

TECHNICAL SPECIFICATION

Terrestrial photovoltaic (PV) modules for consumer products – Design qualification and type approval

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TECHNICAL SPECIFICATION

Terrestrial photovoltaic (PV) modules for consumer products – Design qualification and type approval

INTERNATIONAL
ELECTROTECHNICAL
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The text of this document is based on the following documents:

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Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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TERRESTRIAL PHOTOVOLTAIC (PV) MODULES FOR CONSUMER PRODUCTS – DESIGN QUALIFICATION AND TYPE APPROVAL

1 Scope

This document is intended to apply to terrestrial modules for consumer applications for outdoor operation shorter than those qualified to IEC 61215. The useful service life of modules so qualified depends on their design, their environment and the conditions under which they are operated.

This document classes those PV modules into Category 1, Category 2, and Category 3 with respectively low, medium and high expected outdoor exposure. For the purposes of designing this document, Category 1 (mobile applications) is for applications such as smart phone charging which most likely have “low” outdoor exposure. Category 2 (portable applications) is for emergency power/hiking/camping applications with “medium” outdoor exposure and it needs to have mechanical durability testing due to repeated deployment, potential for being dropped, and other mechanical stresses. Category 3 (attached applications) is for “high” outdoor exposure for applications, such as for motor homes, but is not intended for long-term utility or long-term household rooftop applications. A summary of product categories and potential applications is presented in Annex A.

Category 1 products are intended for installation where general user access and contact to uninsulated live parts is anticipated. Modules are not be combined in series strings operating at more than 35 V (V_{oc}) and do not have a system voltage rating above 35 V. These PV modules are not intended for use in parallel with other PV modules or energy sources, unless the combination provides protection from reverse current and overvoltage protection. The short-circuit current is less than 8 A and the maximum power is less than 240 W when tested under standard test conditions.

This document does not address the particularities of PV modules with integrated electronics, such as energy storage devices, charge controllers, batteries, inverters which may be sold in conjunction with the PV modules. This specification is intended to qualify the PV portion of these devices. It may, however, be used as a basis for testing such PV modules, but does not qualify the electronic portion.

This document does not apply to modules used with concentrators.

The purpose of the test sequence is to determine the electrical, thermal, and mechanical durability characteristics of the module, and to show that the module is capable of withstanding outdoor exposure for different outdoor durations designated as “low”, “medium”, and “high”. Mobile and attached applications are considered to require lower mechanical durability than portable applications, which are more prone to mechanical damage. However, the actual outdoor exposure limits of the modules depend on their design, their environment and the conditions under which they are operated.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60269-6, *Low-voltage fuses – Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems*

IEC 60904-1, *Photovoltaic devices – Part 1: Measurement of photovoltaic current-voltage characteristics*

IEC TS 60904-1-2:2019, *Photovoltaic devices – Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices*

IEC 60904-3, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61215-1:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements*

IEC 61215-1-1:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-1: Special requirements for testing of crystalline silicon photovoltaic (PV) modules*

IEC 61215-1-2:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-2: Special requirements for testing of thin-film Cadmium Telluride (CdTe) based photovoltaic (PV) modules*

IEC 61215-1-3:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-3: Special requirements for testing of thin-film amorphous silicon based photovoltaic (PV) modules*

IEC 61215-1-4:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se)₂ based photovoltaic (PV) modules*

IEC 61215-2:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures*

IEC 61730-1, *Photovoltaic (PV) module safety qualification – Part 1 Requirements for construction*

IEC 61730-2, *Photovoltaic (PV) module safety qualification – Part 2 Requirements for testing*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

IEC TS 62915, *Photovoltaic (PV) modules – Type approval, design and safety qualification – Retesting*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC TS 61836 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

flexible module

PV module that exhibits a radius of curvature of 500 mm or less in at least one direction according to the manufacturer's specification and is capable of bending to conform to a flat or curved surface

Note 1 to entry: A curved module with a rigid shape is not considered a flexible module.

Note 2 to entry: Radius of curvature is defined as shown in Figure 1. During testing, the applied radius of curvature is no smaller than that specified by the manufacturer.

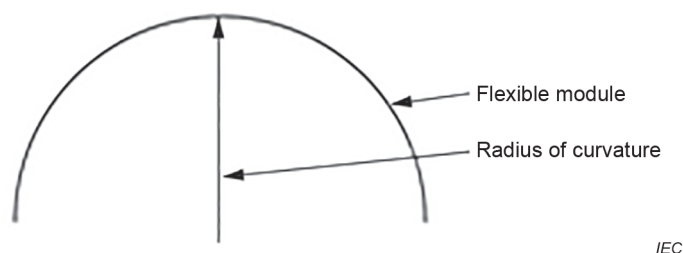


Figure 1 – Geometry that shows radius of curvature of a flexible module

[SOURCE: IEC 61215-1:2021, 3.6]

3.2 foldable module

PV module that is separated into distinct PV sections nominally of the same size and connected by a section that does not contain cells, but has the interconnecting busbars

3.3 representative sample

sample that includes all the components of the module, except some repeated parts

Note 1 to entry: The representative samples shall use all key materials and subassemblies, as detailed in Clause 4 of IEC 61215-1:2021.

3.4 very large module

module that exceeds the size of standard 2,2 m × 1,5 m commercially-available simulators

Note 1 to entry: A very large module exceeds 2,2 m in length or width, or exceeds 1,5 m in both dimensions. Thus a 3 m × 0,3 m module is considered very large, as is a 2,2 m × 2,2 m module.

Note 2 to entry: Very large modules are exempt from class A simulator spatial irradiance uniformity requirements, as detailed in IEC 61215-2 MQT 02.

Note 3 to entry: During test sequences representative samples may be substituted for very large modules, within the limits described in Clause 4.

Note 4 to entry: In future editions, the size threshold to be considered a very large module will likely increase to larger dimensions.

[SOURCE: IEC 61215-1:2021, 3.8]

3.5 consumer product category 1 (mobile applications)

PV module for applications such as smart phone charging with low outdoor exposure

Note 1 to entry: Modules shall not be combined in series strings operating at more than 35 V (V_{oc}) and shall not have a system voltage rating above 35 V.

3.6 consumer product category 2 (portable applications)

PV module applications such as used for emergency power/hiking/camping applications with medium outdoor exposure and mechanical strength withstanding repeated deployment, potential for being dropped, and other mechanical stresses

3.7 consumer product category 3 (attached applications)

PV module for attached applications with high outdoor exposure, such as for motor homes, but not for long-term utility or household rooftop applications

3.8 consumer product module quality test CQMT

3.9

bifacial PV modules

modules that can convert irradiation received on both the front-side and rear-side into electric energy by means of the photovoltaic effect

[SOURCE: IEC 61215-1:2021, 3.9]

3.10

bifaciality coefficients

ratios between the I - V characteristics of the rear-side and the front-side of a bifacial module each measured under Standard Test Conditions (STC – IEC TS 61836), namely the short-circuit current bifaciality coefficient ϕ_{ISC} , the open-circuit voltage bifaciality coefficient ϕ_{VOC} and the maximum power bifaciality coefficient ϕ_{Pmax}

Note 1 to entry: Bifaciality coefficients are fully defined in IEC TS 60904-1-2:2019, 6.2.

[SOURCE: IEC 61215-1:2021, 3.10]

3.11

bifacial nameplate irradiance

BNPI

higher irradiance at which nameplate verification is performed for bifacial modules, corresponding to 1 000 W/m² on the module front and 135 W/m² on the module rear, applied in any method allowed by IEC TS 60904-1-2

[SOURCE: IEC 61215-1:2021, 3.11]

3.12

bifacial stress irradiance

higher irradiance at which currents for stress are measured on bifacial modules, corresponding to 1 000 W/m² on the module front and 300 W/m² on the module rear, applied by any method allowed in IEC TS 60904-1-2, I - V characteristic at which may be extrapolated from lower irradiances

[SOURCE: IEC 61215-1:2021, 3.12]

3.13

type approval

conformity test made on one or more items representative of the production

4 Selection of test samples

The PV module samples shall have been manufactured from specified materials and components in accordance with the relevant drawings and process sheets and have been subjected to the manufacturer's normal inspection, quality control and production acceptance procedures. The PV modules shall be complete in every detail and shall be accompanied by the manufacturer's handling, mounting, and connection instructions. When the PV modules to be tested are prototypes of a new design and not from production, this fact shall be noted in the test report (see Clause 8).

The number of test samples required is derived from the applicable test sequences.

For very large modules (as defined in 3.4), representative samples (as defined in 3.3) may be used for all qualification tests. During the design and manufacturing of the representative samples, attention should be paid to reach the maximum similarity to the full-size product in all electrical, mechanical, and thermal characteristics related to quality and reliability. The cell, encapsulation methods, interconnects, terminations, clearance and creepage distances around all edges, and distance through solid insulation (relied upon insulation and cemented joints) shall be the same as on the actual full-size products.

Limits are placed on how much one may reduce the dimensions of a very large module in making representative samples for qualification testing. In other words, when reducing the shorter dimension, the representative sample shall be at least 0,75 m wide. In reducing the longer dimension, the representative sample shall be at least 1,1 m long. If representative samples are used for any test, the test report shall include a table listing the dimensions of the product being qualified, and for each CMQT, the dimensions of the samples tested. The table shall contain the statement, "Smaller samples were used for some tests as noted above. Use of smaller samples may affect test results." However, for verification of power determination a standard production product shall be measured, either at the test facility or utilizing a test at the manufacturer monitored by the testing entity.

If representative samples are utilized in the damp heat sequence, then one extra module, full-sized, is required, and shall be subjected only to CMQT 10.12 (static mechanical load test) and the requirements therein.

Any representative sample used for CMQT 10.5 (hot-spot endurance test) shall contain the same number of cells per bypass diode (i.e. the same substring size) as the full-size product.

For modules containing bypass diodes which are not accessible in the standard modules as produced, a special sample can be prepared for the bypass diode thermal test (CMQT 10.13). Smaller modules in Category 1 or 2 which might have only a few cells and may not have bypass diodes do not need to undergo this test, however the remainder of the test sequence shall be applied.

For the requirements in the IEC 61215 series, a module shall be considered "bifacial" if the manufacturer claims bifaciality on the nameplate or datasheet, or if the module exhibits a maximum power bifaciality coefficient $\geq 20\%$. If a module is to be tested as a monofacial module, the test laboratory shall verify that the module is monofacial by at least one of the following methods:

- Information from the manufacturer showing that the rear of the cell is fully metallized;
- Spectrally-resolved backsheet transmission data from the module manufacturer; or
- Determination of bifaciality coefficient on one sample according to the procedure in IEC TS 60904-1-2.

5 Marking and documentation

5.1 Nameplate

Each module shall include the following clear and indelible markings for the Category 1, 2 and 3, whichever is applicable:

- a) full name of manufacturer or registered trademark of manufacturer;
- b) type or model number designation;
- c) category in accordance to IEC TS 63163
 - Consumer product Category 1: mobile applications or
 - Consumer product Category 2: portable applications or
 - Consumer product Category 3: attached applications;
- d) serial number (unless marked on other part of the product);
- e) date and place of manufacture; alternatively, serial number allowing to trace the date and place of manufacture;
- f) polarity of terminals or leads (colour coding is permissible);
- g) maximum system voltage;
- h) class of protection against electrical shock (as defined in IEC 61140 and IEC 61730-1);
- i) voltage at open-circuit or V_{OC} including tolerances; For bifacial modules, open-circuit voltage shall be reported at two irradiance levels. The first required irradiance level is 1 000 W/m². The second required irradiance is BNPI, as defined in IEC 61215-1:2021, 3.11;

- j) current at short-circuit or I_{SC} including tolerances; For bifacial modules, short-circuit current shall be reported at two irradiance levels, defined in 5.1i);
- k) module maximum power or P_{max} including tolerances. The minimum value of maximum output power refers to the lowest stabilized power that the manufacturer specifies for the product type (after stabilization). For bifacial modules, P_{max} shall be reported at the two irradiance levels, defined in 5.1i); for bifacial modules the following information including tolerances, shall be given on the nameplate: The values for the short-circuit current bifaciality coefficient ϕ_{Isc} , the open-circuit voltage bifaciality coefficient $\phi_{V_{OC}}$, and the maximum power bifaciality coefficient $\phi_{P_{max}}$, measured at STC as defined in IEC TS 60904-1-2;
- l) for flexible modules, the minimum allowable radius of curvature and if more than one direction to list all the values;
- m) all electrical data shall be shown as relative to STC (1 000 W/m², 25 °C, AM1.5) according to IEC TS 61836), except for bifacial modules where two irradiance levels are required, as defined in 5.1i);
- n) for category 1 module, the statement that this “module cannot be connected to other PV modules or other power sources unless the combination provides protection from reverse current and overvoltage protection”;
- o) for category 3 to state that “modules are not to be used for utility scale or roof top applications”;

International symbols shall be used where applicable.

Compliance of marking is checked by inspection and IEC 61215-2:2021 MQT 06.1.

5.2 Documentation

5.2.1 Minimum requirements

Modules should meet the minimum requirements as specified in IEC 61215-1:2021, 5.2.1.

5.2.2 Information to be given in the documentation

- a) all information required under 5.1g) through k) and in addition l) for bi-facial and m) for flexible modules;
- b) for category 2 and 3: reverse current overload per IEC 61730-2 MST 26;
 - overcurrent protection device type and rating are given in IEC 60269-6. Overcurrent protection devices with a 1 h, 1,35 I_n overload rating, where I_n is the rated value of the overcurrent protection device, are recommended.
 - recommended maximum series/parallel PV module configurations;
- c) manufacturer's stated tolerance for V_{OC} , I_{SC} and maximum power output under standard test conditions;
- d) for Category 2 and 3 the documentation should state that if the module is damaged it could create an electrical shock or fire hazard;
- e) all electrical data mentioned above shall be shown as relative to standard test conditions (1 000 W/m², 25 °C, AM1.5 according to IEC TS 61836).

International symbols shall be used where applicable.

Compliance is checked by inspection and IEC 61215-2:2021, 6.1.

The electrical documentation shall include a detailed description of electrical installation wiring method to be used. The description shall include:

- f) the items listed in IEC 61215-1:2021 (5.2.2 items h) through o);
- g) a statement indicating the fire rating(s) and the applied standard as well as the limitations to that rating (e.g., installation slope, sub structure or other applicable installation information);

NOTE Per IEC 61730-2, fire tests are nationally regulated and typically only required for building integrated or building added products. Hence, the applicability of a fire test does not depend on the class, but on the mounting location.

- h) a statement indicating the design load per each mechanical means for securing the module as evaluated during the static mechanical load test according to CMQT 10.12. At discretion of the manufacturer the test load and/or the safety factor γ_m may be noted, too;
- i) a statement stating that category 1 module “shall not be connected to other PV modules or other power sources unless the combination provides protection from reverse current and overvoltage protection”;
- j) a statement stating that a category 3 module “shall not to be used for utility scale or household roof top applications”.

To allow for increased output of a module resulting from certain conditions of use, the installation instructions shall include relevant parameters specified by manufacturer or the following statement or the equivalent:

"Under normal conditions, a photovoltaic module is likely to experience conditions that produce more current and/or voltage than reported at standard test conditions. Accordingly, the values of I_{SC} and V_{OC} marked on this module should be multiplied by a factor of 1.25 when determining component voltage ratings, conductor current ratings, and size of controls connected to the PV output."

5.2.3 Assembly instructions

These shall be provided with a product shipped in subassemblies and shall be detailed and adequate to the degree required to facilitate complete and safe assembly of the product.

6 Testing

6.1 General

The test laboratory shall use a laboratory simulator control module to be able to detect drifts in their measurement results. The laboratory simulator control module is different than the control module from Category 1 to 3 sequence which is taken from the modules under test. The laboratory simulator control module is a stable module used on a periodic basis to check simulator output after calibration to a specific irradiance.

The modules shall be subjected to the qualification test sequences in Figure 2, Figure 3 or Figure 4 carried out in the specified order. Each box refers to the corresponding subclause in this document. Test procedures and severities, including initial and final measurements where necessary are detailed in Clause 10.

For diagnostic purposes, intermediate measurements of power as detailed in (CMQT 06.1, Table 1) may be undertaken before and after individual tests.

The control module should be taken from the samples being delivered. The control module shall be stored in accordance with the manufacturer's recommendation.

In carrying out the tests, the manufacturer's handling, mounting and connection instructions are to be strictly observed.

Technologies can have different stabilization characteristics and the stabilization procedures are defined in IEC 61215-1-1, IEC 61215-1-2, IEC 61215-1-3 and IEC 61215-1-4. These procedures allow the modules to reach a stabilized condition before the final tests.

For flexible modules (see 3.1), the mounting substrate and adhesive or attachment means shall also be included in the test. If more than one mounting substrate or adhesive or attachment means is allowed per the manufacturer's specification, then the tests shall use the combination that is, considered to be the worst case. The chosen combination(s) shall be reported.

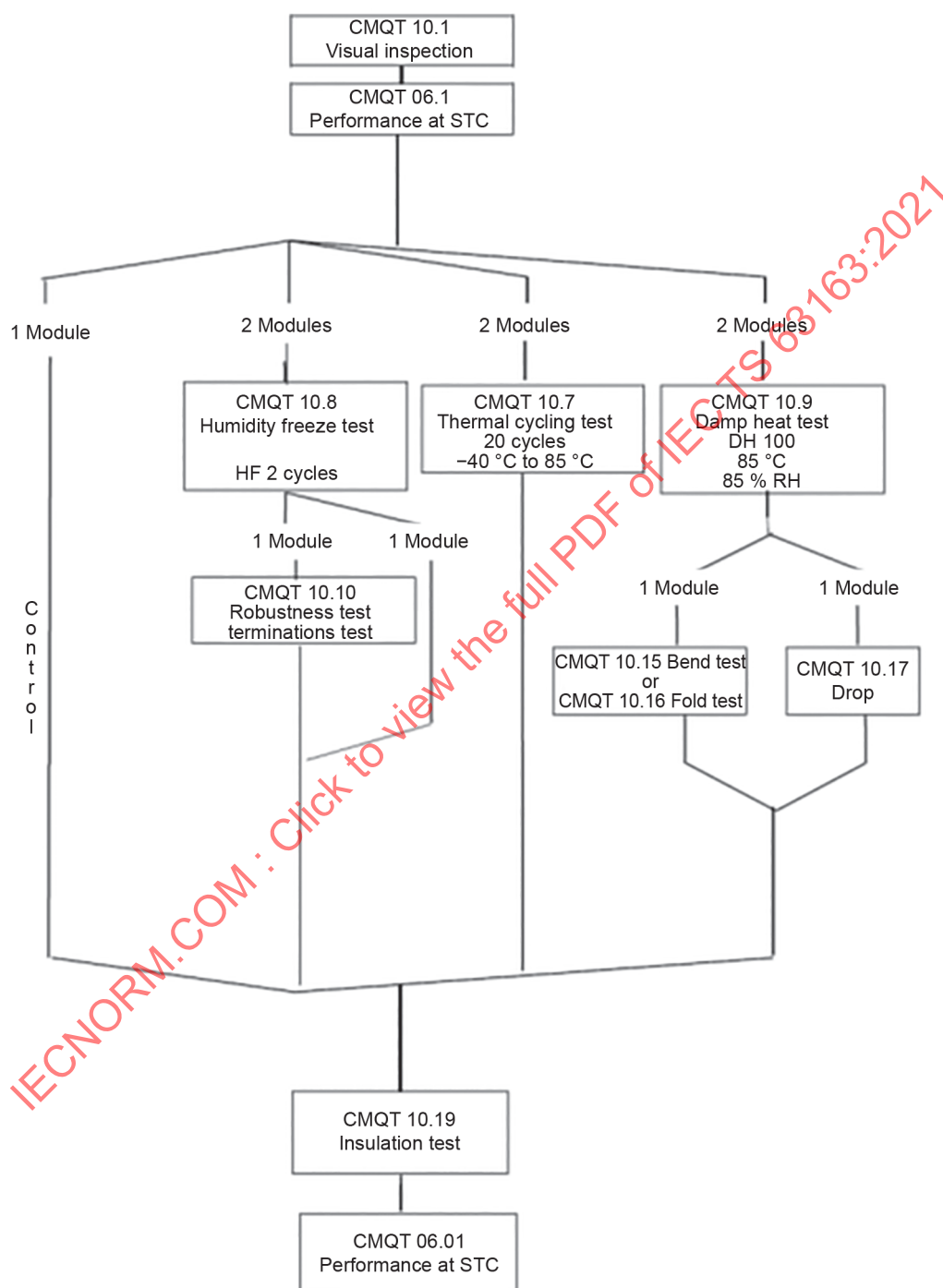
If the manufacturer specifies that the module can be bend in two or more directions, then all the directions shall be tested on the same sample.

Test conditions are summarized in 6.4.

The test levels in 6.4 are the minimum levels required for qualification. If the laboratory and the module manufacturer agree, the tests may be performed with increased severities.

6.2 Qualification test sequence – Category 1

The test flow chart is given in Figure 2.

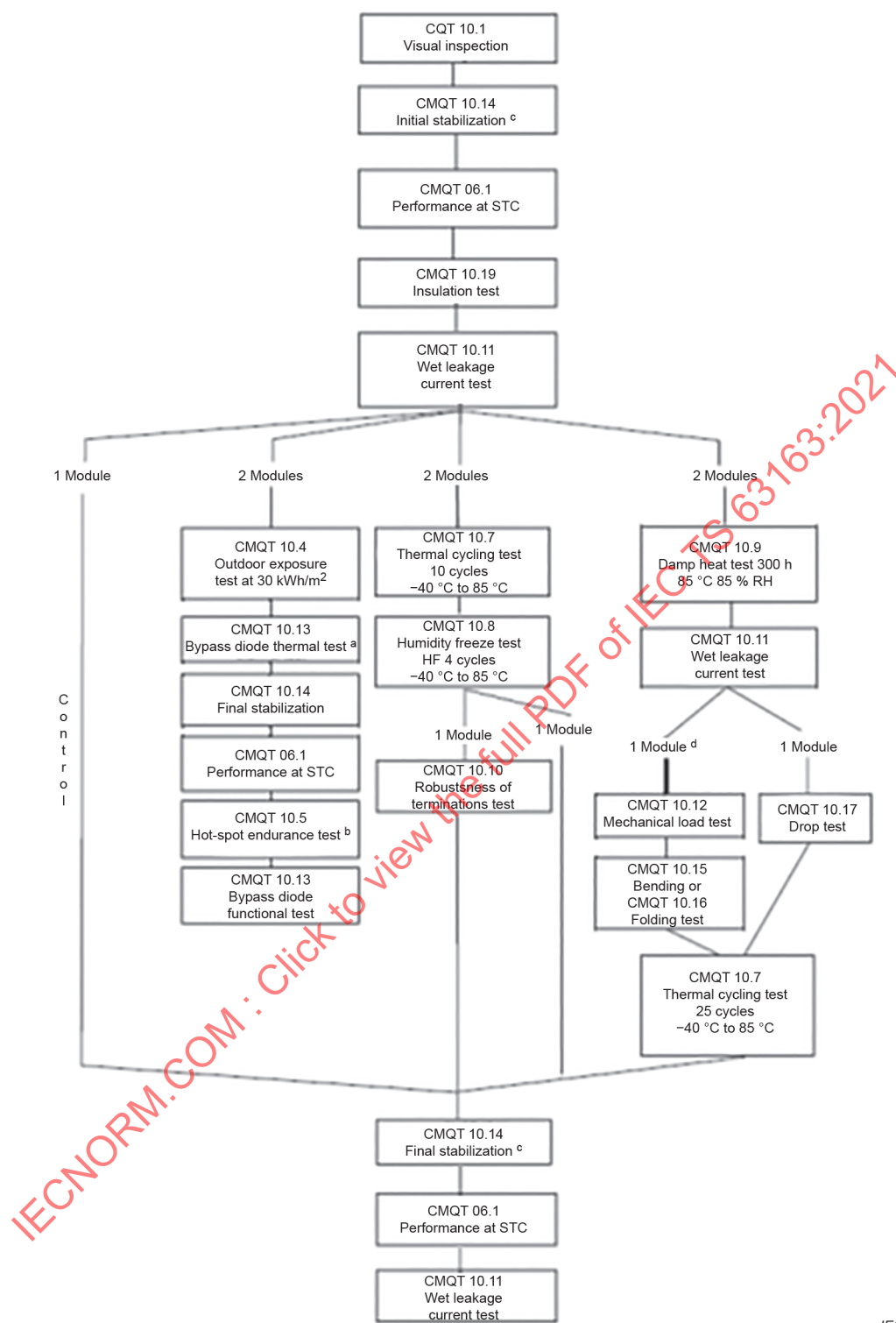


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Figure 2 – Qualification test sequence – Category 1

6.3 Qualification test sequence – Category 2

The test flow chart is given in Figure 3.



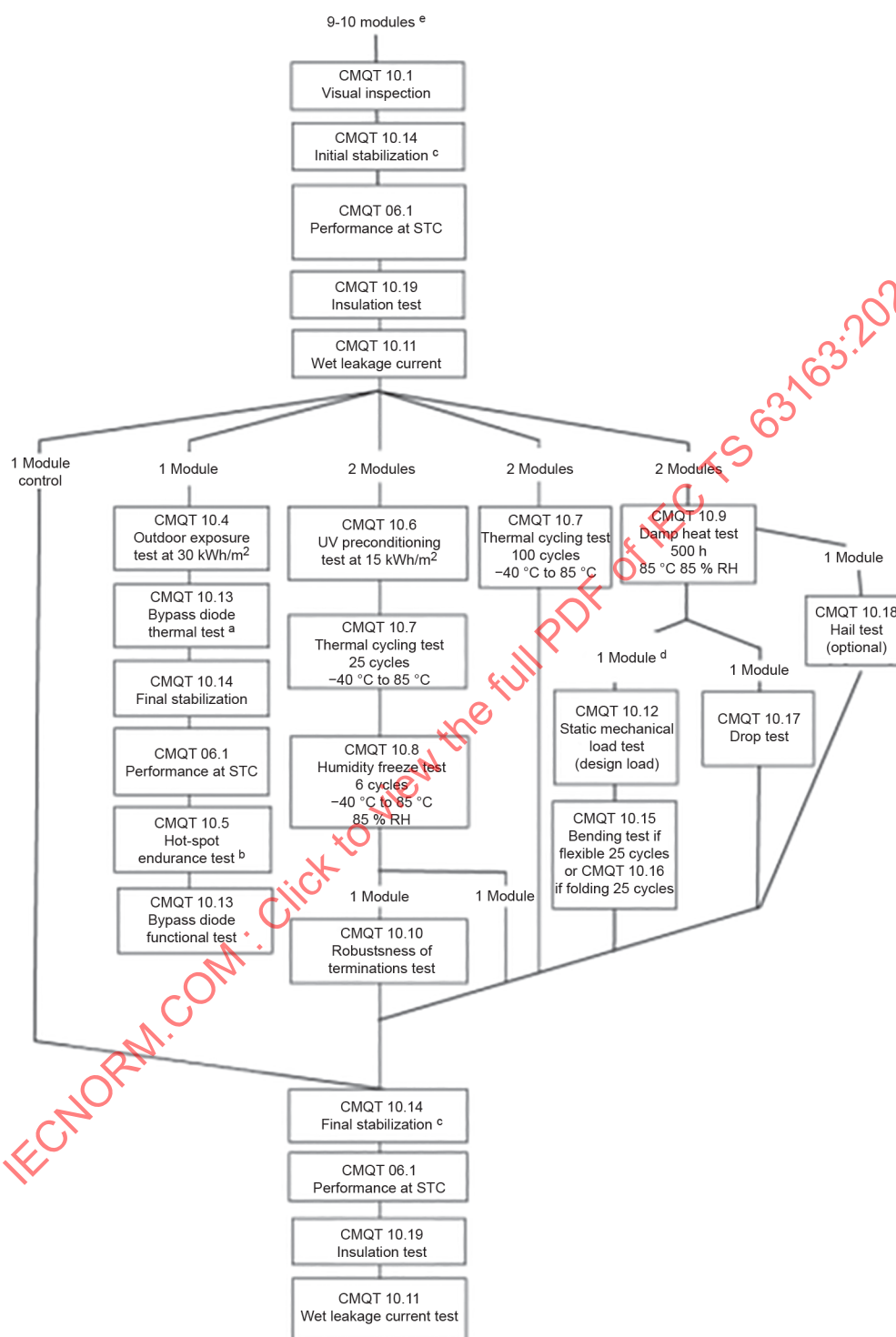
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- ^a If the bypass diodes are not accessible in the standard modules, a special sample can be prepared for the bypass diode thermal test CMQT 10.13 per MQT 18.1 per IEC 61215-2:2021. The bypass diode should be mounted physically as it would be in a standard module, with lead wires attached, as required in MQT 18 of IEC 61215-2:2021. This sample does not have to go through the other tests in the sequence.
- ^b In the outdoor exposure sequence, a different module may be used for the hot-spot endurance test (CMQT 10.5) than is used for the bypass thermal diode test (CMQT 10.13). For this separate module the following test sequence is permissible: CMQT 01, CMQT 10.14, CMQT 06.1, CMQT 10.11, CMQT 10.19, CMQT 10.5 and CMQT 10.12.
- ^c The stabilization CMQT 10.14 may include the verification of an alternate stabilization procedure (see IEC 61215-2:2021).
- ^d If representative samples are utilized in damp heat sequence, one extra module, full-sized, is required, and shall be subjected only to CMQT 10.12 and the requirements therein.

Figure 3 – Qualification test sequence – Category 2

6.4 Qualification test sequence – Category 3

The test flow chart is given in Figure 4.



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^a If the bypass diodes are not accessible in the standard modules, a special sample can be prepared for the bypass diode thermal test CMQT 10.13 per MQT 18.1 per IEC 61215-2:2021. The bypass diode should be mounted physically as it would be in a standard module, with lead wires attached, as required in MQT 18 of IEC 61215-2:2021. This sample does not have to go through the other tests in the sequence.

^b In the outdoor exposure sequence, a different module may be used for the hot-spot endurance test (CMQT 10.5) than is used for the bypass thermal diode test (CMQT 10.13). For this separate module the following test sequence is permissible: CMQT 01, CMQT 10.14, CMQT 06.1, CMQT 10.11, CMQT 10.19, CMQT 10.5 and CMQT 10.12.

^c The stabilization CMQT 10.14 may include the verification of an alternate stabilization procedure (see IEC 61215-2:2021).

^d If representative samples are utilized in damp heat sequence, one extra module, full-sized, is required, and shall be subjected only to CMQT 10.12 and the requirements therein.

^e If hail test is performed one more module is needed.

Figure 4 – Qualification test sequence – Category 3

6.5 Test conditions

A summary of the test conditions is given in Table 1.

Table 1 – Summary of test levels

Test	Title	IEC 63163	IEC 61215-2: 2021	Test conditions
10.1	Visual inspection	CMQT 10.1	MQT 01	Inspect each module under an illumination of not less than 1 000 lux
10.2	Performance at STC	CMQT 06.1	MQT 06.1	Cell temperature: 25 °C, Irradiance: 1 000 W/m ² (and BNPI, for bifacial modules) with IEC 60904-3 reference solar spectral irradiance distribution
10.3	Maximum power determination	CMQT 10.3	MQT 02	Current-voltage characteristic in accordance with IEC 60904-1 at a specific set of irradiance and temperature conditions
10.4	Outdoor exposure test	CMQT 10.4	MQT 08	Category 1: Not required Category 2: 30 kWh/m ² total solar irradiation under resistive load. Category 3: 60 kWh/m ² total solar irradiation under resistive load
10.5	Hot-spot endurance test	CMQT 10.5	MQT 09	Category 1: Not required Category 2 and 3: Exposure to irradiance in worst-case hot-spot condition as per the technology specific part of IEC 61215-2: 2021. For monofacial modules, irradiance is 1 000 W/m ² . For bifacial modules the irradiance is BSI.
10.6	UV preconditioning test	CMQT 10.6	MQT 10	Category 1 and 2: Not required Category 3: 15 kWh/m ² total UV irradiation in the wavelength range from 280 nm to 400 nm, with 3 % to 10 % UV irradiance in the wavelength range from 280 nm to 320 nm, at a module temperature of 60 °C. For bifacial modules, exposure is repeated on the rear side.
10.7	Thermal cycling test	CMQT 10.7	MQT 11	Category 1: TC 20 cycles from -40 °C to +85 °C Category 2: TC 25 cycles from -40 °C to +85 °C (TC 10 for the TC/HF sequence) Category 3: TC 100 cycles from -40 °C to +85 °C (TC 25 for UV/HF/TC sequence) (Optional) Category 1, 2 and 3: According to options provided in some of the technology specific parts of IEC 61215 series. Currently at this time it only applies to 61215-1-4 where a forward bias current can be applied.
10.8	Humidity-freeze test	CMQT 10.8	MQT 12	Category 1: 2 cycles from +85 °C, 85 % RH to -40 °C with circuit continuity monitoring Category 2: 4 cycles from +85 °C, 85 % RH to -40 °C with circuit continuity monitoring Category 3: 6 cycles from +85 °C, 85 % RH to -40 °C with circuit continuity monitoring (Optional) Category 1, 2 and 3: According to options provided in some of the technology-specific parts of IEC 61215 series. Currently at this time it only applies to 61215-1-4: where a forward bias current can be applied.
10.9	Damp heat test	CMQT 10.9	MQT 13	Category 1: 100 h at +85 °C, 85 % RH Category 2: 300 h at +85 °C, 85 % RH Category 3: 500 h at +85 °C, 85 % RH (Optional) Category 1, 2 and 3: With current as per technology specific per IEC 61215-2: 2021 (CMQT 13) or according to options provided in some of the technology-specific parts of IEC 61215 series. Currently at this time it only applies to 61215-1-4: where a forward bias current can be applied.
10.10	Robustness of terminations test	CMQT 10.10	MQT 14	Test of junction box retention if a junction box is attached and cord anchorage if a cord is attached to the junction box or to the module.

Test	Title	IEC 63163	IEC 61215-2: 2021	Test conditions
10.11	Wet leakage current test	CMQT 10.11	MQT 15	Category 1: Not needed Category 2 and 3: Test voltage increase at a rate not exceeding 500 V/s to 500 V or the maximum system voltage for the module, whichever is greater. Maintain the voltage at this level for 2 min. Solution temperature is $(22 \pm 2) ^\circ\text{C}$.
10.12	Static mechanical load test	CMQT 10.12	MQT 16	Category 1: Not required Category 2 and 3: Three cycles uniform load specified by the manufacturer, applied for 1 h to front and back surfaces in turn. Minimum test load 2 400 Pa.
10.13	Bypass diode thermal test	CMQT 10.13	MQT 18	Category 1: Not required Category 2 and 3 to do the following: MQT 18.1: Bypass diode thermal test: 1 h at I_{SC} and $75 ^\circ\text{C}$ then 1 h at 1,25 times I_{SC} and $75 ^\circ\text{C}$ MQT 18.2: Bypass diode functionality test At $25 ^\circ\text{C}$ perform voltage and current measurements For bifacial modules, I_{SC} in the conditions above is that measured at elevated irradiance BSI.
10.14	Stabilization	CMQT 10.14	MQT 19	Category 1: Not required Category 2 and 3: Three consecutive output power measurements P1, P2 and P3 using CMQT 10.3.
10.15	Bending if the module is Flexible	CMQT 10.15	MQT 22	Category 1: 10x Category 2: 25x Category 3: 10x Each cycle rolled around a cylinder with a diameter specified by the module manufacturer over which the flexible modules can be bent.
10.16	Folding if the module is Foldable	CMQT 10.16	Not specified	Category 1 and 3: 10x Category 2: 25x
10.17	Drop test	CMQT 10.17	Not specified	Category 1 and 3: 1 drop from 1m height onto concrete Category 2: 4 drops (one drop per corner) from 1 m height onto concrete
10.18	Hail test	CMQT 10.18	MQT 17	Category 1 and 2: Not required Category 3: Optional per IEC 61215-2:2021
10.19	Insulation test	CMQT 10.19	MQT 03	Category 1, 2 and 3

7 Pass criteria

7.1 General

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:

- For Category 1 products, the initial values of maximum output power, maximum current and maximum voltage at STC when received by the testing laboratory shall not be greater than the nameplate ratings including the listed tolerances.
- For Category 1 products, the final maximum output power at STC shall not be less than 80 % of the nameplate maximum power at STC including tolerances.
- For Category 2 products, the final maximum output power at STC after stabilization shall not be less than 85 % of the nameplate power at STC including tolerances.
- For Category 3 products, the final maximum output power at STC after stabilization shall not be less than 90 % of the nameplate power at STC including tolerances.
- The pass/fail criteria shall consider the laboratory uncertainty of the measurement for all categories shall use the measurement uncertainty in IEC 61215.
- No sample can exhibit any open circuit during the tests.

- g) There is no visual evidence of a major defect, as defined in 7.2.
- h) For categories 2 and 3, the wet leakage current test (CMQT 10.11) requirements need to be met.
- i) The insulation test (CMQT 03) and the requirements need to be met.
- j) Specific requirements of the individual tests need to be met.

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 4 shall be subjected to the whole of the relevant test sequence from the beginning. If one or both 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.

7.2 Major visual defects

For the purposes of design qualification and type approval, the major visual defects are defined in 7.2 (IEC 61215-1:2021. MQT 01).

8 Report

Following type approval, a report of the qualification tests, with measured performance characteristics and details of any failures and re-tests, shall be prepared by the test agency. The report shall contain the detailed specifications for the module. Each test report shall include at least the following information:

- a) a title;
- b) name and address of the test laboratory and location where the tests were carried out;
- c) unique identification of the report and of each page;
- d) name and address of client, where appropriate;
- e) description and identification of the item tested, including indication if it has been evaluated for bifaciality and/or whether it is has been evaluated as a flexible or foldable module;
- f) characterization and condition of the test item;
- g) date of receipt of test item and date(s) of test, where appropriate;
- h) identification of test sequence used and whether the samples passed;
- i) reference to sampling procedure, where relevant;
- j) any deviations from, additions to or exclusions from the test method, and any other information relevant to a specific test, such as environmental conditions, or the irradiation dose in kWh/m² at which stability is reached;
- k) measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate including:
 - open circuit voltage, short circuit voltage and peak power at STC,
 - for Category 2 and 3 the maximum shaded cell temperature observed during the hot-spot test,
 - minimum power observed after stabilization and any failures observed, mounting method(s) utilized in the static mechanical test, the positive/negative test loads and safety factor used in the static mechanical load test, hail ball diameter and velocity and maximum power loss observed mounting method(s) utilized in the static mechanical load test,
 - the positive/negative test loads and the safety factor γ_m used in the static mechanical load test,
 - category 3 optional hail ball if performed record the diameter and velocity used in the hail test,
 - for flexible modules, the diameter of the cylinder over which the module was bent during performance of CMQT 10.15,

- test method used for final stabilization and if bias current if used during environmental testing,
 - any damage witnessed after the drop test,
 - any failures observed, and any retests performed;
- l) any failures observed, and retests performed;
- m) a representation of the markings of the module type including manufacturer's power tolerances;
- n) a summary of results from all pass criteria defined in Clause 7 in absolute and relative change. If tendencies to either higher or lower values are observed this shall be included in the report. The used stabilization procedure (irradiance, temperature, time) needs to be stated in detail;
- o) signature and title, or equivalent identification of the person(s) accepting responsibility for the content of the report, and the date of issue;
- p) statement that the report shall not be reproduced except in full, without the written approval of the laboratory.

9 Modifications

Any change in the materials selection, components or manufacturing process may require a repetition of some or all the tests to maintain qualification of the modified product.

Retesting guidelines are provided in IEC TS 62915.

During retesting, tests that are performed on representative samples do not need to be repeated if the only change to a product is one of size, and the change in product size still allows use of the same representative sample size already tested.

10 Test procedures

10.1 Visual inspection (CMQT 01)

The defects from the list in Clause 8 (IEC 61215-2:2021 MQT 01) are not allowed.

10.2 Performance at STC (CMQT 06.1)

The test of IEC 61215-2:2021 MQT 06.1 is applicable.

10.3 Maximum power determination (CMQT 02)

The test of IEC 61215-2:2021 MQT 02 is applicable.

10.4 Outdoor exposure test (CMQT 10.4)

The test of IEC 61215-2:2021 MQT 08 is applicable with the following radiation levels for the following categories:

Category 1: Not required.

Category 2: 30 kWh/m² total solar irradiation under resistive load.

Category 3: 60 kWh/m² total solar irradiation under resistive load.

10.5 Hot-spot endurance test (CMQT 10.5)

Modules may exhibit performance changes with extended time in storage without light exposure (the "dark soak" effect). To minimize the influence of this dark soak effect, limit the time delay between the outdoor exposure/STC measurement and the hot spot procedure to within 2 to 3 days; the modules are to be stored in the dark at ≤ 25 °C.

This test of IEC 61215-2:2021 MQT 09 is applicable for the following:

Category 1: Not required.

Category 2 and 3: Exposure to irradiance in worst-case hot-spot condition as per the technology specific part and IEC 61215-2:2021. For monofacial modules, irradiance is 1 000 W/m². For bifacial modules the irradiance is BSI.

10.6 UV preconditioning test (CMQT 10.6)

The test of IEC 61215-2:2021 (MQT 10) is applicable per the following:

Category 1 and 2: Not required.

Category 3: 15 kWh/m² total UV irradiation in the wavelength range between 280 nm to 400 nm, with 3 % to 10 % UV irradiance at least in the wavelength range from 280 nm to 320 nm, at a module temperature of 60 °C. For bifacial modules, exposure is repeated on the rear side.

10.7 Thermal cycling test (CMQT 10.7)

The test of IEC 61215-2:2021 (MQT 11) is applicable with the following modifications:

Category 1: TC 20 cycles from -40 °C to +85 °C.

Category 2: TC 25 cycles from -40 °C to +85 °C (TC 10 cycles for the TC/HF sequence).

Category 3: TC 100 cycles from -40 °C to +85 °C (TC 25 cycles for UV/HF/TC sequence).

Category 1, 2 and 3: (Optional method) With current as per technology specific per IEC 61215-2:2021.

10.8 Humidity-freeze test (CMQT 10.8)

The test of IEC 61215-2:2021 MQT 12 is applicable with the following modifications:

Category 1: 2 cycles.

Category 2: 4 cycles.

Category 3: 6 cycles.

Category 1, 2 and 3: (Optional method) With current as per technology specific per IEC 61215-1-4:2021.

10.9 Damp heat test (CMQT 10.9)

The test of IEC 61215-2:2021 MQT13 is applicable with the following methods:

Category 1: Damp heat 100 h + (12 – 0) h.

Category 2: Damp heat 300 h + (24 – 0) h.

Category 3: Damp heat 500 h + (48 -0) h.

Category 1, 2 and 3: (Optional method) With current as per technology specific per IEC 61215-2:2021.

10.10 Robustness of terminations test (CMQT 10.10)

The test of IEC 61215-2:2021 MQT 14 is applicable:

Test of junction box retention if a junction box is attached and cord anchorage if a cord is attached to the junction box or to the module.

10.11 Wet leakage current test (CMQT 10.11)

The test of IEC 61215-2:2021 MQT15 is applicable.

10.12 Static mechanical load test (CMQT 10.12)

The test of IEC 61215-2:2021 MQT 16 is applicable.