IEC TS 63209-1

Edition 1.0 2021-04

TECHNICAL SPECIFICATION

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 27.160

ISBN 978-2-8322-9728-5

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 3
INTRODUCTION 5
1 Scope 6
2 Normative references 6
3 Terms, definitions and abbreviated terms 7
4 Selection of test samples 8
5 Characterization and stabilization techniques to be applied 8
5.1 General 8
5.2 Physical measurement 8
5.3 Visual inspection 8
5.4 Initial stabilization 8
5.5 Performance 8
5.6 Insulation test 8
5.7 Wet leakage current 9
5.8 Electroluminescent imaging 9
5.9 Insulation thickness test 9
5.10 Thermal cycling 9
5.11 Humidity freeze 9
5.12 Final stabilization 9
6 Data collection and stress application 9
6.1 General 9
6.2 Initial characterization 9
6.3 Test sequence 1: Thermal fatigue 10
6.4 Test sequence 2: Mechanical stress 10
6.5 Test sequence 3: Sequential testing including UV stress to module back 11
6.6 Test sequence 4: Damp heat 12
6.7 Test sequence 5: Potential-Induced Degradation (PID) testing 12
7 Report 13
8 Test flow and procedures 14
Annex A (informative) Appropriate use of IEC TS 63209-1 – Potential weaknesses of the included test sequences 15
A.1 General 15
A.2 False negatives/false positives 15
A.3 Approximations to service life 16
A.4 Design to test 16
Annex B (informative) Background on IEC TS 63209-1 17
B.1 General 17
B.2 Sequence 1: Thermal fatigue – Thermal cycling 600 cycles = 3x IEC 61215 (similar to other extended stress protocols) 17
B.3 Sequence 2: Mechanical stress (adds static load to sequence similar to other extended stress protocols) 17
B.4 Sequence 3: Combines UV, moisture and temperature/mechanical cycling to stress polymeric components 17
B.5 Sequence 4: Damp heat moisture exposure – DH 2 000 h = 2x IEC 61215 (similar to other extended stress protocols) 18
B.6 Sequence 5: Potential-Induced Degradation (PID) testing 18
Bibliography 19

Figure 1 – Full test flow – Each box refers to the corresponding MQT in IEC 61215-2 14

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

PHOTOVOLTAIC MODULES – EXTENDED-STRESS TESTING –

Part 1: Modules

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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*