# 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 up to 10 HP capacity.

## 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

### 3.1 Systems

**3.1.1** *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.

**3.1.2** *Motor-Pump Set*

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

**3.1.3** *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.

### 3.2 Parameters

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

| Table 1 – Parameters | | |
|---|---|---|
| **Parameter** | **Symbol** | **Unit** |
| **(1)** | **(2)** | **(3)** |
| Array voltage (DC) | $V_a$ | V |
| Array current (DC) | $I_a$ | A |
| Array open circuit voltage (DC) | $V_{oc}$ | V |
| Array short circuit current (DC) | $I_{sc}$ | A |
| Array maximum power point voltage(DC) | $V_{mpp}$ | V |
| Array maximum power point current (DC) | $I_{mpp}$ | A |
| Pressure as measured | $p$ | kg/cm$^2$ |
| Flow rate | $Q$ | Lps /Lpm /m$^3$h |
| Motor voltage DC or AC | $V_m$ | V |
| Motor current DC or AC | $I_m$ | A |
| Motor voltage (multi-phase AC) | $V_{\mathrm{rms}}$ | V |
| Motor current (multi-phase AC) | $I_{\mathrm{rms}}$ | A |
| Power factor | $cos\text{Ø}$ | - |
| AC frequency (or DC switching frequency) | $F$ | Hz |
| Motor speed | $N$ | min$^{-1}$ |
| Radiation | $E_e$ | $W/m^2$ |
| Temperature | $T$ | $^oC$ |

## 4 TEST SET UP

### 4.1 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.

### 4.2 Precautions for Test Setup:

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

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

c) 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.
d) 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.
e) 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.
f) 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.
g) 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.
h) 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.
i) 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.

### 4.3 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.

### 4.4 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.

### 4.5 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.

**4.6 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* | A | ≤1 percent |
| Pressure/head as measured | *p* | Kg/cm$^2$ | ≤2 percent |
| Flow rate | *Q* | lps | ≤2 percent |
| Solar irradiance | $E_e$ | W/m$^2$ | ≤2 percent |

**4.7 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
l) AAA class Sun simulator for testing of modules performance at STC

**Refer to the block diagram at Figure 3.**

**4.8 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 | ± 10 % = ± 2 meter | ± 0.5 meter |
| 30 | ± 10 % = ± 3 meter | ± 0.7 meter |
| 50 | ± 8 % = ± 4 meter | ± 0.8 meter |
| 70 | ± 7 % = ± 4.9 meter | ± 0.8 meter |
| 100 | ± 7 % = ± 7 meter | ± 1 meter |

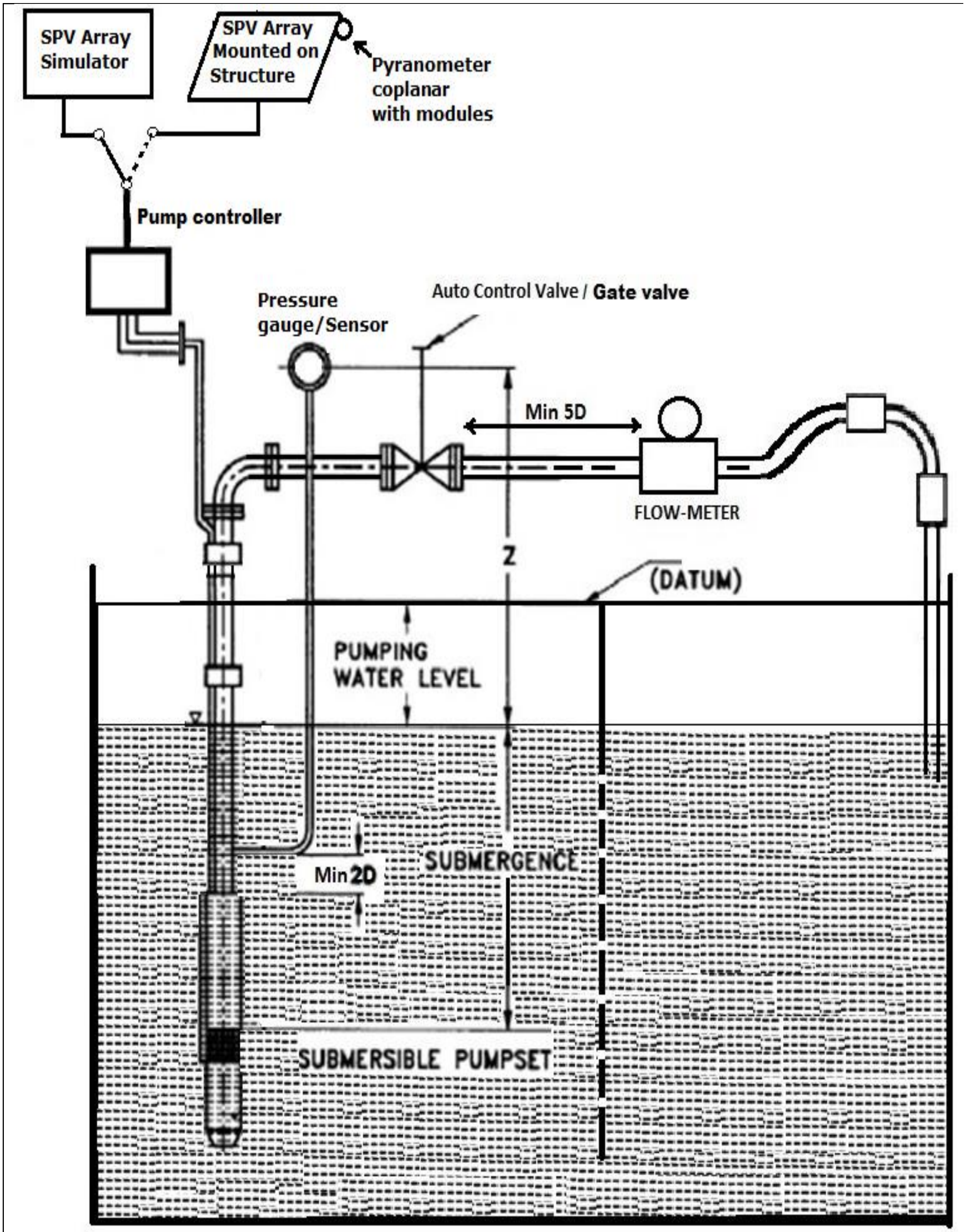


**FIGURE 1– TYPICAL TEST SET-UP FOR SUBMERSIBLE SPV WATER PUMP-SET**

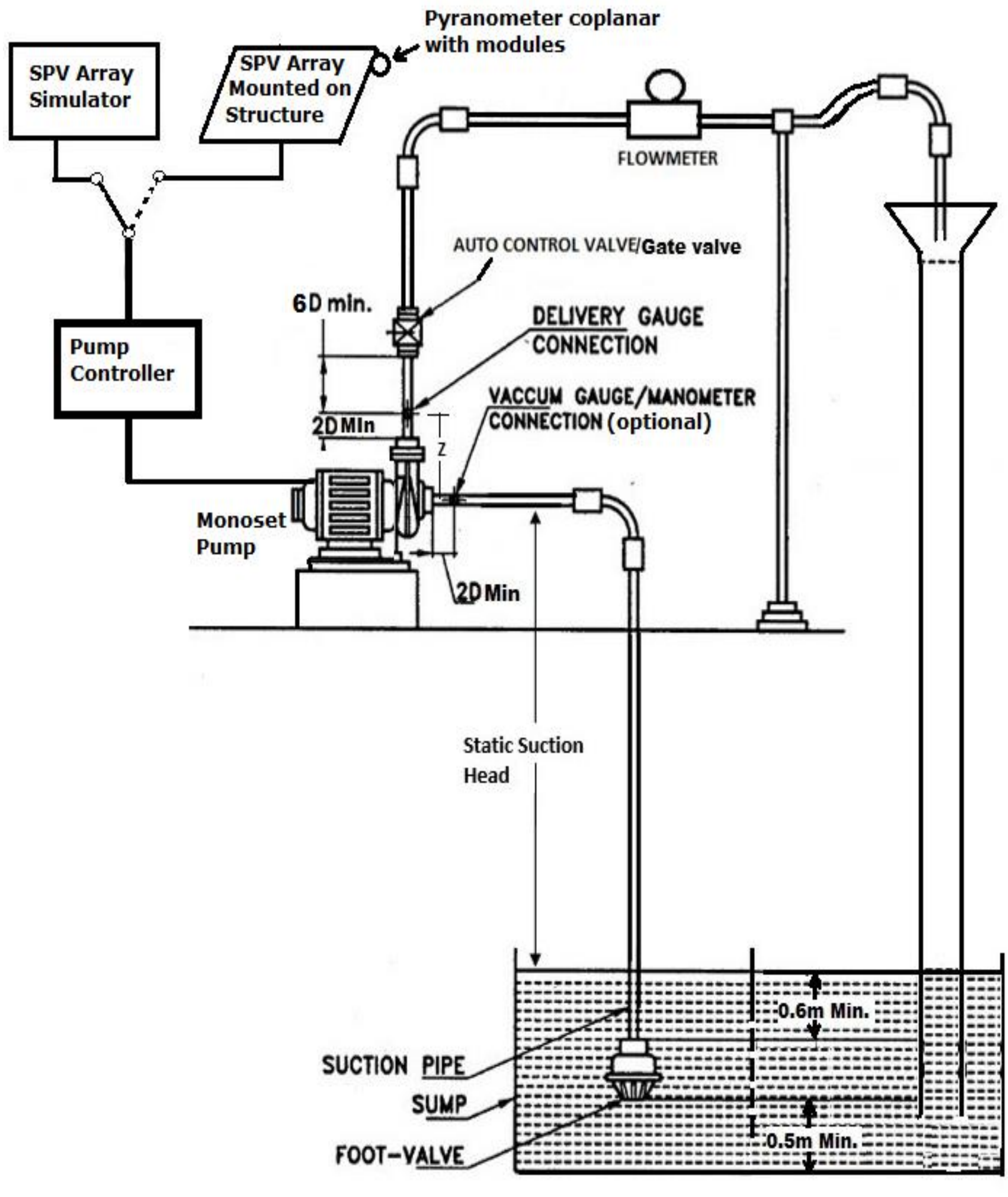


**FIGURE 2 – TYPICAL TEST SET-UP FOR SPV SURFACE/MONO-BLOCK WATER PUMP SET**

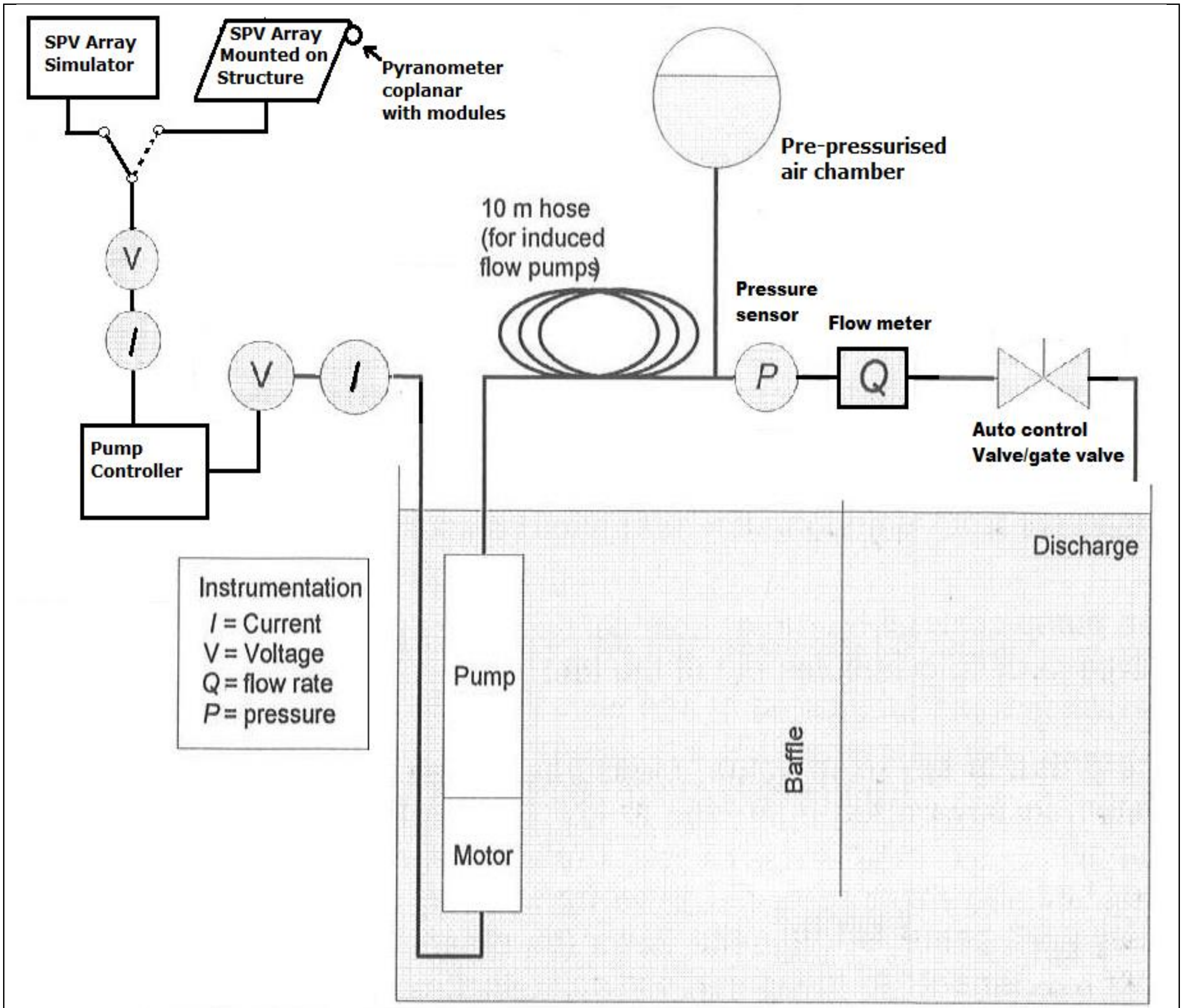


**FIGURE 3 – BLOCK DIAGRAM OF TEST SETUP FOR SUBMERSIBLE PUMP-SET**

## 5.0 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:

1. Dry running: System must shut down within one minute/manufacturer specification in dry running condition (when water level goes below pump inlet).
2. Open circuit: System should not operate if any phase become open circuited, the controller shall be tripped within one minute/manufacturer specified time.
3. 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.

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

### 5.1 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.

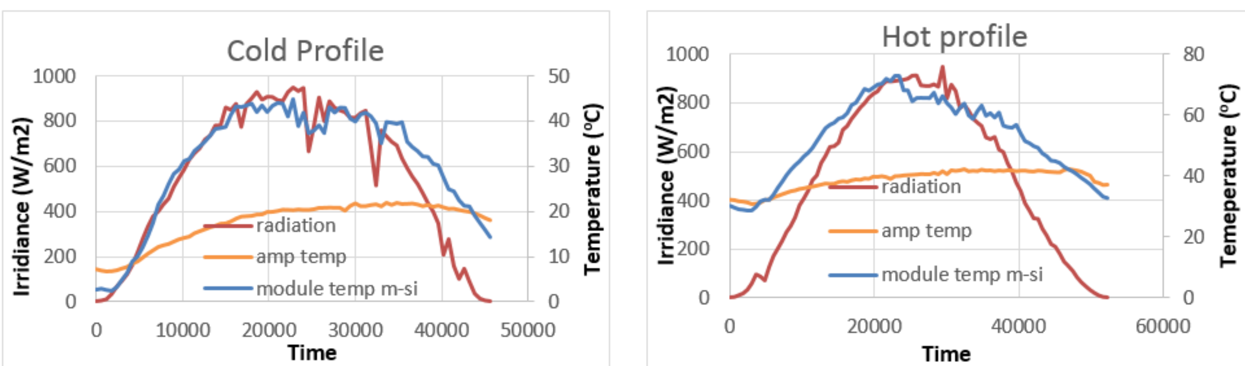


**FIGURE 4 – TYPICAL SOLAR RADIATION HOT AND COLD PROFILE**

Note: Per second data for hot and cold profile may be downloaded from MNRE/NISE website

### 5.2 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 or clause number 11.6 of IEC 61215/ clause number 10.6 IS1 4286. . 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. Then using a PV Array tester measure the PV array output and different radiation intensities starting 100W/ $m^2$ up to 1000 W/$m^2$ (if possible), if 1000W/ $m^2$ is not reached, calculate maximum power output at the maximum sun radiation that can be achieved (say 900 or 800w/ $m^2$). Always measure & record the instantaneous water flow rate at each of the radiation levels, against the PV array output power. A Table listing three parameters sun radiation, array Wattage output and water flow rate at each power output to be recorded. This data is most useful and will be used is subsequent calculations. This data can also be compared with data supplied by manufacturer.

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/$m^2$ 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.

### 5.3 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

### 6.1 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.

### 6.2 Measurement of Head

#### 6.2.1 *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.

**6.2.2** *Suction Head*

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.

For reference a vacuum gauge/absolute pressure gauge/manometer may also be used, if used, then shall be of suitable range for measuring suction head and delivery heads. Instead of mounting gauges directly on the pipes, they may be placed on separate stand.

### 6.3 Measurement of Rate of Flow

A good quality Magnetic flow-meter is desirable for flow measurement, data logging system must 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 ± 0.5 percent.

## 7 CALIBRATION OF APPARATUS

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

## 8 STEP-WISE TEST PROCEDURE

### 8.1 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.

j) Record parameters as given in table 2 recording interval shall be $\leq$ 1 minute.

### 8.2 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 ($W/m^2$), 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 ($kWh/m^2$),
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

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

Total Head $H = H_{SSL} + H_d + Z + ((V_d^2 – V_s^2) / 2g)$

$H_{SSL}$ = 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:

Vd = Velocity at delivery gauge/sensor connection, m/s;

Vs = 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 ($H_{SSL}$)**

**$H_{SSL}$ =** Height in meter from water level to impeller + Altitude correction in meter + water temperature correction in meter.

### 10.1.1 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.

### 10.1.2 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.

**Table 4 – Correction for water temperature**

| Hourly Average of Water Temperature °C | Vapour pressure mWC | Correction in Static suction lift above and below 33°C water 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 |

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

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

## 10.2 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 $m/s^2$.

**10.3 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.

**10.4 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

**10.5 Cumulative Daily Solar Radiation**

Cumulative Solar Radiation ($kWh/m^2$) in a day= Average of instantaneous irradiance reading from Dawn to Dusk ($kW/m^2$) 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.

**10.6 Mismatch in maximum power at STC among modules of array**

The mismatch shall be calculated as under:

$$\%\ Power\ mismatch\ in\ array = \frac{(P_{Max} - P_{Min})}{(P_{Max} + P_{Min})} \times 100$$

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

### 10.7 Efficiency of Array

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

### 10.8 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.

### 10.9 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.

### 10.10 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.

### 10.11 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:

### 11.1 Total per day flow

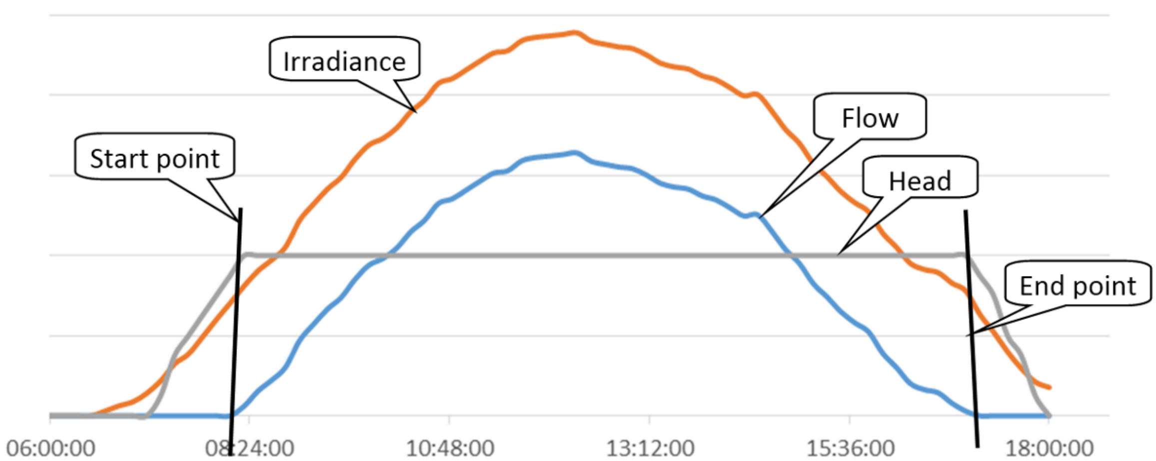


FIGURE 5- TYPICAL GRAPH FOR UNDERSTANDING CALCULATION

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 x 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 test lab has tested and issued approval certificate for a particular model of SPV pumping system using a particular brand of SPV Modules, the applicant may use SPV Modules of other brand for the same model of SPV pumping system without going for retesting of SPV pumping system with other brand of SPV Modules provided the test lab certifies that the SPV Module of other brand is atleast of same wattage capacity and its parameters and characteristics are not inferior to the brand of SPV Module with which the model of SPV pumping system was tested and certified by the testing lab. In addition, configuration of solar array i.e. the number of solar modules in series and/or parallel combination will remain unaltered. Further, in each case the SPV module shall follow the quality control order issued by MNRE from time to time. Following criterion shall be followed:

- Solar Array Maximum voltage Vmpp with new brand module shall be within ±2% of earlier module.
- Modules Efficiency and Fill Factor shall qualify minimum requirement of MNRE specifications
- Array and module Mismatch shall meet the MNRE specifications.

## 13 LABS AUTHORISED FOR SOLAR PUMP TESTING

The National Institute of Solar Energy and any other lab accredited by NABL for testing of solar PV water pumping system as per MNRE specifications and testing procedure are authorized to issue approval certificate on successful testing of a solar PV water pumping system.

## ANNEX A

(*Clause* **2**)

## LIST OF REFERRED STANDARDS

| *IS NO.* | *Title* |
|---|---|
| 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 |
| 8034:2002 | Submersible pump sets - Specification (second revision) |
| 9079:2002 | 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) |
| 14220:1994 | 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 |