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TECHNICAL SPECIFICATION

Photovoltaic modules – Extended-stress testing – Part 1: Modules

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PHOTOVOLTAIC MODULES – EXTENDED-STRESS TESTING –

Part 1: Modules

FOREWORD

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IEC TS 63209-1 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

DTS	Report on voting
82/1820/DTS	82/1873/RVDTS

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

A list of all parts in the IEC 63209 series, published under the general title *Photovoltaic modules – Extended-stress testing*, can be found on the IEC website.

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.

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

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- withdrawn,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

INTRODUCTION

Existing qualification test standards such as IEC 61215 standard series have been very useful for identifying module designs that avoid most early field failures, but are not intended or able to demonstrate long term performance in all locations within the scope of those documents. In order to assess the risk of product failure it has become industry practice for the different stakeholders to require results of test protocols beyond baseline type approval and safety tests according to the IEC 61215 standard series and IEC 61730 standard series. These extended stress test protocols primarily contain aforementioned baseline tests in different sequences and/or increased test duration or number of cycles. They originate from the various experiences made by third parties such as test institutes/ independent engineering firms/ owners engineers and aim to cause aging that would be seen after long term use of PV modules, or apply a “test to failure” approach, aimed to identify weaknesses rather than to replicate field performance. They do not provide detailed reliability or durability predictions/estimates, but have been useful to reveal deficiencies.

With many variants of extended stress test protocols in use, a standardized approach is desired. The included set of extended stress test sequences is intended to standardize the various approaches used by different industry participants, with a benefit of a common data set for reliability reviews, and a practical benefit to module manufacturers who are faced with the challenge of running (and maintaining after product changes) a number of very similar test protocols in parallel.

This global reference comparative document utilizes a common denominator approach considering all the sequences of the variants, and adds to this subset sequences that are uniquely positioned to capture special failure modes, while excluding sequences where test conditions and durations do not show results that are useful for assessing module field performance. This document is intended to align extended test protocols, in order to make results from different institutes more directly comparable and to reduce test costs and time lines for the industry.

This document is intended to provide a set of data to be used for qualitative reliability risk analysis, highlighting potential failure modes and areas possibly in need of improvement. It is only useful for rank ordering modules and materials for special cases, for very large differences in performance, or with respect to specific understood failure modes and mechanisms. A robust module level rank ordering or service life prediction is beyond the scope of this document. A series of component test suites is in development to complement the module level testing in this specification.

PHOTOVOLTAIC MODULES – EXTENDED-STRESS TESTING –

Part 1: Modules

1 Scope

This document is intended to provide information to supplement the baseline testing defined in IEC 61215, which is a qualification test with pass-fail criteria. This document provides a standardized method for evaluating longer term reliability of photovoltaic (PV) modules and for different bills of materials (BOMs) that may be used when manufacturing those modules. The included test sequences in this specification are intended to provide information for comparative qualitative analysis using stresses relevant to application exposures to target known failure modes.

A significant constraint imposed was that the test duration was limited, recognizing that customers of the test will proceed with decisions before the test results are available, if the test takes too long. With this business-relevant limitation, some known failure modes cannot be accurately addressed, most notably those related to long-term ultra-violet light (UV) exposures. While failure modes related to UV stress are known to occur on both front and back side of PV modules, the testing time required to achieve a dose of UV stress that causes changes observed in the field during the module's intended lifetime without overstressing is beyond the scope of this document. The included backside UV stress sequence gives increased confidence for some backsheets with regard to backside cracking, and a frontside UV stress sequence is not included at all, leaving gaps for failure modes, such as encapsulant discoloration, frontside backsheet cracking, frontside delamination, etc.

Other limitations of extended stress testing are described in Annex A. This document identifies vulnerabilities without attempting to gather the information needed to make a service-life prediction, which would require identifying failure mechanisms and their dependencies on all of the stresses. Annex B contains a brief background of the origins of the tests.

Out of scope for this document is its use as a pass-fail criterion. The same module deployed in two different locations may fail/degrade in different ways, so a single test protocol cannot be expected to simultaneously exactly match both results, and will depend upon where and how the product is deployed. Additionally, both false positives and false negatives may occur: due to the highly accelerated and extended nature of some of the stress exposures, the tests may cause some changes that do not occur in the field for some module designs, and degradation which is difficult to accelerate will be missed.

This document was developed with primary consideration for c-Si modules, as reflected in the targeted failure modes. However, the applied stresses are based on the service environment, and as such are relevant to generalized PV modules. Interpretation of the data resulting from these tests should always include the possibility that a design change may cause a new failure to occur. In particular, modules with different form factors (e.g. made without the standard glass frontsheet) may be found to differ in the way they fail. In every case, the data collected in this extended-stress test procedure is used as input to an analysis that may then identify the need for additional testing, to more fully assess module performance relative to the intended deployment conditions.

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

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

IEC 61215-1, *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, *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*

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

IEC 61730 (all parts): *Photovoltaic (PV) module safety qualification*

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 62782, *Photovoltaic (PV) modules – Cyclic (dynamic) mechanical load testing*

3 Terms, definitions and abbreviated terms

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

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
Module Quality Test
MQT
Module Quality Test in accordance with IEC 61215-2

3.2
Module Safety Test
MST
Module Safety Test in accordance with IEC 61730-2

4 Selection of test samples

This document describes data collection methodology. Sample selection, number of samples, and or sample sets are left to the user, based on the purpose of the data collection. The number of samples used in each test may vary between the test sequences and may be selected to emphasize the stresses anticipated in the current application. The confidence in the test results will be greater for a larger number of test samples, and inclusion of multiple samples is encouraged.

5 Characterization and stabilization techniques to be applied

5.1 General

The characterization methods are as described in published standards, such as the IEC 61215 standard series, including the technology-specific portions of these. Baseline characterization shall be completed before application of stress, and repeated after subsequent applications of stress to establish the trend of response to that stress. Additional intermediate tests may be included between application of stresses at the customer's request. For example, additional characterization may be beneficial after mechanical stress is applied.

5.2 Physical measurement

Physical module measurements shall include weight, length, width, and thickness (depth) of frame. Additionally, the cell dimensions shall be recorded. Photographs of module and example cells shall be recorded.

5.3 Visual inspection

Observations are completed as defined in IEC 61215-2, MQT 01. All observations shall be recorded and reported as part of the final report. Photographs shall be used to document any changes and included in the final report.

For the visual inspection of the backsheet after UV exposure, magnification of 10X or greater is recommended using an illumination of at least that specified in IEC 61215-2, MQT 01.

5.4 Initial stabilization

Initial stabilization shall be completed as defined in IEC 61215-2, MQT 19.1. All measurements (as defined in 5.5) shall be recorded after each stabilization step. These data shall be included in the final report.

5.5 Performance

The performance at Standard Test Conditions shall be measured as defined in IEC 61215-2, MQT 06.1. The performance at low-irradiance conditions shall be measured as defined in IEC 61215-2 MQT 07. If the test lab does not have the capability to accurately measure at low irradiance, the low irradiance measurement may be omitted. In both cases, the measurements shall be recorded including V_{oc}, I_{sc}, V_{mp} and I_{mp} in addition to the maximum power. Performance of bifacial modules shall be characterized using IEC TS 60904-1-2 with Standard Test Conditions applied to both the front side and the back side for initial and final characterizations. Additionally (and for intermediate measurements), bifacial modules shall be characterized under bifacial nameplate irradiance (BNPI) as defined in IEC 61215-1. All measurements shall be included in the final report.

5.6 Insulation test

The insulation shall be tested as defined in IEC 61215-2, MQT 03. The insulation resistance measurement shall be recorded and reported as part of the final report.

5.7 Wet leakage current

The wet leakage current shall be measured as defined in IEC 61215-2, MQT 15. The measured leakage current shall be recorded and reported in the final report.

5.8 Electroluminescent imaging

Electroluminescent imaging shall be completed as defined in IEC TS 60904-13, using both low and high injection levels for the initial characterization for all tests. For the post-stress characterization, the low-injection imaging is optional for test sequences 1-4. The low-injection image is required after the PID stress in test sequence 5. All high-injection images and conditions used for their measurement shall be included in the final report. Low-injection images shall be included in the final report for the PID test sequence 5, but may be omitted for the final report for the other test sequences if they are indistinguishable from the high-injection images.

5.9 Insulation thickness test

For modules being stressed according to sequence 3, the final insulation thickness shall be measured on any polymeric insulation sheets using the procedure described in IEC 61730-2, MST 04. The measured thicknesses shall be reported. No pass-fail criteria are applied.

5.10 Thermal cycling

Thermal cycling shall be performed according to IEC 61215-2, MQT 11 with applied current defined in the technology specific subclauses of IEC 61215-1-x. For bifacial modules, current applied during MQT 11 shall be that defined in IEC 61215-1-1:2021: the peak power current at bifacial stress irradiance (BSI).

5.11 Humidity freeze

Humidity freeze shall be performed according to IEC 61215-2, MQT 12 with any technology specific modifications made consistent with IEC 61215-1-x.

5.12 Final stabilization

Final stabilization shall be applied according to MQT 19.2 in IEC 61215-1 and the technology-specific parts of the IEC 61215 series. In sequence 4 (damp heat) of this document, each final stabilization shall include the stress-specific stabilization for B-O LID, as specified in MQT 19.3 of IEC 61215-2:2021.

6 Data collection and stress application

6.1 General

The individual stress application methods (without pass-fail criteria) are as described in IEC 61215 series and IEC 61730 series, including the technology-specific parts of these. This document describes which characterization tools to apply after each interval of stress application. The sequences are summarized in Clause 8.

6.2 Initial characterization

Physical measurements shall be recorded as described in 5.2 to identify variations from sample to sample and to precisely define the properties of the test samples for further comparison. In the final report, these measurements shall be reported and compared with any corresponding values found on the product specifications sheet.

All modules shall be characterized before application of stress using the methods described in 5.2 to 5.8.