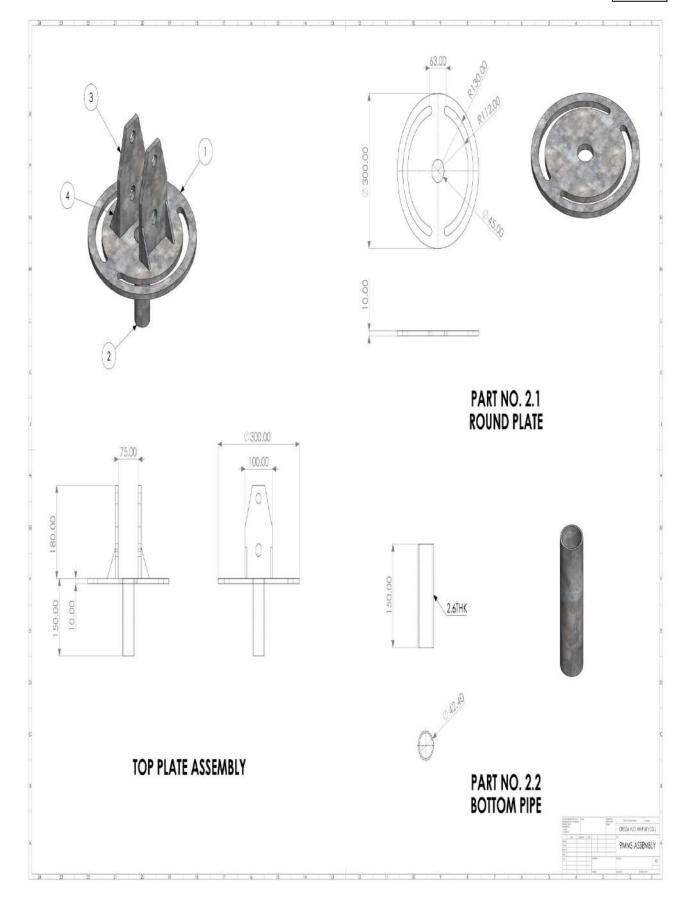


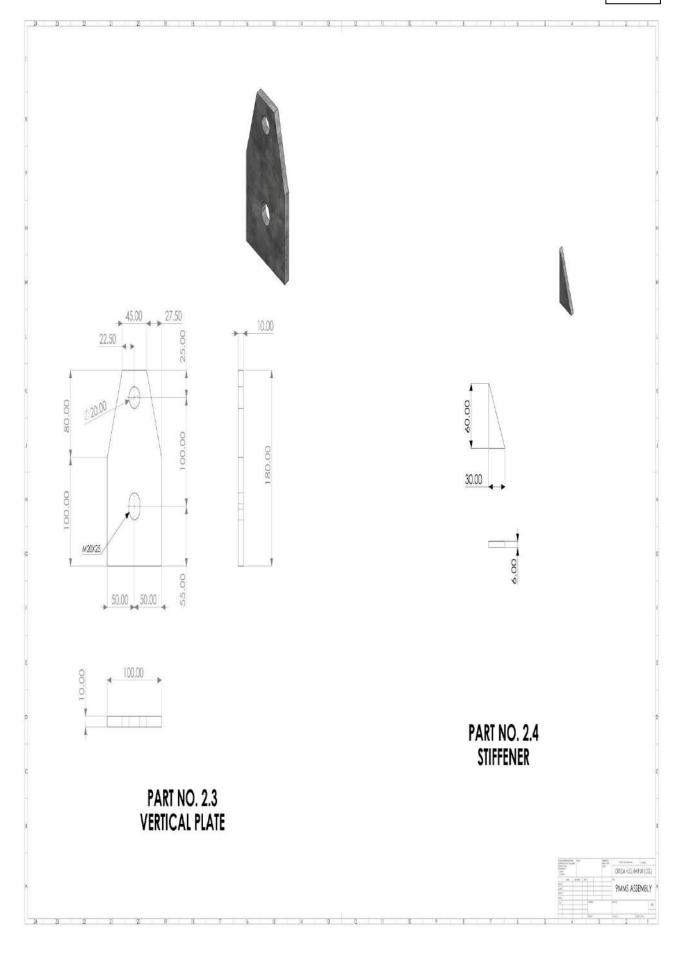


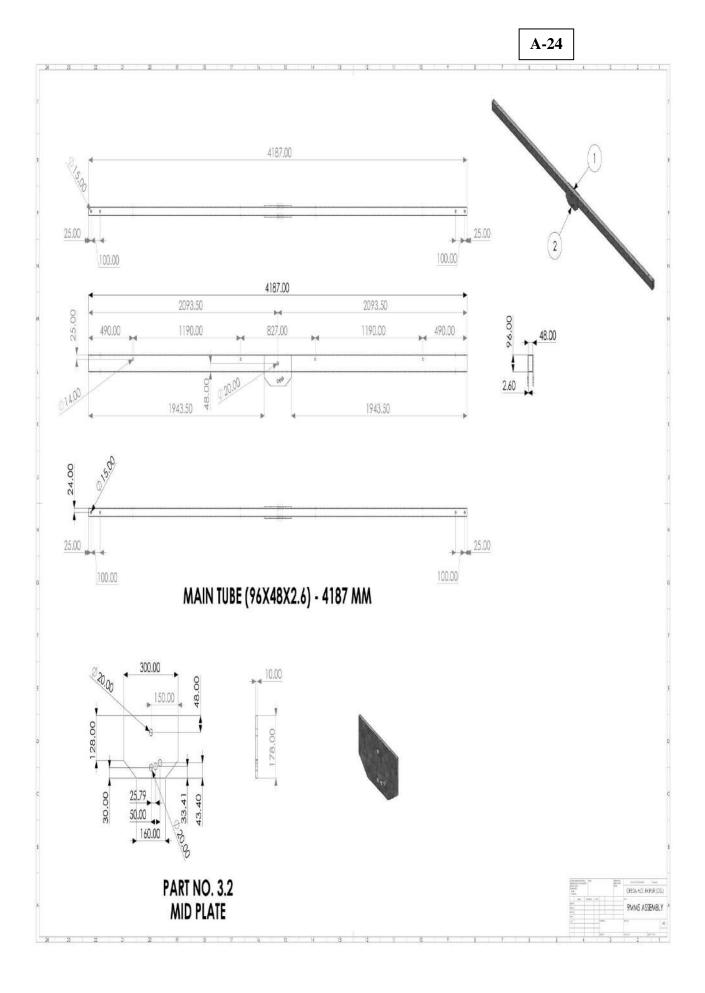


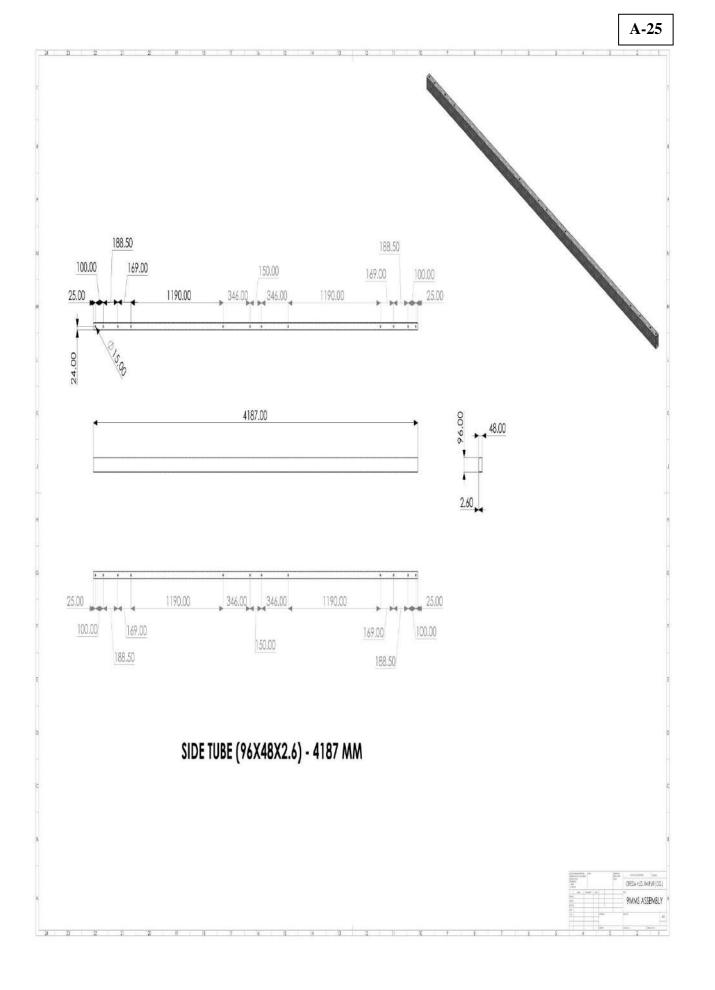




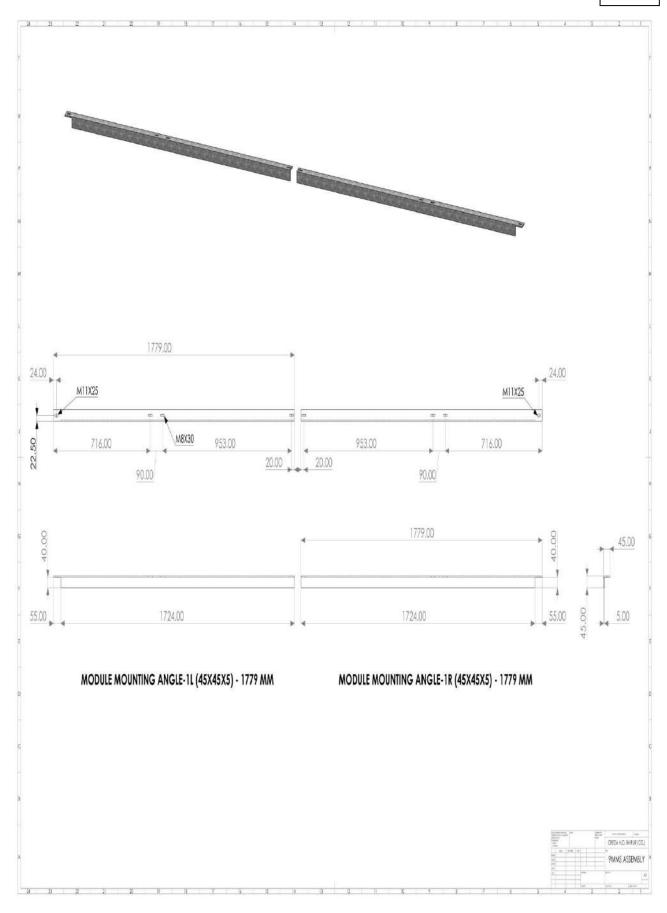


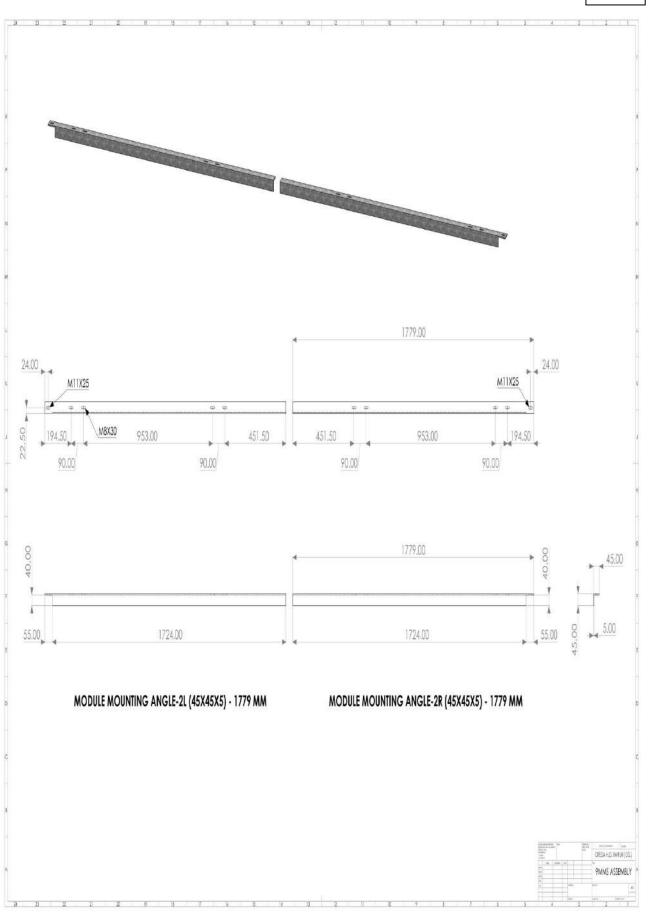


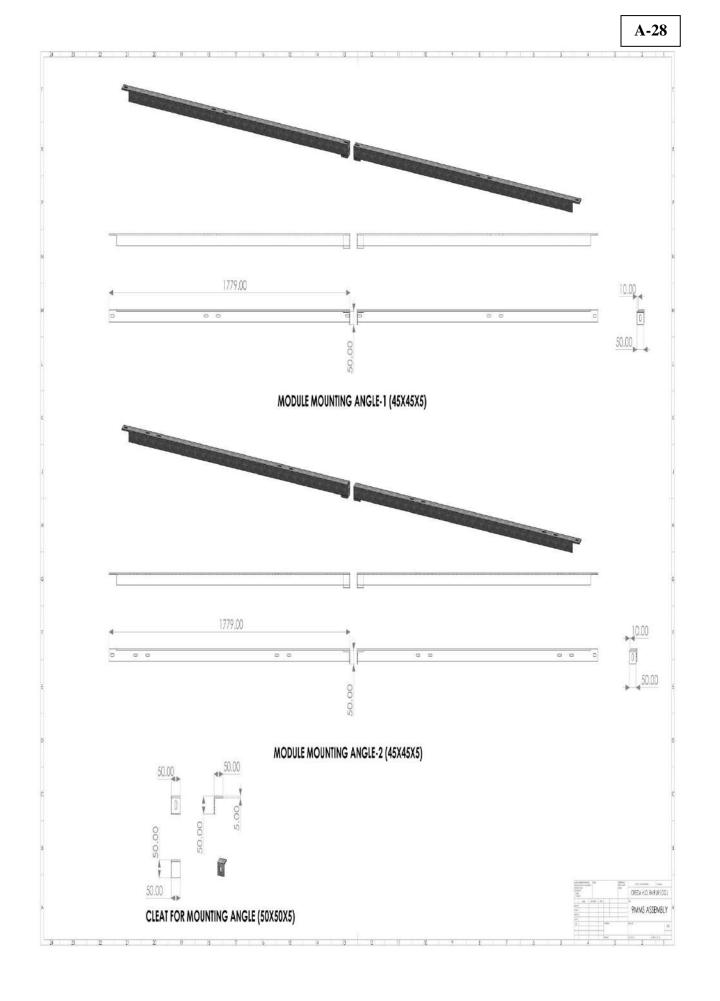


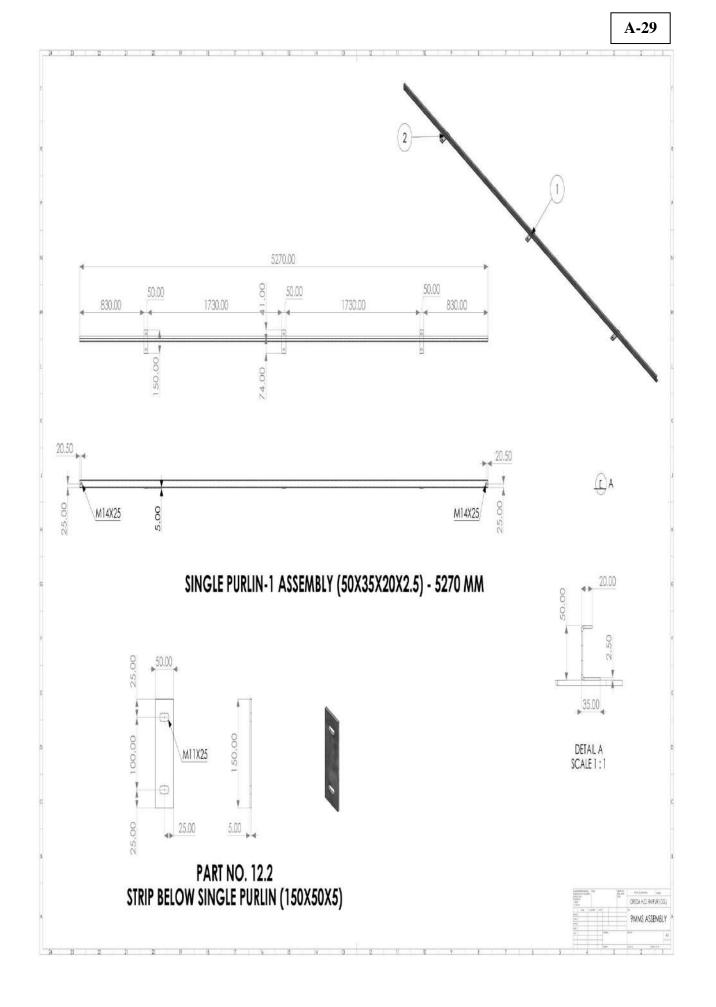


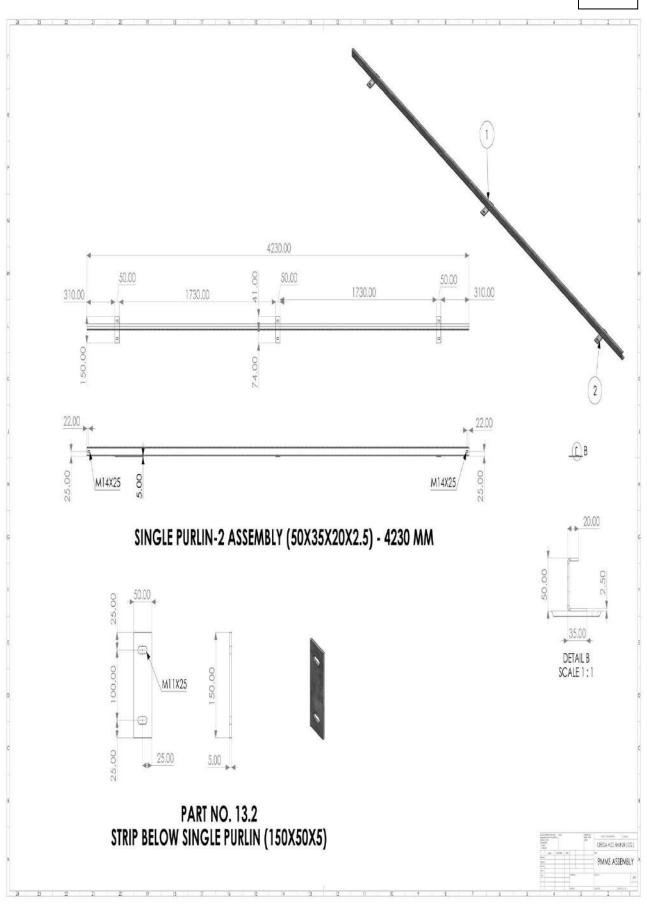


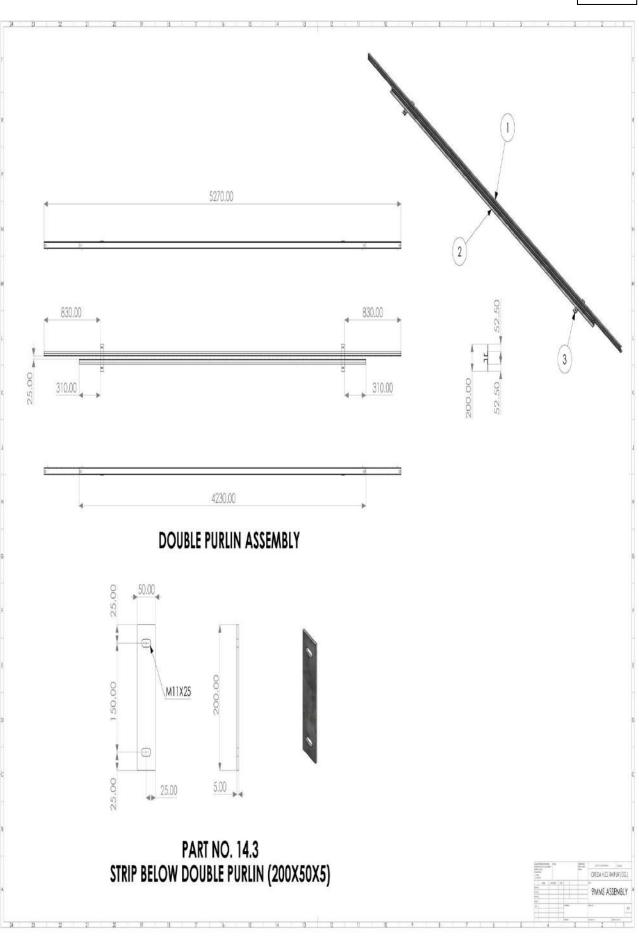


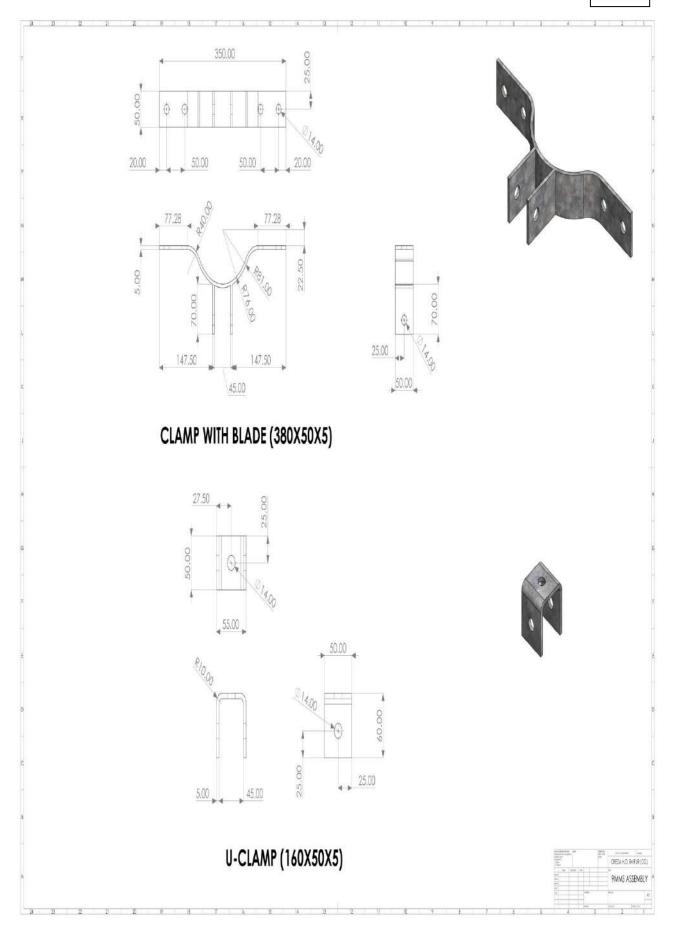


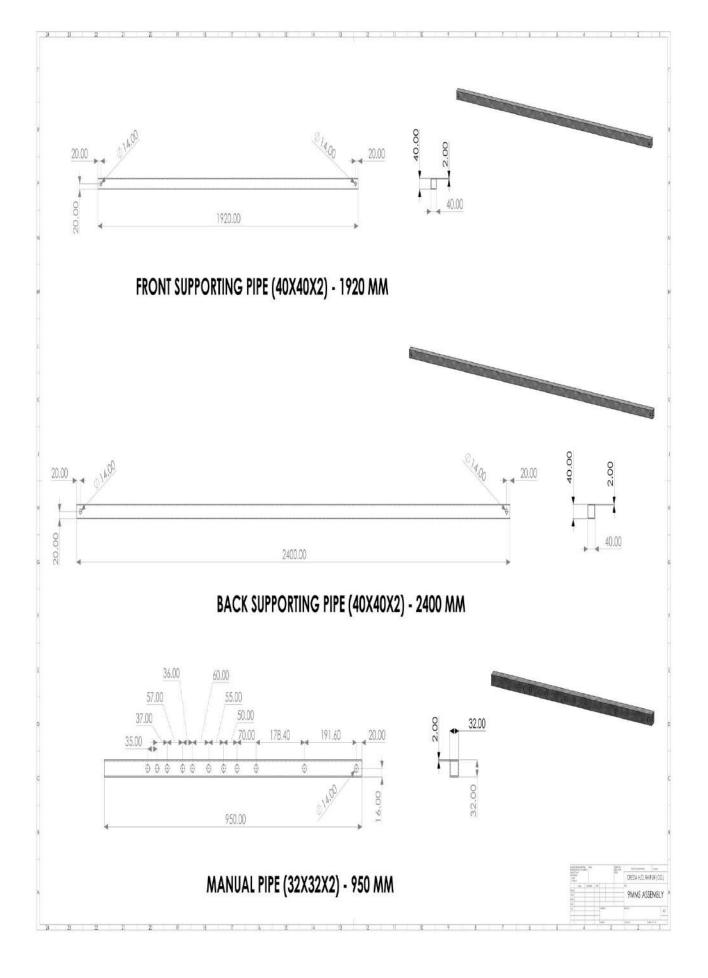


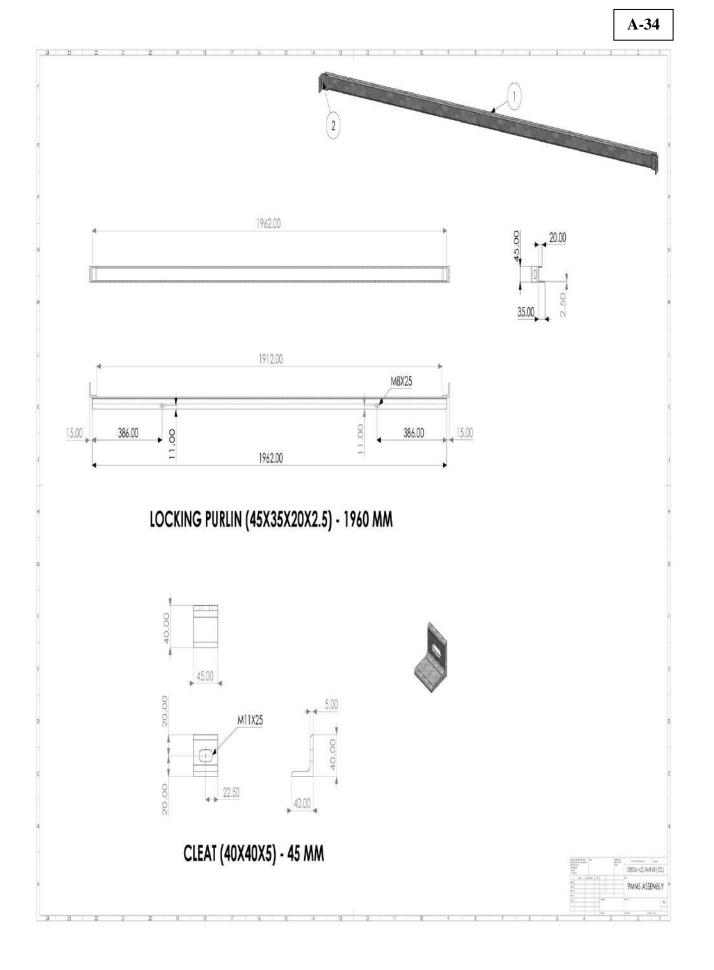


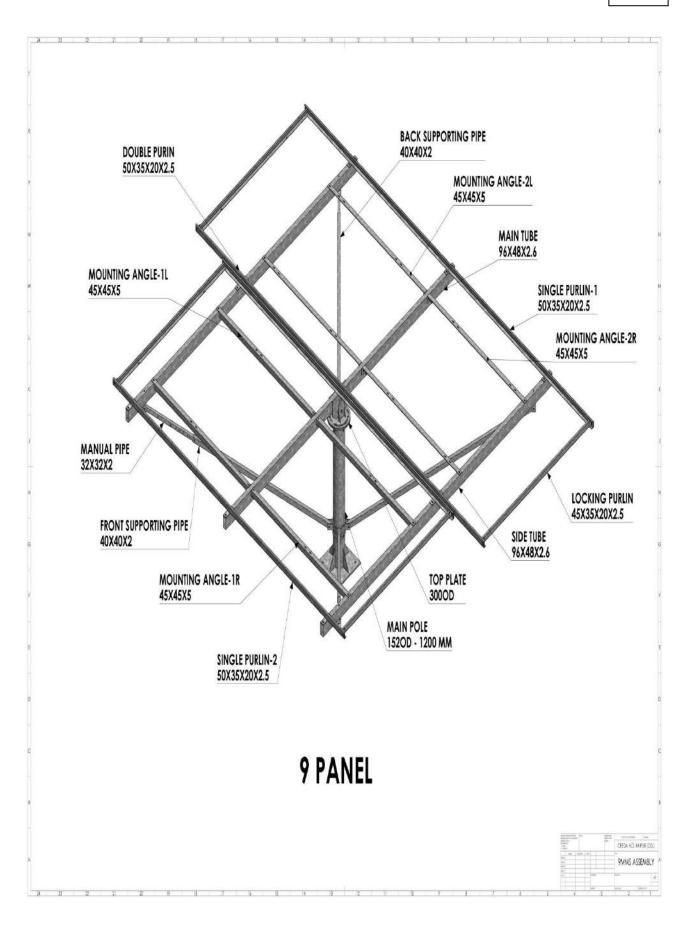


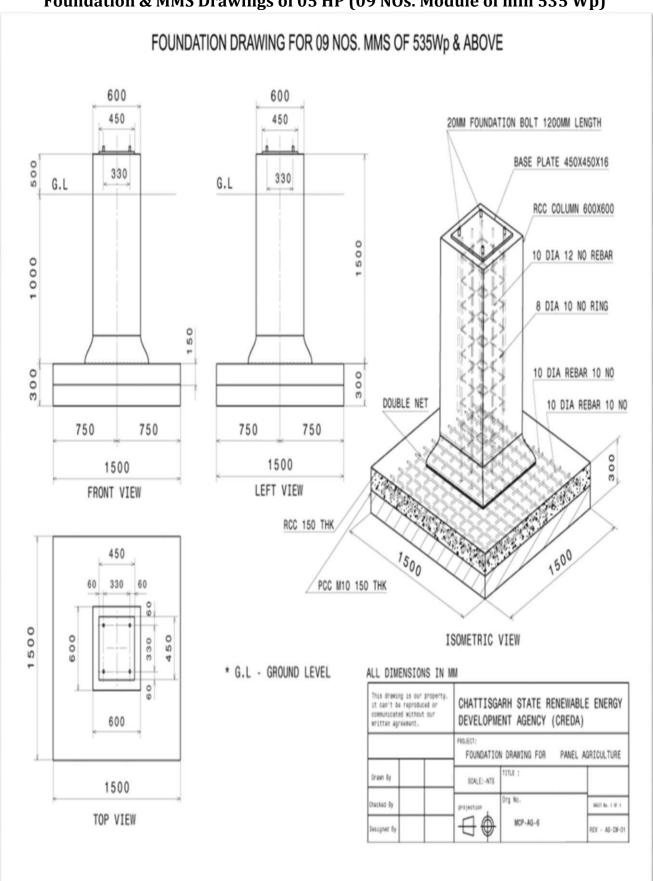




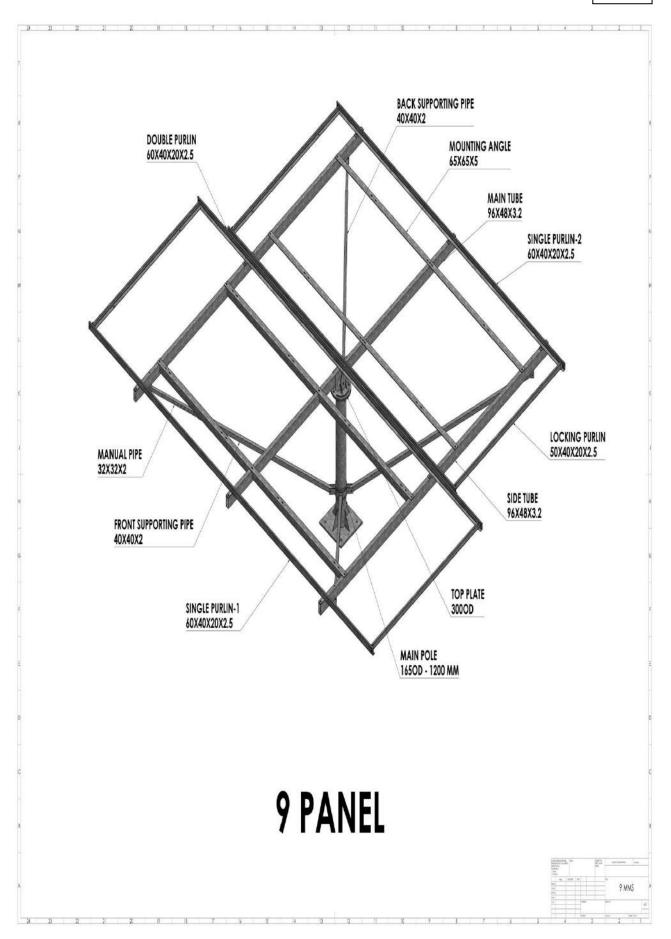


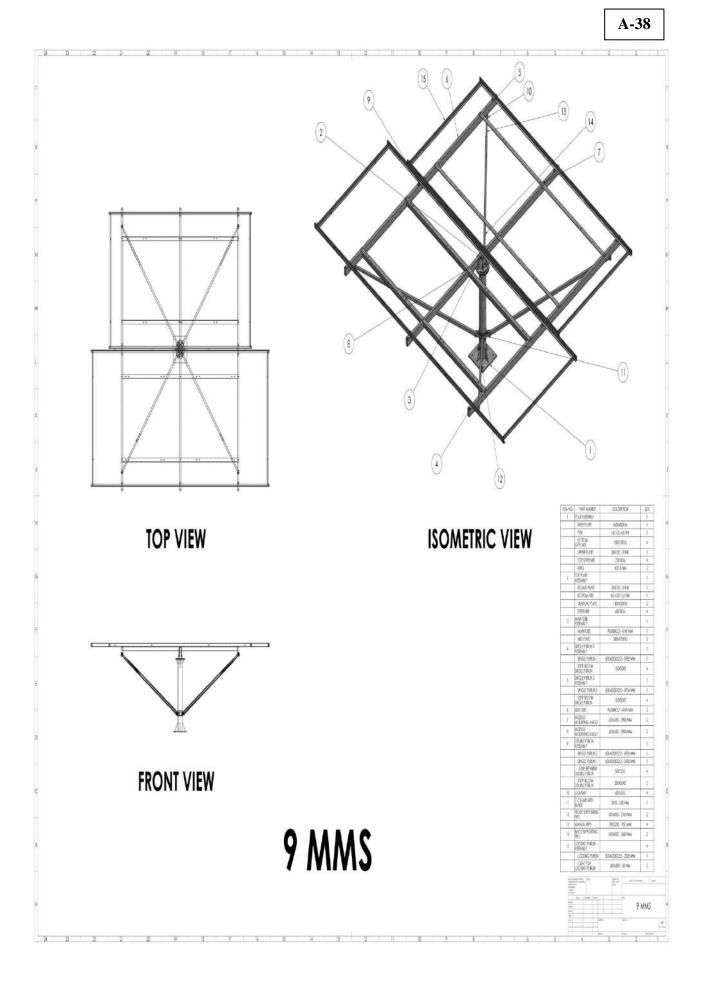




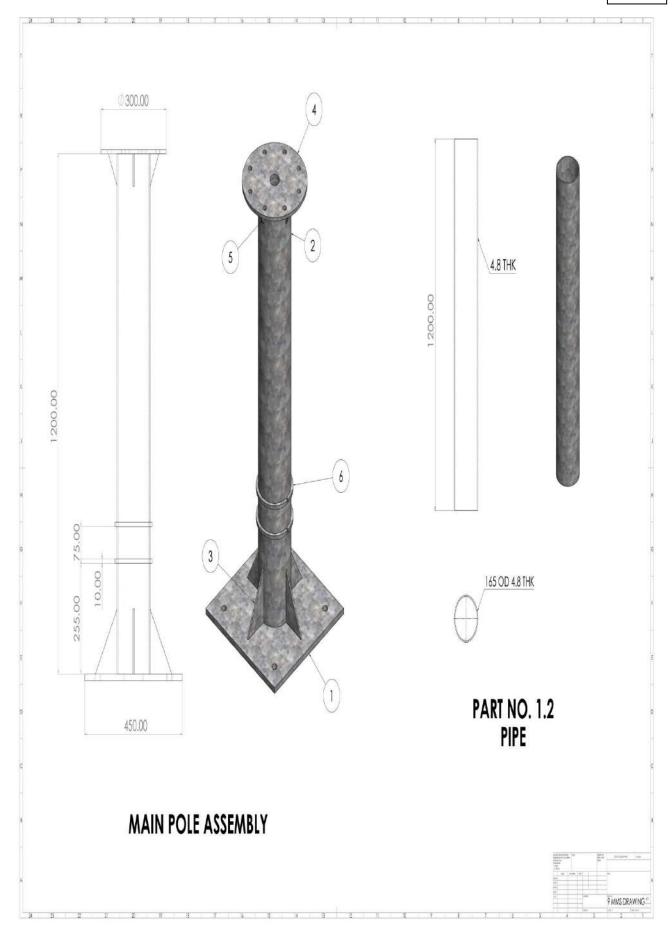


Foundation & MMS Drawings of 05 HP (09 NOs. Module of min 535 Wp)

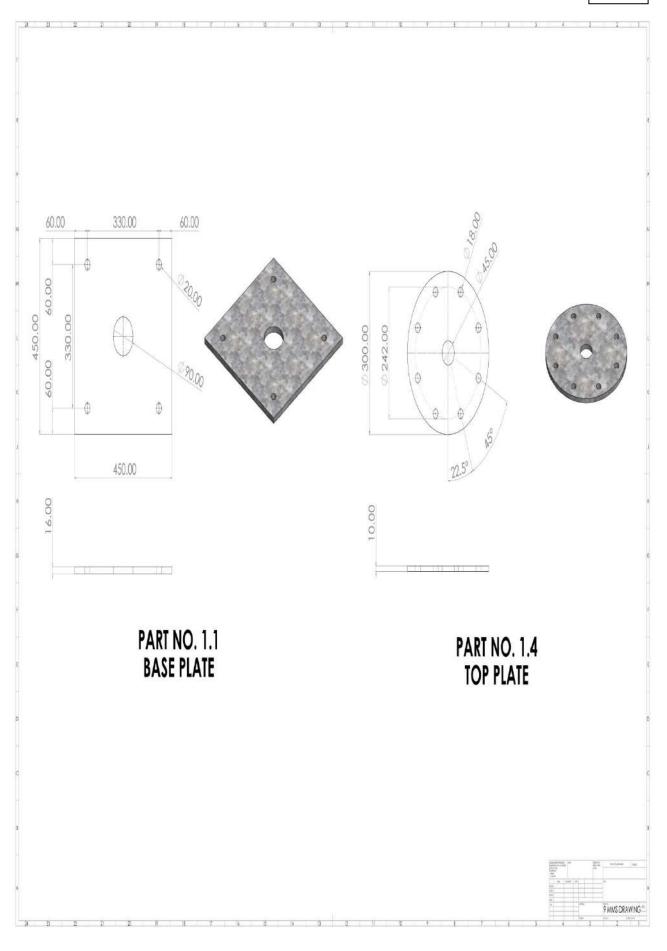




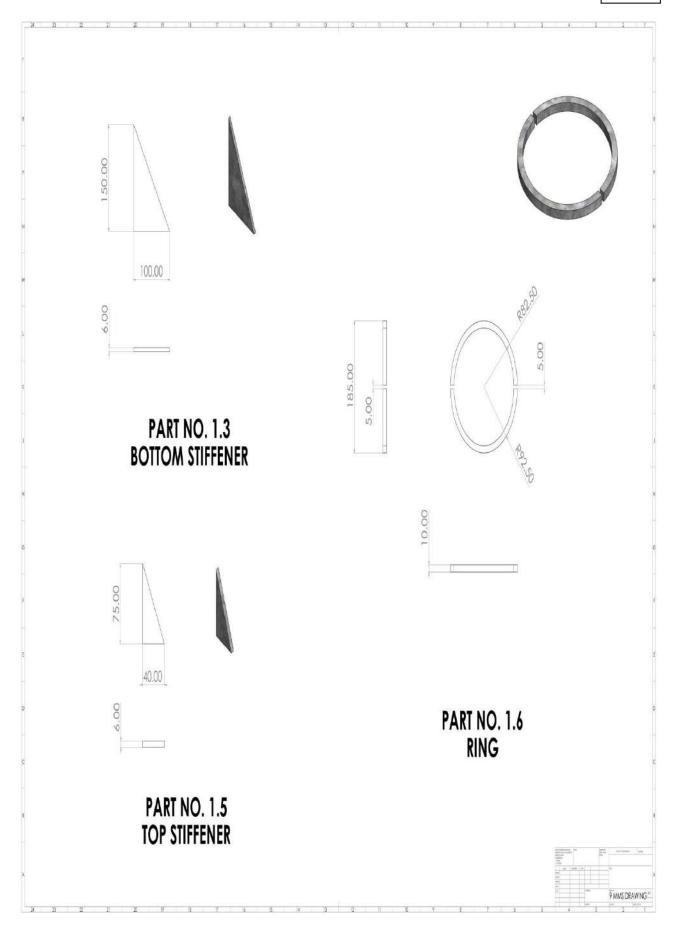




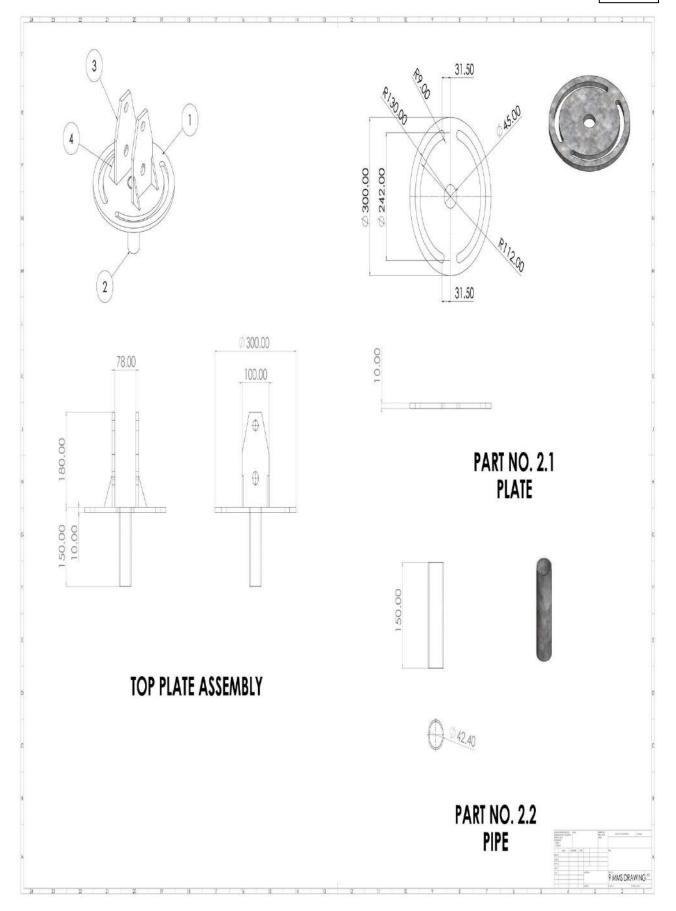




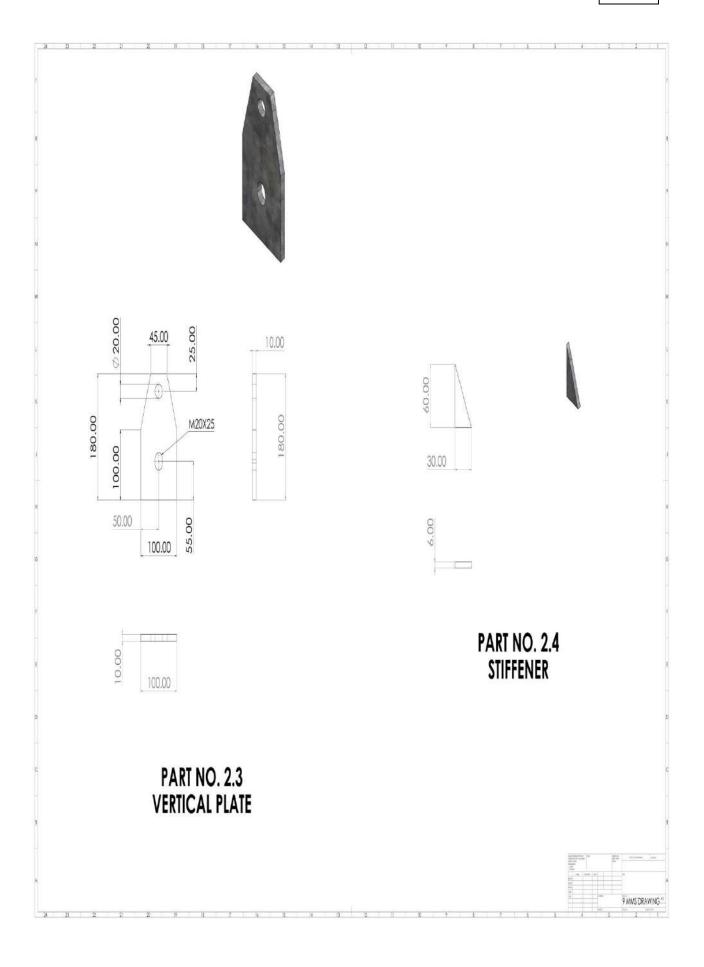


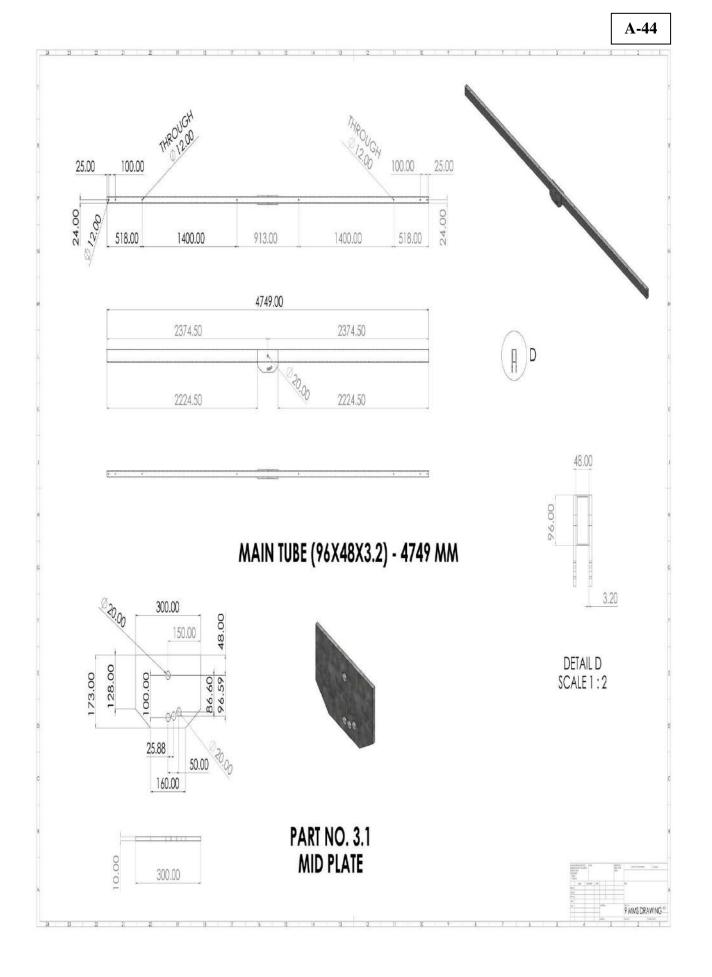


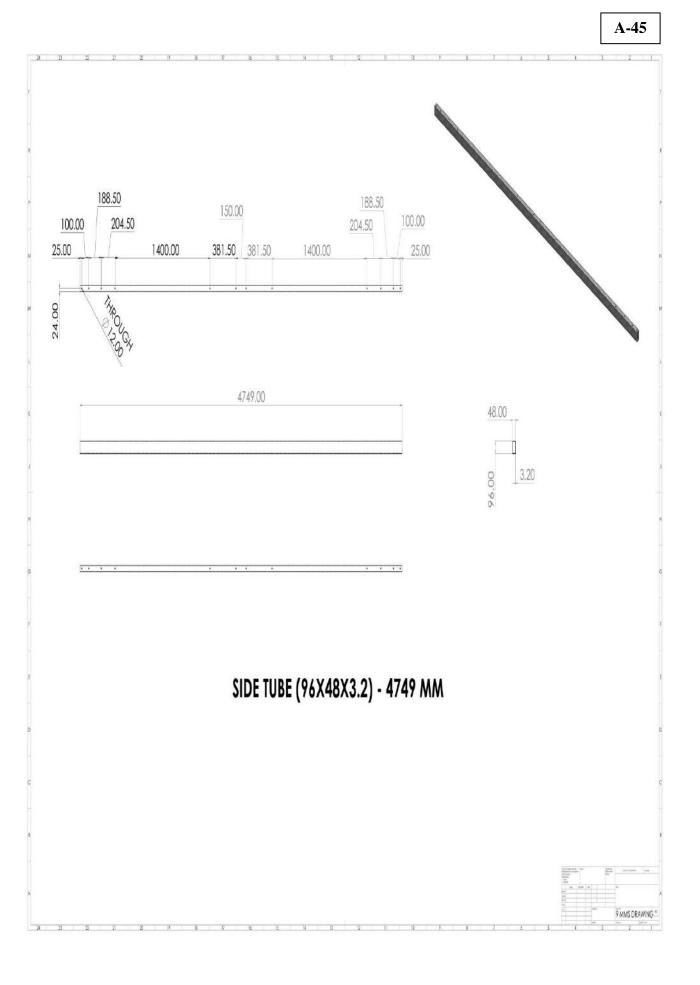


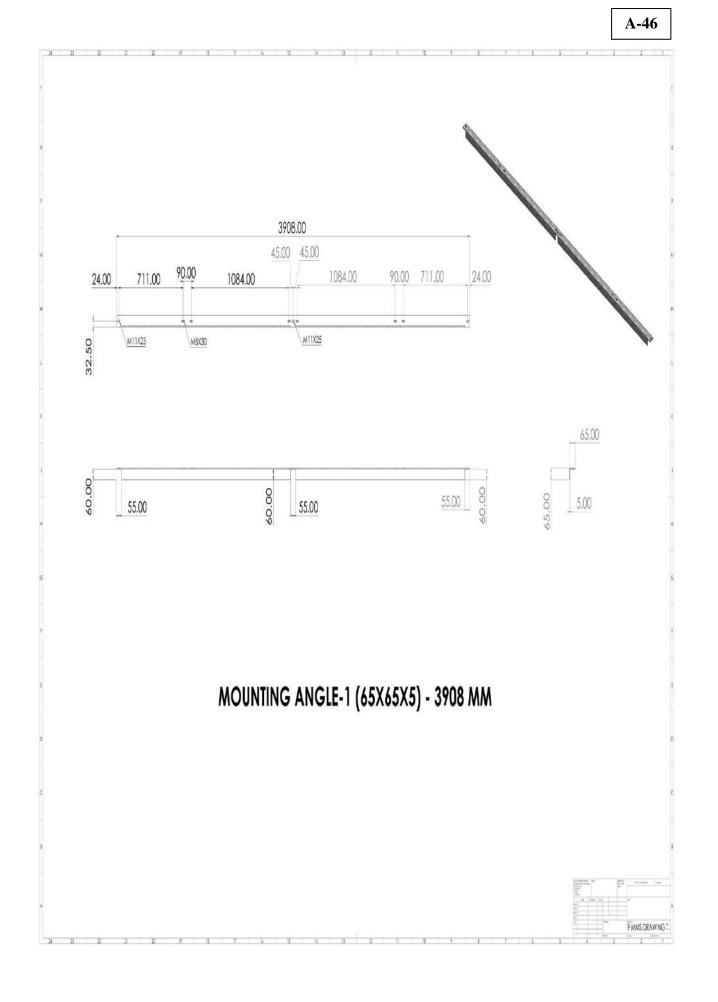


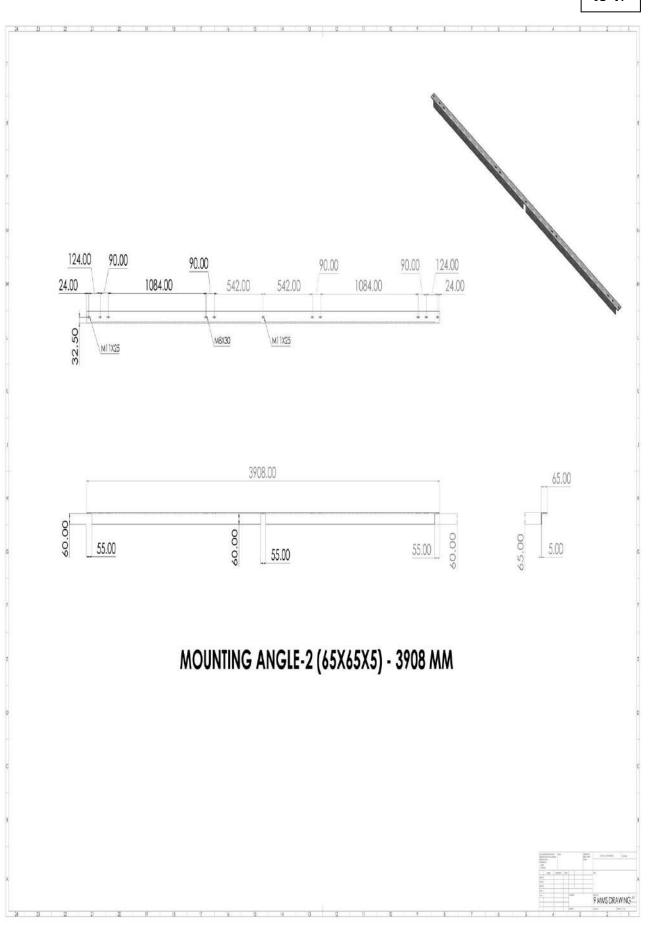


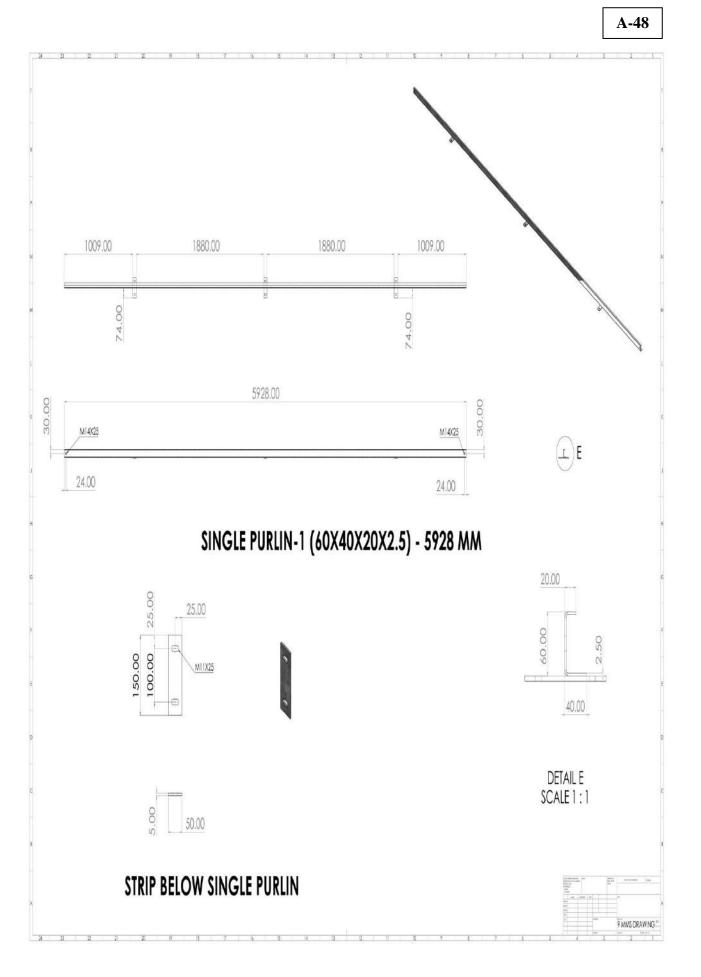


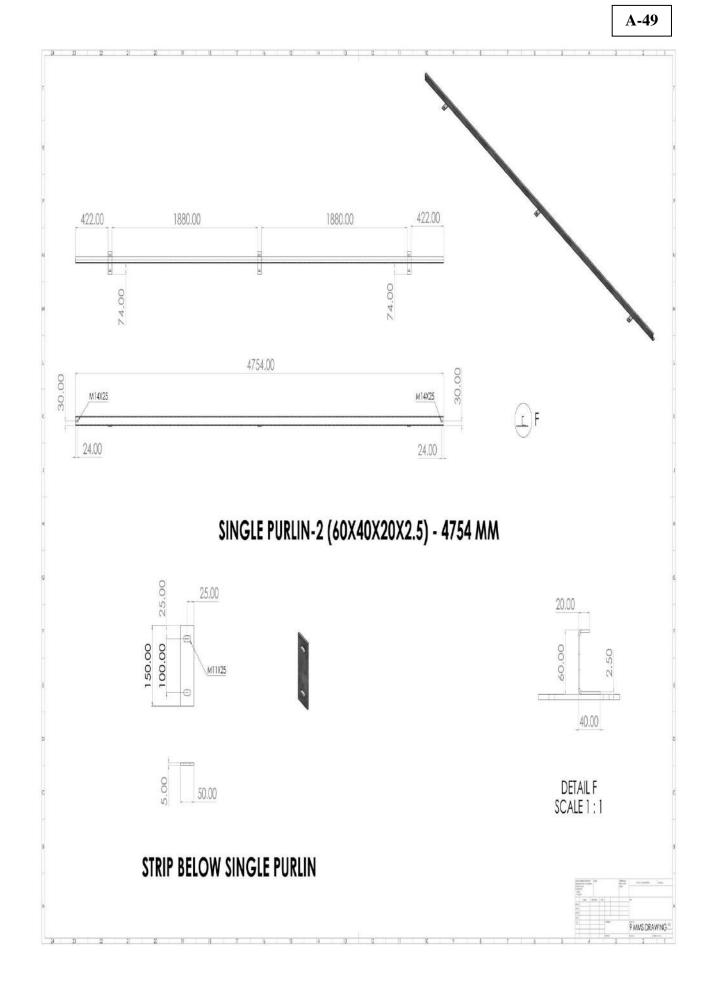




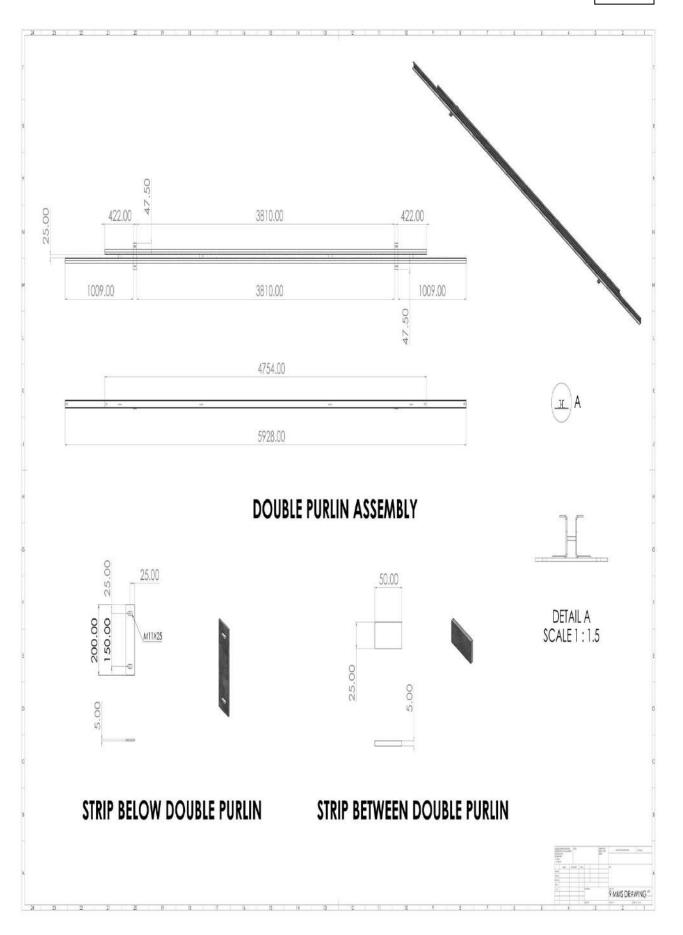


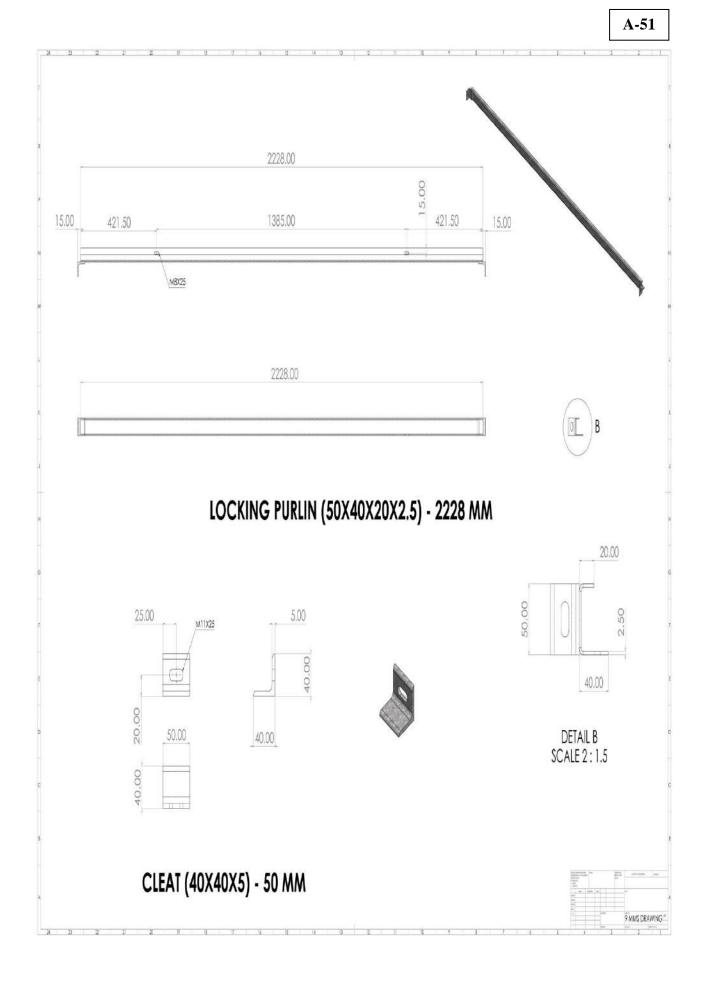




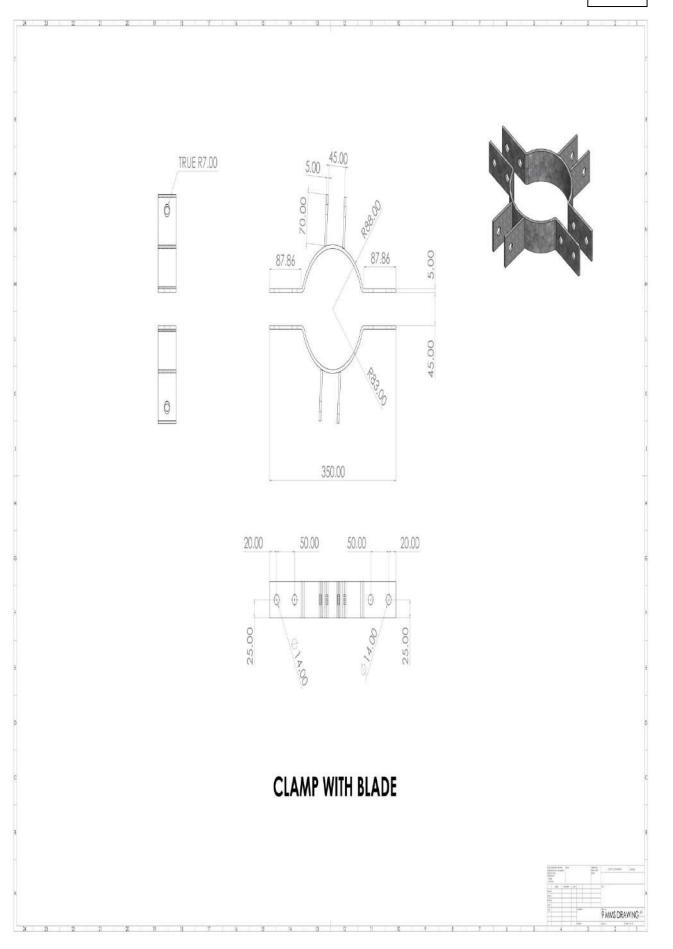


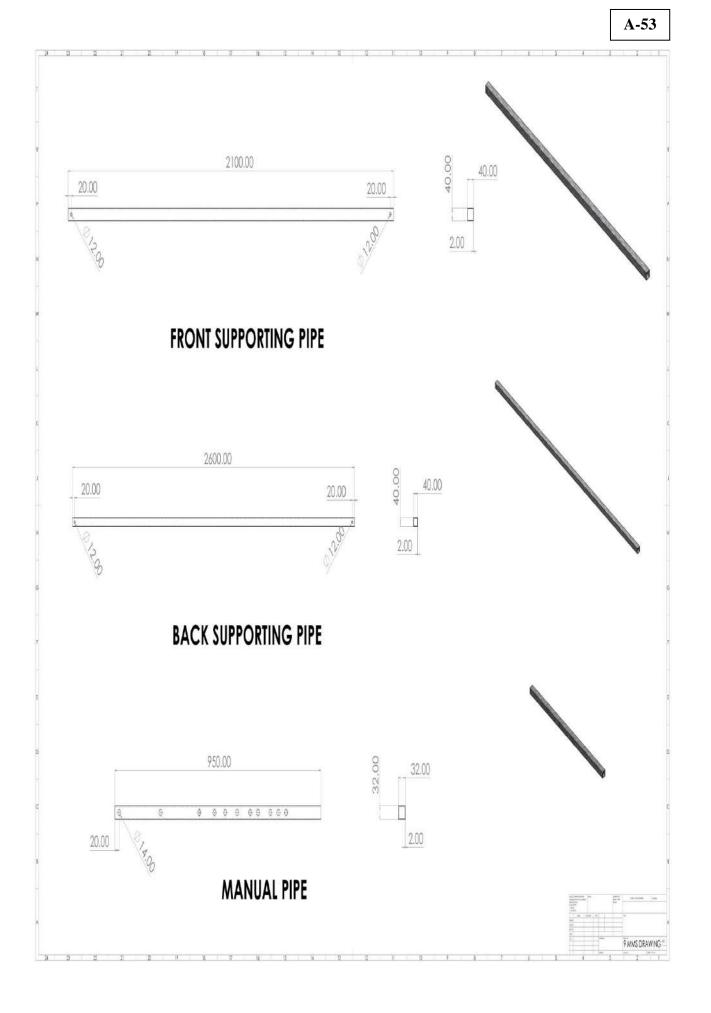


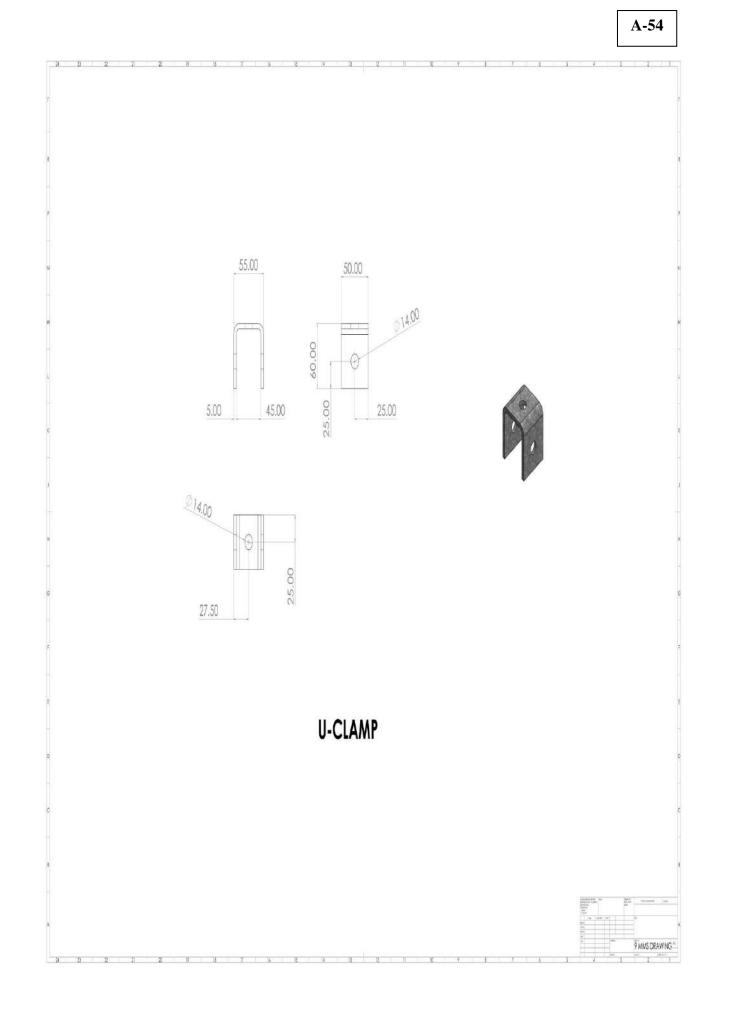












Guidelines on Testing Procedure for Solar Photovoltaic Water Pumping System

1 SCOPE

These Guidelines lays down basis for testing set up and testing procedures for Solar Photovoltaic (SPV) water pumping system. The SPV water pumping system covered are centrifugal pumps of all types from 02, 03 & 05HP.

2 REFERENCE STANDARDS

The Indian and IEC Standards listed at Annex A contain provisions which, through reference in this text, constitute provision of this standard. Latest editions of the indicated standards should be considered.

3 DEFINITION OF SYSTEMS AND PARAMETERS

Systems

Stand-Alone Solar PV Water Pumping System

A Solar PV Water Pumping System in stand-alone operation is neither connected to the grid nor to battery bank and is comprised mainly of the following components and equipment:

PV Modules, cabling, controller, motor pump-set and hydraulic piping. Combination of all these components shall be unique. Any change in combination will be treated as different model of pumping system.

Motor-Pump Set

The Motor-pump set consists of the pump (centrifugal pump) and the driving motor.

Controller

The controller converts the DC power (DC voltage & Current) of the PV array into a high or low DC voltage power, or converts this DC power into single -phase or multi-phase alternating-current power (voltage or alternating current) suitably for driving the motor of Motor-pump set.

NOTE: - The Controller may also include equipment for MPPT, monitoring, metering and for protection purposes.

1.2 Parameters

Following parameter shall be referred during testing of SPV pumping system:

Table 1 Parameters				
Parameter	Symbol	Unit		
(1)	(2)	(3)		
Array voltage (DC)	Va	V		
Array current (DC)	Ia	А		
Array open circuit voltage (DC)	Voc	V		
Array short circuit current (DC)	Isc	А		
Array maximum power point voltage(DC)	Vmpp	V		
Array maximum power point current (DC)	Impp	А		
Pressure as measured	р	kg/cm ²		
Flow rate	Q	Lps /Lpm /m ³ h		
Motor voltage DC or AC	Vm	V		
Motor current DC or AC	I_m	А		
Motor voltage (multi-phase AC)	$V_{ m rms}$	V		
Motor current (multi-phase AC)	I _{rms}	А		
Power factor	cosØ	-		
AC frequency (or DC switching frequency)	F	Hz		
Motor speed	N	Min ⁻¹		
Radiation	E_e	W/m^2		
Temperature	Т	°C		

4 TEST SET UP

Test Set-Up

Illustration(s) of test set-ups are shown in Figure 1 & Figure 2, and a block diagram of required test set-up is shown in Figure 3. All test set-ups shall conform to applicable model test set-ups referred above and the water level in the sump well, locations of throttle valve, flow meter and pressure gauge/sensor connections as indicated in the test set-up(s) shall conform to Figure 1, Figure 2 & Figure 3 accordingly.

Precautions for Test Setup:

Before initiating testing of SPV pump the following precautions must be followed:

- i) In case of direct coupled pump-set, proper alignment of input pipe, output pipe and the sensors shall be ensured.
- ii) Air tightness in suction line shall be ensured and the general layout of the system pipe work should be designed to avoid airlocks.

- i) The offset pipe of suction line shall either be horizontal or inclined upward towards the pump and shall never be inclined downward towards the pump to avoid air trapping.
- ii) For the delivery head, a pressure gauge/sensor shall be connected to the delivery line with tapping as shown in Figures 1 or 2 or 3. The tapping shall be flush with the inside of the pipe and shall have its axis at right angles to the direction of flow. The pipe set up between the pump outlet and the pressure sensor should be the same diameter as the manufacturer's outlet fitting. Sensor/gauge may be connected to the tapping point through a flexible hose.
- iii) Preferably, Digital Pressure sensor/gauges of suitable range need to be used for the measurement of head. Care shall be taken to eliminate any leaks in the connecting pipes and to avoid the trapping of air in the connecting pipe or hose.
- iv) It is assumed that over the normal operating range of the pump the pressure drop due to frictional losses between the pump outlet and the pressure sensor will be negligible and the kinetic energy component of the water at the pump outlet will be small compared to the increase in potential energy due to the increased pressure across the pump.
- v) For instantaneous performance testing, pressure can be sustained by means of a simple gate valve in which a backpressure is sustained by restricting the flow. An automatic control valve(s) may be used to sustain a constant upstream pressure. Pressure may also be sustained by means of a pre-pressurized air chamber operating with a pressure maintaining valve at the outlet. A real water column may also be used.
- vi) A good quality digital flow meter with electrical output linearly proportional to flow rate shall be connected at the other end of the delivery pipe. The distance between the auto control valve and flow meter shell be minimum 1.5 meters to ensure laminar flow of water.
- vii) After flow meter the end of the discharge pipe should be beneath the water surface to prevent splashing. This could cause a mixed water / air bubbles fluid entering the pump inlet and affecting its proper operation. If so then a vertical baffle or a similar arrangement shall be inserted in the tank between the pump intake and the return pipe such that water does not make any splash and avoid any bubbles when spread to the bottom of tank to reach the input pump. In this way any small bubbles will be excluded, as they will remain near the surface. Alternatively, a large pipe can be placed around the pump with its top breaking the surface and an arch cut in its base to allow water entry.

Priming Arrangement

A non-return valve/ foot valve shall be used in suction line, further it may also require suction pipe need to be filled with water for priming purpose in case of surface pumps.

PV Module Array Structures:

For testing the SPV pump using the actual solar array, outdoor PV array structures with different module mounting capacity (4,6,8,10, etc.) should be used. The modules are mounted on the structures with tracking facility to optimize irradiance, power output and accordingly, the total quantity of water pumped in a day.

Sun Simulator PV Module Tester:

To estimate the wattage of the PV modules under STC, a high precession (at least class AAA as per IEC 60904-9) sun simulator module tester is required in the pump testing lab. Alternatively

all PV modules should have STC testing certificate from an NABL accredited test laboratory and the date of testing should not be later than a year. In the STC testing, if the module is found degraded, the degraded data should be used.

Simulator (Electrical) Testing

Ideally, the SPV pump should be tested as per the site conditions where it is designed to operate. The details of outdoor testing are discussed in the next sessions. However, for testing under simulated conditions, a programmable Solar PV (SPV) array simulator capable of simulating a given solar PV array configuration (i.e. the number of modules, the type and the series / parallel combination), site radiation and temperature conditions shall be required for laboratory. Measurement equipment with acceptable accuracy and precision shall be used for detection and data logging of the parameters listed in Table 2.

Table 2 - Core Parameters to be Measured and Recorded					
Parameter	Symbol	Unit	Measurement Uncertainty		
(1)	(2)	(3)	(4)		
SPV Array voltage	Va	V	≤1 percent		
SPV Array current	Ia	А	≤1 percent		
Pressure/head as measured	p	Kg/cm ²	≤2 percent		
Flow rate	Q	lps	≤2 percent		
Solar irradiance	Ee	W/m ²	≤2 percent		

Sump Well (Hydraulic Testing)

For the performance testing of SPV pumps a sump well with sensors for sensing, monitoring and recording of pump parameters will be required. The details of the resources required are given below:

- a) Water tank / sump of required dimensions,
- b) PV Modules, Controller, Motor-pump set, and Other Accessories (Test Sample)
- c) Pressure transducer with data logging system
- d) Flow Meter with data logging system
- e) Suction pipe(s) (if applicable)
- f) Discharge pipe(s)
- g) Pyranometers and Temperature sensors with data logging system
- h) Auto control valves
- i) SPV array Simulator(s) for simulation of module arrays for testing
- j) SPV array for realistic testing
- k) Structure for mounting modules for realistic condition testing
- 1) AAA class Sun simulator for testing of modules performance at STC

Refer to the block diagram at Figure 3.

Constant Head Requirement

Dynamic head variation during test shall be within limit as specified in column 2 of table 3 and the allowable variation in arithmetic average (from start of flow point to end of flow point refer figure 5) of dynamic head shall be within value specified in column 3 of table 3. Any data with head variation during the test beyond the limit specified in column 2 of table 3 shall be treated as garbage data and shall not considered in calculations of daily water output.

Table 3 - Allowable variation in arithmetic average of dynamic head				
Required Dynamic head in (meters)	Allowable variation in dynamic head during test	Allowable variation in arithmetic average of dynamic head		
(1)	(2)	(3)		
10	± 15 % = ± 1.5 meter	± 0.5 meter		
20	$\pm 10\% = \pm 2$ meter	± 0.5 meter		
30	$\pm 10\% = \pm 3$ meter	± 0.7 meter		
50	$\pm 8 \% = \pm 4$ meter	± 0.8 meter		
70	\pm 7 % = \pm 4.9 meter	± 0.8 meter		
100	$\pm 7 \% = \pm 7$ meter	± 1 meter		

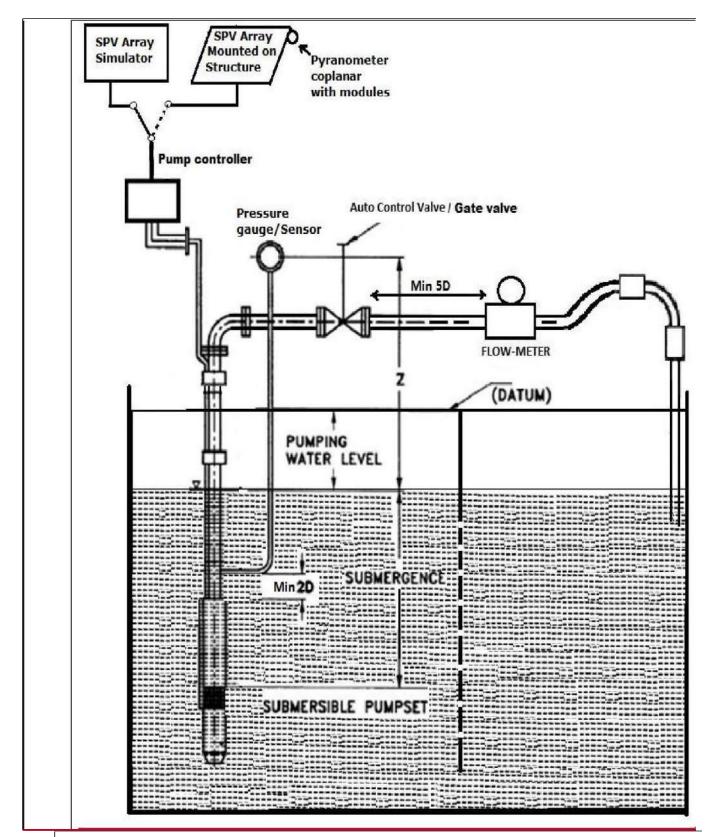
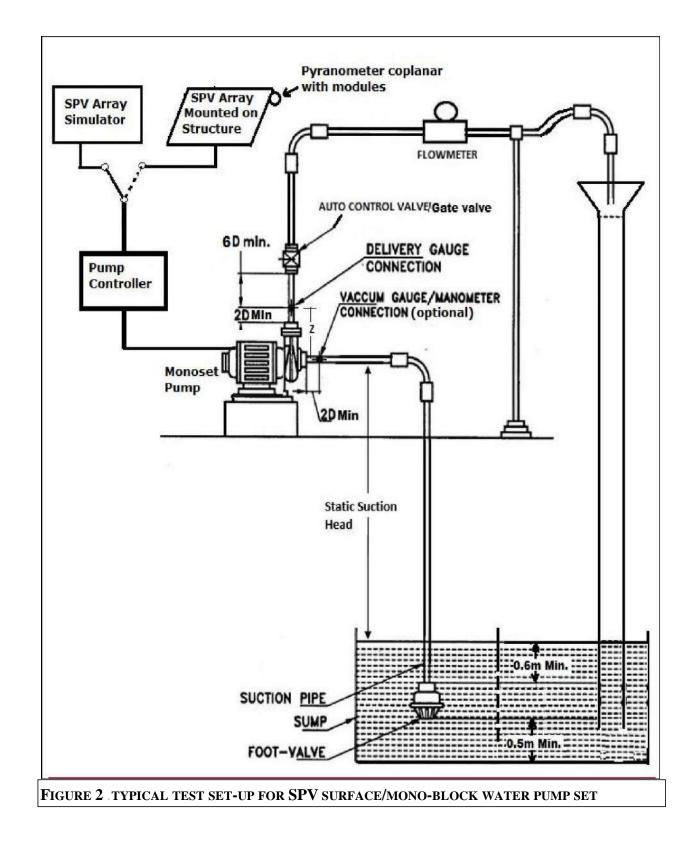
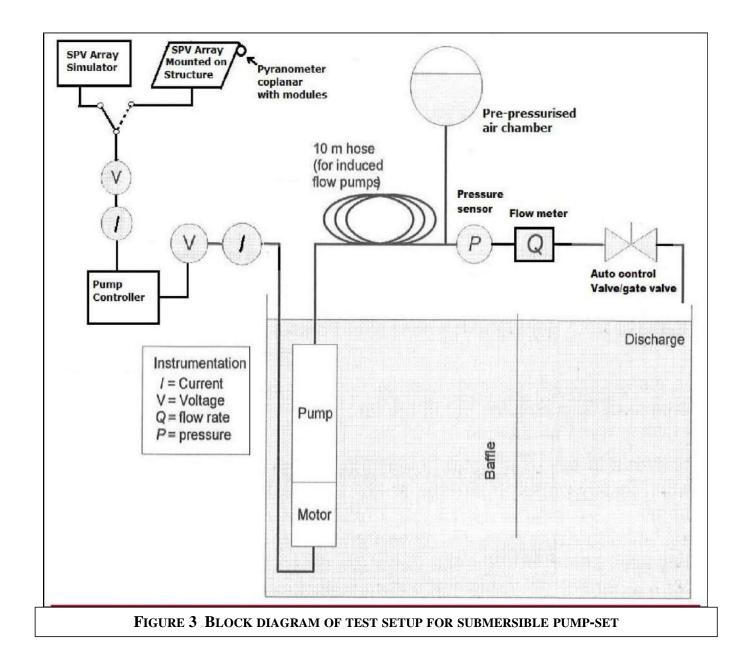


FIGURE 1. TYPICAL TEST SET-UP FOR SUBMERSIBLE SPV WATER PUMP-SET





Test Procedure for Performance Evaluation of SPV Pumping System:

There are three major profiles to be completed for comprehensive certification and qualification of a sample SPV water pump as per this standard. Two steps correspond to two simulation profiles, Hot & Cold. The third step corresponds to actual outdoor conditions testing using natural sun radiation. The SPV water pump sample should attain or exceed the qualification bench marks set by MNRE for the specified model & design, in all the three profiles. Before executing the three profiles testing, it is necessary to conduct the following protections test on the sample:

- j) **Dry running:** System must shut down within one minute/manufacturer specification in dry running condition (when water level goes below pump inlet).
- k) **Open circuit:** System should not operate if any phase become open circuited, the controller shall be tripped within one minute/manufacturer specified time.
- 1) Short circuit: System should not operate if any two or all three-phase short circuited.

4. Reverse polarity: System should not malfunction if polarity of input power is reverse.

5. **Under Voltage**: System shall not operate if terminal voltage goes below limit specified by manufacturer.

6. Surge Protection: Surge protection device (SPD) shall be installed on the input side.

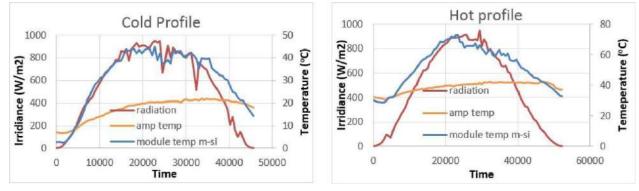
The performance testing of SPV Pumping System for the three procedures are discussed in following sections:

Simulator Methods:

Simulation methods are the easiest and fastest way of estimating SPV pump performance. However, in these methods actual PV array is not used, instead a PV array simulator is used. Here, a Programmable SPV array simulator capable of generating power output equal to actual SPV array under the given radiation and temperature conditions for given SPV array configuration (i.e. the number of modules, the type and the series / parallel combination) will be used. Although any radiation & temperature can be created, for the purpose of testing, two conditions one Hot summer day conditions (hot profile) and the other Winter day conditions (cold profile) shall be used.

Hot & Cold Profiles:

The typical Hot & Cold day profiles are shown Figure 4. These profiles of full day Solar irradiance and temperature shall be loaded in PV array simulator, sequentially one after the other. The simulator output is connected to the motor & pump through the pump controller and the profiles are run-on real-time basis. The performance parameters as given in table 2 are collected every



minute for the entire duration of run time (per day). The total water output and output in liters /watt STC/ day can be estimated at desired constant head / dynamic head for complete duration of profiles. Temperature coefficient of power shall be derived from the IEC 61215/IS 14286 standard test report for the module supplied with the pump of the same model.

FIGURE 4 . TYPICAL SOLAR RADIATION HOT AND COLD PROFILE

Note: Per second data for hot and cold profile may be downloaded from MNRE website using the following link: - <u>https://mnre.gov.in/solar/standard-specs-cost</u>

Outdoor Condition using sun radiation:

To operate the motor-pump set using actual PV array, an array as per the Motor-pump set HP capacity to be designed. The STC wattage of all the PV modules is measured first, as per IEC 60904-1/ IS 12762-1 as suggest by MNRE or clause number 11.6 of IEC 61215 as suggest by MNRE/ clause number 10.6 IS1 4286 as suggest by MNRE. The modules will then be installed on the structures, both in series and parallel combinations, as required, are connected and designed PV module array is created. The array output is connected to Motor & Pump through pump controller.

Per day water output test to be performed at desired constant dynamic head for complete day from dawn to dusk (sunrise to sunset). Irradiance shall be measured at coplanar to modules. Tracking may be done manually or automatically. Total flow shall be corrected at reference Average Daily Solar Radiation of 7.15 kWh/m² on the surface of SPV array (i.e. coplanar with the SPV Modules). Results of the SPV pumping system obtained under outdoor condition shall be compared with data supplied by the applicant and also from the results obtained through simulator testing to assess the performance of the system.

NOTE: -

- Handle PV modules carefully during installation.
- PV modules to be free from dirt (sand, bird droppings etc.,) during test.
- Install PV modules in shadow free access-controlled area.
- Tracking shall be minimum three time in a day for maximum performance
- Pyrono-meter should be mounted co-planer with SPV modules.

Recoding, measurement & logging of flow for the period of hot profile, cold Profile and Realistic condition need to be done.

Remote Monitoring System Verification

Provision for remote monitoring of the installed pumps must be made in the controllers through an integral arrangement and it should be capable of providing live status/parameters through online portal.

6 MEASUREMENTS AND APPARATUS

Solar Radiation Measurement

Solar radiation at coplanar with Module surface shall be measured using pyranometer. Response time of pyranometer should not be more than 15 seconds. Interval between two readings should not be more than one minute for the calculation of average daily solar radiation.

Measurement of Head

Delivery Head

Digital pressure gauge/sensor shall be used, also a data logging system must be used for calculation of average head through day. Interval between two readings should not be more than one minutes for the calculation of average head. Accuracy for pressure sensor shall be within ± 0.5 percent.

Suction Lift

Suction head shall be kept constant by mean of vertical distance from sump water level to centre of pump impeller. Correction in head shall be applied as per atmospheric pressure at the testing place.

Distance measuring scale or laser based sensors may also be used for suction head measurement.

Measurement of Rate of Flow

A good quality Magnetic flow-meter of minimum 0.5% accuracy class shall be used for flow measurement, data logging system shall be used for calculation of cumulative water volume throughout the day. The maximum flow rate of flowmeters should be at least 1.5 times the maximum flow rate of pumps. Instrument can be selected as per 3.2 of IS 11346. Interval between two readings should not be more than one minutes for the calculation of cumulative flow. Accuracy for flowmeters shall be within \pm 0.5 percent.

7 CALIBRATION OF APPARATUS

All measuring instruments are to be calibrated periodically as per requirement.

8 STEP-WISE TEST PROCEDURE

Per Day Water Flow Test of Submersible Pumps

- a) Install the Pump-set as per Figure 1.
- b) Connect Pump-set with controller as per manufacturer instruction

c) Use Solar PV Array Simulator Or actual output from SPV array, for testing of pump-set at given profile.

d) Connect controller with PV array Simulator or with actual SPV array output as per requirement of profile

e) Input STC performance data of each module in the array, into simulator and invoke the desired profile and run the same.

- f) For realistic condition test, make array by mounting all SPV modules on structure(s) by connecting modules in series or parallel as per requirement.
- g) Start controller after connecting it with array or array simulator.

- h) Use head control valve or pre-pressurize tank to keep constant desired dynamic head.
- i) Record parameters as given in table 2 recording interval shall be ≤ 1 minute.

Per Day Water Flow Test of Surface Pumps

- a) Install pumps as per Figure 2
- b) Maintain height to get desirable static suction head as per requirement
- c) Install of foot valve or non-return valve as per manufacturer instructions; and
- d) Follow steps (b) to (j) of para-No. 8.1

9 OBSERVATIONS

The following observations of complete day profile shall be recorded in a test record sheet.

These observations shall be used to derive pump characteristics:

- a) Instantaneous Solar irradiation (W/m²), pyranometer reading
- b) Delivery gauge/sensor readings
- c) Suction gauge/sensor readings / Distance between water level to impeller eye, (if applicable)
- d) Gauge distance correction factor, Z
- e) Calculate cumulative daily solar radiation coplanar with solar modules (kWh/m²),
- f) Calculate total water discharge in a day at desirable constant head (Liters per Day)
- g) Water output per day per watts peak (Liters/Wp)

10 COMPUTATION OF TEST READINGS

Computation of Total Head for Surface (Mono-set) Pumps

Total Head H = HSSL + Hd + Z + ((V 2-V 2) / 2g) ds

- HssL = Total Static suction Lift in meters of water column (measured by calibrated measuring tape or any distance measuring sensors)
- $H_d = Delivery gauge/sensor reading in meters of water column$
- Z = Gauge distance correction factor for delivery gauge centre and inlet pipe centre in meters (refer figure 3). If the delivery gauge centre is below the inlet pipe centre, Z is subtracted from the delivery gauge reading and if the delivery gauge centre is above inlet pipe centre, Z is added to the delivery gauge reading; the

gauge distance correction factor shall never be applied to the suction vacuum gauge or mercury manometer reading irrespective of their positions:

- V_d = Velocity at delivery gauge/sensor connection, m/s;
- V_s = Velocity at suction gauge/sensor connection, m/s; and
- g = Acceleration due to gravity in m/s2.

The Total Static Suction Lift in surface pump (Hssl)

Correction for Altitude

Barometric pressure shall be recorded at test place. The difference between atmospheric pressure at the test place and 10.33 mWC (that is atmospheric pressure at MSL) shall be deducted from Static suction lift.

Correction for Water temperature

Static suction lift specified in below Table shall be increased or reduced as given below when water temperature is below or above 33°C.

\mathbf{r}					
Hourly Average of	Vapour pressure	Correction in Static suction lift			
Water Temperature	mWC	above and below 33°C water			
°C		temperature mWC			
10	013	+ 0.39			
15	0.18	+ 0.34			
20	0.24	+0.28			
25	0.33	+ 0.19			
30	0.43	+ 0.09			
33	0.52	0.00			
35	0.58	- 0.06			
40	0.76	- 0.24			
45	1.00	- 0.48			
50	1.28	- 0.76			
35 40 45	0.58 0.76 1.00	- 0.06 - 0.24 - 0.48			

 Table 4 - Correction for water temperature

Suction head shall be adjusted minimum 3 time in a day as per average water temperature and barometric pressure, by adjusting water level of tank.

Following formula can also be used on behalf of table 4

 $y = -0.0007 x^{2} + 0.0130 x + 0.3079$

Where

HssL = Height in meter from water level to impeller + Altitude correction in meter + water temperature correction in meter.

y = Correction in Static suction lift x = Average of water temperature.

Computation of Total Head for Submersible Pump-sets

Total head $H = H_d + Z + ((V_d^2) / 2g)$

Where:

H_d = Delivery gauge/sensor reading in meters of water column;

- Z = Gauge distance correction factor for delivery gauge. Distance between gauge/sensor center to tank water level (refer figure 1).
- V_d = Velocity at delivery gauge/sensor connection in m/s;
- g = Acceleration due to gravity in m/s².

Total Water Per-Day

Total per day water output shall be calculated by Integration (Sum) of flow rate with respect to time. Integration shall start from the time when pump set achieve desired constant head in morning time (start point refer figure 5) and end at the time when pump set unable to achieve desired constant head in evening time (End point refer figure 5).

In case if Average Daily Solar Radiation found less than requirement then test shall be performed on next sunny day.

Water Output Per Day Per Watt Peak

Water output per day per watts peak (ltr/Wp) = Water output (Liters) per day at specified head / Array STC power in watts-peak

Cumulative Daily Solar Radiation

Cumulative Solar Radiation (kWh/m²) in a day= Average of instantaneous irradiance reading from Dawn to Dusk (kW/m²) X period of time in hours.

This can be obtained through time weight summation of pyranometer readings.

Dawn = Time of sunrise when irradiance become positive from zero value.

Dusk = Time of sunset when irradiance become zero from positive value.

Mismatch in maximum power at STC among modules of array

The mismatch shall be calculated as under:

% Power mismatch in array
$$\frac{(PMax-PMin)}{(PMax+PMin)} \times 100$$

 P_{Max} = Maximum power among modules in array P_{Min} = Minimum power among modules in array

Efficiency of Array

Efficiency of Array = The power output from array / (total area of modules in $m^2 X$ Sun radiation in watts/ m^2)

Fill Factor of Array

Fill factor of Array = This has to be measured using a PV array tester. This depends on the overall series resistances and shunt resistances of modules in the array.

Output Voltage of Array

Output Voltage of Array = Sum of voltages of modules in series In parallel connected module strings, the lowest voltage generating strings will set the voltage.

Output Current of Array

Output Current of an Array = Sum of currents of the parallel strings in the array. The output current of a string is controlled by the lowest current generating module.

Output Power of Array

Output Power of Array = Sum of power of all modules- mismatch loss This can be measured by PV array tester.

11 EXAMPLES:

Total per day flow

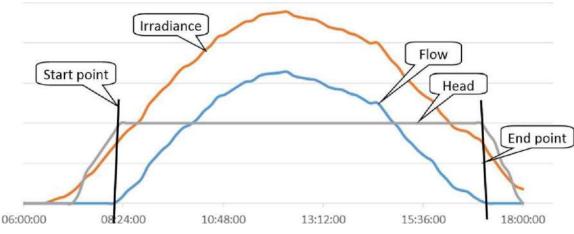


FIGURE 5- TYPICAL GRAPH FOR UNDERSTANDING CALCULATION

If pump achieved constant head at 8:15:30 AM (Start point in figure 5) and in evening pump unable to keep constant desired head at 17:45:30 PM (End point in figure 5).

Flow rate in lps is recorded from 08:15:30 AM to 17:45:30 PM (start point to end point) If the average lps calculated is 3.55 lps then total flow will be

Total duration of flow = End Time - Start time = 17:45:30 - 8:15:30= 9 h: 30 m: 0 s

Total duration from start to end seconds:

=(9x3600) + (30x60) + (0x1) = 34200seconds

Total per day flow in liters = Average flow in lps x total seconds

 $= 3.55 \times 34200 = 121410$ litters

For realistic test, correct total flow at reference Average Daily Solar Radiation as specified in MNRE specifications.

12 TEST REPORTS

In order to have uniformity, the test reports issued by the Labs shall use common format developed by NISE. The test report shall be issued only in the name of applicant and shall clearly indicate whether the Solar PV water pumping system qualify as per MNRE specifications or not along with details. A soft copy of test report shall also be provided to the applicant and shall be made available on web-portal of test lab, which may be accessed by the implementing agencies to verify the authenticity of the report.

13 USE OF OTHER BRAND OF SOLAR MODULES

In case a lest lab has tested and issued approval certificate fir a particular model of SPV pumping system using a particular model of SPV Modules, the applicant may use different models of SPV Modules for the same model of SPV pumping system without going for retesting of complete SPV pumping system with different model of SPV Modules, provided the test lab certifies that the qualitative characteristics of proposed model of SPV Module are not inferior to the SPV Module with which the SPV pumping system was tested. In addition, the total wattage capacity of the Solar Array with proposed model of SPV Modules shall be equal or higher than wattage capacity specified by the MNRE for that model of SPV pumping system. The proposed model of SPV module shall also meet following conditions:

- Solar Array Maximum voltage Vmpp with other brand module shall be within ±2% of earlier module.
- Modules Efficiency and Fill Factor shall qualify minimum requirement of MNRE specifications
- Module to module mismatch in an array shall meet the MNRE specifications.
- SPV module shall follow the quality control order issued by MNRE from time to time.

13 LABS AUTHORISED FOR SOLAR PUMP TESTING

- Any lab accredited by NABL for testing of solar PV water pumping system as per MNRE specifications and testing procedure, and The National Institute of Solar Energy are authorized to issue approval certificate on successful testing of a solar PV water pumping system.
- Soft copy of test report shall be available to implementing agencies on request basis.
- Logged data for Head, flow & radiation shall be preserved by laboratory at-least for 1 year.

	LIST OF REFFERED STANDARD
IS NO. (as suggest by MNRE)	Title
17018-1 : 2018	Solar Photovoltaic Water Pumping System Part 1 Centrifugal Pumps — Specification
14286 : 2010	Crystalline Silicon Terrestrial Photovoltaic (PV) Modules — Design Qualification and Type Approval
3043 : 1987	Code of Practice for Earthing
5120 : 1977	Technical requirements for rotodynamic special purpose pumps (first revision)
11346 : 2003	Tests for Agricultural and Water Supply Pumps — Code of Acceptance
6603 : 2001	Stainless Steel Bars and Flats
6911 : 2017	Stainless steel plate, sheet and strip Stainless steel plate, sheet and strip
7538 : 1996	Three-phase squirrel cage induction motors for centrifugal pumps for agricultural applications
8034 : 2018	Submersible pump sets - Specification (second revision)
9079 : 2018	Electric monoset pumps for clear, cold water for agricultural and water supply purposes - Specification (second revision)
9283 : 2013	Motors for submersible pump sets
11346 : 2002	Code of acceptance tests for agricultural and water supply pumps (first revision)
14220 : 2018	Open well submersible pump sets — Specification
14582 : 1998	Single-phase small AC electric motors for centrifugal pumps for agricultural applications
ISO 9905 : 1994	Technical specifications for centrifugal pumps — Class I
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)
IEC 60146-1-1 : 2009	Semiconductor converters - General requirements and line commutated converters Part 1-1 Specification of basic requirements
IEC 60364-4-41 : 2005	Low-voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock
IEC 60364-7-712 : 2017	Low voltage electrical installations - Part 7-712: Requirements for special installations or locations - Solar photovoltaic (PV) power supply systems
IEC 60529 : 1989	Degrees of protection provided by enclosures (IP Code)
IEC 60947-1 : 2007	Low-voltage switchgear and control gear - Part 1: General rules
IEC 61000-6-2 : 2016	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-3:2006	Electromagnetic compatibility (EMC) - Part 6-3: Generic standards -Emission standard for residential, commercial and light-industrial environments
IS/IEC 61683 :1999	Photovoltaic Systems — Power Conditioners — Procedure for Measuring Efficiency
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 61800-3:2017	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods
IEC 62109-1:2010	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
IEC 62305-3:2010	Protection against lightning - Part 3: Physical damage to structures and life hazard
IEC 62458:2010	Sound system equipment – Electro-acoustical transducers - Measurement of large signal parameters

Universal Solar Pump Controller (USPC)

1. Preamble:

The Controller for Solar PV pumping system is the heart and brain of the system. The Solar PV pumping system deployed at huge cost to the farmer and the exchequer for the Government is currently utilised only for half of the days in a year (around 150 days per year) on an average. In order to optimally utilize the solar photovoltaic system that generates the electricity throughout the year during sunshine hours, the controller supplied for installation of solar pumping system should be able to perform several other tasks for agricultural and other needs of a farmer. This will increase the productivity of agriculture sector and income of farmer. With the use of USPC the solar system could be used effectively throughout the year.

2. Technical Specification for Stand Alone Application

The USPC with SPV modules and structure can be used for agrarian applications such as water pumping, apple grading and polishing system, wheat (grain) flour grinding machine / aata chakki, cutter/chaff, deep-fridger / cold storage, blower fan for cleaning of grains, heating loads and any other standard voltage (400/415V) three phase motor/equipment of capacity not more than the capacity of Solar PV pumping system. The USPC operation schematic diagram is shown in Fig. 1. Further, the applications are not limited upto the few shown in the figure.

I. Following table gives specifications of electrical supply from USPC for motors other than the solar pumps. For operating the pump the USPC must follow the MNRE specifications for SPV pumping systems.

Sr		
No.	Description	Desired requirement
1	Motor Supply Phases	Three phase R-Y-B
2	Rated motor frequency	48-50Hz
3	Frequency operation	0 to 52Hz
4	Rated motor voltage	$415V \pm 5\%$
		Constant V by F or constant
5	Desired motor operation	motor flux control

II. Proposed electrical properties of USPC when operating motors other than motor- pump set:

Sr No.	Description	Desired requirement
1	Characteristic of voltages	Pure sinusoidal or Filtered AC output voltage at motor terminal. No PWM pulses allowed at the motor terminal, as it generates pronounced voltage spikes. The USPC output is intended to use for the traditional induction motors based applications which are design for sinusoidal grid supply.
2	THD of motor terminal voltages	Below 3%
3	THD of motor current (in case of balance/linear motor)	Below 5%

4	Balance supply	Three phases should be balanced and no negative sequence components to be allowed
5	Voltage spikes	Recurring or non-recurring voltage spikes more than 620V (peak of 440V AC supply) is not allowed
6	Alarms and Protections	Output voltage low, Output frequency low/high, Low irradiance/PV power, Current overload, Peak Torque

- III. Controller should be able to run SPV pumping system as per MNRE specifications as well as any other type of motor of suitable rating, subject to the load characteristics of the equipment in which the motor is used is any of the following:
 - a) Constant torque loads
 - b) Constant power loads
 - c) Quadratic loads
 - d) Impact loads
 - e) Hydraulic loads

Subject to the maximum torque being not more than 150% of the rated torque of the motor.

- IV. To ensure energy efficiency of solar PV system and to maintain reliability of PV installation against aging effect, module mismatch with time, partial shading, etc., the desired USPC properties and configuration should be as follows:
 - (a) Static MPPT efficiency of USPC should be equal or more than 98% during operation of 10 to 100% of rated STC PV power, and average MPPT tracking efficiency in the dynamic condition should be greater than 97% with hot and cold profiles when feeding the water pumping, hydraulic or heating loads, so as to maintain MPPT irrespective of variation in solar energy or irradiance.
 - (b) USPC efficiency should be as follows for the operation at 80% rated STC power of the PV array:

Sr No.	SPV pumping system capacity	Controller power efficiency should be more than or equal to
1	2 HP	93.00%
2	3 HP	93.00%
3	5 HP	93.00%

(c) Considering voltage variation over the year due to variation in temperature, irradiance and effect due to ageing, environmental damages to PV panels with time, USPC should have MPPT channels as an integral part of system (or externally connected part) with wide range of input PV voltage for MPPT tracking of the PV panels. Input voltage range variation should be tested as per manufacturer declaration (min, nominal or 90% of the maximum) or if no declaration is made than at least it should be tested as per the table given below:-

Sr	Motor Pump	Input voltage range			
No.	set capacity	Minimum Nominal Maximum			
1	2 HP	(0.85*Vnominal)		(1.15*Vnominal)	
2	3 HP	(0.85*Vnominal)	Nominal	(1.15*Vnominal)	
3	5 HP	(0.85*Vnominal)		(1.15*Vnominal)	

- V. There should be Mode selection located on control panel of the USPC along with display and user should be able to select either to run motor-pump set of any other application. The software/firmware required to operate these applications must get automatically loaded when an appropriate position of the switch is engaged.
- VI. USPC must have at least four numbers of three phase output cables to feed power to the applications. The output power cable for specific application should get selected automatically upon selection of applications via keypad or via mobile or via remote control connectivity. The manual selector switch should not be used at the output to manage different loads. This is to ensure the hassle-free operation of applications by farmer with adequate safety.

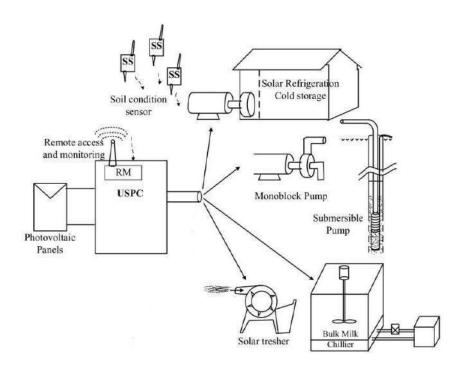


Fig. 1. USPC operation schematic diagram.

VII. USPC based Solar system must be equipped with Remote monitoring and

remote fault identification:

- (a) Remote monitoring features should be integral part of solar pump controller and should provide time wise remote monitoring of PV voltage, PV Power, Water output, head, when used in solar pump mode. When operated in farm equipment mode, it should show, PV voltage, PV power, motor voltage, motor current and motor frequency.
- (b) Cumulative energy generation from PV panels for a month, year and 5 years should be provided.
- (c) Remote monitor should show current status of system like On, Off and fault.
- (d) Software associated with remote monitoring should also provide location of SPV pumping system.
- (e) Controller should have support of sufficient Internal memory/ SD card / memory card to support remote monitoring in case of network failure.

USPC must have IP65 protection or must be housed in a cabinet having at least IP65 protection.

Testing Procedure for Universal Solar Pump Controller (USPC)

USPC must be tested in two principle modes:

- 1. As an offgrid solar pump controller: the testing should be as per MNRE specifications and Test procedure.
- 2. As a controller to operate motorized farm equipment: The testing should be as described below.

To test the USPC in the second mode the test centres must have standard actual mode suitable for 4 loading modes. The input to the USPC must be from a solar PV simulator using the hot and cold profiles issued by MNRE. Following tests may be performed on USPC driving the agrarian load like Atta Chakki, Chaff Cutter and Deep Freezer under test. The USPC must be able to operate these motors of the attached agrarian load, so that they deliver the rated torque and are able to also operate till 150% of the rated torque for 30 seconds.

S.No.	Test Performed	Expected result	Test Lab	Remarks
			Observation	
1	Application description on screen and selection of	LCD screen provided on controller need to shows various applications which can be selected by keypad using up-down and enter key		
2	Mode operation of applications (Automatic: through keypad or remote / Manual: control	Universal Solar Agriculture controller should come with multiple outputs which can be permanently connected to the application by selecting appropriate options for example following applications should automatically started by USPC by appropriate mean such as keypad or remote for selection.		
	switches)	(i) Water Pumping		

		(iii) i) Deep frid Storage (iv) At Manual changeov	ta Chakki ver is not allowe			
3	Application	USPC should have				
	Specific output (Application	application specif				
	specific	output of the con				
	software)	suitable for above	e mentioned	-		
		applications				
4	Input PV voltage range Minimum – Voc at					
	STC Nominal – Voc at STCMaximum – Voc at STC					
5	USPC Efficiency measurement in	Efficiency of the	e UPSC at min	imum	VOC	
	Hot and cold profile shouldbe measured as per BSEN 50530/IEC 62891 as suggested by MNRE	Load %	Charge controller eff (%)	Power tracking Efficiency (%)	Overall charge controller efficiency (%)	7
		10				
		25				
		50				
		75				
		100				
		Efficiency of the	LIPSC of Nom	inal	VOC	
		10				
		25				
		50				
		75				
		100				
		Efficiency of the		of More	VOC	
		Efficiency of the 10	UPSC at 90 %	o or ivrax		
		25				
		50		1		
		75		1		
		100				
	1			1		
		Dynamic MPPT	Efficiency			

		Cold Profile		
6	Ripple and distortionat output on full load	Should below 5 % after 25 % loading condition		
7	Measureme nt of Output voltage waveform	Three phase output with up to440 V rms pure Sine Wave tobe measured at least 4 times between 300W/m2 irradiance and maximum irradiance as per the irradiance profile.	CF value should be provided by lab for voltage and current	
8	Operation at differentoutput from array with all four load types (Array wattage as per MNRE model:	AboveWatt DC output Should not stop functioning at any load condition. Observation shouldbe recorded.	Power value should be recorded by the lab with all agrarian load	Motor current should be recorded (for torque behavior) It must be almost constant
	Example 4800 Wparray) At 40% Power At 50% Power At 75% Power At 100% Power		supported by USPC	irrespective of available DC power from array (motor running condition). This is for Impact loading condition (such as Chaff cutter) current variation need to be recorded by laboratory.
9	Operation at differentoutput from array with all four load types (Array wattage as MNRE model: Example 4800 Wp array) At 10 % Power At 25 % Power At 30 % Power	USPC need to run all the agrarian load in variable frequency at the lower irradiance value The load may be increased beyond 150% of rated torqueto determine at what level themotor is stalling and stoppingand it must trigger 'torque overload' alert. If it goes beyond 150% of the motor rated torque the USPC musttrip indicating an 'overloadtripping'.	Motor current should be recorded (for torque behavior) as it is a function of V/F ratio controlled by USPC	
10	Total circuit protection observation	 Soft Startup, low radiation protection, overload protection, Open circuit protection Reverse polarity protection 		

Expected output of individual applications must be specify as per their power rating and SPV capacity, such as:

1. kg/hour grinding of atta chakki, and granularity.

- 2. Volumetric Iceing of cold storage in x hours.
- 3. Output in terms of kg/hours for a specific capacity grass-cutter.
- 4. Output must be quantify in terms of rate of volume or weight as above for any other applications.

All the test labs authorised to conduct testing for off-grid solar pumping system as per MNRE specifications may also conduct testing of USPC as per procedure prescribed above and issue testing certificates.