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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Thin-film terrestrial photovoltaic (PV) modules – Design qualification and type approval

Modules photovoltaïques (PV) en couches minces pour application terrestre – Qualification de la conception et homologation

IEC 61646:2008

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

THIN-FILM TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – DESIGN QUALIFICATION AND TYPE APPROVAL

FOREWORD

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International Standard IEC 61646 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This second edition cancels and replaces the first edition published in 1996. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

The major change is in the pass/fail criteria. It no longer relies on meeting a plus/minus criterion before and after each test, but rather on meeting the rated power after all of the tests have been completed and the modules have been light-soaked. This was done to eliminate the technology-specific preconditioning necessary to accurately measure the changes caused by the test. (Some modules lose power in light while others lose power during dark heat.) Since all modules must work after exposure to light, this seemed liked a good approach and will streamline the test procedure, hopefully reducing the testing cost.

- Updated Normative references.
- Added a definition of "minimum value of maximum output power".

- Modified the wording in Major visual defects to allow some bending and misalignment without failure.
- Added requirements to the report from ISO/IEC 17025.
- Removed the “Twist Test” as was done from IEC 61215, since no one has ever failed this test.
- Made the pass/fail criteria for insulation resistance and wet leakage current dependent on the module area.
- Added the temperature coefficient of power (δ) to the required measurements.
- Modified temperature coefficient section to allow for measurements under natural sunlight or a solar simulator.
- Deleted reference plate method from NOCT.
- Added apparatus sections to those test procedures that did not have apparatus sections in edition 1.
- Rewrote the hot-spot test.
- Eliminated edge dip method from wet leakage current test.
- Changed mechanical load test to 3 cycles to be consistent with other standards.
- Added bypass diode thermal test.

The text of this standard is based on the following documents:

FDIS	Report on voting
82/512/FDIS	82/528/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

THIN-FILM TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – DESIGN QUALIFICATION AND TYPE APPROVAL

1 Scope and object

This International Standard lays down requirements for the design qualification and type approval of terrestrial, thin-film photovoltaic modules suitable for long-term operation in general open-air climates as defined in IEC 60721-2-1. This standard is intended to apply to all terrestrial flat plate module materials not covered by IEC 61215.

The test sequence is derived from IEC 61215 for the design qualification and type approval of terrestrial crystalline silicon PV modules. However, it no longer relies on meeting a plus/minus criterion before and after each test, but rather on meeting a specified percentage of the rated minimum power after all of the tests have been completed and the modules have been light-soaked. This eliminates the technology-specific preconditioning necessary to accurately measure the changes caused by the test.

This standard does not apply to modules used with concentrators.

The object of this test sequence is to determine the electrical and thermal characteristics of the module and to show, as far as possible within reasonable constraints of cost and time, that the module is capable of withstanding prolonged exposure in climates described in the scope. The actual life expectancy of modules so qualified will depend on their design, their environment and the conditions under which they are operated.

2 Normative references

The following referenced documents are indispensable for the application 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 60068-1: *Environmental testing – Part 1: General and guidance*

IEC 60068-2-21: *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

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

IEC 60410, *Sampling plans and procedures for inspection by attributes*

IEC 60721-2-1, *Classification of environmental conditions – Part 2-1: Environmental conditions appearing in nature – Temperature and humidity*

IEC 60891, *Procedures for temperature and irradiance corrections to measured I-V characteristics of crystalline silicon photovoltaic (PV) devices*

IEC 60904-1:2006, *Photovoltaic devices – Part 1: Measurements of photovoltaic current-voltage characteristics*

IEC 60904-2, *Photovoltaic devices – Part 2: Requirements for reference solar devices*

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

IEC 60904-7, *Photovoltaic devices – Part 7: Computation of spectral mismatch error introduced in the testing of a photovoltaic device*

IEC 60904-9, *Photovoltaic devices – Part 9: Solar simulator performance requirements*

IEC 60904-10, *Photovoltaic devices – Part 10: Methods of linearity measurements*

IEC 61215, *Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories.*

3 Sampling

Eight modules for qualification testing (plus spares as desired) shall be taken at random from a production batch or batches, in accordance with the procedure given in IEC 60410. The modules shall have been manufactured from specified materials and components in accordance with the relevant drawings and process sheets and shall have been subjected to the manufacturer's normal inspection, quality control and production acceptance procedures. The modules shall be complete in every detail and shall be accompanied by the manufacturer's handling, mounting and connection instructions, including the maximum permissible system voltage.

If the bypass diodes are not accessible in the standard modules, a special sample can be prepared for the bypass diode thermal test (see 10.18). The bypass diode should be mounted physically as it would be in a standard module, with a thermal sensor placed on the diode as required in 10.18.2. This sample does not have to go through the other tests in the sequence.

When the 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).

4 Marking

Each module shall carry the following clear and indelible markings:

- name, monogram or symbol of manufacturer;
- type or model number;
- serial number;
- polarity of terminals or leads (colour coding is permissible);
- maximum system voltage for which the module is suitable;
- nominal and minimum values of maximum output power at STC, as specified by the manufacturer for the product type.

The minimum value of maximum output power refers to the lowest stabilized power that the manufacturer specifies for the product type (for example after any light induced degradation or recovery).

NOTE If the modules to be tested are prototypes of a new design and not from production, the results of this test sequence may be used to establish the module minimum power rating.

The date and place of manufacture shall be marked on the module or be traceable from the serial number.

5 Testing

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 10. However, with regard to the tests of 10.2, 10.4, 10.6 and 10.7, it should be noted that the procedures laid down in IEC 60891 for temperature and irradiance corrections to measured I-V characteristics apply only to linear modules. Use IEC 60904-10 to assess linearity. If the module is non-linear, these tests shall be carried out within ±5 % of the specified irradiance and within ±2 °C of the specified temperature.

NOTE 1 Where the final measurements for one test serve as the initial measurements for the next test in the sequence, they need not be repeated. In these cases, the initial measurements are omitted from the test.

For diagnostic purposes, intermediate measurements of maximum power (10.2) may be undertaken before and after individual tests.

NOTE 2 The control module should be stored in accordance with the manufacturer's recommendation.

Any single test, executed independently of a test sequence, shall be preceeded by the initial tests of 10.1, 10.2 and 10.3.

In carrying out the tests, the tester shall strictly observe the manufacturer's handling, mounting and connection instructions. Tests given in 10.4, 10.5, 10.6 and 10.7 may be omitted if future IEC 61853 has been or is scheduled to be run on this module type.

Thin film technologies can have different stabilization characteristics. It is impossible to define a single stabilisation procedure applicable to all thin film technologies. This procedure tests the modules "as received" and attempts to reach a stabilised condition before final test.

Test conditions are summarized in Table 1.

NOTE 3 The test levels in Table 1 are the minimum levels required for qualification. If the laboratory and the module manufacturer agree, the tests may be performed with increased severities.

6 Pass criteria

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:

a) after the final light soaking, the maximum output power at STC is not less than 90 % of the minimum value specified by the manufacturer in Clause 4;

   NOTE The pass/fail criteria must consider the laboratory uncertainty of the measurement. As an example, if the laboratory extended uncertainty, 2 sigma of the STC measurement, is ±5 %, then a maximum power measurement greater than 85,5 % of the minimum specified value would be the pass criteria.

b) no sample has exhibited any open-circuit during the tests;

c) there is no visual evidence of a major defect, as defined in Clause 7;

d) the insulation test requirements are met after the tests;

e) the wet leakage current test requirements are met at the beginning and the end of each sequence and after the damp heat test;

f) specific requirements of the individual tests are 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 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.

7 Major visual defects

For the purposes of design qualification and type approval, the following are considered to be major visual defects:

a) broken, cracked, or torn external surfaces, including superstrates, substrates, frames and junction boxes;

b) bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the installation and/or operation of the module would be impaired;

c) voids in, or visible corrosion of any of the thin film layers of the active circuitry of the module, extending over more than 10 % of any cell;

d) bubbles or delaminations forming a continuous path between any part of the electrical circuit and the edge of the module;

e) loss of mechanical integrity, to the extent that the installation and/or operation of the module would be impaired;

f) Module markings (label) is no longer attached or the information is unreadable.

8 Report

Following type approval, a certified report of the qualification tests, with measured performance characteristics and details of any failures and re-tests, shall be prepared by the test agency in accordance with ISO/IEC 17025. Each certificate or 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 certification or report and of each page.

d) Name and address of client, where appropriate.

e) Description and identification of the item tested.

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 method used.

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 tests, such as environmental conditions.

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, the maximum shaded cell temperature observed during the hot-spot test, spectrum of the lamp used for the UV prescreening test, minimum power observed after light soaking and any failures observed. If the maximum power loss observed after each of the tests has been measured it should also be reported.

l) A statement of the estimated uncertainty of the test results (where relevant).

m) A signature and title, or equivalent identification of the person(s) accepting responsibility for the content of the certificate or report, and the date of issue.

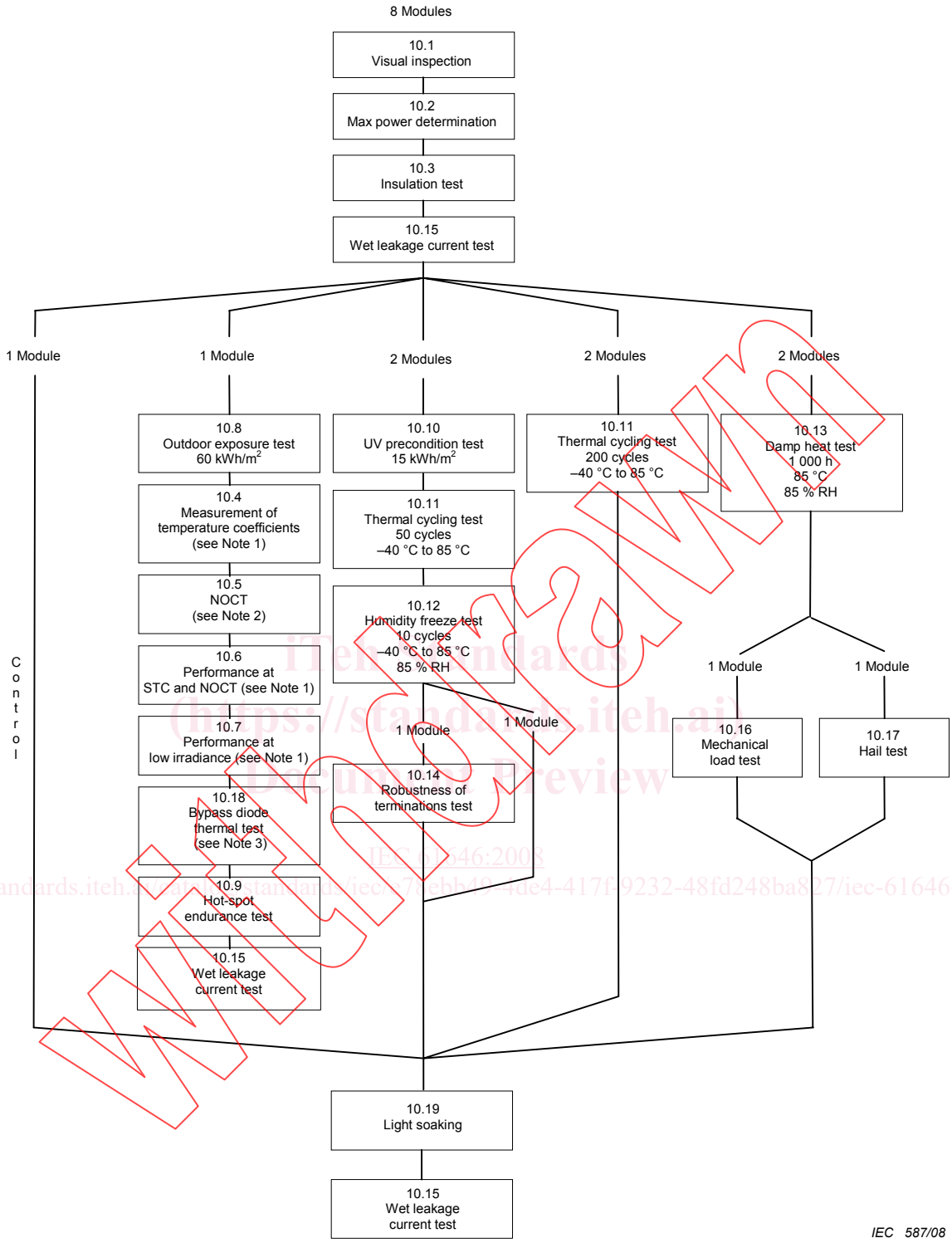
n) Where relevant, a statement to the effect that the results relate only to the items tested.

o) A statement that the certificate or report shall not be reproduced except in full, without the written approval of the laboratory.

A copy of this report shall be kept by the laboratory and manufacturer for reference purposes.

9 Modifications

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.



NOTE 1 May be omitted if future IEC 61853 has been performed.

NOTE 2 In the case of modules not designed for open-rack mounting, the NOCT may be replaced by the equilibrium mean solar cell junction temperature in the standard reference environment, with the module mounted as recommended by the manufacturer.

NOTE 3 If the bypass diodes are not accessible in the standard modules, a special sample can be prepared for the bypass diode thermal test (10.18). The bypass diode should be mounted physically as it would be in a standard module, with a thermal sensor placed on the diode as required in 10.18.2. This sample does not have to go through the other tests in the sequence.

NOTE 4 For diagnostic purposes intermediate measurements of maximum power (10.2) may be undertaken before and after individual tests. If the control module is used for these measurements make sure it has been pre-conditioned per the manufacturers recommendation.

Figure 1 – Qualification test sequence