IEC 63202-1

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Photovoltaic cells – Part 1: Measurement of light-induced degradation of crystalline silicon photovoltaic cells

Cellules photovoltaïques – Partie 1: Mesure de la dégradation induite par la lumière des cellules photovoltaïques au silicium cristallin

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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.
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International Standard IEC 63202-1 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

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

FDIS	Report on voting
82/1565/FDIS	82/1583/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.

A list of all parts in the IEC 63202 series, published under the general title *Photovoltaic cells*, can be found on the IEC website.

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- withdrawn,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.

PHOTOVOLTAIC CELLS –

Part 1: Measurement of light-induced degradation of crystalline silicon photovoltaic cells

1 Scope

This part of IEC 63202 describes procedures for measuring the light-induced degradation (LID) of crystalline silicon photovoltaic (PV) cells in simulated sunlight. The magnitude of LID in a crystalline silicon PV cell is determined by comparing maximum output power at Standard Test Conditions (STC) before, and after, exposure to simulated sunlight at a specified temperature and irradiance.

The purpose of this document is to provide standardized PV cell LID information to help PV module manufacturers in minimizing the mismatch between cells within the same module, thereby maximizing power yield.

When compared to PV module LID measurements described in the IEC 61215 series, several extra experimental factors have been found to show significant impact on the PV cell LID test, which were not considered by IEC 61215-2. This document provides a conditioning and measurements procedure and parameter settings required for consistent PV cell LID measurements.

LID magnitude is one important factor of cell quality. For cells from the same sorting bin, the most important factor is the distribution of output power after LID.

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

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

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

3 Terms and definitions

No terms and definitions are listed in this document.

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

4 Apparatus

The following apparatus are required to perform the test procedures defined in this document:

a) Solar simulator 1: Solar simulator for *I-V* curve measurements in accordance with IEC 60904-9, with means to measure cell temperature accurately to within ±1 °C, and the means to simultaneously measure the current and voltage produced by the PV cell as defined in IEC 60904-1.

b) An environmental chamber or a space that meets following requirements:

   1) One or more irradiance sensors (meeting the requirements of IEC 60904-2) to monitor the cumulative irradiance;

   2) The means to mount test cells co-planar with the irradiance sensors;

   3) The capability to control cell temperature in the range of (60 ± 5) °C during the light exposure;

   4) Relative humidity ≤ 50 %;

   5) The internal air shall be free of corrosive or contaminating contents.

c) Solar simulator 2: Class BBB (or better) steady-state solar simulator in accordance with IEC 60904-9, featuring a capability to provide irradiance of (1 000 ± 50) W/m^2 on cells mounted in an environmental chamber.

5 Sampling

A minimum of twenty PV cells is required for this test. Additional cells can be tested to make up for any mechanical or handling damaged samples.

Under normal sampling criteria, test cells are randomly selected from the same sorting bin and the same production batch. If cells are to be selected using a special sampling criterion, the detailed sampling specification shall be included in the final report. All samples for this test shall be assigned a unique identification number for tracking and reporting purpose.

Selected PV cells shall be stored in a sealed and dark container immediately after *I-V* measurements to minimize the ambient light exposure.

6 Procedure for conditioning and evaluation

6.1 Following the procedures required in IEC 60904-1, measure the *I-V* curve of each cell at STC. Each measurement shall be repeated three times. Calculate the intermittent power, P_n (n=0,1,2…), as the average of the maximum power reading from the three *I-V* curves. Between each measurement, the cell shall be rested for more than 3 s, to allow the cell temperature to recover to its initial value. The contacting scheme for cell testing should not be changed or disturbed during this test. The repeatability of these three readings shall be better than 0,2 %.

6.2 Place the sampled cells in the test chamber (Clause 4b), and expose all the sampled cells to solar simulator 2 with an irradiance of (1 000 ± 50) W/m^2. To compensate for spatial non-uniformity, it is recommended to systematically rotate cells to different locations in the chamber between exposure cycles. During light exposure, the temperature of all cells shall be maintained within the range of (60 ± 5) °C.

6.3 After the exposure described in Step 6.2 is cumulated to 5 kWh/m^2, repeat Step 6.1.

To practically simplify the overall test, 5 kWh/m^2 is recommended for the first cycle instead of 1kWh/m^2. This first cycle exposure may be adjusted based on cell technology or desired test conditions.

6.4 Repeat Step 6.2 to a light exposure of 1 kWh/m^2, and then repeat Step 6.1.

6.5 For each sample cell, repeat Step 6.4 until it reaches the LID quasi-stabilization condition, whereby the sample cell fulfils the following condition:

$$\frac{P_{\max} - P_{\min}}{P_{average}} < 0{,}5\,\%$$

where P_{max}, P_{min} and $P_{average}$ are calculated from three consecutive output power measurements P_{n-2}, P_{n-1} and $P_{n.}$

A similar formula and method are used for determining the magnitude of change of I_{mp}.

Where applicable, a similar formula and method can also be used for cell efficiency η and other parameters.

When one particular test cell reaches the above mentioned LID quasi-stabilization condition, its data for the last I-V measurements shall be properly recorded, and the cell shall be exempt from further testing.

6.6 For samples that do not achieve quasi-stabilization, as defined in Step 6.5, repeat Step 6.2 to a light exposure of 1 kWh/m^2, and the repeat Step 6.1.

6.7 A sample is exempt from further testing when either of the following conditions is met:

a) LID quasi-stabilization, as defined in Step 6.5, has been achieved, or
b) Cumulative exposure has reached 20 kWh/m^2.

6.8 The test terminates when all cells are exempt from further testing. All data shall be recorded properly for the final report.

When the purpose of the test is to observe LID performance, the test may be continued beyond 20 kWh/m^2.

6.9 It is recommended to conduct the test without time delay between cycles; otherwise, put the samples at room temperature (25 °C ± 5 °C) in a dark container, which is sealed or with nitrogen gas purging.

6.10 Periodic electroluminescence (EL) testing of the samples is recommended to determine whether or not cells are damaged due to repeated handling. If any damage is observed, by either EL test or other ways, the data shall be specially marked in the final report.

7 Report

Following completion of the procedure, a report of the test shall be prepared by the agency. Additionally the following shall be included.

a) Description and identification of the item tested, including the specimen size, testing cells details such as their origin and pedigree;

b) Measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate. Refer to Annex A for an example. Compulsory experimental data required to be reported for all samples include:

   1) Initial P_{mp} and I_{mp};

   2) P_{mp} and I_{mp} at termination;

   3) Exposure required to reach quasi-stabilization; and

   4) Condition of the sample at end-of-test (i.e. quasi-stabilized, not quasi-stabilized, or broken);

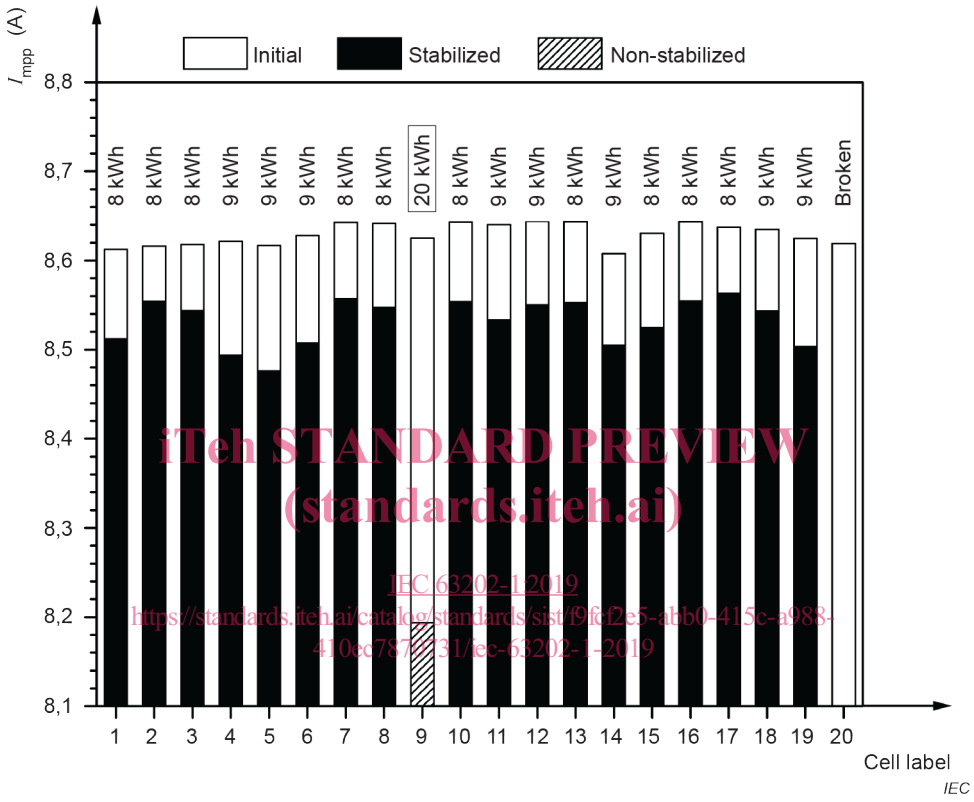
c) A statistical analysis of the experimental data, when requested;

d) A statement of the estimated uncertainty of the test results, where relevant.

Annex A
(informative)

Bar charts presented in the test report, showing the absolute value of I_{mp} degradation for all specimens after conditions in 6.1, 6.7 and 6.10 are met

The suggested template is shown in Figure A.1.



Key

White box: initial value

Black box: stabilized value

Hatched box: non-stabilized value after maximum exposure

Single white box: damaged during the test (through EL image)

Figure A.1 – I_{mp} values of all test samples before and after LID tests

For the bar charts, it is recommended to use gray scale coloring only, for maximum readability on black-and-white printed hardcopies.