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TECHNICAL SPECIFICATION

Photovoltaic (PV) modules – Cyclic (dynamic) mechanical load testing

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62782, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
82/971/DTS	82/1014A/RVC

Full information on the voting for the approval of this technical specification 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 stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

PHOTOVOLTAIC (PV) MODULES – CYCLIC (DYNAMIC) MECHANICAL LOAD TESTING

1 Scope

This technical specification provides a test method for performing a cyclic (dynamic) mechanical load test in which the module is supported at the design support points and a uniform load normal to the module surface is cycled in alternating negative and positive directions. This test may be utilized to evaluate if components within the module including solar cells, interconnect ribbons and/or electrical bonds within the module are susceptible to breakage or if edge seals are likely to fail due to the mechanical stresses encountered during installation and operation. This test can be performed at any module temperature within the normal operating temperature range. Since the results have been determined to depend on the module temperature during the application of the load it is critical to maintain the module at a constant temperature during the performance of this test.

This technical specification has historically been applied to rigid modules. It cannot be applied to flexible modules unless they are designed to be mounted in a rigid manner. In which case, the cyclic (dynamic) mechanical load test can be applied to the flexible module in its rigid mounting system.

This test has been written as a standalone technical specification, but it is likely to be used in conjunction with other test standards. Typically, this test itself will not result in power loss, but when followed by additional stress tests like thermal cycling and humidity freeze, the damage done by the mechanical cycling results in power loss that would not have occurred due only to the thermal cycling and humidity freeze tests. For example, the transportation testing procedure (IEC 62759) includes the requirements for such a cyclic (dynamic) mechanical load test followed by 50 thermal cycles and 10 humidity freeze cycles.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 60904-12, *Photovoltaic devices – Part 12: Infrared thermography of photovoltaic modules*[1]

IEC TS 60904-13, *Photovoltaic devices – Part 13: Electroluminescence of photovoltaic modules*[1]

IEC 61215-1:2016, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements*

IEC 61215-2:2016, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures*

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

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1 To be published.

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

3 Terms and definitions

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

4 Apparatus

The apparatus for this technical specification include:

a) Equipment for performing the cyclic (dynamic) loading: this equipment shall be capable of applying a uniform load of 1 000 Pa ± 100 Pa onto the module surface in both directions to simulate pressure and tensile loads at a rate between 3 and 7 cycles per minute. The prescribed load is of uniform pressure, P, and is most appropriately applied with a pressure of air or vacuum. If a piston system (or other non-uniform application) is used to load the module, the force each piston (or applicators) exert is $F = PA/n$, where A is the area of the module and n is the number of pistons. To ensure a similar effect to the module, the maximum, perpendicular, center-to-center distance between evenly loaded points shall be 20 cm or less. If one piston consists of multiple loading points this maximum distance refers to both the loading points within and between pistons. The maximum perpendicular distance between the module frame and an evenly loaded point shall also be 20 cm or less.

b) Means for monitoring, throughout the test, the continuity of the internal circuit of each module.

c) Means for monitoring the temperature of the module to an accuracy of ±2,0 °C and repeatability of ±0,5 °C. The temperature sensors shall be attached to the front or back surface of the module near the middle without interfering with the cyclic loading.

d) Infrared (IR) camera and a constant current power supply capable of providing between one and two times the Standard Test Condition (STC) maximum power current of the module in the forward direction. (See future IEC TS 60904-12.)

e) Electroluminescence (EL) equipment and a constant current power supply capable of providing between 0,1 and 1 times the STC short circuit current of the module in the forward direction. (See future IEC TS 60904-13.)

The IR and EL systems do not have to be capable of observing the module while it is under test. These tests can be performed independent of the cyclic (dynamic) load test equipment.

5 Initial measurements

The following measurements shall be performed on the test module before beginning the stress testing.

a) Perform a visual inspection of the module in accordance with IEC 61215-2 MQT 01.

b) Perform the initial module stabilization procedure in accordance with IEC 61215-2 MQT 19.1.

c) Measure the maximum power performance of the module in accordance with IEC 61215-2 MQT 02.

d) Perform an insulation test in accordance with IEC 61215-2 MQT 03.

e) Perform a wet leakage current test in accordance with IEC 61215-2 MQT 15.

f) Perform an EL scan of the module using a forward bias current between 0,1 and one times the STC short circuit current to identify cracked cells and other breaks in the cell junction. Note the observed broken cells, interconnects and/or electrical bonds or any additional anomalies observed in the test report (Clause 8k) as identified in future IEC TS 60904-13.

g) Perform an IR scan of the module using a forward bias current between the STC maximum power current and twice the STC maximum power current to identify areas of localized heating. Note the observed areas of localized heating in the test report (Clause 8k) as identified in future IEC TS 60904-12.

If there is reason to use a current of more than *Isc* in either the IR or EL test, check with the module manufacturer to determine that such a high current will not damage the module.

6 Procedure

a) Equip the module so that the electrical continuity of the internal circuit can be monitored continuously during the test.

b) Mount the module on the cyclic (dynamic) loading equipment using the method prescribed by the manufacturer including the mounting means (clips/clamps and any kind of fastener) and underlying support rails. If there are different possibilities each mounting method needs to be evaluated separately. For all mounting methods, mount the module in a manner where the distance between the fixing points is worst case, which is typically at the maximum distance.

c) Set the module temperature at the desired level. Monitor the module temperature throughout the application of the cyclic loading. Maintain module temperature within ±2 °C of the selected temperature during the application of the cyclic loading.

d) Apply the cyclic (dynamic) mechanical load and cycle it 1 000 times using a maximum pressure of ±1 000 Pa (with a tolerance of ±100 Pa) and a rate between 3 and 7 cycles per minute. (Cycles being defined as one positive and one negative load application.)

e) Monitor continuity throughout the test.

Measuring continuity requires only a small current flow (1% of Isc would be more than adequate). However, there may be cases where it would be useful or interesting for the test to be performed with a higher current flow, up to the STC peak power current. If that is the case this fact should be noted in the test report (Clause 8 j). Such a test could end up causing arcing in broken cells or broken interconnects.

Cyclic (dynamic) mechanical load tests are normally performed in the laboratory at room temperature. However, there may be cases where it is of interest to perform the test at either lower temperatures to simulate stress during winter or at higher temperatures to simulate stress during summertime operation. Temperature ranges shall be limited by the minimum/maximum operating temperature of module and mounting materials under test (e.g. clip rubber, washers, etc.). The module temperature during the cyclic loading should be noted in the test report (Clause 8 j).

7 Final measurements

a) Perform a visual inspection of the module in accordance with IEC 61215-2 MQT 01.

b) Perform the final module stabilization procedure in accordance with IEC 61215-2 MQT 19.2.

c) Measure the maximum power performance of the module in accordance with IEC 61215-2 MQT 02.

d) Perform an insulation test in accordance with IEC 61215-2 MQT 03.

e) Perform a wet leakage current test in accordance with IEC 61215-2 MQT 15.

f) Perform an EL scan of the module using a forward bias current between 0,1 and one times the STC short circuit current to identify changes in the module using the guidance from future IEC TS 60904-13.

g) Perform an IR scan of the module using a forward bias current between the STC peak power current and twice the STC peak power current to identify changes in the module using guidance from future IEC TS 60904-12.

Report all results including any changes noted in the module particularly the number of broken cells, broken interconnects and broken electrical connections observed.

The EL and IR scans are used for informational purposes only, not as requirements. As such, they should not impact the results of the visual inspection.

8 Test report

A report of the test shall be prepared by the test agency in accordance with ISO/IEC 17025. The report shall contain the detail specification for the specimens. 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 report and of each page;

d) name and address of client, where appropriate;

e) description and identification of the module(s) tested;

f) characterization and condition of the test module;

g) date of receipt of test module and date(s) of test, where appropriate;

h) identification of test method used including a description of the equipment used to apply the uniform load;

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 the specific mounting system used, environmental conditions, module temperature and current flow utilized during the test;

k) measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate, including the maximum power loss after each test, the number of broken cells observed before and after each test and any other significant changes observed;

l) indication if any of the following are observed after the cyclic (dynamic) mechanical load test sequence or after any subsequent tests as discussed in Annex A:

   1) interruption of current flow during the test (this interruption may be intermittent and in phase with the load cycling. If so, the test report should note on which cycle the interruption began and on which part of the cycle the interruption in current flow occurs);

   2) evidence of major visual defects, as defined in Clause 8 of IEC 61215-1:2016;

   3) a value of insulation resistance measured below the accepted value of 40 $M\Omega \times m^2$ when measured at 500 V or maximum systems voltage, whichever is greater; or

   4) the wet leakage current measured insulation resistance times the area of the module shall not be less than 40 $M\Omega \times m^2$, when measured at 500 V or maximum systems voltage, whichever is greater;

m) a statement of the estimated uncertainty of the test results (where relevant);

n) a signature and title, or equivalent identification of the person(s) accepting responsibility for the content of the report, and the date of issue;

o) where relevant, a statement to the effect that the results relate only to the items tested;

p) a statement that the report shall not be reproduced except in full, without the written approval of the laboratory.

Annex A
(informative)

Subsequent testing

While cyclic (dynamic) mechanical load testing often does damage to a PV module, there is usually minimal observed power loss after completion of the test. The use of subsequent stress tests has resulted in observed power loss. The following are two examples:

a) If the cyclic (dynamic) mechanical load testing breaks cells and/or interconnect ribbons, subsequent exposure to 50 thermal cycles (MQT 11 from IEC 61215-2) and 10 humidity freeze cycles (MQT 12 from IEC 61215-2) can lead to significant loss in peak power.

b) If the cyclic (dynamic) mechanical load testing damages the module's edge seal, subsequent exposure to damp heat testing (MQT 13 from IEC 61215-2) could result in moisture ingress and subsequent power loss.

Therefore, this technical specification can be used in conjunction with additional accelerated stress tests to evaluate the overall impact on module performance.

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COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch