OPERATION and MAINTENANCE MANUAL

An Operation, Instruction and Maintenance Manual, in English and the local language, should be provided with the Solar Study Lamp. The following minimum details must be provided in the Manual:

- Basic principles of Photovoltaics
- A small write-up (with a block diagram) on Solar Study Lamp - its components, PV module, battery, electronics and luminaire and expected performance.
- Significance of indicators.
- Type, Model number, Voltage, capacity of the battery, used in the system.
- The make, model number, country of origin and technical characteristics (including IESNA LM-80 report) of W-LEDs used in the lighting system.
- Clear instructions on mounting, operation, regular maintenance and trouble shooting of the Solar Study Lamp.
- Instructions on replacement of battery.
- DO's and DONT's.

INDICATORS

- The system should have two indicators, green and red.
- The green indicator should indicate the charging under progress and should glow only when the charging is taking place. It should stop glowing when the battery is fully charged.
- Red indicator should indicate the battery "Load Cut Off' condition.

List of BIS standards applicable for components of Solar PV Applications

SI. No. (1)	Product (2)	Indian Standard Number (3)	Title of Indian Standard (4)
1.	Crystalline Silico n Terrestrial Photovoltaic (PV) modules (Si wafer based)	IS 14286	Crystalline Silicon Terrestrial Photovoltaic (PV) modules – Design Qualification and Type Approval
2.	Thin Film Terrestrial Photovoltaic (PV) Modules (a-Si, CiGs and CdTe)	IS 16077	Thin-Film Terrestrial Photovoltaic (PV) Modules -Design Qualification and Type Approval
3.	PV Module (Si wafer and Thin film)	IS/ IEC 61730 (Part 1) IS/ IEC 61730 (Part 2)	Photovoltaic (PV) Module Safety Qualification Part 1 Requirements for Construction Photovoltaic (PV) Module Safety Qualification Part 2 Requirements for Testing
4.	Power converters for use in photovoltaic power system	IS 16221 (Part 1) IS 16221 (Part 2)	Safety of Power Converters for use in Photovoltaic Power Systems Part1- General Requirements Safety of Power Converters for Use in Photovoltaic Power Systems Part 2-Particular Requirements for Inverters
5.	Storage batteries	IS 16270	Secondary Cells and Batteries for Solar Photovoltaic Application General-Requirements and Methods of Test.
6.	LED Lights & Luminaires	IS 16101 IS 16102 IS 16103 IS 16107	General Lighting - LEDs and LED modules – Terms and Definitions Self-Ballasted LED Lamps for General Lighting Services Led Modules for General Lighting Luminaires Performance Luminaires Performance.

Annexure E

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 0.75kW/1 HP up to 11.25kW/15 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^3h
Motor voltage DC or AC	V_m	V
Motor current DC or AC	I_m	A
Motor voltage (multi-phase AC)	V_{rms}	V
Motor current (multi-phase AC)	I_{rms}	A
Power factor	$cos\emptyset$	-
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

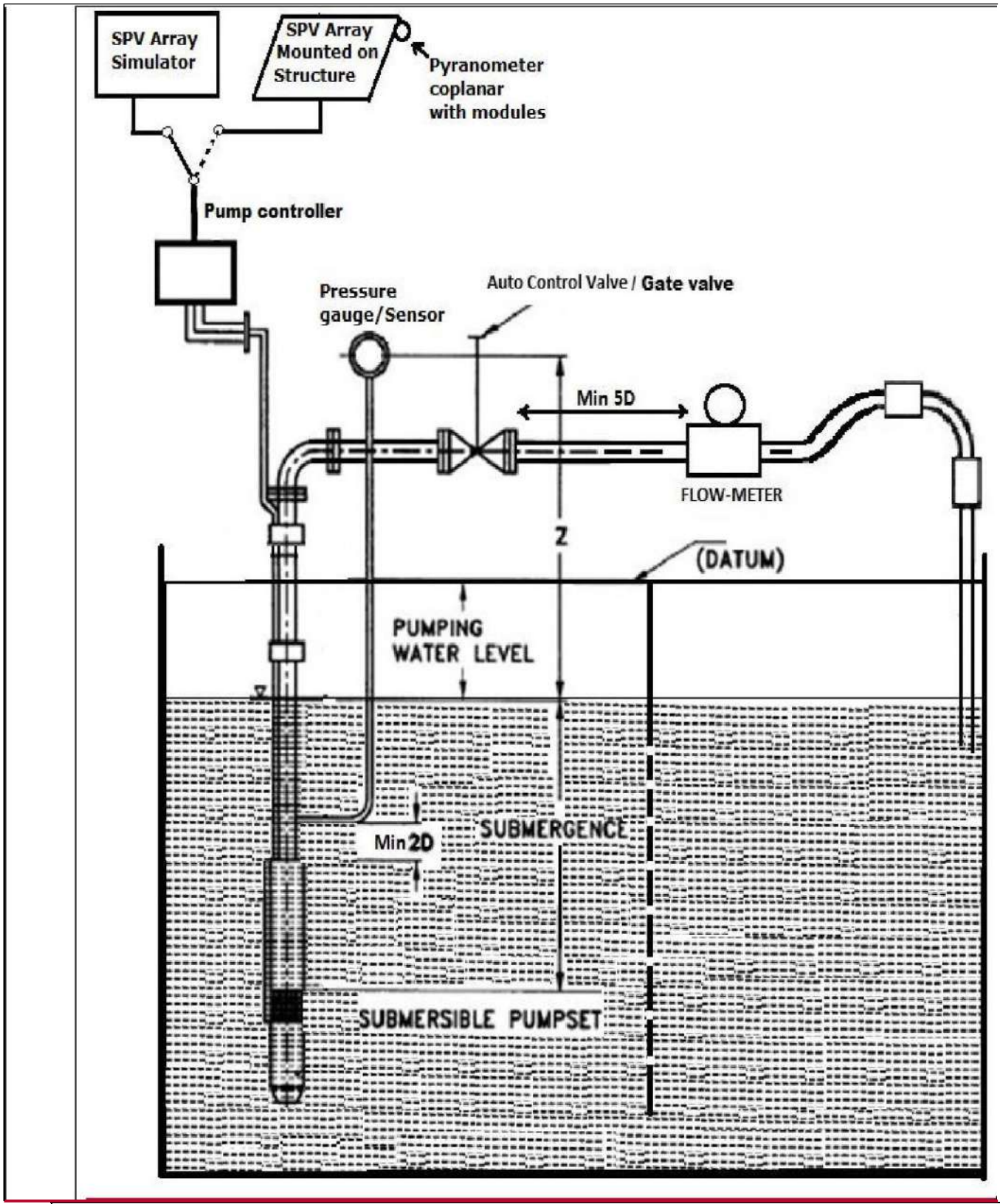

FIGURE 1 TYPICAL TEST SET-UP FOR SUBMERSIBLE SPV WATER PUMP-SET