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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Photovoltaic (PV) modules – Transportation testing – Part 1: Transportation and shipping of module package units

Modules photovoltaïques (PV) – Essais de transport – Partie 1: Transport et expédition d'unités d'emballage de modules

IEC 62759-1:2022-07(en-fr)

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

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

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PHOTOVOLTAIC (PV) MODULES – TRANSPORTATION TESTING –

Part 1: Transportation and shipping of module package units

FOREWORD

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IEC 62759-1 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is an International Standard.

This second edition cancels and replaces the first edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Cancellation of tests and references to relevant standards for CPV.
b) Deletion of different classes for PV modules.
c) Deletion of requirement for minimum 10 modules per shipping unit.
d) Implementation of stabilization as intermediate measurement.
e) Addition of pass/fail criteria.
f) Change of requirements for retesting.

g) Change of number of cycles in dynamic mechanical load test. See also clause 6.4.2.1.

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

Draft	Report on voting
82/2029/FDIS	82/2052/RVD

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

The language used for the development of this International Standard is English.

A list of all parts in the IEC 62759 series, published under the general title *Photovoltaic (PV) modules – Transportation testing*, can be found on the IEC website.

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 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 (PV) MODULES – TRANSPORTATION TESTING –

Part 1: Transportation and shipping of module package units

1 Scope

Photovoltaic (PV) modules are electrical devices intended for continuous outdoor exposure during their lifetime. Existing type approval standards do not consider mechanical stresses that may occur during transportation to the PV installation destination.

This part of IEC 62759 describes methods for the simulation of transportation of complete package units of modules and combined subsequent environmental impacts.

A list of design modifications which require a retest is provided in Annex B.

This document applies to flat plate photovoltaic modules.

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 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

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

IEC 61215-1:2021, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 1: Test requirements*

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

IEC 61730-2:2022*, Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing*

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

IEC TS 62782:2016, *Photovoltaic (PV) modules – Cyclic (dynamic) mechanical load testing*

ASTM D880-92, *Standard Test Method for Impact Testing for Shipping Containers and Systems*

ASTM D4169-16, *Standard Practice for Performance Testing of Shipping Containers and Systems*

ASTM D4728:2006, *Standard Test Method for Random Vibration Testing of Shipping Containers*

ASTM D5277-92, *Test method for performing programmed horizontal impact using an inclined impact tester*

ISTA 3E:2017, *Unitized Loads of Same Product*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836 and 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
bandwidth
difference in Hz between the upper and lower limits of a frequency band

Note 1 to entry: For the purposes of the described test method, the bandwidth may be considered equivalent to the frequency resolution of a spectrum analysis.

3.2
overall g_{RMS}
square root of the integral of power spectral density over the total frequency range

Note 1 to entry: It describes the severity or harshness of the testing grade.

3.3
root mean square
RMS
square root of the mean square value

Note 1 to entry: In the exclusive case of a sine wave, the RMS value is 0,707 times peak value.

3.4
random vibration
oscillation whose instantaneous amplitude is not prescribed for any given instant in time

Note 1 to entry: The instantaneous amplitudes of a random vibration are prescribed by a probability distribution function, the integral of which, over a given amplitude range, will give the probable percentage of time that the amplitude will fall within that range.

Note 2 to entry: Random vibration contains no periodic or quasi-periodic components.

3.5
packaging
material and technology used to protect goods from transportation stresses and separate individual units from each other

3.6
power spectral density
PSD
expression of random vibration in terms of mean square acceleration per unit of frequency

Note 1 to entry: Power spectral density is the limit of the mean square amplitude in a given rectangular waveband divided by the bandwidth, as the bandwidth approaches zero.

Note 2 to entry: The units are $(m/s^2)^2/Hz$, it is equal to m^2/s^3. The coherent non-SI unit is g^2/Hz.

4 Sampling

As test samples for the basic transportation and shock test methods, a shipping unit of PV modules, shall be taken at random from a production batch or batches. When the test samples are prototypes of a new design and not from production, this fact shall be noted in the test report. The shipping unit shall contain the usual number of PV modules.

Further three PV modules are to be taken from a separate shipping unit not undergoing any transportation simulation.

Use the regular shipment packaging materials with the modules, as marketed and designed by the manufacturer.

The modules shall have been manufactured from specified materials and components in accordance with the relevant drawings and process sheets and shall have been subjected to the manufacturer's normal inspection, quality control and production acceptance procedures.

The modules shall be complete in every detail, including a type label and shall be accompanied by the manufacturer's handling, mounting, shipping/packaging and installation instructions, including the information of the maximum permissible system voltage.

The test specimen of shipping unit shall be packed in accordance with the standard procedures used to ship modules to customers.

5 Handling

The test samples shall be handled with suitable care prior to the application of the tests described in this document. It should be ensured that the test samples are not exposed to additional mechanical impacts in form of shocks, rough handling, dropping, etc.

For the transportation from the manufacturer to the test laboratory special care should be taken to avoid any kind of damage. A special packaging concept, e.g. an additional packaging, special transportation method, etc., may be considered for this particular shipping route (manufacturer – test site). Testing shall be carried out without additional packaging.

6 Testing procedures

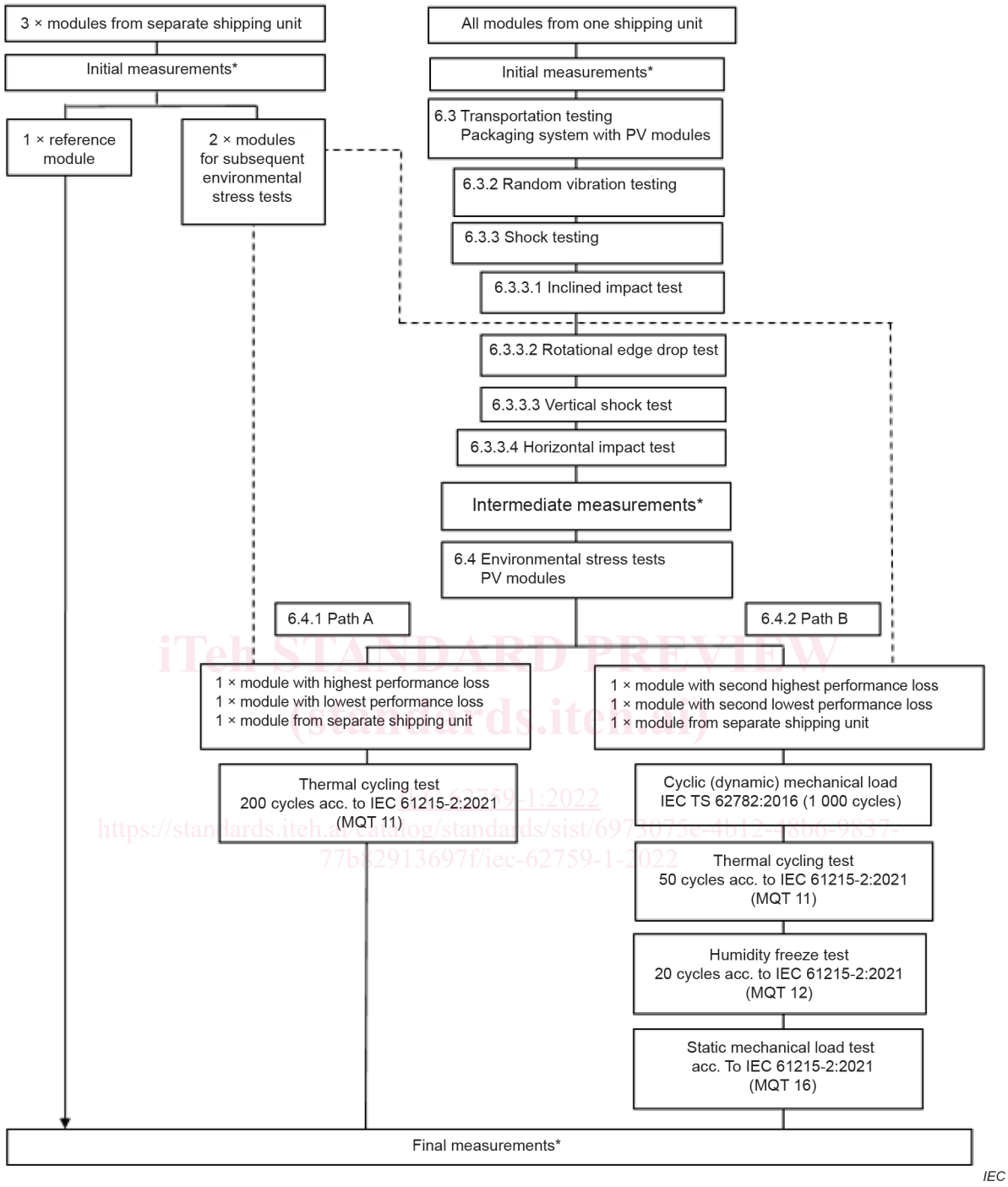
6.1 General

Performance measurements, visual inspection, insulation and wet leakage current testing shall be performed in accordance with IEC 61215-2:2021, MQT 01, MQT 02, and in accordance with IEC 61730-2:2022, MST 16 and MST 17 as reference initial and control measurements.

Electroluminescence images according to IEC TS 60904-13 may be used to detect cracks which are not visible at initial and intermediate status (no pass/fail criteria are specified).

The actual transportation test is shown in Figure 1. The sequences of combined transportation stress testing and the possible effects of these impacts on the PV modules shall detect early failures in regards to future life time stresses.

Separate modules, that have not undergone any transportation testing, are also subjected to the stress tests in sequences A and B. These modules shall be used to identify if defects are caused by transportation test and subsequent environmental test, or by environmental test only.



* See 6.2 for details on measurements.

Figure 1 – Test sequences for PV modules

6.2 Measurements

Each initial, intermediate and final measurement shall characterize the electrical performance of the PV modules and document the influence of the stress tests. The initial, intermediate and final measurements are:

- Visual inspection according to IEC 61215-2:2021 (MQT 01)
- Stabilization (optional for intermediate measurements) according to IEC 61215-2:2021 (MQT 19)
- Maximum power determination according to IEC 61215-2:2021 (MQT 02)

- Insulation test according to IEC 61730-2:2022 (MST 16)
- Continuity test of equipotential bonding according to IEC 61730-2:2021 (MST 13)
- Wet leakage current test according to IEC 61730-2:2022 (MST 17)
- Electroluminescence images according to IEC TS 60904-13 or alternative methods, e.g. dark I-V, may be used to detect cracks which are not visible at initial and intermediate status (no pass/fail criteria are specified).

NOTE While the maximum power determination is only a reference measurement, some PV technologies may need stabilization according to their respective type approval standard to arrive at meaningful data.

6.3 Transportation testing

6.3.1 General

Performing tests of random vibration and various shock tests on the complete package system of modules simulates road transportation and the related mechanical impacts on shipping units and the PV modules that are contained within.

The packaged-product shall be stored at laboratory ambient temperature and humidity for 12 h prior to starting the tests.

NOTE Sequence B of Figure 1 can be extended by the UV preconditioning test to be able to coordinate with IEC 61215 if desired.

While the PV modules are carefully unpacked, the modules shall be marked: the original packaging state and the module position, e.g. vertically or horizontally stacked within the shipping unit shall be adequately documented.

After the initial measurements described in 6.2, the modules shall be restored to their original packaged condition in order to perform the tests described in 6.3.2 and 6.3.3.

6.3.2 Random vibration testing

6.3.2.1 Purpose

Transportation simulation is achieved through a random vibration test. Truck transportation is considered to be the most severe method of long distance transportation for shipping goods. The truck transportation test therefore covers most other means of transportation.

6.3.2.2 Apparatus

Test equipment as described in ASTM D4728:2006, Clause 5 – Apparatus shall be used.

6.3.2.3 Procedure

The transportation simulation shall be performed in accordance with ASTM D4169-16 with one complete stack of modules:

The applied test profile shall meet the following requirements:

a) A frequency range from 1 Hz to 200 Hz.

b) A test severity not below 0,54 g_{RMS} as described in Annex A.

c) The test duration shall last at least 180 min.

d) Excitation axis: vertical.

Following the random vibration test, a series of shock tests shall be carried out on the shipping unit.

6.3.3 Shock testing

6.3.3.1 Incline impact test

6.3.3.1.1 Purpose

The incline impact test shall be performed to simulate stress potentially caused by forklift transportation.

6.3.3.1.2 Apparatus

Test equipment as described in ASTM D880-92 shall be used.

6.3.3.1.3 Procedure

The procedure as described in ISTA 3E Test Block 2 shall be followed.

6.3.3.2 Rotational edge drop test

6.3.3.2.1 Purpose

A rotational edge drop test shall be performed to test the integrity of the shipping supporting units pallet.

6.3.3.2.2 Apparatus

Test equipment as described in ISTA 3E Test Block 3 shall be used.

6.3.3.2.3 Procedure

The procedure as described in ISTA 3E Test Block 3 shall be followed.

6.3.3.3 Vertical shock test

6.3.3.3.1 Purpose

A shock test according to IEC 60068-2-27 shall be performed. This test procedure simulates stresses as may be caused by potholes or sidewalk edges which are not covered by the random vibration test.

6.3.3.3.2 Apparatus

Test equipment as described in IEC 60068-2-27:2008, Clause 4 shall be used.

The following deviation will be tolerated, if the applied variations are explained and clearly documented in the report:

- Extension of the mounting table in order to fit larger package units in an appropriate way.

6.3.3.3.3 Procedure

100 half sinusoidal shocks with duration of 11 ms shall be applied vertically (z direction).

6.3.3.4 Horizontal impact test

6.3.3.4.1 Purpose

For testing the integrity of the shipping unit regarding internal displacements or displacements of the shipping goods against the pallet, an incline impact test shall be performed in accordance with ASTM D5277-92. This test simulates sudden deceleration and sideward acceleration in curves during truck transportation.

6.3.3.4.2 Apparatus

Test equipment as described in ASTM D5277-92 shall be used.

6.3.3.4.3 Procedure

A test according to ASTM D5277-92 "test method for performing programmed horizontal impact using an incline impact tester" shall be performed. The difference compared to the incline impact test is that the shipping unit is decelerated on the transport sledge / transport vehicle.

The pallet has to be restrained, and the load on top of the pallet has to be unrestrained.

The characteristic of this impact shall be half sinusoidal shock like. The half sinus shock shall have a deceleration of 1 g and a length of 350 ms and shall be applied on each horizontal side.

It is common to start with an initial value of 0,3 g and increase the deceleration stepwise until the integrity of the shipping unit is damaged or the end value of 1 g is reached.

6.4 Environmental stress tests

6.4.1 Path A

6.4.1.1 General

The transportation test is followed by a thermal cycling test in accordance with IEC 61215-2:2021 MQT 11 for 200 cycles.

6.4.1.2 Sample allocation for path A

a) 1 x module (highest power loss relative to initial measurement after transport simulation);

b) 1 x module (lowest power loss relative to initial measurement after transport simulation);

c) 1 x module from separate shipping unit.

NOTE The thermal cycling test represents the worst case variability of temperature in temperate climates. In general, PV modules are multilayer products. Each material (layer) has a different thermal expansion. This causes stress between the layers while thermal cycling. The cells, the joints and cell/string connectors may be especially prone to strains.

6.4.2 Path B

6.4.2.1 General

The transportation test is followed by a dynamic mechanical load test according to IEC TS 62782 (1 000 cycles), a thermal cycling test according to IEC 61215-2:2021 MQT 11 with 50 cycles and a humidity-freeze test according to IEC 61215-2:2021 MQT 12 with 20 cycles. The sequence concludes with a mechanical load test according to MQT 16 of IEC 61215-2:2021 in upwards and downwards direction.

The dynamic mechanical load test for photovoltaic modules is described in IEC TS 62782. The module shall be installed according to the installation manual of the manufacturer. If different mounting techniques are possible, the worst case mounting situation shall be applied.

6.4.2.2 Sample allocation for path B

a) 1 x module (second highest power loss relative to initial measurement after transport simulation);

b) 1 x module (second lowest power loss relative to initial measurement after transport simulation);

c) 1 x module from separate shipping unit.