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Edition 1.0 2015-06

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

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FOREWORD

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The text of this standard is based on the following documents:

FDIS	Report on voting
82/962/FDIS	82/982/RVD

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

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

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

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication 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- withdrawn,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 and object

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, it does however not include pass/fail criteria.

This standard is designed so that its test sequence can co-ordinate with those of IEC 61215 or IEC 61646, so that a single set of samples may be used to perform both the transportation simulation and performance evaluation of a photovoltaic module design. This standard applies to flat plate photovoltaic modules, but may also be used as a basis for testing of CPV modules and assemblies.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 60068-2-64, *Environmental testing – Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance*

IEC 61215:2005, *Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61646:2008, *Thin-film terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61730-2:2004, *Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing*

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

IEC 62108:2007, *Concentrator photovoltaic (CPV) modules and assemblies – Design qualification and type approval*

IEC 62782, *Dynamic mechanical load testing for photovoltaic (PV) modules* (to be published)

ISO 13355, *Packaging – Complete, filled transport packages and unit loads – Vertical random vibration test*

ASTM D880-92:2008, *Standard Test Method for Impact Testing for Shipping Containers and Systems*

ASTM D4169:2008, *Standard Practice for Performance Testing of Shipping Containers and Systems*

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

ASTM D5277:1992, *Test method for performing programmed horizontal impact using an incline impact tester*

ISTA 3E:2009, *Unitized Loads of Same Product*

MIL STD 810G, *Test Method Standard for Environmental Engineering Considerations and Laboratory Tests*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836:1999 and the following apply.

3.1
bandwidth
difference in Hz between the upper and lower limits of a frequency band. 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. It describes the severity or harshness of the testing grade

3.3
root mean square
r.m.s.
square root of the mean square value. In the exclusive case of a sine wave, the r.m.s. value is 0,707 times peak value

3.4
random vibration
oscillation whose instantaneous amplitude is not prescribed for any given instant in time. 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. 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. The units are g^2/Hz (g^2/cycles/s). 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

3.7
grade A PV modules
100 % functional modules without any visual or functional defects

3.8
grade B or lower PV modules
grade B or lower modules may have visual or functional defects. The modules should be equivalent to grade A modules regarding their mass, size and mechanical behavior.

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. The shipping unit shall contain the usual amount of PV modules. This test procedure is however designed for shipping units containing at least 10 modules. For further testing (path A and B for PV modules) at least six grade A modules are needed from the shipping unit.

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

Grade B or lower modules can be used to fill up the shipping system (uniform distribution) of samples, completing it to a regular shipping unit. Each individual substitute shall cover the same mass, size and bending stiffness as the modules to be tested in the subsequent environmental impact tests.

The shipping unit shall contain at least 25 % grade A modules. If the shipping unit contains less than 24 modules at least six grade A modules shall be provided.

In case of horizontal shipping the bottom and the top of the shipping unit shall be made up with grade A modules and in case of vertical shipping the outer modules of the shipping unit shall be made up with grade A modules.

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

NOTE For CPV modules the sample numbers may vary, as shipping units may be much larger.

5 Handling

The test samples shall be handled with suitable care prior to the application of the tests described in this standard. It shall 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 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, insulation and wet leakage current testing shall be performed in accordance with IEC 61215:2005 respectively IEC 61646:2008, 10.2, 10.3 and 10.15 as relative initial and control measurements. Electroluminescence or thermal images can be used to support the evaluation of the samples initial and intermediate status (e. g. micro cracks, defects, etc.).

The initial and visual inspection in accordance with IEC 61215:2005, 10.1 or IEC 61646:2008, 10.1 for PV modules and IEC 62108:2007, 10.1 for CPV modules shall also be part of the assessment.

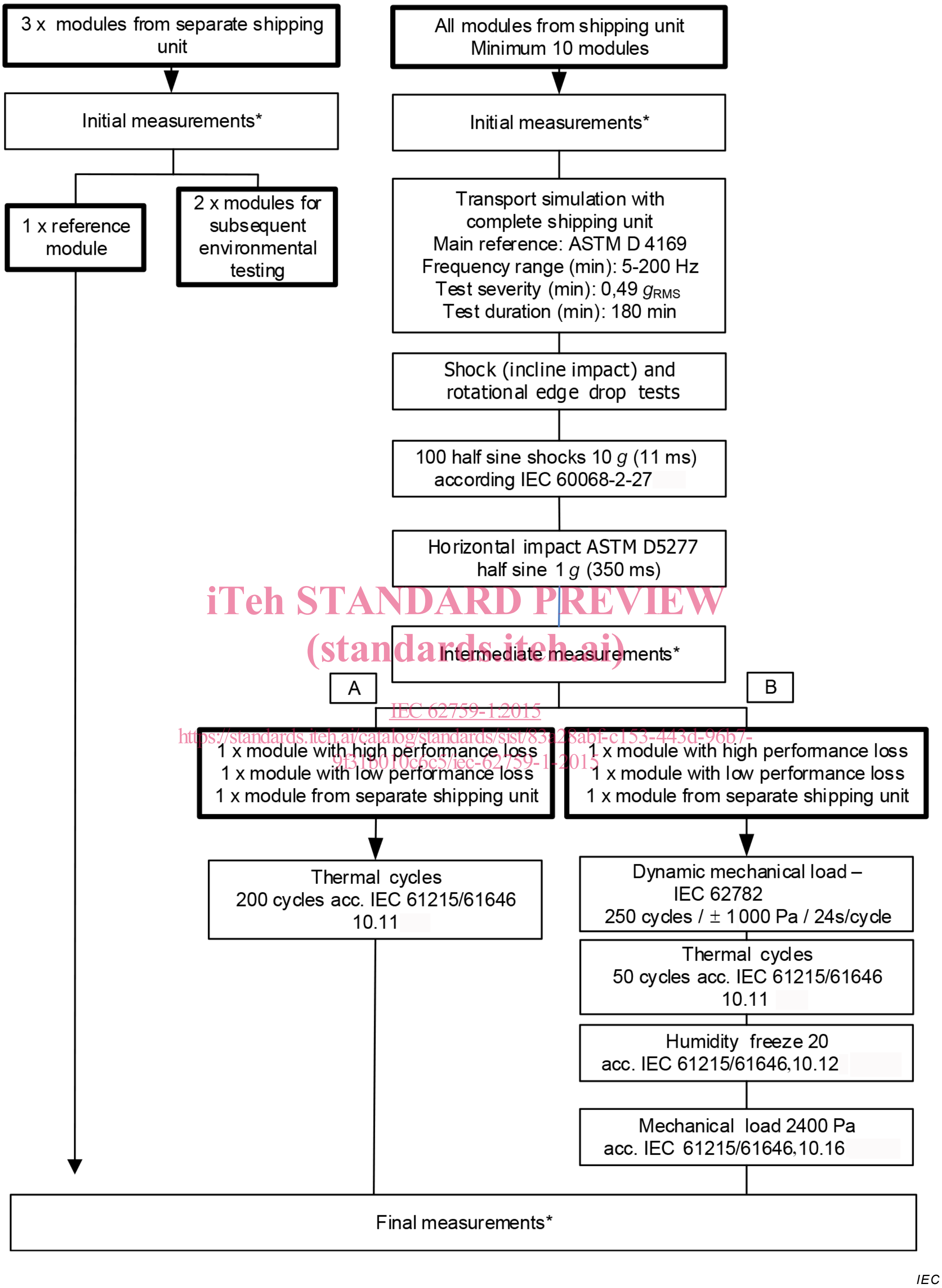
The actual transportation test is shown in Figure 1 for PV modules; Figure 2 shows a possible test sequence for CPV modules. The sequences of combined transportation stress testing and the possible effects of these impacts on the PV modules shall detect early failures in regards to future life-time stresses.

If a manufacturer wishes to combine the testing to this standard with type approval testing, sequence A of Figure 1 can also be used in conjunction with IEC 61215 respectively IEC 61646 testing. Combined testing will increase the risk of failure in type approval testing, as the transportation testing will pose additional stress to the samples.

Sequence B of Figure 1 could be extended with the UV preconditioning test and then also be coordinated with IEC 61215 respectively IEC 61646.

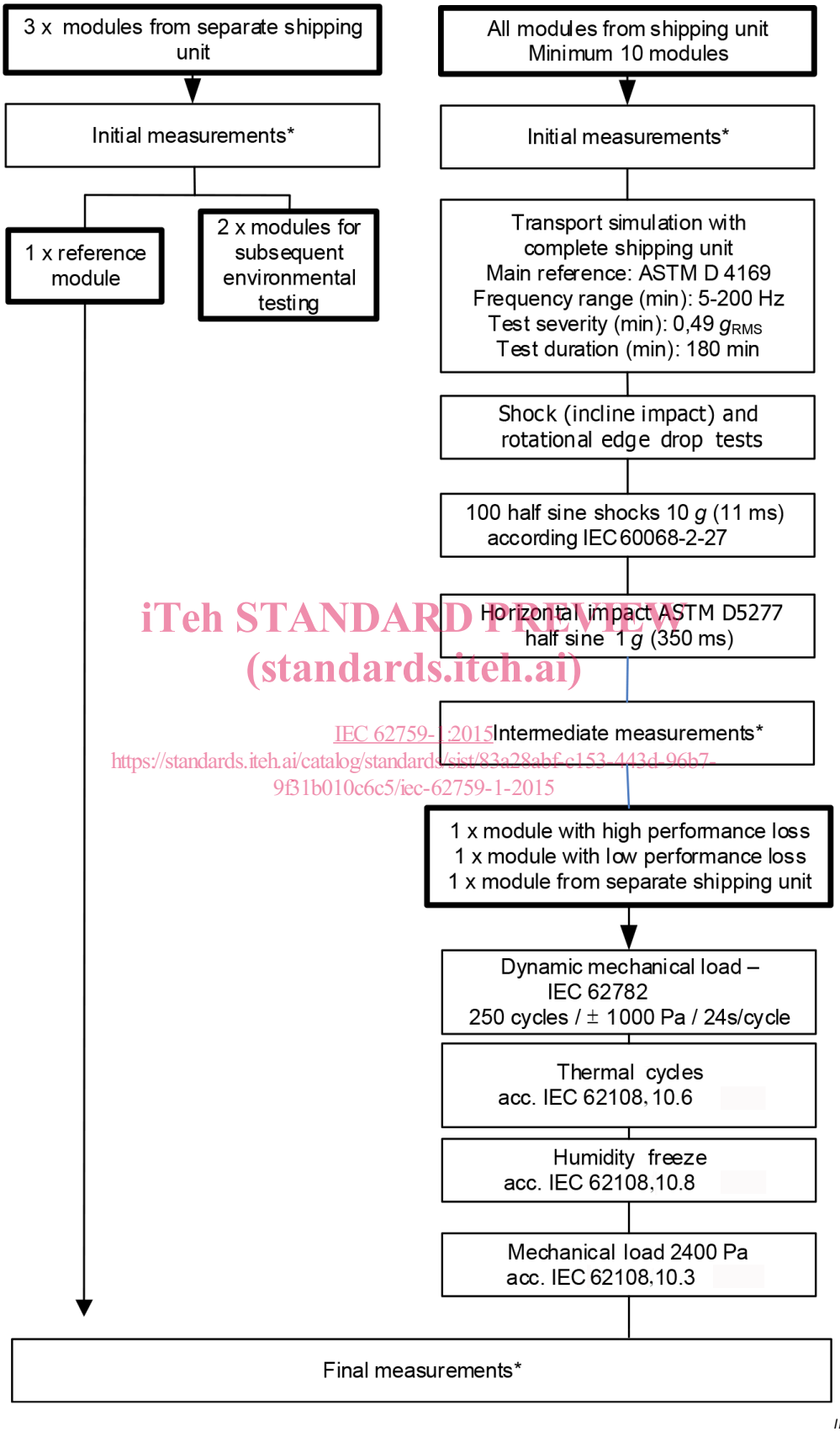
The proposed test sequence in Figure 2 for CPV modules can also be adjusted to coordinate with IEC 62108. The sequence shall be adjusted depending on whether receivers or modules are tested. For receivers, instead of the pre-thermal cycling and humidity freeze test, the thermal cycling test according to IEC 62108:2007, 10.8 may be performed.

Separate modules, that have not undergone any transportation testing, are also subjected to the stress tests in sequences A and B. Failures induced by the transportation simulation and potentially worsen defects due to the environmental stress tests shall be identified in comparison to the modules tested without any transportation pre-damages.


3 x modules from separate shipping unit
Initial measurements*
1 x reference module
2 x modules for subsequent environmental testing
All modules from shipping unit
Minimum 10 modules
Initial measurements*
Transport simulation with complete shipping unit
Main reference: ASTM D 4169
Frequency range (min): 5-200 Hz
Test severity (min): 0,49 gRMS
Test duration (min): 180 min
Shock (incline impact) and rotational edge drop tests
100 half sine shocks 10 g (11 ms) according IEC 60068-2-27
Horizontal impact ASTM D5277 half sine 1 g (350 ms)
Intermediate measurements*
A
B
1 x module with high performance loss
1 x module with low performance loss
1 x module from separate shipping unit
1 x module with high performance loss
1 x module with low performance loss
1 x module from separate shipping unit
Thermal cycles
200 cycles acc. IEC 61215/61646 10.11
Dynamic mechanical load – IEC 62782
250 cycles / ± 1 000 Pa / 24s/cycle
Thermal cycles
50 cycles acc. IEC 61215/61646 10.11
Humidity freeze 20
acc. IEC 61215/61646,10.12
Mechanical load 2400 Pa
acc. IEC 61215/61646,10.16
Final measurements*
IEC

* See 6.2 for details on measurements.

Figure 1 – Test sequences for PV modules



* See 6.2 for details on measurements.

Figure 2 – Test sequences for CPV 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 61215:2005, IEC 61646:2008, respectively IEC 62108:2007, 10.1
- Maximum power determination according to IEC 61215:2005, IEC 61646:2008, respectively IEC 62108:2007, 10.2
- Insulation test according to IEC 61215:2005, IEC 61646:2008, 10.3 respectively IEC 62108:2007, 10.4
- Ground continuity test according to IEC 61730-2:2004,10.4 respectively IEC 62108, 10.3
- Wet leakage current test according to IEC 61215:2005, IEC 61646:2008, 10.15 respectively IEC 62108, 10.5
- Optionally electroluminescence (only for PV modules) or infrared imaging can be used for analysing modules for cracked or broken solar cells, etc.

While the maximum power determination is only a relative measurement, some PV technologies may require preconditioning 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 (C)PV modules that are contained within.

NOTE Sequence B of Figure 1 can be extended by the UV preconditioning test to be able to coordinate with IEC 61215 or IEC 61646 if desired.

While the (C)PV modules are carefully unpacked, the modules shall be marked: the original packaging situation and the module position within the package 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 under 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, section 5 – Apparatus, shall be used.

6.3.2.3 Procedure

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

The applied test profile shall meet the following requirements: