



TEST REPORT

IEC 61215-series:2016**Terrestrial photovoltaic (PV) modules – Design qualification and type approval****Report reference No.**..... : CCTI-2019031531S**Date of issue** : Mar. 21, 2019**Total number of pages**..... : 47**Testing Laboratory name**..... : Shenzhen CCTI Technology Co., Ltd.**Address**..... : Room 301, 3rd Floor, Office Building, Fushan Industrial Zone, Qiaotou Community, Fuhai Street, Bao'an District, Shenzhen, China.**Applicant's name** : NANTONG GAMKO NEW ENERGY CO.,LTD.**Address**..... : 1-302,BUILDING 98,HANYANGHUAYUAN,HAIAN DEVELOPMENT ZONE,HAIAN CITY,JIANGSU,P.R.CHINA**Test specification****Standard**..... : EN 61215-1-1:2016
EN 61215-1:2016
EN 61215-2:2017**Test procedure** : CE-LVD test report**Non-standard test method** : N/A**Test Report Form No.**..... : IEC 61215**TRF Originator** : N/A**Master TRF** : Dated 2009-05**Copyright © 2009 IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components (IECEE System). All rights reserved.**

This publication may be reproduced in whole or in part for non-commercial purposes as long as the IECEE is acknowledged as copyright owner and source of the material. IECEE takes no responsibility for and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.

Test item description : SOLAR PANEL**Trademark**..... : GAMKO**Manufacturer's name** : NANTONG GAMKO NEW ENERGY CO.,LTD.**Address**..... : 1-302,BUILDING 98,HANYANGHUAYUAN,HAIAN DEVELOPMENT ZONE,HAIAN CITY,JIANGSU,P.R.CHINA**Model and/or type reference**..... : GKAXXX (XXX STAND FOR 1W-600W)
GKA12PXXX,GKA18PXXX,GKA24PXXX,GKA36PXXX,GKA40PXXX,
GKA42PXXX,GKA48PXXX,GKA54PXXX,GKA60PXXX,GKA72PXXX,
GKA96PXXX,GKA108PXXX,GKA12MXXX,GKA18MXXX,GKA24MXX
X,GKA36MXXX,GKA40MXXX,GKA42MXXX,GKA48MXXX,GKA54MX
XX,GKA60MXXX,GKA72MXXX,GKA96MXXX,GKA108MXXX
(XXX STAND FOR 1W-600W)**Rating(s)** : DC 37.3V, 8.85A, 330W

Testing procedure and testing location:**Testing Laboratory.....: Shenzhen CCTI Technology Co., Ltd.****Address.....: Room 301, 3rd Floor, Office Building, Fushan Industrial Zone, Qiaotou Community, Fuhai Street, Bao'an District, Shenzhen, China.**
-----**Date of Test.....: Mar. 15, 2019 to Mar. 21, 2019**
-----**Tested by (name + signature).....: Abby Long**
-----**Reviewed by (name + signature).....: Jason Wang**
-----**Approved by (name + signature).....: Corey Mao**
-----

Summary of testing:

Tests performed (name of test and test clause):

-EN 61215-1-1:2016

-EN 61215-1:2016

-EN 61215-2:2017

The submitted samples were found to comply with the requirements of above specification.

Testing location:

Shenzhen CCTI Technology Co., Ltd.

Room 301, 3rd Floor, Office Building, Fushan Industrial Zone, Qiaotou Community, Fuhai Street, Bao'an District, Shenzhen, China.

Test case verdicts

Test case does not apply to the test object..... : N(.A.)

Test item does meet the requirement : P(ass)

Test item does not meet the requirement : F(ail)

General remarks

"This report is not valid as a CB Test Report unless appended to a CB Test Certificate issued by a NCB, in accordance with IEC 61215-1:2016".

This test report shall not be reproduced except in full without the written approval of the testing laboratory. The test results presented in this report relate only to the item tested.

"(see remark #)" refers to a remark appended to the report.

"(see appended table)" refers to a table appended to the report.

Throughout this report a comma is used as the decimal separator.

Copy of marking plate:

SOLAR PANEL

Model: GKAXXX (XXX STAND FOR 1W-600W)

DC 37.3V, 8.85A, 330W



Importer: XXXXXX

Address: XXXXXX

Manufacturer: NANTONG GAMKO NEW ENERGY CO.,LTD.

Address: 1-302,BUILDING 98,HANYANGHUAYUAN,HAIAN DEVELOPMENT ZONE,HAIAN CITY,JIANGSU,P.R.CHINA

Made in China

Remark on above marking:

1, The height of CE symbols is more than 5 mm;

2, The height of WEEE symbols is more than 7 mm;

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
5	Marking		P
	Each module shall carry the following clear and indelible markings		P
	– name, monogram or symbol of manufacturer		P
	– type or model number	See Copy of marking plate	P
	– serial number		P
	– polarity of terminals or leads (colour coding is permissible)	+: FF --: 00	P
	– maximum system voltage for which the module is suitable	1000V	P
	The date and place of manufacture shall be marked on the module or be traceable from the serial number		P

6	Testing		P
	Before beginning the testing, all modules, including the control, shall be exposed to sunlight (either real or simulated) to an irradiation level of $5\text{kWh} \cdot \text{m}^{-2}$ to $5.5\text{kWh} \cdot \text{m}^{-2}$ while open-circuited		P
	The modules shall be divided into groups and subjected to the qualification test sequences in Figure 1, carried out in the order laid down. Each box refers to the corresponding subclause in this standard. Test procedures and severities, including initial and final measurements where necessary, are detailed in Clause 11	See clause 11	P
	In carrying out the tests, the tester shall strictly observe the manufacturer's handling, mounting and connection instructions. Tests given in 11.4, 11.5, 11.6 and 11.7 may be omitted if future IEC 61853 has been or is scheduled to be run on this module type		P
	Test conditions are summarized in Table 1	See table 1	P

7	Pass criteria		P
	A module design shall be judged to have passed the qualification tests, and therefore to be IEC type approved, if each test sample meets all the following criteria		P
	a) the degradation of maximum output power does not exceed the prescribed limit after each test nor 8 % after each test sequence	$\leq 8\%$ of stated value	P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	b) no sample has exhibited any open circuit during the tests	No open circuit	P
	c) there is no visual evidence of a major defect, as defined in Clause 6	No defect	P
	d) the insulation test requirements are met after the tests	Refer to the insulation clause	P
	e) the wet leakage current test requirements are met at the beginning and the end of each sequence and after the damp heat test	tested	P
	f) specific requirements of the individual tests are met	tested	P
	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 meeting the requirements of Clause 3 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	All testing samples met the identify requests	P

8	Major visual defects		P
	For the purposes of design qualification and type approval, the following are considered to be major visual defects:		P
	a) broken, cracked, or torn external surfaces, including superstrates, substrates, frames and junction boxes;	No such defects	P
	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.	Not be impaired	P
	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;	No crack in cell	P
	d) bubbles or delaminations forming a continuous path between any part of the electrical circuit and the edge of the module;	No such defects	P
	e) loss of mechanical integrity, to the extent that	No such defects	P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	the installation and/or operation of the module would be impaired.		
9	Report		P
	Following type approval, a certified report of the qualification tests, with measured performance characteristics and details of any failures and re-test, shall be prepared by the test agency in accordance with ISO/IEC 17025. The report shall contain the detail specification for the module. Each certificate or test report shall include at least the following information:		P
	a) a title;		P
	b) name and address of the test laboratory and location where the tests were carried out;		P
	c) unique identification of the certification or report and of each page;		P
	d) name and address of client, where appropriate;		P
	e) description and identification of the item tested;		P
	f) characterization and condition of the test item;		P
	g) date of receipt of test item and date(s) of test, where appropriate;		P
	h) identification of test method used;		P
	i) reference to sampling procedure, where relevant;		P
	j) any deviations from, additions to or exclusions from the test method, and any other information relevant to a specific tests, such as environmental conditions;		P
	k) measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate including temperature coefficients of short-circuit current, open-circuit voltage and peak power, NOCT, power at NOCT, STC and low irradiance, spectrum of the lamp used for the UV pre-screening test, maximum power loss observed after all of the tests, and any failures observed;		P
	l) a statement of the estimated uncertainty of the test results (where relevant);		P
	m) a signature and title, or equivalent identification of the person(s) accepting responsibility for the		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	content of the certificate or report, and the date of issue;		
	n) where relevant, a statement to the effect that the results relate only to the items tested;		P
	o) a statement that the certificate or report shall not be reproduced except in full, without the written approval of the laboratory.		P
	A copy of this report shall be kept by the manufacturer for reference purposes.		P

10	Modifications		N
	Any change in the design, materials, components or processing of the module may require A repetition of some or all of the qualification tests to maintain type approval.	The same design, materials, components	N

11	Test procedures		P
11.1	Visual inspection		P
	To detect any visual defects in the module.		P
11.1.2	Procedure	Tested	P
	Carefully inspect each module under an illumination of not less than 1 000 lux for the following conditions:		P
	– cracked, bent, misaligned or torn external surfaces;		P
	– broken cells;		P
	– cracked cells;		P
	– faulty interconnections or joints;		P
	– cells touching one another or the frame;		P
	– failure of adhesive bonds;		P
	– bubbles or delaminations forming a continuous path between a cell and the edge of the module;		P
	– tacky surfaces of plastic materials;		P
	– faulty terminations, exposed live electrical parts;		P
	– any other conditions which may affect performance.		P
	Make note of and/or photograph the nature and position of any cracks, bubbles or delaminations, etc. which may worsen and adversely affect the module performance in subsequent tests. After above tests, no such	defects	P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
11.1.3	Requirements		P
	Visual conditions other than the major visual defects listed in Clause 7 are acceptable for the purposes of type approval.		P
11.2	Maximum power determination		P
11.2.1	Purpose		P
	To determine the maximum power of the module before and after the various environmental tests. Repeatability of the test is the most important factor.		P
11.2.2	Apparatus		P
	a) A radiant source (natural sunlight or a solar simulator class B or better in accordance with IEC 60904-9).	Solar simulator B	P
	b) A PV reference device in accordance with IEC 60904-2 or IEC 60904-6. If a class B simulator is used the reference device shall be a reference module of the same size with the same cell technology (to match spectral response) as the test specimen.		P
	c) A suitable mount for supporting the test specimen and the reference device in a plane normal to the radiant beam		P
	d) A means for monitoring the temperature of the test specimen and the reference device to an accuracy of ± 1 °C and repeatability of $\pm 0,5$ °C.		P
	e) Equipment for measuring the current of the test specimen and reference device to an accuracy of $\pm 0,2$ % of the reading;		P
	f) Equipment for measuring the voltage of the test specimen and reference device to an accuracy of $\pm 0,2$ % of the reading		P
11.2.3	Procedure		P
	Visual conditions other than the major visual defects listed in Clause 7 are acceptable for the purposes of type approval.		P
11.2	Maximum power determination	500W	P
11.2.1	Purpose		P
	To determine the maximum power of the module before and after the various environmental tests. Repeatability of the test is the most important factor.		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
11.2.2	Apparatus		P
	a) A radiant source (natural sunlight or a solar simulator class B or better in accordance with IEC 60904-9).	Solar simulator B	P
	b) A PV reference device in accordance with IEC 60904-2 or IEC 60904-6. If a class B simulator is used the reference device shall be a reference module of the same size with the same cell technology (to match spectral response) as the test specimen.		P
	c) A suitable mount for supporting the test specimen and the reference device in a plane normal to the radiant beam		P
	d) A means for monitoring the temperature of the test specimen and the reference device to an accuracy of $\pm 1\text{ }^{\circ}\text{C}$ and repeatability of $\pm 0,5\text{ }^{\circ}\text{C}$.		P
	e) Equipment for measuring the current of the test specimen and reference device to an accuracy of $\pm 0,2\text{ }\%$ of the reading;		P
	f) Equipment for measuring the voltage of the test specimen and reference device to an accuracy of $\pm 0,2\text{ }\%$ of the reading		P
11.2.3	Procedure		P
	Determine the current-voltage characteristic of the module in accordance with IEC 60904-1 at a specific set of irradiance and temperature conditions (a recommended range is a cell temperature between $25\text{ }^{\circ}\text{C}$ and $50\text{ }^{\circ}\text{C}$ and an irradiance between $700\text{ W}\cdot\text{m}^{-2}$ and $1\text{ }100\text{ W}\cdot\text{m}^{-2}$) using natural sunlight or a class B or better simulator conforming to the requirements of IEC 60904-9. In special circumstances when modules are designed for operation under a different range of conditions, the current-voltage characteristics can be measured using temperature and irradiance levels similar to the expected operating conditions. Temperature and irradiance corrections can be made in accordance with IEC 60891 in order to compare sets of measurements made on the same module before and after environmental tests. However, every effort should be made to assure that peak power		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	measurements are made under similar operating conditions, that is minimize the magnitude of the correction by making all peak power measurements on a particular module at approximately the same temperature and irradiance. Repeatability of the maximum power measurement must be better than $\pm 1\%$.		
11.3	Insulation test		P
11.3.1	Purpose		P
11.3.2	Apparatus		P
	a) DC voltage source, with current limitation, capable of applying 500 V or 1 000 V plus twice the maximum system voltage of the module according to 10.3.4 c).		P
	b) An instrument to measure the insulation resistance.		P
11.3.3	Test conditions		P
	The test shall be made on modules at ambient temperature of the surrounding atmosphere (see IEC 60068-1) and in a relative humidity not exceeding 75 %.	(20~22)°C, 68%	P
11.3.4	Procedure	Tested	P
	a) Connect the shorted output terminals of the module to the positive terminal of a d.c. insulation tester with a current limitation.		P
	Determine the current-voltage characteristic of the module in accordance with IEC 60904-1 at a specific set of irradiance and temperature conditions (a recommended range is a cell temperature between 25 °C and 50 °C and an irradiance between 700 W·m ⁻² and 1 100 W·m ⁻²) using natural sunlight or a class B or better simulator conforming to the requirements of IEC 60904-9. In special circumstances when modules are designed for operation under a different range of conditions, the current-voltage characteristics can be measured using temperature and irradiance levels similar to the expected operating conditions. Temperature and irradiance corrections can be made in accordance with IEC 60891 in order to compare sets of measurements made on the same module before and after		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	environmental tests. However, every effort should be made to assure that peak power measurements are made under similar operating conditions, that is minimize the magnitude of the correction by making all peak power measurements on a particular module at approximately the same temperature and irradiance. Repeatability of the maximum power measurement must be better than ± 1 %.		
11.4	Measure of temperature coefficient		P
11.4.2	Equipment		P
11.4.3	Procedure		P
	There are two acceptable procedures for measuring the temperature coefficients.		N
11.4.3.1	Procedure in natural sunlight		N
	a) Measurement in natural sunlight shall only be made when:		N
	– the total irradiance is at least as high as the upper limit of the range of interest		N
	– the irradiance variation caused by short-term oscillations (clouds, haze, or smoke) is less than ± 2 % of the total irradiance as measured by the reference device;		N
	– the wind speed is less than $2 \text{ m}\cdot\text{s}^{-1}$		N
	b) Mount the reference device co-planar with the test module so that both are normal to the direct solar beam within $\pm 5^\circ\text{C}$. Connect to the necessary instrumentation.		N
	c) If the test module and reference device are equipped with temperature controls, set the controls at the desired level.		N
	d) If temperature controls are not used, shade the specimen and the reference device from the sun and wind until its temperature is uniform within $\pm 1^\circ\text{C}$ of the ambient air temperature, or allow the test specimen to equilibrate to its stabilized temperature, or cool the test specimen to a point below the required test temperature and then let the module warm up naturally. The reference device should also stabilize within $\pm 1^\circ\text{C}$ of its equilibrium temperature before proceeding		N
	e) Record the current-voltage characteristic and		N

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	temperature of the specimen concurrently with recording the short-circuit current and temperature of the reference device at the desired temperatures. If necessary, make the measurements immediately after removing the shade.		
	f) The irradiance G_0 shall be calculated in accordance with IEC 60891 from the measured current (I_{sc}) of the PV reference device, and its calibration value at STC (I_{rc}). A correction should be applied to account for the temperature of the reference device T_m using the specified temperature coefficient of the reference device α_{rc} .		N
	g) Adjust the temperature by means of a controller or alternately exposing and shading the test module as required to achieve and maintain the desired temperature. Alternately, the test module may be allowed to warm-up naturally with the data recording procedure of item d) performed periodically during the warm-up.		N
	h) Ensure that the test module and reference device temperature are stabilized and remain constant within $\pm 1^\circ\text{C}$ and that the irradiance as measured by the reference device remains constant within $\pm 1\%$ during the recording period for each data set. All data must be taken at $1000\text{ W}\cdot\text{m}^{-2}$ or be translated to that irradiance level.		N
	i) Repeat steps d) through h). Module temperatures shall be such that the range of interest is at least 30°C and that it is spanned in at least four approximately equal increments. A minimum of three measurements shall be made at each of the test conditions.		N
	Procedure with a solar simulator		P
	a) Determine the short-circuit current of the module at the desired irradiance at room temperature, in accordance with IEC 60904-1.	$I_{sc}=10.28\text{A}$	P
	b) Mount the test module in the equipment used to change the temperature. Mount the PV reference device within the simulator beam. Connect to the instrumentation.		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	c) Set the irradiance so that the test module produces the short-circuit current determined in item a). Use the PV reference device to maintain this irradiance setting throughout the test.		P
	d) Heat or cool the module to a temperature of interest. Once the module has reached the desired temperature, measure I_{sc} , V_{oc} and peak power. Change the module temperature in steps of approximately 5 °C over a range of interest of at least 30 °C and repeat the measurements of I_{sc} , V_{oc} and peak power.		P
11.4.3.3	Calculation of temperature coefficients		P
	a) Plot the values of I_{sc} , V_{oc} and P_{max} as functions of temperature and construct a least-squares-fit curve through each set of data		P
	b) From the slopes of the least squares fit straight lines for current, voltage and P_{max} , calculate α , the temperature coefficient of short circuit current, β , the temperature coefficient of open-circuit voltage, and δ , the temperature coefficient of P_{max} , for the module.	$\alpha=0.005$	P
11.5	Measurement of nominal operating cell temperature (NOCT)		P
11.5.1	Purpose		P
	To determine the NOCT of the module.		P
11.5.2	Introduction		P
	NOCT is defined as the equilibrium mean solar cell junction temperature within an open- rack mounted module in the following standard reference environment (SRE):		P
	– tilt angle:		P
	– total irradiance:	1000w/m ²	P
	– ambient temperature:	20°C	P
	– wind speed:	60m/s	P
	– electrical load:	Opened circuit	N
	NOCT can be used by the system designer as a guide to the temperature at which a module will operate in the field and it is therefore a useful parameter when comparing the performance of different module designs. However, the actual operating temperature at any particular time is affected by the mounting structure, irradiance,		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	wind speed, ambient temperature, sky temperature and reflections and emissions from the ground and nearby objects. For accurate performance predictions, these factors shall be taken into account.		
	Two methods for determining NOCT are described.		P
	The first, called "the primary method", is universally applicable to all PV modules. In the case of modules not designed for open-rack mounting, the primary method may be used to determine the equilibrium mean solar cell junction temperature in the SRE, with the module mounted as recommended by the manufacturer.		P
	The second, called "the reference-plate method", is faster but is applicable only to PV modules of the type which respond to changes of ambient temperature (within restricted ranges of wind speed and irradiance) in the same way as the reference plates used in the measurement. Crystalline silicon modules with a glass front and plastic back are in this category. The reference plates are calibrated using the same procedure as in the primary method.		P
11.5.3	Primary method		P
11.5.3.1	Principle		P
	This method is based on gathering actual measured cell temperature data under a range of environmental conditions including the SRE. The data are presented in a way that allows accurate and repeatable interpolation of the NOCT.		P
	– total irradiance:	1000w/m ²	P
	– ambient temperature:	20°C	P
	– wind speed:	60m/s	P
	– electrical load:	Opened circuit	N
	NOCT can be used by the system designer as a guide to the temperature at which a module will operate in the field and it is therefore a useful parameter when comparing the performance of different module designs. However, the actual operating temperature at any particular time is affected by the mounting structure, irradiance,		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	adding 20 °C to the value of (T _J – T _{amb}) interpolated at the SRE irradiance of 800 W·m ⁻² . Finally, a correction factor, dependent on the average temperature and wind speed during the test period, is added to the preliminary NOCT to correct it to 20 °C and 1 m·s ⁻¹ .		
11.5.3.2	Apparatus		P
	The following apparatus is required:		P
	a) an open rack to support the test module(s) and pyranometer in the specified manner (see 10.5.3.3). The rack shall be designed to minimize heat conduction from the modules and to interfere as little as possible with the free radiation of heat from their front and back surfaces;		P
	b) a pyranometer, mounted in the plane of the module(s) and within 0,3 m of the test array;		P
	c) instruments to measure wind speed down to 0,25 m·s ⁻¹ and wind direction, installed approximately 0,7 m above the top of the module(s) and 1,2 m to the east or west;		P
	d) an ambient temperature sensor, with a time constant equal to or less than that of the module(s), installed in a shaded enclosure with good ventilation near the wind sensors;		P
	e) cell temperature sensors, attached by solder or thermally conductive adhesive to the backs of two solar cells near the middle of each test module, or other equipment necessary for IEC-approved measurement of cell temperature;		P
	f) a data acquisition system with temperature measurement accuracy of ±1 °C to record the following parameters within an interval of no more than 5 s:		P
	– irradiance,		P
	– ambient temperature,		P
	– cell temperature,		P
	– wind speed,		P
	– wind direction.		P
11.5.3.3	Test module mounting		P
	Tilt angle: the test module(s) shall be positioned so that it (they) is (are) tilted at 45° ± 5° to the horizontal with the front side pointed toward the	45°	P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	equator.		
	Height: the bottom edge of the test module(s) shall be 0,6 m or more above the local horizontal plane or ground level.	1m	P
	Configuration: to simulate the thermal boundary conditions of modules installed in an array, the test module(s) shall be mounted within a planar surface that extends at least 0,6 m beyond the module(s) in all directions. For modules designed for free-standing, open-back installations, black aluminum plates or other modules of the same design shall be used to fill out the remaining open area of the planar surface.		P
	Surrounding area: there shall be no obstructions to prevent full irradiance of the test module(s) during the period from 4 h before local solar noon to 4 h after local solar noon. The ground surrounding the module(s) shall not have an abnormally high solar reflectance and shall be flat and level or sloping away from the test fixture in all directions. Grass, other types of vegetation, black asphalt or dirt are acceptable for the local surrounding area.		P
11.5.3.4	Procedure Tested		P
	a) Set up the apparatus with the test module(s), as described in 10.5.3.3. Ensure that the test module(s) are open-circuited.		P
	b) On a suitable, clear, sunny day with little wind, record, as a function of time, the cell temperature, the ambient temperature, the irradiance, wind speed and wind direction.		P
	c) Reject all data taken during the following conditions		P
	– irradiance below $400 \text{ W} \cdot \text{m}^{-2}$;		P
	– in a 10-min interval after the irradiance varies by more than 10 % from the maximum value to the minimum value recorded during that 10 min period;		P
	– wind speeds outside the range $1 \text{ m} \cdot \text{s}^{-1} \pm 0,75 \text{ m} \cdot \text{s}^{-1}$;		P
	– ambient temperatures outside the range $20^\circ\text{C} \pm 15^\circ\text{C}$ or varying by more than 5°C from the maximum to the minimum value recorded during		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	one data collection run;		
	– in a 10-min interval after a wind gust of more than $4 \text{ m}\cdot\text{s}^{-1}$;		P
	– wind direction within $\pm 20^\circ$ of east or west.		P
	d) From a minimum of 10 acceptable data points covering an irradiance range of at least $300 \text{ W}\cdot\text{m}^{-2}$, making sure that data points are from both before and after solar noon, plot $(T_J - T_{\text{amb}})$ as a function of irradiance. Use regression analysis to fit the data points.		P
	e) Determine the value of $(T_J - T_{\text{amb}})$ at $800 \text{ W}\cdot\text{m}^{-2}$ and add 20°C to give the preliminary value of NOCT		P
	f) Calculate the average ambient temperature, T_{amb} , and the average wind speed, V , associated with the acceptable data points and determine the appropriate correction factor from Figure 2.		P
	g) Add the correction factor to the preliminary NOCT to correct it to 20°C and $1 \text{ m}\cdot\text{s}^{-1}$. This sum is the NOCT of the module.		P
	h) Repeat the entire procedure on two additional days and average the three values of NOCT for each test module.		P
11.5.4	Reference-plate method		P
11.5.4.1	Principle		P
	This method is based on the principle of comparing the temperature of the test module(s) with that of standard reference plates under the same conditions of irradiance, ambient temperature and wind speed. The steady-state temperature of the reference plate in the SRE is determined using the primary method described in 10.5.3.		P
	– wind speeds outside the range $1 \text{ m}\cdot\text{s}^{-1} \pm 0,75 \text{ m}\cdot\text{s}^{-1}$;		P
	– ambient temperatures outside the range $20^\circ\text{C} \pm 15^\circ\text{C}$ or varying by more than 5°C from the maximum to the minimum value recorded during one data collection run;		P
	– in a 10-min interval after a wind gust of more than $4 \text{ m}\cdot\text{s}^{-1}$;		P
	– wind direction within $\pm 20^\circ$ of east or west.		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	d) From a minimum of 10 acceptable data points covering an irradiance range of at least $300 \text{ W}\cdot\text{m}^{-2}$, making sure that data points are from both before and after solar noon, plot $(T_J - T_{amb})$ as a function of irradiance. Use regression analysis to fit the data points.		P
	e) Determine the value of $(T_J - T_{amb})$ at $800 \text{ W}\cdot\text{m}^{-2}$ and add $20 \text{ }^{\circ}\text{C}$ to give the preliminary value of NOCT		P
	f) Calculate the average ambient temperature, T_{amb} , and the average wind speed, V , associated with the acceptable data points and determine the appropriate correction factor from Figure 2.		P
	g) Add the correction factor to the preliminary NOCT to correct it to $20 \text{ }^{\circ}\text{C}$ and $1 \text{ m}\cdot\text{s}^{-1}$. This sum is the NOCT of the module.		P
	h) Repeat the entire procedure on two additional days and average the three values of NOCT for each test module.		P
11.5.4	Reference-plate method		P
11.5.4.1	Principle		P
	This method is based on the principle of comparing the temperature of the test module(s) with that of standard reference plates under the same conditions of irradiance, ambient temperature and wind speed. The steady-state temperature of the reference plate in the SRE is determined using the primary method described in 10.5.3.		P
	The NOCT of the test module is obtained by correcting the temperature difference between the test module and the reference plates to the SRE and adding this value to the mean steady-state temperature of the reference plates in the SRE. It has been established that the measured temperature difference is insensitive to fluctuations in irradiance and to small changes in ambient temperature and wind speed.		P
11.5.4.2	Reference plate Performed		P
	aluminum alloy to the dimensions shown in Figure 3. The front surface shall be painted matte black and the back surface gloss white. Means shall be		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	provided for measuring the temperature of the reference plates to the required accuracy. One method employing two thermocouples is shown in Figure 3. One thermocouple is cemented into each branch of the milled groove with thermally conductive and electrically insulating adhesive, after removing any insulation for a distance of 25 mm from the junction. The remainder of the thermocouple wires are finally cemented into the groove with conductive putty.		
	At least three reference plates shall be made and calibrated, using the primary method described in 10.5.3. The steady-state temperatures so determined shall be within the range 46 °C to 50 °C and shall differ by no more than 1 °C. One of the reference plates shall be kept unused as a control. Before making a NOCT measurement, the steady-state temperatures of the reference plates shall be checked against that of the control plate under the acceptable conditions indicated in item c) of 10.5.3.4 to detect any change in their thermal properties. If the measured temperatures of the reference plates differ by more than 1 °C, the reason for this shall be investigated and necessary corrective action taken before proceeding with the Test.		P
11.5.4.3	Test site		P
	Select a flat test site with negligible wind disturbance from buildings, trees and topographical features. Non-uniform reflections from the ground and objects behind the test plane shall be avoided.		P
11.5.4.4	Apparatus		P
	The following apparatus is required (see Figure 4).		P
	The NOCT of the test module is obtained by correcting the temperature difference between the test module and the reference plates to the SRE and adding this value to the mean steady-state temperature of the reference plates in the SRE. It has been established that the measured temperature difference is insensitive to fluctuations in irradiance and to small changes in ambient		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	temperature and wind speed.		
11.5.4.2	Reference plate Performed		P
	aluminum alloy to the dimensions shown in Figure 3. The front surface shall be painted matte black and the back surface gloss white. Means shall be provided for measuring the temperature of the reference plates to the required accuracy. One method employing two thermocouples is shown in Figure 3. One thermocouple is cemented into each branch of the milled groove with thermally conductive and electrically insulating adhesive, after removing any insulation for a distance of 25 mm from the junction. The remainder of the thermocouple wires are finally cemented into the groove with conductive putty.		P
	At least three reference plates shall be made and calibrated, using the primary method described in 10.5.3. The steady-state temperatures so determined shall be within the range 46 °C to 50 °C and shall differ by no more than 1 °C. One of the reference plates shall be kept unused as a control. Before making a NOCT measurement, the steady-state temperatures of the reference plates shall be checked against that of the control plate under the acceptable conditions indicated in item c) of 10.5.3.4 to detect any change in their thermal properties. If the measured temperatures of the reference plates differ by more than 1 °C, the reason for this shall be investigated and necessary corrective action taken before proceeding with the test		P
11.5.4.3	Test site		P
	Select a flat test site with negligible wind disturbance from buildings, trees and topographical features. Non-uniform reflections from the ground and objects behind the test plane shall be avoided.		P
11.5.4.4	Apparatus		P
	The following apparatus is required (see Figure 4).		P
	a) A number of reference plates, as described in 10.5.4.2 (one more than the number of modules to be tested simultaneously).		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	b) A pyranometer or a PV reference device.		P
	c) An open rack to support the test module(s), reference plates and pyranometer tilted at $45^\circ \pm 5^\circ$ to the horizontal with the front side toward the equator. Each module shall be closely flanked by two reference plates with the lower edge of the module(s) approximately 1 m above the ground. The rack shall be designed to minimize heat conduction from the module(s) and plates and to interfere as little as possible with the free radiation of heat from their front and back surfaces.		P
	d) Instruments to measure wind speed down to $0,25 \text{ m}\cdot\text{s}^{-1}$ and wind direction, installed approximately 0,7 m above the top of the module(s) and 1,2 m to the east or west, as shown in Figure 4.		P
	e) An ambient temperature sensor with a time constant equal to or less than that of the modules, installed in a shaded enclosure with good ventilation near the wind sensors. f) Cell temperature sensors, attached by solder or thermally conductive adhesive to the backs of two solar cells near the middle of each module, or other equipment necessary for IEC-approved measurement of cell temperature.		P
	g) A data acquisition system with temperature measurement accuracy of $\pm 1^\circ \text{C}$ to record the following parameters within an interval of no more than 5 s:		P
	– irradiance;		P
	– ambient temperature;		P
	– cell temperature;		P
	– wind speed;		P
	– wind direction;		P
	– reference-plate temperatures.		P
11.5.4.5	Procedure		P
	a) Set up the apparatus with the test module(s) and reference plates as shown in Figure 4. Ensure that the test module(s) are open-circuited.		P
	a) A number of reference plates, as described in 10.5.4.2 (one more than the number of modules to be tested simultaneously).		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	b) A pyranometer or a PV reference device.		P
	c) An open rack to support the test module(s), reference plates and pyranometer tilted at $45^\circ \pm 5^\circ$ to the horizontal with the front side toward the equator. Each module shall be closely flanked by two reference plates with the lower edge of the module(s) approximately 1 m above the ground. The rack shall be designed to minimize heat conduction from the module(s) and plates and to interfere as little as possible with the free radiation of heat from their front and back surfaces.		P
	d) Instruments to measure wind speed down to $0,25 \text{ m}\cdot\text{s}^{-1}$ and wind direction, installed approximately 0,7 m above the top of the module(s) and 1,2 m to the east or west, as shown in Figure 4.		P
	e) An ambient temperature sensor with a time constant equal to or less than that of the modules, installed in a shaded enclosure with good ventilation near the wind sensors. f) Cell temperature sensors, attached by solder or thermally conductive adhesive to the backs of two solar cells near the middle of each module, or other equipment necessary for IEC-approved measurement of cell temperature.		P
	g) A data acquisition system with temperature measurement accuracy of $\pm 1^\circ\text{C}$ to record the following parameters within an interval of no more than 5 s:		P
	– irradiance;		P
	– ambient temperature;		P
	– cell temperature;		P
	– wind speed;		P
	– wind direction;		P
	– reference-plate temperatures.		P
11.5.4.5	Procedure		P
	a) Set up the apparatus with the test module(s) and reference plates as shown in Figure 4. Ensure that the test module(s) are open-circuited.		P
	b) On a suitable, clear, sunny day with little wind, record, as a function of time, the cell temperature(s) of the test module(s), the		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	reference-plate temperature, irradiance, ambient temperature, wind speed and wind direction.		
	c) Reject all data taken during, or for 15 min after, the following conditions:		P
	– irradiance below $750 \text{ W}\cdot\text{m}^{-2}$ or above $850 \text{ W}\cdot\text{m}^{-2}$;		P
	– irradiance varying by more than $\pm 40 \text{ W}\cdot\text{m}^{-2}$ during one data collection run;		P
	– wind speeds above $2 \text{ m}\cdot\text{s}^{-1}$ that continue for more than 30 s;		P
	– wind speeds below $0,5 \text{ m}\cdot\text{s}^{-1}$;		P
	– wind direction within $\pm 20^\circ$ of east or west;		P
	– differences between temperatures of the reference plates greater than 1°C .		P
	d) For each data point in the selected period, take the mean temperature TP of all the reference plates.		P
	e) For each data point in the selected period and for each test module:		P
11.6	Performance at STC and NOCT		P
11.6.1	Purpose		P
	To determine how the electrical performance of the module varies with load at STC ($1\,000 \text{ W}\cdot\text{m}^{-2}$, 25°C cell temperature, with the IEC 60904-3 reference solar spectral irradiance distribution) and at NOCT and an irradiance of $800 \text{ W}\cdot\text{m}^{-2}$, with the IEC 60904-3 reference solar spectral irradiance distribution		P
11.6.2	Apparatus		P
	a) A radiant source (natural sunlight or a solar simulator class B or better) in accordance with IEC 60904-9.		P
	b) A PV reference device in accordance with IEC 60904-2 or IEC 60904-6. If a class B simulator is used, the reference device shall be a reference module of the same size with the same cell technology to match spectral response.		P
	c) A suitable mount for supporting the test specimen and the reference device in a plane normal to the radiant beam.		P
	d) A means for monitoring the temperature of the test specimen and the reference device to an		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	accuracy of ± 1 °C and repeatability of $\pm 0,5$ °C.		
	e) Equipment for measuring the current of the test specimen and reference device to an accuracy of $\pm 0,2$ % of the reading.		P
	f) Equipment for measuring the voltage of the test specimen and reference device to an accuracy of $\pm 0,2$ % of the reading.		P
	g) Equipment necessary to change the temperature of the test specimen to the NOCT temperature measured in 10.5.		P
11.6.3	Procedure		P
11.6.3.1	STC		P
	Maintain the module at 25 °C and trace its current-voltage characteristic at an irradiance of 1 000 W·m ⁻² (as measured by a suitable reference device), in accordance with IEC 60904-1, using natural sunlight or a class B or better simulator conforming to the requirements of IEC 60904-9.		P
11.6.3.2	NOCT		P
	Heat the module uniformly to NOCT and trace its current-voltage characteristic at an irradiance of 800 W·m ⁻² (as measured by a suitable reference device), in accordance with IEC 60904-1, using natural sunlight or a class B or better simulator conforming to the requirements of the IEC 60904-9.		P
	If the reference device is not spectrally matched to the test module, use IEC 60904-7 to calculate the spectral mismatch correction.		P
11.7	Performance at low irradiance		P
11.7.1	Purpose		P
	To determine how the electrical performance of the module varies with load at 25 °C and an irradiance of 200 W·m ⁻² (as measured by A suitable reference device), in accordance with IEC 60904-1 using natural sunlight or a simulator class B or better conforming to the requirements of IEC 60904-9.		P
11.7.2	Apparatus		P
	a) A radiant source (natural sunlight or a solar simulator class B or better) in accordance with IEC 60904-9.		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	b) Equipment necessary to change the irradiance to $200 \text{ W}\cdot\text{m}^{-2}$ without affecting the relative spectral irradiance distribution and the spatial uniformity in accordance with IEC 60904-10.		P
	c) A PV reference device in accordance with IEC 60904-2 or IEC 60904-6.		P
	d) A suitable mount for supporting the test specimen and the reference device in a plane normal to the radiant beam.		P
	e) A means for monitoring the temperature of the test specimen and the reference device to an accuracy of $\pm 1 \text{ }^{\circ}\text{C}$ and repeatability of $\pm 0,5 \text{ }^{\circ}\text{C}$.		P
	f) Equipment for measuring the current of the test specimen and reference device to an accuracy of $\pm 0,2 \%$ of the reading.		P
	g) Equipment for measuring the voltage of the test specimen and reference device to an accuracy of $\pm 0,2 \%$ of the reading.		P
11.7.3	Procedure		P
	Determine the current-voltage characteristic of the module at $25 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$ and an irradiance of $200 \text{ W}\cdot\text{m}^{-2}$ (as measured by a suitable reference device), in accordance with IEC 60904-1 using natural sunlight or a class B or better simulator conforming to the requirements of IEC 60904-9. The irradiance shall be reduced to the specified level by using neutral filters or some other technique, which does not affect the spectral irradiance distribution. (See IEC 60904-10 for guidance on reducing the irradiance without changing the spectral irradiance distribution.)		P
11.8	Outdoor exposure test		P
11.8.1	Purpose		P
	To make a preliminary assessment of the ability of the module to withstand exposure to outdoor conditions and to reveal any synergistic degradation effects which may not be detected by laboratory tests.		P
11.8.2	Apparatus		P
	a) A device capable of measuring solar irradiation, with an uncertainty of less than $\pm 5 \%$.		P
	b) Means to mount the module, as recommended		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	by the manufacturer, co-planar with the irradiation measuring device.		
	c) A load sized such that at STC the module will operate near the maximum power point.		P
11.8.3	Procedure		P
	a) Attach the resistive load to the module and mount it outdoors, as recommended by the manufacturer, co-planar with the irradiation monitor. Any hot-spot protective devices recommended by the manufacturer shall be installed before the module is tested.		P
	b) Subject the module to an irradiation totalling 60 k Wh·m ⁻² , as measured by the monitor, under conditions conforming to general open-air climates, as defined in IEC 60721-2-1.		P
11.8.4	Final measurements		P
	Repeat the tests of 10.1, 10.2 and 10.3.		P
11.8.5	Requirements		P
	The requirements are as follows:		P
	– no evidence of major visual defects, as defined in Clause 7;		P
	– the degradation of maximum output power shall not exceed 5 % of the value measured before the test;		P
	– insulation resistance shall meet the same requirements as for the initial measurements.		P
11.9	Hot-spot endurance test		P
11.9.1	Purpose		P
11.9.2	Hot-spot effect		P
	Hot-spot heating occurs in a module when its operating current exceeds the reduced shortcircuit current of a shadowed or faulty cell or group of cells within it. When such a condition occurs, the affected cell or group of cells is forced into reverse bias and must dissipate power, which can cause overheating.		P
	Figure 6 illustrates the hot-spot effect in a module of a series string of cells, one of which, cell Y, is partially shadowed. The amount of power dissipated in Y is equal to the product of the module current and the reverse voltage developed across Y. For any irradiance level, maximum		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	power is dissipated in the short-circuit current condition, when the reverse voltage across Y is equal to the voltage generated by the remaining ($s - 1$) cells in the module. This is shown in Figure 6 by the hatched rectangle constructed at the intersection of the reverse I-V characteristic of Y with the image of the forward I-V characteristic of the ($s - 1$) cells.		
	Because the reverse characteristics can vary considerably from cell to cell, it is necessary to classify cells as voltage limited (type A) or current limited (type B), according to how the reverse characteristic intersects the "test limit zone" shown in Figure 7.		P
	Figure 6 applies to type A cells. It illustrates that the maximum dissipation in a faulty or shadowed type A cell occurs when the reverse characteristic intersects the image of the ($s - 1$) characteristic at its maximum power point.		P
	In contrast, Figure 8 shows that the maximum dissipation in a type B cell occurs when it is fully shadowed. But it should be noted that, in this case, the dissipated power may be only a fraction of the total power available from the module.		P
11.9.3	Classification of cell interconnection		P
	Solar cells in a PV module are connected in one of the following ways:		P
	Case SP: series-parallel connection, i.e. a parallel connection of p strings, each with s cells in series; see Figure 9;		P
	Case SPS: Series-parallel-series connection, i.e. a series connection of b blocks, where each block consists of a parallel connection of p strings, each with s cells in series. See Figure 10.		N
	By-pass diodes, if present, limit the reverse voltage of the enclosed cells and therefore define the part of the circuit to be tested. The maximum internal power dissipation occurs with the module short-circuited.		N
11.9.4	Apparatus		P
	a) Radiant source 1. Steady-state solar simulator or natural sunlight capable of an irradiance of not		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	less than $700 \text{ W}\cdot\text{m}^{-2}$ with a non-uniformity of not more than $\pm 2 \%$ and a temporal stability within $\pm 5 \%$.		
	b) Radiant source 2. Class C steady-state solar simulator (or better) or natural sunlight with an irradiance of $1\,000 \text{ W}\cdot\text{m}^{-2} \pm 10 \%$.		N
	c) Module I-V curve tracer.		P
	d) Set of opaque covers for test cell shadowing in 5% increments.		P
	e) An appropriate temperature detector, if required.		N
11.9.5	Procedure		P
	Any hot-spot protective devices recommended by the manufacturer shall be installed before the module is tested.		P
11.9.5.1	Case S	Not case S	N
	a) Expose the unshadowed module to radiant source 1 at an irradiance of not less than $700 \text{ W}\cdot\text{m}^{-2}$. Measure the I-V characteristic and determine the current at maximum power, I_{MP}		N
	b) Short-circuit the module and select a cell by one of the following methods:		N
	1) With the module exposed to radiant source 1 at a stable irradiance of not less than $700 \text{ W}\cdot\text{m}^{-2}$, determine the hottest cell using an appropriate temperature detector. (An infrared (IR) camera is recommended).		N
	2) Under the irradiance specified for step a), completely shadow each cell in turn and select the cell or one of the cells which gives the biggest decrease in short-circuit current when shadowed. During this process, the irradiance shall not change by more than $\pm 5 \%$.		N
	c) Under the same irradiance (within $\pm 3 \%$) as used in step a), completely shadow the selected cell and check that the short circuit current (ISC) of the module is less than the peak power current (I_{MP}) of the module, as determined in step a). If this condition does not occur, the condition of maximum power dissipation within a single cell cannot be set. In this case, proceed with the selected cell completely shadowed, omitting step		N

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	d) Gradually decrease the shadowed area of the selected cell until ISC of the module coincides as closely as possible with IMP. In this condition, the maximum power is dissipated within the selected cell.		N
	e) Expose the module to radiant source 2. Note the value of ISC and keep the module in the condition of maximum power dissipation, readjusting the shadow, if necessary, to maintain ISC at the specified level. Under these conditions the module temperature should be $50\text{ }^{\circ}\text{C} \pm 10\text{ }^{\circ}\text{C}$.		N
	f) Maintain this condition for a total exposure time of 5 h.		N
11.9.5.2	Case SP		P
	a) Expose the unshadowed module to radiant source 1 at an irradiance of not less than $700\text{ W}\cdot\text{m}^{-2}$. Measure the I-V characteristic and determine ISC (*), the short-circuit current corresponding to the condition of maximum hot spot power dissipation, from the following equation, assuming that all strings generate the same current:		P
	b) Short-circuit the module and select a cell by one of the following methods:		P
	1) with the module exposed to radiant source 1 at a stable irradiance of not less than $700\text{ W}\cdot\text{m}^{-2}$, determine the hottest cell using an appropriate temperature detector;		P
	2) under the irradiance specified in step a), completely shadow each cell in turn and find the cell which gives the biggest decrease in shortcircuit current when shadowed. During this process, the irradiance shall not change by more than $\pm 5\%$.		P
	c) Under the same irradiance as in step a) (within $\pm 3\%$), check that, with the selected cell fully shadowed, ISC of the module is less than ISC (*), as determined in step a). If this condition does not occur, the condition of maximum power dissipation within a single cell cannot be set. In this case, proceed with the selected cell fully shadowed, omitting step d).		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	d) Gradually decrease the shadowed area of the selected cell until ISC of the module coincides as closely as possible with ISC (*). In this condition, the maximum power is dissipated within the selected cell.		P
	e) Expose the module to radiant source 2. Note the value of ISC and keep the module in the condition of maximum power dissipation, readjusting the shadow, if necessary, to maintain ISC at the specified level. Under these conditions the module temperature should be 50 °C± 10 °C.		P
	f) Maintain this condition for a total exposure time of 5 h.		P
11.9.5.3	Case SPS		N
	a) Short-circuit the unshadowed module and expose it to radiant source 1 at a stable irradiance of not less than 700 W·m ⁻² . Take at random at least 30 % of the cells in the module, fully shadow each cell in turn and measure the temperature at which it stabilizes, using thermal imaging equipment or other appropriate means.		N
	b) Fully shadow the hottest cell found in step a).		N
	c) While continuing to monitor its temperature, gradually decrease the shadowed area and determine the condition in which maximum temperature is achieved.		N
	d) Expose the module to radiant source 2 and keep it in the shadowed condition established in step c). Under these conditions the module temperature should be 50 °C ± 10 °C.		N
	e) Maintain this condition for a total exposure time of 5 h.		N
11.9.6	Final measurements		P
	Repeat the tests of 10.1, 10.2 and 10.3.		P
11.9.7	Requirements		P
	The requirements are as follows:		P
	– no evidence of major visual defects, as defined in Clause 7. If there is evidence of serious damage that does not qualify as a major visual defect, repeat the test on 2 additional cells. If there is no visual damage around either of these two cells the module type passes the hot spot test;		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	– the degradation of maximum output power shall not exceed 5 % of the value measured before the test;	< 5%	P
	– insulation resistance shall meet the same requirements as for the initial measurements.		P
11.10	UV preconditioning test		P
11.10.1	Purpose		P
	To precondition the module with ultra-violet (UV) radiation before the thermal cycle/ humidity freeze tests to identify those materials and adhesive bonds that are susceptible to UV degradation.		P
11.10.2	Apparatus		P
	a) Equipment to control the temperature of the module while it is irradiated by UV light. The equipment must be capable of maintaining the module temperature at $60\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.	58 °C-62 °C	P
	b) Means for measuring and recording the temperature of the module(s) to an accuracy of $\pm 2\text{ }^{\circ}\text{C}$. The temperature sensors shall be attached to the front or back surface of the module near the middle. If more than one module is tested simultaneously, it will suffice to monitor the temperature of one representative sample.		P
	c) Instrumentation capable of measuring the irradiation of the UV light produced by the UV light source at the test plane of the module(s), within the wavelength ranges of 280 nm to 320 nm and 320 nm to 385 nm with an uncertainty of $\pm 15\%$.		P
	d) A UV light source capable of producing UV irradiation with an irradiance uniformity of $\pm 15\%$ over the test plane of the module(s) with no appreciable irradiance at wavelengths below 280 nm and capable of providing the necessary irradiation in the different spectral regions of interest as defined in 10.10.3.		P
11.10.3	Procedure		P
	a) Using the calibrated radiometer measure the irradiance at the proposed module test plane and assure that at wavelengths between 280 nm and 385 nm it does not exceed $250\text{ W}\cdot\text{m}^{-2}$ (i.e. about five times the natural sunlight level) and that it has a uniformity of $\pm 15\%$ over the test plane.		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	b) Mount an open-circuited module in the test plane at the location selected in a), normal to the UV irradiance beam. Make sure that the module temperature is $60\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.		P
	c) Subject the module(s) to a total UV irradiation of $15\text{ kWh}\cdot\text{m}^{-2}$ in the wavelength range between 280 nm and 385 nm, with at least $5\text{ kWh}\cdot\text{m}^{-2}$ in the wavelength band between 280 nm and 320 nm, while maintaining the module temperature within the prescribed range.	Performed	P
	d) Means for applying a current equal to the STC peak power current of the module(s) under test.		P
	e) Means for monitoring the flow of current through each module during the test.		P
11.11.3	Procedure		P
	a) Install the module(s) at room temperature in the chamber.		P
	b) Connect the temperature monitoring equipment to the temperature sensor(s). Connect each module to the appropriate current supply by connecting the positive terminal of the module to the positive terminal of the power supply and the second terminal accordingly. During the 200 thermal cycle test set the current flow to the measured STC peak power current within $\pm 2\%$. Current flow shall only be maintained when the module temperature is above $25\text{ }^{\circ}\text{C}$. During the 50 thermal cycle test no current flow is required.		P
	c) Close the chamber and subject the module(s) to cycling between module temperatures of $-40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ and $+85\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$, in accordance with the profile in Figure 11. The rate of change of temperature between the low and high extremes shall not exceed $100\text{ }^{\circ}\text{C/h}$ and the module temperature shall remain stable at each extreme for a period of at least 10 min. The cycle time shall not exceed 6 h unless the module has such a high heat capacity that a longer cycle is required. The number of cycles shall be as shown in the relevant blocks in Figure 1.		P
	d) Throughout the test, record the module temperature and monitor the current flow through		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	the module(s).		
11.11.4	Final measurements		P
	After a minimum recovery time of 1 h, repeat the tests of 10.1, 10.2 and 10.3.	Retested	P
11.11.5	Requirements		P
	The requirements are as follows:	No below defects	P
	– no interruption of current flow during the test;		P
	– no evidence of major visual defects, as defined in Clause 7;		P
	– the degradation of maximum output power shall not exceed 5 % of the value measured before the test;		P
	– insulation resistance shall meet the same requirements as for the initial measurements.		P
11.12	Humidity-freeze test		P
	e) Means for monitoring the flow of current through each module during the test.		P
11.11.3	Procedure		P
11.12.1	Purpose		P
	The purpose of this test is to determine the ability of the module to withstand the effects of high temperature and humidity followed by sub-zero temperatures. This is not a thermal shock test		P
11.12.2	Apparatus		P
	a) A climatic chamber with automatic temperature and humidity control, capable of subjecting one or more modules to the humidity-freeze cycle specified in Figure 12.	85%RH, 20h, no RH, 4h, total 10C	P
	b) Means for mounting or supporting the module(s) in the chamber, so as to allow free circulation of the surrounding air. The thermal conduction of the mount or support shall be low, so that, for practical purposes, the module(s) is (are) thermally isolated.		P
	c) Means for measuring and recording the module temperature to an accuracy of ± 1 °C. (It is sufficient to monitor the temperature of one representative sample, if more than one module is being tested.)	One module to test	P
11.12.3	Procedure		P
	a) Attach a suitable temperature sensor to the front or back surface of the module(s) near the		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	middle.		
	b) Install the module(s) at room temperature in the climatic chamber.		P
	c) Connect the temperature monitoring equipment to the temperature sensor(s).		P
	d) After closing the chamber, subject the module(s) to 10 complete cycles in accordance with the profile in Figure 12. The maximum and minimum temperatures shall be within ± 2 °C of the specified levels and the relative humidity shall be maintained within ± 5 % of the specified value at all temperatures above room temperature. Performed P e) Throughout the test, record the module temperature.		P
11.12.4	Final measurements		P
	After a recovery time between 2 h and 4 h, repeat the test of 10.3. Repeat the tests of 10.1 and 10.2.	Retested	P
11.12.5	Requirements		P
	The requirements are as follows:		P
	– no evidence of major visual defects, as defined in Clause 7;	No defects Complied with Clause 8	P
	– the degradation of maximum output power shall not exceed 5 % of the value measured before the test;	500W	P
	– insulation resistance shall meet the same requirements as for the initial measurements.		P
11.13	Damp-heat test		P
11.13.1	Purpose		P
	To determine the ability of the module to withstand the effects of long-term penetration of humidity.		P
11.13.2	Procedure		P
	The test shall be carried out in accordance with IEC 60068-2-78 with the following provisions:		P
	a) Preconditioning		P
	The module(s), being at room temperature, shall be introduced into the chamber without preconditioning.		P
	The module(s), being at room temperature, shall be introduced into the chamber without preconditioning.		P
	b) Severities		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	The following severities are applied:		P
	Test temperature: 85 °C ± 2 °C	84 °C	P
	Relative humidity: 85 % ± 5 %	88 %	P
	Test duration: 1 000 h	1000h	P
11.13.3	Final measurements		P
	After a recovery time between 2 h and 4 h, repeat the tests of 10.3 and 10.15. Repeat the tests of 10.1 and 10.2.		P
11.13.4	Repeat the tests of 10.1 and 10.2.		P
	The requirements are as follows:	Comply with below requirements	P
	– no evidence of major visual defects, as defined in Clause 7;		P
	– the degradation of maximum output power shall not exceed 5 % of the value measured before the test;		P
	– the insulation test and the wet leakage current test shall meet the same requirements as for the initial measurements.		P
11.14	Robustness of terminations test		P
11.14.1	Purpose		P
	To determine that the terminations and the attachment of the terminations to the body of the module will withstand such stresses as are likely to be applied during normal assembly or handling operations.		P
11.14.2	Types of terminations		P
	Three types of module terminations are considered:		P
	– type A: wire or flying lead		N
	– type B: tags, threaded studs, screws, etc.;		P
	– type C: connector.		N
11.14.3	Procedure		P
	Preconditioning: 1 h at standard atmospheric conditions for measurement and test.		P
11.14.3.1	Type A terminations		N

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	Tensile test: as described in IEC 60068-2-21, test Ua, with the following provisions:		N
	– all terminations shall be tested;		N
	– tensile force shall never exceed the module weight.		N
	Bending test: as described in IEC 60068-2-21, test Ub, with the following provisions:		N
	– all terminations shall be tested;		N
	– method 1-10 cycles (1 cycle is 1 bend in each opposite direction).		N
11.14.3.2	Type B terminations		P
	Tensile and bending tests:	Performed	P
	a) for modules with exposed terminals, each termination shall be tested as for type A terminations;		N
	b) if the terminations are enclosed in a protective box, the following procedure shall be applied:	Use protective box	P
	– a cable of the size and type recommended by the module manufacturer, cut to a suitable length, shall be connected to the terminations inside the box using the manufacturer's recommended procedures. The cable shall be taken through the hole of the cable gland, taking care to utilize any cable clamp arrangement provided. The lid of the box shall be securely replaced. The module shall then be tested as for type A terminations.		P
	Torque test: as described in IEC 60068-2-21, test Ud with the following provisions:		P
	– all terminations shall be tested;		P
	– severity		P
	The nuts or screws should be capable of being loosened afterwards unless they are specifically designed for permanent attachment.		P
11.14.3.3	Type C terminations		N
	A cable of the size and type recommended by the module manufacturer, cut to a suitable length, shall be connected to the output end of the connector and the tests for type A terminations shall be carried out.		N
11.14.4	Final measurements		P
	Repeat the tests of 10.1, 10.2 and 10.3.		P
11.14.5	Requirements		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	The requirements are as follows:	Comply with below requirements	P
	– no evidence of mechanical damage;		P
	– the degradation of maximum output power shall not exceed 5 % of the value measured before the test;		P
	– insulation resistance shall meet the same requirements as for the initial measurements.		P
11.15	Wet leakage current test		P
11.15.1	Purpose		P
	To evaluate the insulation of the module under wet operating conditions and verify that moisture from rain, fog, dew or melted snow does not enter the active parts of the module circuitry, where it might cause corrosion, a ground fault or a safety hazard.		P
11.15.2	Apparatus		P
	a) A shallow trough or tank of sufficient size to enable the module with frame to be placed in the solution in a flat, horizontal position. It shall contain a water/wetting agent solution meeting the following requirements:		P
	Resistivity: 3 500 $\Omega \cdot \text{cm}$ or less	$\leq 3\,500\,\Omega \cdot \text{cm}$	P
	Surface tension: 0,03 $\text{N} \cdot \text{m}^{-1}$ or less	$\leq 0,03\,\text{N} \cdot \text{m}^{-1}$	P
	Temperature: 22 $^{\circ}\text{C} \pm 3\,^{\circ}\text{C}$	(21~23) $^{\circ}\text{C}$	P
	The depth of the solution shall be sufficient to cover all surfaces except junction box entries not designed for immersion.		P
	b) Spray equipment containing the same solution.		P
	c) DC voltage source, with current limitation, capable of applying 500 V or the maximum rated system voltage of the module, whichever is more.	1000V	P
	d) Instrument to measure insulation resistance.	Insulation Resistance Meter	P
11.15.3	Procedure		P
	All connections shall be representative of the recommended field wiring installation and precautions shall be taken to ensure that leakage currents do not originate from the instrumentation wiring attached to the module.		P
	a) Immerse the module in the tank of the required solution to a depth sufficient to cover all surfaces except junction box entries not designed for immersion. The cable entries shall be thoroughly		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	sprayed with solution. If the module is provided with a mating connector, the connector should be immersed during the test.		
	b) Connect the shorted output terminals of the module to the positive terminal of the test equipment. Connect the liquid test solution to the negative terminal of the test equipment using a suitable metallic conductor.		P
	c) Increase the voltage applied by the test equipment at a rate not to exceed $500 \text{ V} \cdot \text{s}^{-1}$ to 500 V or the maximum system voltage for the module, whichever is greater. Maintain the voltage at this level for 2 min. Then determine the insulation resistance.	1000 V	P
	d) Reduce the applied voltage to zero and shortcircuit the terminals of the test equipment to discharge the voltage build-up on the module.		P
11.15.4	Requirements		P
	The requirements are as follows:		P
	– For modules with an area of less than $0,1 \text{ m}^2$ the insulation resistance shall be not less than 400 M Ω .		P
	– For modules with an area larger than $0,1 \text{ m}^2$ the measured insulation resistance times the area of the module shall be not less than 40 M $\Omega \cdot \text{m}^2$.	$> 100 \text{ M}\Omega \cdot \text{m}^2$	P
11.16	Mechanical load test		P
11.16.1	Purpose		P
	The purpose of this test is to determine the ability of the module to withstand wind, snow, static or ice loads.		P
11.16.2	Apparatus		P
	a) A rigid test base which enables the modules to be mounted front-side up or front-side down. The test base shall enable the module to deflect freely during the load application.		P
	b) Instrumentation to monitor the electrical continuity of the module during the test.		P
	c) Suitable weights or pressure means that enable the load to be applied in a gradual, uniform manner.		P
11.16.3	Procedure		P
	a) Equip the module so that the electrical	Installed According to product	P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	continuity of the internal circuit can be monitored continuously during the test.	manual	
	b) Mount the module on a rigid structure using the method prescribed by the manufacturer. (If there are different possibilities, use the worst one, where the distance between the fixing points is at maximum.)		P
	c) On the front surface, apply gradually a load corresponding to 2 400 Pa, spread uniformly. (This load may be applied pneumatically or by means of weights covering the entire surface. In the latter case, the module shall be mounted horizontally.) Maintain this load for 1 h.	Performed	P
	d) Apply the same procedure on the back surface of the module.		P
	e) Repeat steps c) and d) for a total of three cycles.		P
11.16.4	Final measurements		P
	Repeat the tests of 10.1, 10.2 and 10.3.		P
11.16.5	Requirements		P
	a) Equip the module so that the electrical continuity of the internal circuit can be monitored continuously during the test.	Installed According to product manual	P
	b) Mount the module on a rigid structure using the method prescribed by the manufacturer. (If there are different possibilities, use the worst one, where the distance between the fixing points is at maximum.)		P
	c) On the front surface, apply gradually a load corresponding to 2 400 Pa, spread uniformly. (This load may be applied pneumatically or by means of weights covering the entire surface. In the latter case, the module shall be mounted horizontally.) Maintain this load for 1 h.	Performed	P
	d) Apply the same procedure on the back surface of the module.		P
	e) Repeat steps c) and d) for a total of three cycles.		P
11.16.4	Final measurements		P
	Repeat the tests of 10.1, 10.2 and 10.3.		P
11.16.5	Requirements		P
	The requirements are as follows	Comply with below	P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
		Requirements	
	-no intermittent open-circuit fault detected during the test		P
	-no evidence of major visual defects, as defined in Clause 7;		P
	-the degradation of maximum output power shall not exceed 5 % of the value measured before the test;		P
	– insulation resistance shall meet the same requirements as for the initial measurements.		P
10.17	Hail test		P
10.17.1	Purpose		P
	To verify that the module is capable of withstanding the impact of hailstones.	Performed	P
11.17.2	Apparatus		P
	a) Moulds of suitable material for casting spherical ice balls of the required diameter. The standard diameter shall be 25 mm but any of the other diameters listed in Table 2 may be specified for special environments.		P
	b) A freezer, controlled at $-10\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$. P		P
	c) A storage container for storing the ice balls at a temperature of $-4\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$		P
	d) A launcher capable of propelling an ice ball at the specified velocity, within $\pm 5\%$, so as to hit the module within the specified impact location. The path of the ice ball from the launcher to the module may be horizontal, vertical or at any intermediate angle, so long as the test requirements are met.		P
	e) A rigid mount for supporting the test module by the method prescribed by the manufacturer, with the impact surface normal to the path of the projected ice ball.		P
	f) A balance for determining the mass of an ice ball to an accuracy of $\pm 2\%$.		P
	g) Un instrument pour mesurer la vitesse de la bille de glace avec une précision de $\pm 2\%$. Le capteur de vitesse doit être placé à moins de 1 m de la surface du module en essai.		P
	An instrument for measuring the velocity of the ice ball to an accuracy of $\pm 2\%$. The velocity sensor shall be no more than 1 m from the surface		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	of the test module.		
	As an example, Figure 13 shows in schematic form a suitable apparatus comprising a horizontal pneumatic launcher, a vertical module mount and a velocity meter which measures electronically the time it takes the ice ball to traverse the distance between two light beams. This is only one example as other types of apparatus including slingshots and spring driven testers have been successfully utilized.		P
11.17.3	Procedure		P
	a) Using the moulds and the freezer, make sufficient ice balls of the required size for the test, including some for the preliminary adjustment of the launcher.		P
	b) Examine each one for cracks, size and mass. An acceptable ball shall meet the following criteria:		P
	– no cracks visible to the unaided eye		P
	– diameter within $\pm 5\%$ of that required;		P
	– mass within $\pm 5\%$ of the appropriate nominal value in Table 2.		P
	c) Place the balls in the storage container and leave them there for at least 1 h before use.		P
	d) Ensure that all surfaces of the launcher likely to be in contact with the ice balls are near room temperature.		P
	e) Fire a number of trial shots at a simulated target in accordance with step g) below and adjust the launcher until the velocity of the ice ball, as measured with the velocity sensor in the prescribed position, is within $\pm 5\%$ of the appropriate hailstone test velocity in Table 2.		P
	f) Install the module at room temperature in the prescribed mount, with the impact surface normal to the path of the ice ball.		P
	g) Take an ice ball from the storage container and place it in the launcher. Take aim at the first impact location specified in Table 3 and fire. The time between the removal of the ice ball from the container and impact on the module shall not exceed 60 s.		P
	h) Inspect the module in the impact area for signs		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	of damage and make a note of any visual effects of the shot. Errors of up to 10 mm from the specified location are acceptable.		
	i) If the module is undamaged, repeat steps g) and h) for all the other impact locations in Table 3, as illustrated in Figure 14.		P
11.17.4	Final measurements		P
	Repeat the tests of 10.1, 10.2 and 10.3.		P
11.17.5	Requirements		P
	The requirements are as follows:		P
	– no evidence of major visual defects, as defined in Clause 7;		P
	– the degradation of maximum output power shall not exceed 5 % of the value measured before the test;		P
	– insulation resistance shall meet the same requirements as for the initial measurements.		P
11.18	Bypass diode thermal test		P
11.18.1	Purpose		P
	To assess the adequacy of the thermal design and relative long-term reliability of the by-pass diodes used to limit the detrimental effects of module hotspot susceptibility.	Performed	P
11.18.2	Apparatus		P
	a) Means for heating the module to a temperature of $75^{\circ}\text{C} \pm 5^{\circ}\text{C}$.		P
	b) Means for measuring and recording the temperature of the module(s) to an accuracy of $\pm 1^{\circ}\text{C}$		P
	c) Means for measuring the temperature of any bypass diodes provided with the module. Care should be taken to minimize any alteration of the properties of the diode or its heat transfer path.		P
	d) Means for applying a current equal to 1,25 times the STC short-circuit current of the module under test and means for monitoring the flow of current through the module, throughout the test.		P
11.18.3	Procedure		P
	a) Electrically short any blocking diodes incorporated in the module.		P
	b) Determine the rated STC short-circuit current of the module from its label or instruction sheet.		P

IEC 61215-1			
Clause	Requirement Test	Result - Remark	Verdict
	c) Prepare to measure the temperature of the bypass diodes during the test.		P
	d) Connect wires of the manufacturer's minimum recommended wire gauge to the output terminals of the module. Follow the manufacturer's recommendations for wire entry into the wiring compartment and replace the wire compartment cover.		P
	e) Heat the module to $75\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$. Apply a current to the module equal to the short circuit current of the module as measured at $\text{STC} \pm 2\%$. After 1 h measure the temperature of each bypass diode. Using the information provided by the diode manufacturer calculate the junction temperature from the measured case temperature and the power dissipated in the diode using the following formula.	75 °C	P
	f) Increase the applied current to 1,25 times the short-circuit current of the module as measured at STC while maintaining the module temperature at $75\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$. Maintain the current flow for 1 h.		P
	g) Verify that the diode is still operational.		P
11.18.4	Final measurements		P
	Repeat the tests of 10.1, 10.2 and 10.3.		P
11.18.5	Requirements		P
	The requirements are as follows:	Comply with below requirements	P
	– the diode junction temperature as determined in 10.18.3.e) shall not exceed the diode manufacturer's maximum junction temperature rating;		P
	– no evidence of major visual defects, as defined in Clause 7;	Performed	P
	– the degradation of maximum output power shall not exceed 5 % of the value measured before the test;		P
	– insulation resistance shall meet the same requirements as for the initial measurements;		P
	– the diode shall still function as a diode after the conclusion of the test.		P

Table 1-Testing condition

Test	Item	condition
11.1	Visual inspection	See 11.1.2
11.2	Maximum power determination	Comply with IEC 60904-1
11.3	Insulation test	1000V;time:1m';insulated resistance:≥50MΩ
11.4	Temperature modulus	Comply with IEC 60904-10
11.5	Measurement of nominal operating cell temperature (NOCT)	Total irradiance: 1000W/m ² Testing temperature: 25℃ Wind speed: 50m/s
11.6	Performance at STC and NOCT	Cell temperature: 25℃ and NOCT Irradiance:1000 and 800W/m ²
11.7	Performance at low irradiance	Cell temperature: 25℃
11.8	Outdoor exposure test	Irradiance: 1000 W/m ²
11.9	Hot-spot endurance test	Total irradiance: 60kW/m ²
11.10	UV preconditioning test	UV: 280nm~385nm Total irradiance: 15kW/m ²
11.11	Hot-circle test	-40℃ to +80℃ 50 and 200 times repeat
11.12	Humidity-freeze test	Humidity: 85%+85℃ to -40℃ 10 times repeat
11.13	Damp-heat test	+85℃; 85% humidity; 1000h
11.14	Robustness of terminations test	Comply IEC 60068-2-21
11.15	Wet leakage current test	See 11.14
11.16	Mechanical load test	2400Pa load; 1h; 2 times repeat
11.17	Hail test	25mm; 23m/s; 11 times strike
11.18	Bypass diode thermal test	75℃ and Isc; 1h 75℃ and 1.25Isc; 1h

Table 2 - Crystalline silicon Tempered glass Photovoltaic (PV) Solar Module

Parameters	Type	GKAXXX (XXX STAND FOR 1W-600W)
	Silicon	Polycrystalline
Maximum Power Watt		330W
Production Tolerance		±3%
Maximum Power voltage	V	37.30
Maximum Power current	A	8.85
Open circuit voltage	V	45.90
Short circuit current	A	9.26
size of module(wide and high)		1956*992*40mm
Surface		Low iron tempered glass
frame (type, material and thickness)		Anodized Aluminium frame, 40mm thickness

number of cells	156
Weight per piece Kgs	22.5kg
type of junction box	PV junction box
cable type and length, connector type	PV cable, 900mm Plug and socket MC4
maximum system voltage	1000VDC
NOCT (Nominal operating cell temperature)	25°C
Dielectric Isolation	1000VDC max
Storage temperature	-40°C - +85°C
Wind Bearing	60m/s(200kg/sq.m)
Impact Resistance Hail Impact Test	227g steel ball fall down from 1m height
Quality warranty	20 years 90% and 30 years 80% of power output

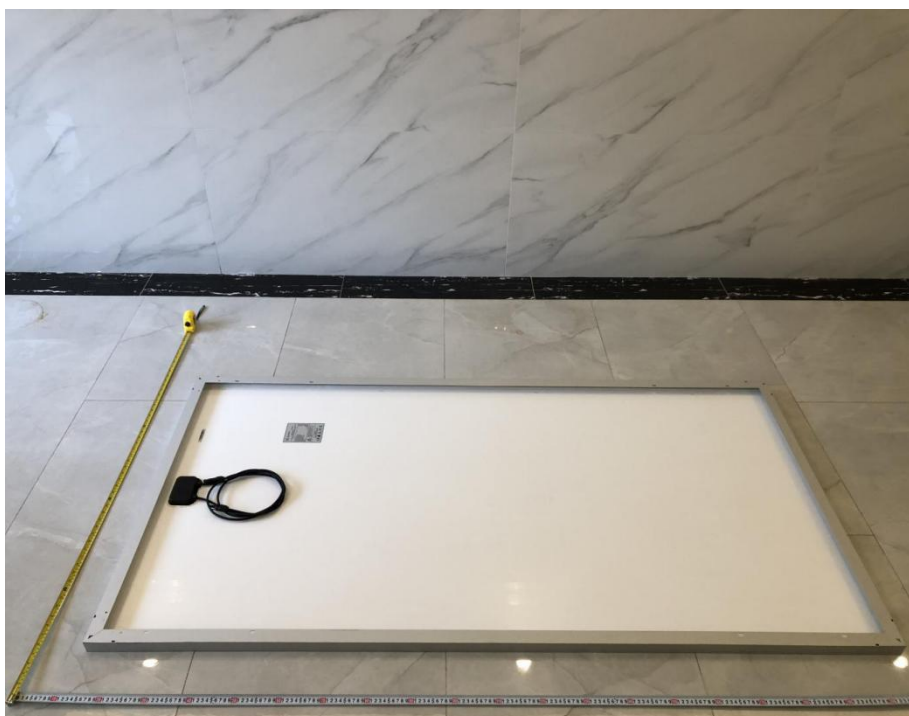
APPENDIX I

(Photos of the EUT)

EUT Photo 1



EUT Photo 2



EUT Photo 3



EUT Photo 4



***** END OF REPORT *****