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Extended thermal cycling of PV modules – Test procedure

Cycle thermique étendu de modules PV – Procédure d'essai

IEC 62892:2019

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**EXTENDED THERMAL CYCLING OF PV MODULES –
TEST PROCEDURE****FOREWORD**

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The text of this International Standard is based on the following documents:

FDIS	Report on voting
82/1537/FDIS	82/1560/RVD

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

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

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INTRODUCTION

The IEC 61215 series defines test requirements for the design qualification of flat-plate PV modules for long-term operation in general open-air climates. IEC TS 62941 provides technical guidance in application of the type-approval testing.

This document, IEC 62892, supplements IEC 61215 by providing an extended thermal cycling test intended to differentiate PV modules with improved durability to thermal cycling and evaluate modules for deployment in locations most susceptible to thermal cycling type stress.

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EXTENDED THERMAL CYCLING OF PV MODULES – TEST PROCEDURE

1 Scope

This document defines a test sequence that extends the thermal cycling test of IEC 61215-2. It is intended to differentiate PV modules with improved durability to thermal cycling and evaluate modules for deployment in locations most susceptible to thermal cycling type stress¹. This document is based on the ability for 95 % of the modules represented by the samples submitted for this test to pass an equivalency of 500 thermal cycles, as defined in IEC 61215-2:2016, 4.11.3, with a maximum power degradation of less than 5 %. Provisions are also provided to reduce overall test time by increasing the maximum cycle temperature and/or the number of modules submitted for test.

The test procedure in this document was developed based on analysis of the stress on tin-lead solder bonds on crystalline silicon solar cells in a glass superstrate type package. Changes to lead-free solder have an effect on the acceleration factors but not enough to change the overall results of this test. Monolithic type modules with integral cell interconnection do not suffer from this specific type of stress but there are still electrical connections within the module, for example between the integrated cell circuit and the module bus bars, that may be subject to wear out from thermal cycling. Flexible modules (without glass) are not stressed in the same way as those with glass superstrates or substrates, therefore use of the equivalency factor employed in this document may not be applicable to these modules.

2 Normative references

IEC 62892:2019

<https://standards.iteh.ai/catalog/standards/sist/96b85f5c-35a3-4923-b94c-e20116556d16/iec-62892-2019>

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

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

IEC 61215-1-2, *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, *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, *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*

¹ Guidance is provided in Annex B to assess if this test is warranted for the targeted deployment location.

IEC 61215-2:2016, *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*

IEC TS 62941:2016, *Terrestrial photovoltaic (PV) modules – Guideline for increased confidence in PV module design qualification and type approval*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836 as well as the following 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

equivalent cycles

number of thermal cycles that imparts the same amount of solder fatigue damage

4 Sampling

Modules for these tests shall be taken at random from a production batch or batches of a module type that is already certified to IEC 61215, IEC 61730-1 and IEC 61730-2. The modules 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 modules shall be complete in every detail and shall be accompanied by the manufacturer's handling, mounting and connection instructions.

The relation between the number of modules submitted for testing and the required number of cycles is detailed Table 1 and Annex A. A minimum of three modules shall be submitted for testing, two for the actual testing and one as control.

Because these tests are designed for accelerated stress testing of production modules, engineering samples are not allowed.

5 Marking and documentation

Each module shall include clear and indelible markings as defined in IEC 61215-1. Modules shall be supplied with documentation conforming to the requirements in IEC 61215-1. Documentation consistent with the requirements of Clause 4 of IEC TS 62941:2016 shall also be available for inspection by the test agency to ensure adequacy of the Quality Management System.

6 Modifications

Changes in material selection, components and manufacturing process that would trigger retesting of the 200 thermal cycles leg in IEC TS 62915 would also require retest to this document.

7 Test procedure

7.1 Initial evaluations

- a) Visual inspection in accordance with IEC 61215-2 Module Qualification Test (MQT) 01.
- b) Maximum power determination in accordance with IEC 61215-2 MQT 02.
- c) Insulation test in accordance with IEC 61215-2 MQT 03.
- d) Wet current leakage test in accordance with IEC 61215-2 MQT 15.

7.2 Thermal cycling test

7.2.1 Purpose

The purpose of the thermal cycling test is to determine the ability of the PV modules to withstand thermal mismatch, fatigue, and other stresses caused by rapid, non-uniform or repeated changes of temperature.

7.2.2 Apparatus

In accordance with IEC 61215-2:2016, 4.11.2.

7.2.3 Procedure

In accordance with IEC 61215-2:2016, 4.11.3 with the following modifications:

- a) The maximum temperature of the cycle (T_{MAX}) may be increased above 85 °C to reduce the number of required cycles according to Table 1. (T_{MAX}) shall be specified by the submitting party and recorded in the test report.
- b) During the thermal cycling test set the continuous current flow during the heat up cycle to the technology specified current in IEC 61215-2 at temperature from –40 °C to (T_{MAX}) –5 °C. During cool down, the –40 °C dwell phase and temperatures above (T_{MAX}) –5 °C the continuous current shall be reduced to no more than 1,0 % of the measured STC peak power current to measure continuity.
- c) The number of cycles shall be as shown in Table 1. Annex A may be used to calculate the required number of thermal cycles when more than 10 modules are submitted for test or when $T_{MAX} - 85\text{ °C} > 25\text{ °C}$.

Table 1 – Number of required thermal cycles, N_R

$T_{MAX}-85$ °C	Number of modules submitted for test								
	2	3	4	5	6	7	8	9	10
0	731	683	651	627	609	593	580	569	559
1	711	665	634	611	592	577	565	554	544
2	693	647	617	594	577	562	550	539	530
3	674	630	601	579	562	547	535	525	516
4	657	614	585	564	547	533	521	511	502
5	640	598	570	549	533	519	508	498	489
6	623	583	555	535	519	506	495	485	477
7	608	568	541	521	506	493	482	473	465
8	592	553	528	508	493	481	470	461	453
9	577	539	514	495	481	468	458	449	441
10	563	526	501	483	469	457	447	438	430
11	549	513	489	471	457	445	436	427	420
12	535	500	477	459	446	434	425	417	409
13	522	488	465	448	435	424	414	406	399
14	509	476	454	437	424	413	404	396	390
15	497	465	443	427	414	403	394	387	380
16	485	453	432	416	404	394	385	378	371
17	473	443	422	406	394	384	376	368	362
18	462	432	412	397	385	375	367	360	353
19	451	422	402	387	376	366	358	351	345
20	441	412	393	378	367	358	350	343	337
21	430	402	383	369	358	349	342	335	329
22	420	393	375	361	350	341	334	327	321
23	411	384	366	353	342	333	326	320	314
24	401	375	358	344	334	326	319	312	307
25	392	367	349	337	327	318	311	305	300

NOTE The relationship employed to calculate the number of required cycles in Table 1 is based on a Coffin-Manson style empirical relationship for solder thermal fatigue and a one-parameter Weibull analysis and dictates that 95 % of the modules represented by the samples submitted for this test will pass an equivalency of 500 qualification level thermal cycles [1, 2]². This relationship is applicable for both PbSn and Pb-free solders. FEM simulations of a PV module have demonstrated that this relationship results in a conservative estimate for equivalency [3]. These simulations show that softening of the module's encapsulant at high temperatures will result in a faster rate of solder damage accumulation. Therefore, while prescribing a higher maximum cycle temperature will reduce the overall test time, the equivalency of that test, or overall stress, may be greater than intended.

7.3 Final evaluations

- Visual inspection in accordance with IEC 61215-2 MQT 01.
- Maximum power determination in accordance with IEC 61215-2 MQT 02.
- Insulation test in accordance with IEC 61215-2 MQT 03.
- Wet leakage current test in accordance with IEC 61215-2 MQT 15.
- Bypass diode functionality test in accordance with IEC 61215-2 MQT 18.2.

² Numbers in square brackets refer to the Bibliography.

When implementing the tests from IEC 61215-2, the requirements of the technology specific standards (IEC 61215-1-1, IEC 61215-1-2, IEC 61215-1-3 and IEC 61215-1-4) shall be taken into account.

7.4 Requirements

The requirements are as follows:

- no interruption of current flow during the test;
- no evidence of major visual defects, as defined in IEC 61215-1:2016, Clause 7;
- the degradation of maximum output power shall not exceed 5 % of the value measured before the test;
- insulation resistance shall meet the same requirements as for the initial measurements.
- any by-pass diodes shall still function as diodes.

NOTE Electroluminescence imaging may be a useful technique to image the location of failed, or failing, solder bonds.

8 Reporting

Following completion of the testing, a report of the 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 detail specification 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;
- f) characterization and condition of the test item;
- g) date of receipt of test item and date(s) of test, where appropriate;
- h) reference to sampling procedure;
- i) any deviations from, additions to, or exclusions from, the test method and any other information relevant to a specific tests, such as environmental conditions and the test procedure used to validate that the by-pass diodes were functional at the end of the test sequence;
- j) measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate including maximum power loss observed after all of the tests, dry and wet insulation resistance changes due to the tests and evidence of changes that might ultimately lead to performance degradation;
- k) a statement of the estimated uncertainty of the test results (where relevant);
- l) a signature and title, or equivalent identification of the person(s) accepting responsibility for the content of the report, and the date of issue;
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