

**China National Development and Reform Commission
GEF/the World Bank
China Renewable Energy Development Project**

Solar Home Systems Implementation Standard

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China Renewable Energy Development Project Solar Home Systems Implement Standard

1 Background and Scope

China National Development and Reform Commission (NDRC)/GEF/the World Bank China Renewable Energy Development Project management office published *Solar Home Systems and Wind-Photovoltaic Hybrid Energy Systems Specifications for GEF/WB China Renewable Energy Commercialization Promotion Development Project* in 1999. Based on this specification, the National Technical Committee of Energy Foundation and Standard Management published GB/T 19064-2003 *Solar Home System Specifications and Test Procedure*. This implement standard is, in turn, based on experiences in the past few years, and consulted users, equipment providers, system integrators, test laboratories, national and international experts. Compare to GB/T 19064-2003, there are some necessary corrections, modifications and complement.

For easier use and comparison, this implement standard is arranged in the order of components. Under each component section, it gives technical specifications, test methods and technical requirements.

China NDRC/GEF/the World Bank Renewable Energy Development Project will use this standard as the primary qualification requirement for purchasing and subsidizing, starting from January 1, 2006.

This implement standard is applicable to solar home systems rated up to 500 W.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, the following editions and amendments (except errata) not apply, but the users are encouraged to study and negotiate the possible adoption. For undated references, the latest edition of the referenced document applies.

GB/T 2423.1-2001 Environmental testing - Part 2: Tests. Tests A: Cold (idt IEC 60068-2-1:1990)

GB/T 2423.2-2001 Environmental testing - Part 2: Tests. Tests B: Dry heat (idt IEC 60068-2-2:1974)

GB/T 2423.10-1995 Environmental testing - Part 2: Tests - Test Fc: Vibration (sinusoidal) (idt IEC 60068-2-6:1982) (Latest Ed 6.0 1995-03)

GB/T 2829-2002 Sampling table for periodical testing (for steady state production process)

GB 5008.1-1991 Lead-acid starter batteries – Technical conditions

GB/T 7000.1-1996 Luminaires - Part 1: General requirements and tests (idt IEC 60598-1:1992) (Latest Ed 6.0 2003-10)

GB/T 9535-1998 Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval (idt IEC 61215:1993) (Latest Ed 2.0 2005-04)

GB/T 10682-2002 Double-capped fluorescent lamps - Performance specifications (neq IEC 60081:1997) (Latest Ed 5.1 2002-05)

GB/T 13337.1-1991 Stationary acidspray-proof lead-acid batteries – Technical conditions

GB/T15142-2002 General specification for vented nickel-cadmium prismatic rechargeable single cells

GB/T 17262-2002 Single-capped fluorescent lamps - Performance specifications (neq IEC 60901:2000) (Latest Ed 2.2, 2001-11)

GB/T 17263-2002 Self-ballasted lamps for general lighting services - Performance requirements (neq IEC 60969:2002)

GB/T 19064-2003 Solar home system specifications and test procedure

JB/T 9740.4-1999 Installation guide for low speed wind energy conversion system

YD/T 799-2002 Valve regulated lead acid batteries for communication applications

IEC 60061-1 Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 1: Lamp caps (*Latest Ed 3.4 2005-01*)

IEC 60068-2-78:2001 Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state.

3 Definition

This standard adopts the following definition.

3.1 Solar Home Systems (SHS)

Solar home system (includes photovoltaic and wind-photovoltaic hybrid system), is an off-grid home-use photovoltaic (PV) power system which is made of PV module or array, battery, controller, DC/AC inverter, circuit protection devices and appliance. Hybrid system includes also wind generator and its controller, and other components.

3.2 Photovoltaic Modules

The smallest complete environmentally protected assembly of interconnected photovoltaic cells.

3.3 Cycle Life of Battery

Total number of full charge and discharge cycles obtained during the battery service life.

3.4 Charge Controllers

A device that automatically prevents the over-charge or over-discharge of batteries used in a SHS system.

3.5 DC/AC Inverters

A device converts DC electricity into AC electricity.

3.6 DC Luminaire

Luminaires which use DC power, rated voltage is not higher than 12V, with a built-in ballaster, can be used with lamp holders which meet GB/T 10682 (nearly equivalent to IEC60081) or GB/T 17262 (nearly equivalent to IEC60901) standards. The purpose of these luminaires is for general lighting. It includes self-ballasted fluorescent lamps and DC semi-luminaires.

3.7 DC Self-ballasted Lamps

A lamp and a lamp holder with devices for lamp starting and ballasting. They can not be separated.

3.8 DC Semi-luminaire

Similar to self-ballasted lamps, but the lamp and the lamp holder can be separated.

Note 1. lamp and the holder can be easily separated;

Note 2. lamp holder will last longer than the lamp, so when replacing lamps, the lamp holder may continue to be used;

Note 3. lamp holder is a connector to power source.

4 System Classification and Configuration

4.1 System Classification

Based on the power source, a solar home system can be categorized into two types, one is PV only system, the other is PV and wind hybrid system. The PV only system can also be categorized into DC system and AC system.

4.2 System Configuration

Basic configurations and main components of different types of systems are illustrated in Figures 1, 2 and 3.

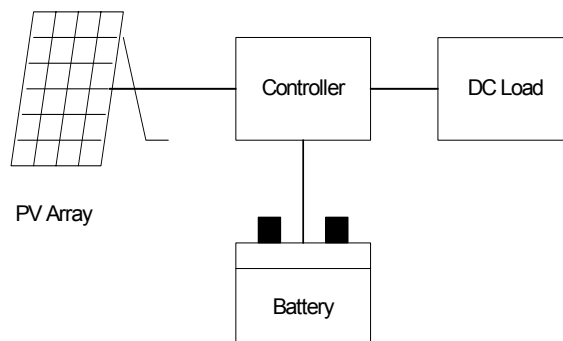


Figure 1 DC Type PV Solar Home System

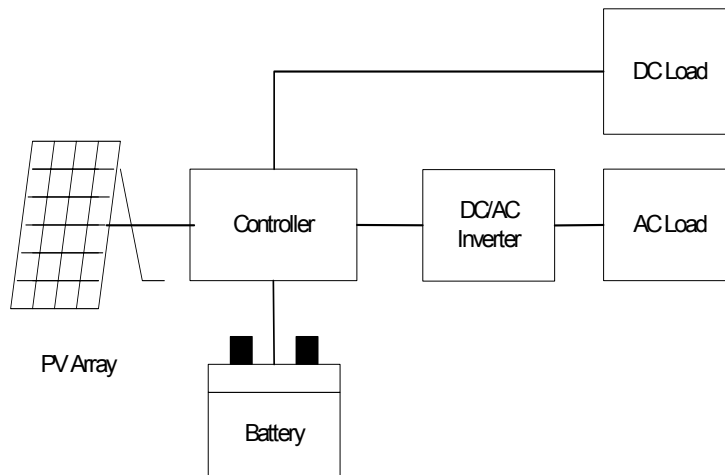


Figure 2 AC Type PV Solar Home System

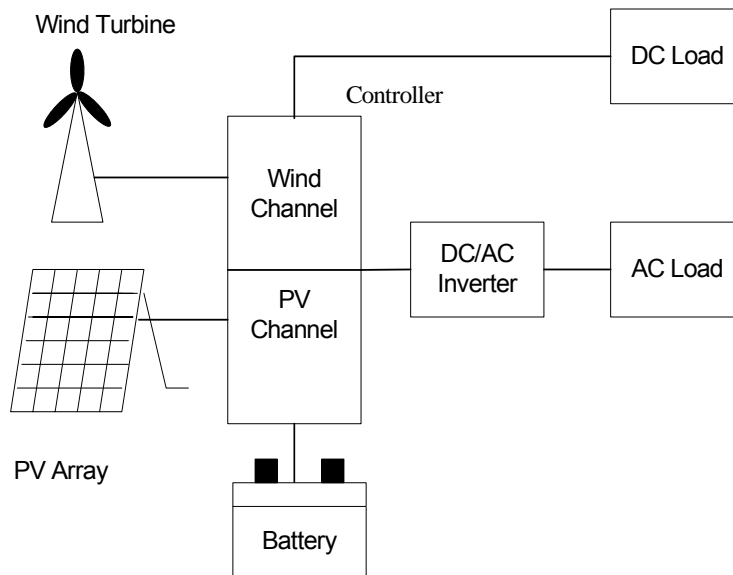


Figure 3 PV-wind Hybrid Solar Home System

5 PV Module and Array

5.1 General Requirement of PV Array

A PV array is made of one or more PV modules. If there is more than one module, the current and voltage of each module should be basically consistent, to reduce the loss from series or parallel connection. The total power of the PV array should be designed based on local solar irradiation and load parameters; and the number of modules on each series or parallel strings should be designed based on the system voltage and current.

A PV array rack is used to support PV modules. All fasteners should be designed so they will ensure the connection between modules and the rack, and make change out of individual modules possible. The rack and modules should survive under maximum wind load of 120 km/h.

The PV array may be installed on the roof of a building. If so, it shall be connected to the main structure of the building, not only to the roofing materials. For ground installation, the minimum distance between the ground and modules is recommended to be 0.3m, to reduce the wind load and soil splash on the array, and to increase the heat dissipation. The ground rack shall be securely connected to a foundation in order to support the array weight and the design wind load.

The tilt angle of the rack may be adjustable or fixed. The fixed angle should be the one which can produce maximum power during the design month (for example, the month with minimum average daily solar irradiation).

For small portable power systems, the PV modules should include a rack which can be easily and securely placed under the sun during the operation.

5.2 Visual Inspection

Visual inspection of a module should be carried out according to GB/T 9535-1998, section 10.1.

5.3 Marking

The marking and the contents on the marking should survive minimum 10 years under natural environment. The attachment to the module should be permanent. The marking should include the following information:

- company name, address and logo;
- module type/model number and serial number;
- date of manufacture (could be traceable from the serial number);
- cell type (mono-Si, poly-Si, or others);
- electrical performance under standard test condition (STC) of AM1.5, irradiance $1000\text{W}/\text{m}^2$ and 25°C cell temperature:
 - peak power (P_{max}) xxx W
 - peak power voltage (V_{mp}) xx.x V
 - peak power current (I_{mp}) x.x A
 - short-circuit current (I_{sc}) x.x A
 - open-circuit voltage (V_{oc}) xx.x V
 - maximum system voltage xxx V
- product certification (year, certification organization, applied standard)

Polarity of all terminals or leads shall be clearly marked.

5.4 Major Visual Defect

During qualification testing, if a module is found to have following major visual defects, it should be declared to have failed the test (GB/T 9535-1998, section 7):

- a) broken, cracked, or torn external surfaces, including superstrates, substrates, frames and junction boxes;
- b) bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the installation and/or operation of the module would be impaired;
- c) a crack in a cell the propagation of which could remove more than 10 % of that cell's area from the electrical circuit of the module;
- d) bubbles or delaminations forming a continuous path between any part of the electrical circuit and the edge of the module;
- e) loss of mechanical integrity, to the extent that the installation and/or operation of the module would be impaired.

5.5 Electrical Performance at STC

The module's current-voltage characteristic curve at STC condition (25°C cell temperature, 1000W/m² irradiance, and spectrum meets GB/T 6495.3-1996 standard AM 1.5) should be measured under natural sun light or by using a Class A solar simulator which meets GB/T 6495.1-1996 standard.

The measured maximum power (P_{max}) should be in -5% to +10% of rated power.

5.6 Insulation Test

Module insulation test should be performed according to GB/T 9535-1998, section 10.3.

When 1,000V plus twice the maximum system voltage is applied between the shorted module leads and exposed metal parts for 1min, there shall be no dielectric breakdown or surface tracking. When 500V is applied, the measured resistance times the area of the module shall not be less than 40 MΩ·m² if the module area is larger than 0.1m².

5.7 Measurement of Temperature Coefficients

The measurement of module temperature coefficient should be performed according to GB/T 9535-1998, section 10.4.

5.8 Measurement of Nominal Operating Cell Temperature (NOCT)

NOCT is defined as the equilibrium mean solar cell junction temperature within an open- rack mounted module in the following standard reference environment:

- Tilt angle: at 45° tilt from the horizontal
- Total irradiance: 800 W/m²
- Ambient temperature: 20 °C
- Wind speed: 1 m/s¹
- Electrical load: nil (open circuit).

The NOCT measurement should be performed according to GB/T 9535-1998, section 10.5.

5.9 Performance at NOCT

The measurement of performance at NOCT should be performed according to GB/T 9535-1998, section 10.6.

5.10 Performance at Low Irradiance

Module performance at low irradiance should be measured according to GB/T 9535-1998, section 10.7, at 25°C cell temperature and 200 W/m² natural sun light or class A solar simulator (using an appropriate reference cell).

5.11 Outdoor Exposure Test

According to GB/T9535-1998, section 10.8, subject the module to an irradiation totalling 60kWh/m². The module should meet the following requirements:

- a) no evidence of major visual defects (5.4);
- b) the degradation of maximum output power shall not exceed 5 % of the value measured before the test;
- c) insulation resistance shall meet the same requirements as for the initial measurements.

5.12 Hot-spot Endurance Test

According to GB/T 9535-1998, section 10.9, conduct the hot-spot test under 1,000kW/m² for 5 hours.

The module shall meet the requirements of 5.11 a) ~ c).

Note: The maximum internal power dissipation of the diode occurs when the circuit element protected by the bypass diode is short circuited. Usually this is accomplished by short circuiting the whole module. If the module does not bypass diodes, check the manufacturer's instructions to see if a maximum number of series modules is recommended before installing bypass diodes. If the maximum number of modules recommended is greater than one, the subsequent tests in this section should be performed with that number of modules in series. If this number is large a constant current power supply may be substituted for all but the test module. In this case, the current of the power supply should be set at *I_{MP}* during the 5 h exposure.

5.13 UV Preconditioning Test

In accordance with GB/T 9535-1998, 10.10, subject the module to a total UV irradiation of 15 kWh/m² in the wavelength range between 280 and 385 nm, with at least 5 kWh/m² in the wavelength band between 280 and 320 nm, while maintaining the module temperature within 60 ± 5°C.

The module shall meet the requirements of 5.11 a) ~ c).

5.14 Thermal Cycling Test

In accordance with GB/T 9535-1998, section 10.11, subject the module to 200 cycles of temperature cycling from -40 to +85°C (humidity control is not required). The maximum duration of each cycle shall be less than 6 hours. Current of *I_{mp}* should flow through the module when its temperature is above 25°C.

The module shall meet the requirements of 5.11 a) ~ c) after the test, and no interruption of current flow during the test.

Note: Current flow when the temperature being above 25°C is a new requirement by IEC 61215:2005. If a module has already been certified per GB/T 9535-1998/IEC 62108:1993, it has to pass this new test before July 1, 2006.

5.15 Humidity-freeze Test

In accordance with GB/T 9535-1998, 10.12, after 50 temperature cycling test (5.14), subject the module to 10 cycles of humidity-freeze test as follows: Begin the cycle by subjecting the test sample to 20 hours at +85°C and 85% relative humidity; reduce the temperature to -40°C, return to 85°C/85% RH for the completion of one cycle. The whole cycle is about 24 hours.

The module shall meet the requirements of 5.11 a) ~ c).

5.16 Damp-heat Test

In Accordance with GB/T 9535-1998, 10.13, subject the module to 1,000 hours of damp-heat test at a temperature of +85°C and 85% relative humidity, continuously.

The module shall meet the requirements of 5.11 a) ~ c).

5.17 Robustness of Terminations Test

In accordance with GB/T 9535-1998, section 10.14, each electrical termination cable should subject to a tensile test no more than the weight of the module or a required bending test. Other type of terminations should be tested per 10.14.

The module shall meet the requirements of 5.11 a) and b).

5.18 Mechanical load test

In accordance with GB/T 9535-1998, 10.16, subject the module to 2,400Pa mechanical load test on both superstrates and substrate, 1 hour each side, total of 3 cycles.

The module shall meet the requirements of 5.11 a) ~ c).

5.19 Hail test

In accordance with GB/T 9535-1998, 10.17, subject the module to a hail impact test.

The module shall meet the requirements of 5.11 a) ~ c).

5.20 Wet Leakage Current Test

Immerse the module in a tank with the required solution (IEC 61215:2005, section 10.15), apply a DC voltage between shorted leads and the solution for 2 min, measure the leakage current and calculate the resistance. The measured insulation resistance times the area of the module shall not be less than 40 MΩ·m².

This is a newly added test on IEC 61215:2005, all module manufacturers are encouraged to meet this new requirement as soon as possible.

5.21 Bypass Diode Thermal Test

With the module set to a temperature of 75±5°C, apply a reverse current equal to I_{sc} to each bypass diode under test for 1 hour. The measured diode case temperature shall not exceed the diode manufacturer's maximum junction temperature rating. Then increase the current to 1.25*I_{sc} for 1 hour. The diode shall still function as a diode after the conclusion of the test.

The module shall meet the requirements of 5.11 a) ~ c).

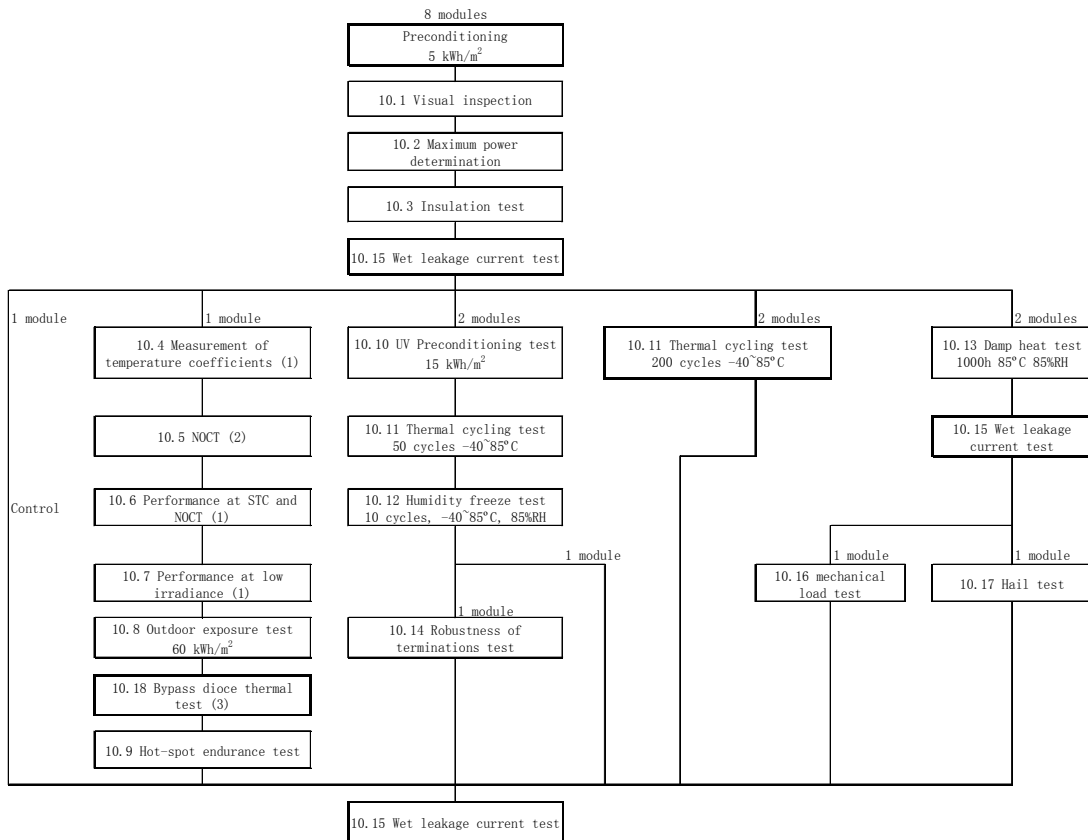
This is a newly added test on IEC 61215:2005, all module manufacturers are encouraged to meet this new requirement as soon as possible.

5.22 Testing and Certification

PV modules used for solar home systems should meet the requirement of GB/T 9535-1998 or IEC 61215:1993 standards. Test laboratory and certification organization shall have ISO/IEC 17025 accreditation.

Figure 4 shows the qualification test sequence of GB/T 9535-1998. The newly added tests or changed tests on IEC 61215:2005 have been marked as thicker boxes, and the deleted twist test has been removed from the figure. In accordance with Figure 4, randomly select eight modules from a production batch or batches, assign these eight test samples to five sequences, then conduct all the test. If two or more modules do not meet these test criteria, the design shall be deemed not to have met the qualification requirements. Should one module fail any test, another two modules shall be subjected to the whole of the relevant test sequence from the beginning. If one or both of these modules also fail, the design shall be deemed not to have met the qualification requirements. If, however, both modules pass the test sequence, the design shall be judged to have met the qualification requirements.

Above test program is for design qualification, if the condition meets GB/T 14007-1992, 6.3.1, this program should be performed. The acceptance test can be performed according to GB/T 14007-1992, 6.2.



注:

- 1 May be omitted if IEC 61853 has been performed.
- 2 In the case of modules not designed for open-rack mounting, the NOCT may be replaced by the equilibrium mean solar cell junction temperature in the standard.
- 3 If the bypass diodes are not accessible in the module type under test, a special sample can be prepared for this test.

Figure 4 Qualification Test Sequence

6 Battery and Battery Container

6.1 General requirement

6.1.1 Battery

A battery bank can be made of one or more batteries through serial/parallel connection. The number of batteries in parallel should not be more than four.

Battery types which are suitable for solar home systems include deep-cycle lead acid battery, sealed lead acid battery, vented lead acid battery, nickel cadmium alkaline battery, etc. Deep-cycle lead acid battery is preferred.

The minimum capacity of the battery should be designed according to local autonomy days, eg. the continuous overcast or rainy days. Depth of Discharge (DOD) should be designed as 80% for deep cycle batteries, and 50% for shallow cycle batteries.

Copper or copper coated lead strips should be used as intercell connectors. Battery shall provide bolt terminal posts for easy connection. Corrosion-inhibiting compound should be applied to all battery terminals to reduce the corrosion. The positive and negative terminals shall be clearly marked. The polarity marking shall survive at least as long as the life of the battery.

Batteries may be shipped with or without electrolyte. If it is shipped without electrolyte, filled electrolyte and other chemical additives shall meet the manufacturer's technical requirements.

If a sealed battery is used at the elevation above 2500m, the manufacturer's approval shall be obtained.

6.1.2 Battery container

Decide if a battery container is required according to the type and location of its application. The container should have adequate ventilation, and should be designed that terminal posts and electrolyte are not accessible by users. Container materials shall be durable. Use acid-resistant materials or coatings in the area where contact with acid solution is possible. Container should be strong enough to support the weight of the battery.

6.2 Maximum self-discharge rate

At 25°C, the maximum allowable self-discharge rate for all type of batteries should be less than 3% of capacity at 10h discharge rate in every 28 days.

6.3 Cycle life

At 25°C, the cycle life shall be above 600 cycles (shallow cycle batteries with average DOD of 50%, and deep-cycle batteries with average DOD of 80%).

6.4 Battery test standards

Batteries used in solar home systems shall meet the following test standards:

- a) For lead-acid starter battery: GB 5008.1-1991;
- b) For stationary acid spray-proof lead-acid batteries: GB/T 13337.1-1991;
- c) For vented nickel-cadmium prismatic rechargeable battery: GB/T 15142-2002;
- d) For valve regulated lead-acid battery: YD/T 799-2002.

Batteries should be tested and certified by an organization which is accredited to do so per ISO/ IEC 17025.

7 Charge/discharge controller

7.1 General requirement


A charge/discharge controller could be a stand alone device or be combined with an inverter.

Before controller's shipment, manufacturers should preset all set points based on targeted battery characteristics and the environmental condition of the destination. Batteries at different state of charges (SOC) could have different charging rates and patterns.

Controllers used for solar home systems with PV array maximum power great than 10W or with wind turbines should have battery high voltage disconnect (HVD) and low voltage disconnect (LVD) protection functions.

7.2 Visual inspection

Charge controllers should meet following visual inspection requirement:

- a) No damage or be wetted on all major components and parts;
- b) No missing or lost components or parts;
- c) Coatings or paint on device enclosure should be firm and even, no peeling, rust or cracks;
- d) All marks, symbols and words on front panel meet the requirement, and function indicators are correct and clear;
- e) All switches operations are easy, smooth and reliable;
- f) Label contents meet the  nical requirements;
- g) Polarities of connections to PV arrays, modules, batteries and loads are clearly marked.

7.3 Environmental conditions and tests

7.3.1 Normal operation conditions

Ambient temperature: $-5^{\circ}\text{C} \sim +55^{\circ}\text{C}$;

Relative humidity: $\leq 93\%$, no condensation;

Elevation: $\leq 1,000\text{m}$; if $> 1,000\text{m}$, reduce the capacity according to GB/T 3859.2-1993.

7.3.2 Storage and transportation condition

Temperature: $-20^{\circ}\text{C} \sim +70^{\circ}\text{C}$;

Vibration: Frequency 10 to 55Hz, amplitude 0.7mm, duration on each axis 2hrs. After the test, the controller should be able to operate normally.

7.3.3 Low temperature storage test

In accordance with GB/T 2423.1-2001, Test A, device without shipping packaging, no power input and no battery. Test at temperature of $-25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 16hrs, recover at standard ambient condition for 2hrs, the controller should be able to operate normally.

7.3.4 Low temperature operation test

In accordance with GB/T 2423.1-2001, Test A, device without shipping packaging. Test at temperature of $-5^{\circ}\text{C} \pm 2^{\circ}\text{C}$, connect rated input and load for 2hrs, recover at standard ambient condition for 2hrs, the controller should be able to operate normally.

7.3.5 High temperature storage test

In accordance with GB/T 2423.2-2001, Test B, device without shipping packaging, no power input and no battery. Test at temperature of $+70^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 2hrs, recover at standard ambient condition for 2hrs, the controller should be able to operate normally.

7.3.6 High temperature operation test

In accordance with GB/T 2423.2-2001, Test B, device without shipping packaging. Test at temperature of $+55^{\circ}\text{C} \pm 2^{\circ}\text{C}$, connect rated input and load for 2hrs, recover at standard ambient condition for 2hrs, the controller should be able to operate normally.

7.3.7 Damp heat test

In accordance with GB/T 2423.9-2001, Test C_b, device without shipping packaging, no power input and no battery. Test at temperature of $+40^{\circ}\text{C} \pm 2^{\circ}\text{C}$, relative humidity $85\% \pm 5\%$ for 48hrs, recover at standard ambient condition for 2hrs, the controller should be able to operate normally.

7.4 HVD and reconnect function

It is not recommended to use short-circuiting PV module or array to control HVD, because the short-circuit condition is harmful for modules (such as hot-spot effect). The voltage values given below are for reference only. If the battery manufacturer has specified requirements, the controller shall set up accordingly. The voltage value should consider the discharge rate also.

7.4.1 On/off type controller

Figure 5 is a test circuit for on/off type controller's HVD and reconnect functions. Connect DC power to battery input terminals to simulate the battery. Adjust the DC voltage to HVD point, the charge control switch should turn off; lower the DC voltage to reconnect point, the charge switch should turn on again.

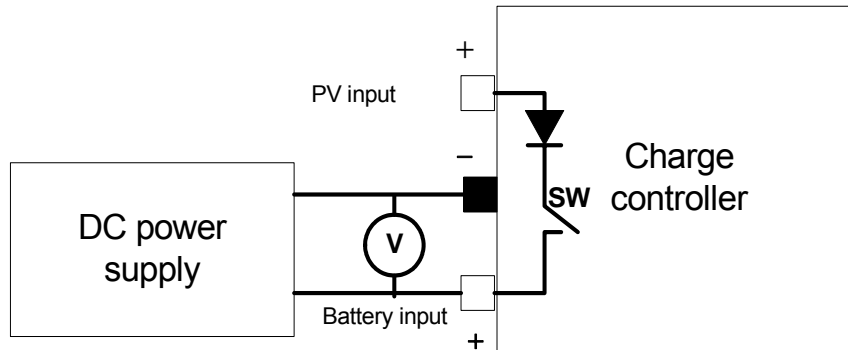


Figure 5 On/off controller HVD and reconnection test

For on/off controller and nominal battery voltage of 12V, the following values are provided for reference:

- a) Starter lead-acid batteries: HVD at 15.0V- 15.2V, reconnect at 13.6V-13.9V;
- b) Stationary lead-acid batteries: HVD at 14.8V-15.0V, reconnect at 13.4V-13.7V.
- c) Valve regulated lead-acid batteries: HVD at 14.1V-14.5V, reconnect at 13.1V-13.4V.

7.4.2 PWM controller

Figure 6 is a test circuit for PWM type controller’s HVD and reconnect functions. A DC power supply is connected to the PV array input terminals, and a battery is connected as in normal installations. Adjust the DC voltage to charge the battery. When the battery voltage is close to the HVD, the charging current should be decreased; when the battery voltage reaches HVD, the current should be close to zero. If the battery voltage decreases, the current should increase accordingly.

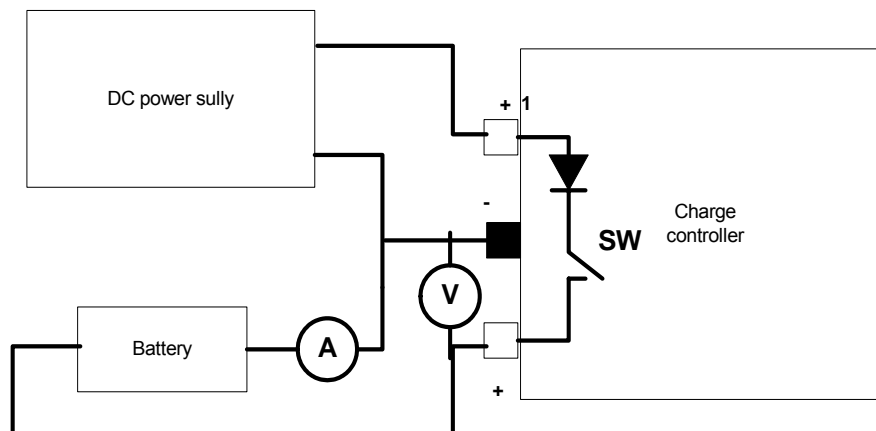


Figure 6 PWM controller HVD and reconnection test

The main difference between PWM and on/off controllers is there is no specific reconnect point. For PWM controller and nominal battery voltage of 12V, reference HVD points are:

- a) Starter lead-acid batteries: HVD at 15.0 V- 15.2V;
- b) Stationary lead-acid batteries: HVD at 14.8V - 15.0V;
- c) Valve regulated lead-acid batteries: HVD at 14.1V-14.5V.

7.5 LVD and Reconnect

Following LVD and reconnect voltage set points are for reference only. If there is a requirement from the battery manufacturer, the set points should be chosen accordingly. They should also consider the influence of discharge rate. A controller could have different levels of outputs, when main load is disconnected by LVD, some critical load (or very small load) could still be powered for a period of time.

Figure 7 is a test circuit for LVD and reconnect functions. Connect a DC power supply to battery input terminals to simulate the battery. An adjustable resistor is connected to the load terminals to simulate the load. Set the load current to its rated value, then lower the DC voltage. When the voltage reaches LVD, the controller should disconnect the load. When the voltage is higher than the reconnect point, the load should be connected again. If there is a LVD latching function, the reconnection needs a manual reset.

For a nominal 12V battery, reference LVD points are:

- a) LVD: 10.8V-11.4V;
- b) Automatic or manual reconnect: 13.2V-13.5V.

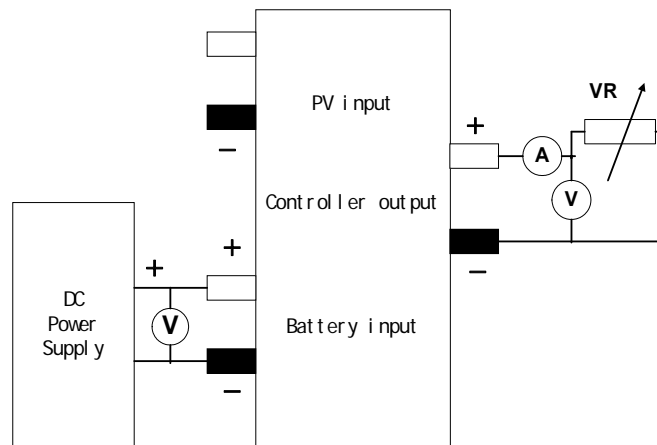


Figure 7 LVD and reconnect test

7.6 Self consumption

Figure 8 is a test circuit for LVD and reconnect functions. Disconnect the PV input and load, then connect a DC power supply to the battery input terminals. The maximum self consumption current by the controller should be less than 1% of the rated charging current or 0.4W, whichever is larger.

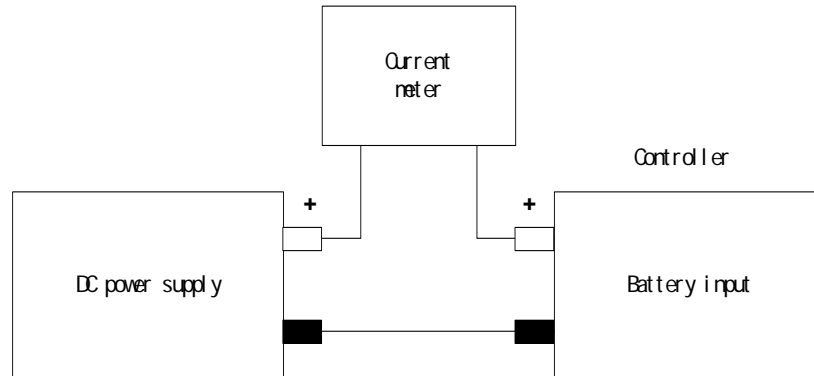


Figure 8 Self consumption test

7.7 Temperature compensation

For a location that has a large range of ambient temperature changes, the controller should include temperature compensation function.

Place the controller's temperature sensor in a temperature chamber. Obtain a temperature versus HVD voltage curve. The temperature coefficient should meet technical requirements of the battery.

7.8 Voltage drop on charge and discharge circuits

Connect a DC power supply to PV input (output) terminals, and adjust it to the rated charging current, then measure the voltage drop of controller's charge (discharge) circuit.

The voltage drop on charge and discharge circuits should not be higher than 5% of the rated system voltage.

7.9 Protection functions

Charge controller should have following protection functions.

7.9.1 Load short circuit protection

Inspect to determine if there are load short circuit protection components in the controller.

7.9.2 Internal short circuit protection

Inspect to determine if there are internal short circuit protection components in the controller.

7.9.3 Reverse discharge protection

Controller should have a function to prevent the reverse discharge from battery to PV array.

Figure 9 is a test circuit to test for a reverse discharge protection function. Connect a DC power supply to the battery input terminals and an ammeter to the PV input terminals. Adjust the DC voltage and observe if there is any current passing through the PV input terminals. If there is no current, the reverse discharge protection works.

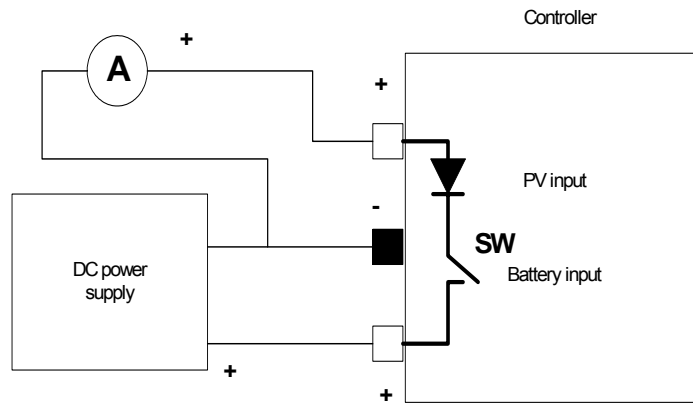


Figure 9 Battery reverse discharge protection test

7.9.4 Reverse polarity protection

Connect a DC power supply to the controller's battery input terminals in reverse polarity, and check if there is any damage on controller or power supply.

7.9.5 Lightning protection

Visually check the lightning protection components, verify that their type and ratings can absorb the shocking energy.

7.9.6 Over voltage endurance

Connect a DC power supply to the controller's PV input terminals. Apply 1.25 times V_{oc} for 1hr. Examine to be certain there is no damage to the controller.

7.9.7 Over current endurance

Connect a DC power supply to the controller's PV input terminals, and a variable resistor to battery input terminals. Adjust the resistor so that the charging current reaches 1.25 times I_{sc} , maintaining it for 1hr. Examine to be certain there is no damage to the controller.

7.10 Battery state of charge indicator

The system should provide an indicator to show the battery state of charges:

- a) Fully charged indicator: battery is fully charged, the charge current from PV array is reduced or disconnected;
- b) Low voltage indicator: battery voltage is low and should start to reduce power consumption;
- c) Load disconnect indicator: battery voltage is below LVD and load has been disconnected.

The indicators can be LEDs, analog needle meters, digital meters or audible alarms. These indicators should be clear and self-explaining, so the user can understand the battery state of charge without reference to the user manual.

7.11 Testing rule

7.11.1 Acceptance test

Acceptance tests should check each device.

The test should be conducted according to Table 2. If there is a failure, the reason should be investigated, and the problem should be corrected, then re-conduct the acceptance test. If there is still malfunction, the device should be deemed to have failed.

7.11.2 Routine test

If the device is produced in batches, routine tests should be conducted for each batch if it is produced continuously, the test should be conducted at least once a year. When there is a major change in design, process, component, or materials, the routine test should be performed.

Controllers should be tested and certified by an organization which is accredited to do so per ISO/ IEC 17025.

Samples for routine tests should be randomly selected from the products that have passed acceptance tests, in accordance with GB/T 2829, and Table 1 and Table 2.

Table 1. RQL and the criteria

Class	Class B	Class C
RQL	40 (2; 0, 1)	120 (2; 2, 3)

Table 2 Controller testing items

Test Item	Failure Class		Test method
	B	C	Requirement
Visual inspection		○	7.2
Marking inspection		○	
Documentations		○	
Setting points	○		7.1
On/off controller's HVD and reconnection	○		7.4.1
PMW controller's HVD	○		7.4.2
Temperature compensation	○		7.7
LVD and reconnection	○		7.5
Self consumption	○		7.6
Voltage drop on charge/discharge circuits	○		7.8
Vibration	○		7.3.2
Load short circuit protection	○		7.9.1
Internal short circuit protection	○		7.9.2
Reverse discharge protections	○		7.9.3
Reverse polarity protection	○		7.9.4
Lightening protection	○		7.9.5
High voltage endurance	○		7.9.6

High current endurance	○		7.9.7
Low temperature operation	○		7.3.4
High temperature operation	○		7.3.6
Damp heat test	○		7.3.7

8 DC luminaire

DC luminaries could be DC powered self-ballasted fluorescent lamp, or DC powered semi-luminaire.

8.1 Visual inspection

DC luminaire should meet following visual inspection requirement:

- a) No damage or be wetted on all major components and parts;
- b) No missing or lost components and parts;
- c) Lampshade should be removable for cleaning or for changing bulbs;
- d) When changing the light bulb, live parts should not be accessible;
- e) All marks, symbols and words on front panel meet the requirements, and function indicators are correct and clear;
- f) Label contents meet the technical requirements;
- g) Power source connections and their polarities should be clearly marked.

8.2 Marking



Mark clearness test: gently wipe the mark with a water damped cloth for 15s. After the mark dries, gently wipe the mark with an alcohol damped cloth for another 15s, after which the mark should still be clear.

8.2.1 Required label contents on products

Labels on DC lamps should be clear and indelible. If necessary, a covering film can be added to protect the label.

- a) Product source: Manufacturer's or distributor's name or trademark, in Chinese or English, or logos;
- b) Product name: in Chinese or English, such as, DC powered self-ballasted fluorescent lamp, or DC powered semi-luminaire;
- c) Product model number: include power supply type, rated voltage, rated power, in Chinese, English, alphabetic letters, or numbers, such as:DC12V10W;
- d) Product major electrical parameters: include power supply type, rated voltage, rated power, in Chinese, English, alphabetic letters, or numbers, and can also be expressed by model number;
- e) Production or shipping date, serial or lot number: in Chinese, English, alphabetic letters, numbers, or other symbols;
- f) Caution sign: Power source connections and their polarities, in Chinese, English, alphabetic letters, numbers, or other symbols.

8.2.2 Required label contents in users manual or on package

- a) Detailed instructions for proper installation, use and maintenance: installation method, position and location of hand on the lamp when exchange the bulb;



- b) Warning, such as “High voltage on terminals, risk of electrical shock, when change the bulb”;
- c) Type of the lamp and lamp holder, such as self-ballasted fluorescent lamp (non-separable), plug in fluorescent lamp; installation types, such as fixed, portable, snap in; electrical shock prevention types, 0, I, or II; sealed types with IPxx;
- d) For semi-luminaire, self consumption power and maximum power under malfunction conditions;;
- e) If there is a restriction for lamp’s operation, such as the caps on top, bottom or horizontal, it shall be marked;
- f) Marks for other restrictions, such as for outdoor use, its dust-proof or water-proof classes.
- g) Applicable standard: GB/T19064-2003.

8.3 Lamp holder’s interchangeability

Lamp caps, holders and bulbs should have good contacts and be interchangeable. They should meet the requirements for E27 lamps in IEC 60061 section 1. Inspection on dimensions should be performed according to IEC 60061, section 3.

8.4 Starting characteristic

Starting tests should be performed on fresh samples. Use the rated minimum starting temperature, or at $-25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, if there is no minimum starting temperature specified. Samples should be placed in a draught-free atmosphere at the specified temperature with excessive draughts for 24 hours before testing.

At the above temperature, when apply 90% of rated voltage, the lamp should start in 10s and keep working.

8.5 Initial light and electrical performance

Measurement of initial light and electrical performance should be performed according to GB/T 17262-2002 and GB/T 17263-2002.

8.5.1 Rated power

Under rated voltage, the difference between initial power and rated power should be less than $5\% + 0.5\text{W}$.

8.5.2 Initial lumens and lumen efficiency

Under rated voltage, initial lumens of a lamp should be no less than 200 lm, and the efficiency should be no less than 40 lm/W.

In 90% to 120% of rated voltage, initial lumens and its efficiency should not be less than 90% of that value at rated voltage.

8.5.3 Initial Photometric characteristics

Initial photometric characteristics should be measured in a draught-free atmosphere at $+25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, by a spectroradiometer. It should meet:

- a) The reading of the chromaticity coordinates x and y of a lamp shall meet the requirement, and in any case, the difference between the reading and the rated value shall be not great than 5 SDCM (Standard Deviation of Color Matching);
- b) The initial reading of the general color rendering index shall be not less 80;
- c) The temperature of color shall be not great than 4500K.

8.6 Stability of light output

After 2000h operation, lumens and lumen efficiency should not be less than 80% of their initial values.

8.7 Average life span

Life span test should be performed at atmosphere with draught-free, $+15^{\circ}\text{C} \sim +50^{\circ}\text{C}$, no sharp vibration or collision. Lamp is in vertical position with the cap on top.

Turn the lamp on for 165min, and off for 20min. During the 165min on time, test with 90%, 100% and 120% of rated voltages, each for 55min.

Without counting the off time, the average life span of lamps (50% of total lamps failed) should be no less than 3000h.

8.8 Reliability (switch) test

Reliability test should be performed at $+25^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Lamp is in vertical position with the cap on top. Double-capped fluorescent lamp is in horizontal position.

Lamps should be applied with 90% to 120% of rated voltage, and turned on for 6s, off for 294s. In the total of 500h (include on time and off time), or 6000 cycles, the lamp should still be operational.

8.9 Operation frequency

Measure the DC luminaire's operation frequency when the lamp is on with the voltage changes between 90% to 120% of rated voltage. The minimum frequency should be 20kHz.

This test is only applicable for semi-luminaires. If the frequency of electronic ballast is 40kHz or higher, this test can be omitted.

8.10 Current waveform

The ballast shall be operated at its rated voltage. After lamp stabilization, the waveform of the lamp operating current shall comply with the following conditions (only applicable for semi-luminaire).

- a) Successive half-cycles shall present similar forms and their peak values shall be equal to within 4%.
- b) The maximum ratio of peak current value to rms value shall not exceed 1.7.

8.11 Power consumption

Under the following conditions, lamps, lamp holders and power sources should not be damaged, and power consumption should not be higher than 20% of rated power. For small lamps with rated power less than 7W, it should not be higher than 1.6W:

- a) Luminaire is operating under normal condition, and the lamp then removed from the holder;
- b) Lamps open circuited or failed;
- c) Reverse polarity from DC source to the lamp holder for 1h.

8.12 Mechanical strength

During mechanical strength (torque) test, the torque should be gradually applied, from 0 to required value (3N-m for E27 lamp holders).

After the mechanical strength test, the luminaire should not be damaged, and its safety is not reduced. If adhesives are used between bulb and the cap, the connection should keep firm. If there is no adhesive, allowed turning should be less than 10°.

8.13 Wet resistance

Before the wet resistance test, samples should be placed in an environmental chamber for 48h. Chamber temperature should be a chosen value in the range of (20°C to 30°C) ±1°C and relative humidity 91% to 95%. Apply 500V DC on following locations for 1min, and measure the wet resistance:

- a) between exposed metal parts and electrical terminals, $\geq 2M\Omega$;
- b) between live parts and outer parts of the luminaire, $\geq 4M\Omega$;
- c) between live parts of different polarity, $\geq 2M\Omega$

8.14 Fire and ignition test

The following fire and ignition tests should be performed on DC luminaires:

- a) Flammability test on insulation materials used for holding live parts. Apply testing flame on the location where the highest temperature is anticipated during normal operation for 10s;
- b) Hot wire test on insulation materials served as enclosure of, but not for holding, live parts. Apply 650°C hot wire on the location where the highest temperature is anticipated during normal operation for 10s;

Any flame or burning on samples shall be extinguished in 30s after the testing flame or hot wire is removed, and any residue material dropping as a result of these tests shall not ignite a single layer of paper horizontally placed 200mm ± 5mm under the sample.

8.15 Protection under abnormal conditions

DC luminaire may experience some abnormal conditions during operation. The safety feature, however, shall not be decreased under these conditions.

- a) One electrode of lamp damaged, so the lamp can not start;
- b) Lamp can not start but both electrodes are intact;
- c) Lamp is working, but one electrode was damaged;

Lamp/ballast should have reverse polarity protection, it will be checked by reversely connect the luminaire to a power supply for 1h.

When doing the test, do not short-circuiting or open-circuiting the parts or devices, if they are not designed for these conditions. During the test, the luminaire shall not cause fire, release flammable gases, or live parts become accessible.

8.16 High temperature test

A steel ball pressure test shall be conducted to evaluate the insulation materials used on DC luminaires.

Put the sample in a temperature chamber, with a minimum temperature of 125°C when parts retaining current carrying parts, and 75°C for other parts. The surface of the part to be tested shall be placed in the horizontal position and a steel ball of 5 mm diameter pressed against this surface with a force of 20N. After 1h the ball shall be removed from the sample, and the sample shall be cooled by immersion in cold water for 10s. The diameter of the impression shall be measured and shall not exceed 2mm.

8.17 Structure test for semi-luminaire

DC semi-luminaire should meet the requirement of GB/T 7000.1-1996. Except specified otherwise, following requirements are checked through visual inspection.

- a) Per GB/T 7000.1-1996, section 4.2, luminaires incorporating components or parts intended to be replaceable shall be so designed that there is sufficient space to permit replacement of such components or parts without difficulty and without impairing safety.

NOTE: Sealed-in components and riveted parts are not replaceable components.

- b) Per GB/T 7000.1-1996, section 4.3, wireways shall be smooth and free from sharp edges, burrs, flashes and the like, which might cause abrasion of the insulation of the wiring. Parts such as metal set screws shall not protrude into wireways. Compliance is checked by inspection and, if necessary, by dismantling and reassembling the luminaire.

- c) Double and reinforced insulation

- Per GB/T 7000.1-1996, section 4.10.1, for metal encased class II luminaires, contact between following shall be effectively prevented:

- mounting surfaces and parts with basic insulation only,
- accessible metal parts and basic insulation.

NOTE This requirement does not exclude the use of bare conductors if adequate protection is provided.

- Per GB/T 7000.1-1996, section 4.10.2, openings in double or in reinforced insulation shall not give straight access to live parts,
- Per GB/T 7000.1-1996, section 4.10.3, for parts of class II luminaires which serve as supplementary insulation or reinforced insulation:
 - either they shall be fixed so that they cannot be removed without being seriously damaged;
 - or they shall be unable to be replaced in an incorrect position.

- d) Electrical connections and current-carrying parts

- Per GB/T 7000.1-1996, section 4.11.1, electrical connections shall be so designed that contact pressure is not transmitted through insulating material other than ceramic, pure mica or other material with characteristics at least equivalent, unless there is sufficient resilience in the metallic parts to compensate for any possible shrinkage of the insulating material.
- Per GB/T 7000.1-1996, section 4.11.2, self-tapping screws shall not be used for the connection of current-carrying parts, unless they clamp these parts directly in contact with each other, and are provided with a suitable means of locking.
- Per GB/T 7000.1-1996, section 4.11.3, screws and rivets which serve as electrical as well as mechanical connections shall be locked against loosening. Spring washers may provide satisfactory locking.
- Per GB/T 7000.1-1996, section 4.11.4, current-carrying parts shall be of copper, an alloy containing at least 50 % copper, or a material having at least equivalent characteristics. If necessary, by chemical analysis.

- e) Mechanical strength

- Per GB/T 7000.1-1996, section 4.13.1, luminaires shall have adequate mechanical strength and be so constructed as to be safe after such rough

handling as may be expected in normal use. Compliance is checked by applying blows to the sample by means of the spring-operated impact test.

- Per GB/T 7000.1-1996, section 4.13.2, metal parts enclosing live parts shall have adequate mechanical strength. A straight unjointed test finger is used, and the finger is pressed against the surface with a force of 30 N.

8.18 Testing and certification

DC luminaires should be tested and certified by an organization which is accredited to do so per ISO/ IEC 17025.

Samples for routine tests should be randomly selected from the products that have passed acceptance tests, in accordance with GB/T 2829, and Table 3.

Table 3 Luminaire testing items

No	Testing	Method and requirement	Number of Samples	Criteria
1	Marking	8.2	8	1,2
2	interchangeability	8.3		
3	Mechanical strength	8.12	8	1,2
3	Wet resistance	8.13	3	0,1
4	Protections	8.15	5	0,1
5	High temperature test	8.16	1	0,1
6	Fire and ignition test	8.14		
7	Structure test for semi-luminaire	8.17	1	0,1
8	Starting characteristic	8.4	10	1,2
9	Rated power	8.5.1		
	Initial lumens and lumen efficiency	8.5.2		
10	Initial photometric characteristics	8.5.3		
11	Stability of light output	8.6		
12	Average life span	8.7	10	5*
13	Reliability (switch) test	8.8	5	0,1
14	Operation frequency	8.9	3	0,1
15	Current waveform	8.10		
16	Open circuit power consumption	8.11		

9 DC/AC inverter

DC/AC inverter is a device converting DC power to AC power. Inverters used for solar home systems shall meet anticipated system AC loads. Inverters could be integrated with charge controller.

9.1 Environmental condition

9.1.1 Normal operation condition

Ambient temperature: -5 to 40°C;

Relative humidity: $\leq 93\%$, no condensation;

Elevation: $\leq 1000\text{m}$, if $>1000\text{m}$, reduce the capacity according to GB/T 7260.

9.1.2 Storage and transportation condition

Temperature: -20 to 70°C ;

Vibration: Frequency 10 to 55Hz, amplitude 0.7mm, duration on each axis 2hrs. After the test, the inverter should be able to operate normally.

9.2 Visual and structural requirement

Following items should be checked by visual inspection:

- a) Label contents meet the technical requirements;
- b) Polarities of connections to PV arrays, modules, batteries and loads are clearly marked;
- c) No damage or be wetted on all major components and parts;
- d) No missing or lost components and parts;
- e) Coatings or paint on device enclosure should be firm and even, not peel off, no rust and no cracks;
- f) All marks, symbols and words on front panel meet requirements, and function indicators are correct and clear.

9.3 Output voltage range

Figure 10 is a test circuit for output voltage range test. Set the output power at the rated value, change input voltage in the range of 90% to 120% of its rated value, and measure the output voltage. The output voltage range should be within 10% of its rated value.

As for controller and inverter integration system, on the grounds that the controller passed the test, Set the output power at the rated value, change input voltage in the range of the point HVD to LVD of the controller, and measure the output voltage. The output voltage range should be within 10% of its rated value.

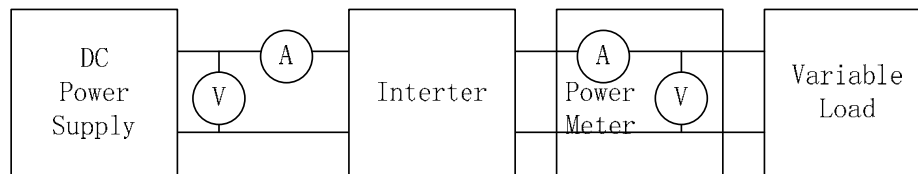


Figure 10 Output voltage range test

9.4 Output frequency

Measure the output frequency at rated output power and in the range of 90% to 120% of rated input voltage. The frequency shall be $50\text{Hz} \pm 1\text{Hz}$.

9.5 Harmonic distortion

Measure output voltage harmonic distortion at rated input voltage and output power. The total distortion for sine wave inverter shall be $\leq 5\%$.

9.6 Efficiency

Measure the efficiency at rated input voltage. When output power is $\geq 75\%$ of rated output power, efficiency shall be $\geq 80\%$.


9.7 Acoustic noise

Measure acoustic noise at rated input voltage, with the psophometer located at 1/2 height of the equipment and in the front of 3m. Under both 50% and full rated output power, the noise shall be $\leq 65\%$.

9.8 Output power characteristics

At rated input voltage and output power, and 25°C ambient temperature, inverter shall operate continuously and reliably for at least 4h.

At rated input voltage and 125% rated output power, inverter shall operate safely for at least 1min.

At rated input voltage and 150% rated output power, inverter shall rate safely for at least 10s.

The inverter shall be able to survive capacitive and inductive load shocks.

9.9 Self consumption current

Measure input DC current when there is no load connected. The self consumption load shall be $< 3\%$ of rated input current, or $< 1W$, whichever is larger.

9.10 Protection functions

9.10.1 Low voltage protection

When input voltage is lower than LVD as in section 7.5, inverter shall be able to turn itself off for protection.

9.10.2 Overcurrent protection

When working current is 150% of the rated current, inverter shall be able to turn itself off for protection. When the current is back to normal, inverter shall be able to operate normally again.

9.10.3 Short-circuit protection

When output circuit is shorted, inverter shall be able to turn itself off for protection. When the short-circuit condition is corrected, the inverter shall be able to operate normally again. Test for this protection function could be performed with a variable resistive load, and by adjusting the resistor to 0 ohms.

9.10.4 DC input miswiring protection

When DC input to inverter is miswired, or the DC source's positive output is connected to inverter's negative input terminal, and DC source's negative output is connected to inverter's positive input terminal, the inverter shall be able to turn itself off for protection. When wiring polarity is corrected, the inverter shall be able to operate normally again.

9.10.5 Lightning protection

Inverter shall have lightning protection function. Visually inspect if lightning protection components are installed, or use a lightning tester to do voltage and current shock test, to check if the components meet their technical specifications.

9.11 Safety requirement

9.11.1 Insulation resistance

Both electrical insulation resistances from DC input to inverter enclosure and from AC output to inverter enclosure shall be $\geq 50M\Omega$.

9.11.2 Hi-pot requirement

Apply 500V and 50Hz AC between inverter DC input and enclosure for 1min. No arc or breakdown shall occur.

Apply 1500V and 50Hz AC between inverter AC output and enclosure for 1min. No arc or breakdown shall occur.

9.11.3 Accessibility of output terminals

Safety receptacles shall be used for high voltage output terminals, so that users can not touch live parts unintentionally.

9.12 Low temperature storage test

In accordance with GB/T 2423.1-2001, Test A, device without shipping packaging, no power input and no battery. Test at temperature of $-25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 16hrs, recover at standard ambient condition for 2hrs, the inverter should be able to operate normally.

9.13 Low temperature operation test

In accordance with GB/T 2423.1-2001, Test A, device without shipping packaging. Test at temperature of $-5^{\circ}\text{C} \pm 2^{\circ}\text{C}$, connect rated input and load for 2hrs, recover at standard ambient condition for 2hrs, the controller should be able to operate normally.

9.14 High temperature storage test

In accordance with GB/T 2423.2-2001, Test B, device without shipping packaging, no power input and no battery. Test at temperature of $+70 \pm 2^{\circ}\text{C}$ for 2hrs, recover at standard ambient condition for 2hrs, the controller should be able to operate normally.

9.15 High temperature operation test

In accordance with GB/T 2423.2-2001, Test B, device without shipping packaging. Test at temperature of $+40^{\circ}\text{C} \pm 2^{\circ}\text{C}$, connect rated input and load for 2hrs, recover at standard ambient condition for 2hrs, the controller should be able to operate normally.

9.16 Damp heat test

In accordance with GB/T 2423.9-2001, Test C_b, device without shipping packaging, no power input and no battery. Test at temperature of $+40^{\circ}\text{C} \pm 2^{\circ}\text{C}$, relative humidity $85\% \pm 5\%$ for 48hrs, recover at standard ambient condition for 2hrs, the controller should be able to operate normally.

9.17 Testing rule

9.17.1 Acceptance test

Acceptance tests should check each device.

The test should be conducted according to Table 5. If there is a failure, the reason should be investigated, and the problem should be corrected, then re-conduct the acceptance test. If it is still malfunction, the device should be deemed as fail.

9.17.2 Routine test

If the device is produced in batches, the test should be conducted for each batch; if it is produced continuously, the test should be conducted at least once a year. When there is a major change in design, process, component, or materials, the routine test should be performed.



Inverters should be tested and certified by an organization which is accredited to do so per ISO/ IEC 17025.

Samples for routine tests should be randomly selected from the products that have passed the acceptance test. In accordance with GB/T 2829, at least two samples should be tested. Based on Table 4, the class B testing should sample 2 items from at least 40 products, and if both samples pass, the batch is pass, otherwise, if there is one fail, the batch should deemed to be failed. The class C testing should sample 2 items from at least 120 products.

Table 4. RQL and the criteria

Class	Class B	Class C
RQL	40 (2; 0, 1)	120 (2; 2, 3)

Table 5. Inverter testing items

Test Item	Test method Requirement	Failure Class	
		B	C
Visual	9.2		o
Marking			o
Documentation			o
Output voltage range	9.3	o	
Output frequency	9.4	o	
Harmonic distortion	9.5	o	
Efficiency	9.6	o	
Acoustic noise	9.7	o	
Output power characteristics	9.8	o	
Self consumption current	9.9	o	
Low voltage protection	9.10.1	o	
Overcurrent protection	9.10.2	o	
Short-circuit protection	9.10.3	o	
DC input miswiring protection	9.10.4	o	
Lightning protection	9.10.5	o	
Insulation resistance	9.11.1	o	
Hi-pot requirement	9.11.2	o	
Accessibility of output terminals	9.11.3	o	
Low temperature operation	9.13	o	
High temperature operation	9.15	o	
Damp heat	9.16	o	
Vibration	9.1.2	o	

10 Wind turbine

10.1 Wind turbine

Wind turbines shall be supplied with a tower, and the tower shall be designed to survive 120km/h wind speed. Materials used for the tower shall be anti-rust, such as galvanized steel, stainless steel, or steel with proper coatings. The foundation of the tower shall be strong enough to support the total weight of the wind turbine system and the designed maximum wind load.

Installation of wind turbines should meet the requirements in JB/T 9740.4-1999 Installation guide for low speed wind energy conversion system.

Wind turbine systems shall include a charge controller which can control the charge, discharge and provide protection. Controllers shall meet the requirements in 10.2.

Following factors should be considered for wind turbine installation:

- a) Installation locations should be carefully chosen, taking into account the number of people or animals that may be in; proximity of the sites. The blades should be at least 3m above ground;
- b) No significant obstacles which may cause strong turbulence and vibration of the turbine shall exist around the wind turbine;
- c) Reduce the distance from the turbine to load to minimize electric transfer loss;
- d) Wind turbine and tower shall have reliable grounding to prevent lightning damage;
- e) Acoustic noise should be less than 65dB when measured from 30m distance.

Only wind turbines designed for off-grid should be used on solar home systems.

Wind turbines should meet technical requirements on GB/T 13981-1992, GB/T 10760.1-1989 and GB/T16437-1996.

10.2 Controller for wind turbine

Input power of the controller shall have a capacity to handle two times the wind turbine's rated output power.

Controller use on wind turbine which requires a dump load for dissipating excessive energy shall be able to switch the load from battery to the dump load when battery is fully charged. The dump load power rating shall be at least twice the wind turbine's rated output power.

Controller shall have a current limiting function to prevent damages from sudden current or voltage surge caused by wind gusts.

Before controller's shipment, manufacturers should preset all set points (HVD and reconnect, LVD and reconnect) based on targeted battery characteristics and the environmental condition of the destination. Batteries at different state of charges (SOC) and ambient temperature could have different charging rates and patterns.

Charge controller should have following protection functions:

- a) Prevent batteries from over charging or over discharging;
- b) Prevent load short circuit condition;
- c) Prevent load reverse polarity connection;
- d) Prevent wind turbine and battery reverse polarity connection;

- e) Prevent internal short circuit of controller, inverter and other devices;
- f) Prevent lightning damage on electrical circuits.

When all LEDs are off, the maximum self consumption current should be less than 1% of rated charge current.

The voltage drop on charge and discharge circuits should not be higher than 5% of the rated system voltage.

Controller shall be able to survive bumps and vibration during transportation.

11 Wire and receptacle

11.1 Wire

All electrical wires shall use standard insulated copper wire. If necessary, the wire should be rated for direct solar exposure, direct bury, or water proof.

For permanent installation, conduit should be used if the exposure could cause some damage; if the wire has already been firmly attached to building structure, conduit may not be necessary; if the wire is passing through roof, wall or other structure, it should be protected with conduit. When wire is passing through a roof, water sealant shall be applied.

All wire field connections shall use connection terminals, screw and nuts, or special plugs. Screw and nuts shall only be used indoors and be in a specially designed connection enclosure. Rated current at any connections shall be no less than the circuit rated current. All connections shall be in a connection enclosure.

Wire should be chosen based on current, voltage drop and strength requirements. Current should not cause excessive wire temperature, the voltage drop should be less than 3%, and the wire size should ensure enough mechanical strength.

All wires shall have clear mark for polarity (color or label).

11.2 Load connection or output receptacle

The solar home system shall provide a safety means to connect load, by either connection terminals, or electrical receptacles. User operated connectors shall have clear marks for polarity, and have short circuit and reverse polarity protections.

Current limiting devices, such as fuses, circuit breaks, or electronic circuits, shall be functioning reliably and effectively.

12 Documentation requirement

System supplier shall provide two manuals and one warranty certificate. User's manual shall be at least one copy per system. The technical manual, includes installation, operation and maintenance manuals, is for installers and maintenance technicians. It shall include all necessary details for installation, operation and maintenance.

Manuals shall be written in Chinese and/or in local languages. Manual shall be simple and clear, more figures and tables are encouraged for easy understanding.

12.1 User's manual

User's manual should include at least following content:

- a) Brief introduction for system principle, especially the relationship between daily solar irradiance and usable energy;
- b) Description of all hardware which requires user's observation or operation, such as the status of switches and indicators;
- c) Provide correct operation rules, clearly point out what kind of load should be used with care, and what kind of loads are not allowed;
- d) Operation rules should include warnings, such as, during low solar irradiance or battery voltage is too low, energy usage shall be reduced, if battery voltage reaches LVD, all loads shall be disconnected;
- e) Guidelines for solar array maintenance and methods to reduce or eliminate shading;
- f) All maintenance made by the user;
- g) Emergency shut off procedures and suggested time interval to turn system on after abnormal conditions;
- h) Guideline for reset after a system failure.

12.2 Technical manual

Technical manual should include at least the following:

- a) Size and weight of the system and its components;
- b) A complete set of user's manual;
- c) Detailed part list, include component manufacturer, specification, warranty, PV module I-V curve, and battery charge/discharge curve, etc.;
- d) A complete set of installation instructions;
- e) Acceptance test procedures after the system installation, include inspections for all set points;
- f) Procedures and requirements for year around maintenance performed by the user;
- g) Guideline for system and component failure repair, include the diagnostics and repairs performed by component provider or local technicians. It is important to note in the manual that what kind of maintenance is not permitted to be performed by untrained persons;
- h) A system functional diagram using a one line diagram to show electrical connections and rated values for all components; mechanical and structure diagrams are also needed;
- i) Procedure for system emergency shut down.

Acceptance test procedure after the system installation should include:

- a) Adjust directions, tilt angle and avoid shading if needed, to make sure the location is suitable for maximum energy generation;
- b) Make sure after the installation and before the first use, the battery is fully charged;
- c) During the charging process, measure the current from the PV array. It should be done on a sunny day;
- d) Check all components to make sure they are working properly;
- e) Measure voltage drops on all circuits, and make sure they meet the minimum voltage drop requirement;
- f) All measured data should be recorded, filed and made available to the user;
- g) Train users on system principles, load management, status check and maintenance procedure.

12.3 Component documentation

Technical documents of controller and inverter shall be complete and included in technical manual. It should include following contents:

- a) Installation instructions;
- b) Operation instructions;
- c) Technical specifications and parameters;
- d) Safety requirements;
- e) Guideline for troubleshooting;
- f) Information for replacement parts;
- g) Warranty information;
- h) Manufacturer, production date and standard.