BS EN 61215-1:2016

BSI Standards Publication

Terrestrial photovoltaic (PV) modules — Design qualification and type approval

Part 1: Test requirements

bsi.

National foreword

This British Standard is the UK implementation of EN 61215-1:2016. It is identical to IEC 61215-1:2016. Together with BS EN 61215-1-1:2016, BS EN 61215-1-2, BS EN 61215-1-3 and BS EN 61215-1-4, it partially supersedes BS EN 61215:2005.

The UK participation in its preparation was entrusted to Technical Committee GEL/82, Photovoltaic Energy Systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements (IEC 61215-1:2016)

Modules photovoltaïques (PV) pour applications terrestres - Qualification de la conception et homologation - Partie 1: Exigences d'essai (IEC 61215-1:2016)

Terrestrische Photovoltaik-(PV-)Module - Bauarteignung und Bauartzulassung - Part 1: Prüfanforderungen (IEC 61215-1:2016)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

The text of document 82/1046/FDIS, future edition 1 of IEC 61215-1, prepared by IEC/TC 82 “Solar photovoltaic energy systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61215-1:2016.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2017-01-13
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2019-04-13

This document supersedes partially EN 61215:2005.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61215-1:2016 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)
Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60050	series	International Electrotechnical Vocabulary	-	series
IEC 60269-6	-	Low-voltage fuses -- Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems	EN 60269-6	-
IEC 60891	-	Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics	EN 60891	-
IEC 60904-1	-	Photovoltaic devices -- Part 1: Measurement of photovoltaic current-voltage characteristics	EN 60904-1	-
IEC 60904-3	-	Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data	EN 60904-3	-
IEC 60904-10	-	Photovoltaic devices -- Part 10: Methods of linearity measurement	EN 60904-10	-
IEC 61215-2	-	Terrestrial photovoltaic (PV) modules - Design qualification and type approval -- Part 2: Test procedures	EN 61215-2	-
IEC 61730-2	-	Photovoltaic (PV) module safety qualification -- Part 2: Requirements for testing	EN 61730-2	-
IEC 61853-1	-	Photovoltaic (PV) module performance testing and energy rating -- Part 1: Irradiance and temperature performance measurements and power rating	EN 61853-1	-
IEC 61853-2	-	Photovoltaic (PV) module performance testing and energy rating -- Part 2: Spectral response, incidence angle and module operating temperature measurements	-	-
IEC/TS 61836	-	Solar photovoltaic energy systems - Terms, definitions and symbols	CLC/TS 61836	-
IEC/TS 62915	-	Photovoltaic (PV) Modules - Retesting for type approval, design and safety qualification	-	-
ISO/IEC 17025	-	General requirements for the competence of testing and calibration laboratories	EN ISO/IEC 17025	-
ISO/IEC Guide 98-3	-	Uncertainty of measurement -- Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – DESIGN QUALIFICATION AND TYPE APPROVAL –

Part 1: Test requirements

FOREWORD

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International Standard IEC 61215-1 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This first edition of IEC 61215-1 cancels and replaces the second edition of IEC 61215, published in 2005; it constitutes a technical revision.

This edition of IEC 61215-1 includes the following significant technical changes with respect to the second edition of IEC 61215:2005 and the second edition of IEC 61646:2008:

a) New standard series structure consistent with other IEC standards: Part 1 lists general requirements, Part 1-x specifics for each PV technology and Part 2 defines testing. All tests defined in Part 2 are MQTs (module quality tests).
b) Sampling procedure rewritten (Clause 4).
c) Marking requirements better defined for name plate and general documentation.

d) Pass/fail criteria have been divided into two “gates”. Gate No. 1 verifies the initial maximum power at STC with respect to name plate rating and Gate No. 2 defines the power loss during accelerated aging testing.

e) Revised hot-spot endurance test (MQT 09).

f) Update of the other tests to be consistent with changes in IEC 61646.

g) Removal of the method for measuring temperature coefficients and reference to IEC 60891.

h) Definition of NMOT as the nominal module operating temperature measured with the module under maximum power conditions.

i) Rewriting of the standard using NMOT instead of NOCT and reference to future IEC 61853-2 for the test procedure.

j) Rewriting of the robustness of termination test (MQT 14) to include evaluation of both cables and junction boxes.

k) Stabilization of PV modules implemented. This replaces either light soaking procedure from IEC 61646 or preconditioning from IEC 61215.

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

FDIS	Report on voting
82/1046/FDIS	82/1074/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.

A list of all parts in the IEC 61215 series, published under the general title *Terrestrial photovoltaic (PV) modules – Design qualification and type approval,* can be found on the IEC website.

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

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.

INTRODUCTION

Whereas Part 1 of this standard series describes requirements (both in general and specific with respect to device technology), the sub-parts of Part 1 define technology variations and Part 2 defines a set of test procedures necessary for design qualification and type approval. The test procedures described in Part 2 are valid for all device technologies.

TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – DESIGN QUALIFICATION AND TYPE APPROVAL –

Part 1: Test requirements

1 Scope and object

This part of IEC 61215 lays down IEC requirements for the design qualification and type approval of terrestrial photovoltaic (PV) modules suitable for long-term operation in general open-air climates, as defined in IEC 60721-2-1. This standard is intended to apply to all terrestrial flat plate module materials such as crystalline silicon module types as well as thin-film modules.

This standard does not apply to modules used with concentrated sunlight although it may be utilized for low concentrator modules (1 to 3 suns). For low concentration modules, all tests are performed using the current, voltage and power levels expected at the design concentration.

This standard does not address the particularities of PV modules with integrated electronics, it may however be used as a basis for testing such PV modules.

The objective of this test sequence is to determine the electrical and thermal characteristics of the module and to show, as far as possible within reasonable constraints of cost and time, that the module is capable of withstanding prolonged exposure in climates described in the scope. The actual lifetime expectancy of modules so qualified will depend on their design, their environment and the conditions under which they are operated.

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 60050 (all parts), *International Electrotechnical Vocabulary* (available at http://www.electropedia.org)

IEC 60269-6, *Low-voltage fuses – Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems*

IEC 60891, *Photovoltaic devices – Procedures for temperature and irradiance corrections to measured I-V characteristics*

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

IEC 60904-3, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 60904-10, *Photovoltaic devices – Part 10: Methods of linearity measurement*

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

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 61853-1, *Photovoltaic (PV) module performance testing and energy rating – Part 1: Irradiance and temperature performance measurements and power rating*

IEC 61853-2, *Photovoltaic (PV) module performance testing and energy rating – Part 2: Spectral response, incidence angle, and module operating temperature measurements*[1]

IEC TS 62915, *Photovoltaic (PV) modules – Retesting for type approval, design and safety qualification*[1]

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ISO/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms, definitions and abbreviations

For the purposes of this document, the terms and definitions in IEC 60050 and IEC 61836 apply, as well as the following.

3.1
bins of power classes
power (typically maximum power) sorting criteria from the PV module manufacturer

3.2
tolerances <on label>
value range of electrical parameters on the label of the PV module as given by the manufacturer

3.3
MQT
Module Quality Test

3.4
type approval
conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-581:2008, 581-21-08 – Type test]

3.5
reproducibility <of measurements>
closeness of agreement between the results of measurements of the same value of a quantity, when the individual measurements are made under different conditions of measurement:

– principle of measurement,
– method of measurement,
– observer,

1 To be published.

– measuring instruments,
– reference standards,
– laboratory,
– under conditions of use of the instruments, different from those customarily used,

after intervals of time relatively long compared with the duration of a single measurement. [≈ VIM 3.7]

Note 1 to entry: The concepts of "principle of measurement" and "method of measurement" are respectively defined in VIM 2.3 and 2.4.

Note 2 to entry: The term "reproducibility" also applies to the instance where only certain of the above conditions are taken into account, provided that these are stated.

[SOURCE: IEC 60050-311:2001, 311-06-07]

4 Test samples

The PV module samples shall have been manufactured from specified materials and components in accordance with the relevant drawings and process sheets and have been subjected to the manufacturer's normal inspection, quality control and production acceptance procedures. The PV modules shall be complete in every detail and shall be accompanied by the manufacturer's handling, mounting, and connection instructions. When the PV modules to be tested are prototypes of a new design and not from production, this fact shall be noted in the test report (see Clause 9).

The number of test samples required is derived from the applicable test sequences (see Clause 11).

Special test samples may be required for tests such as the bypass diode test MQT 18 (see IEC 61215-2).

For qualification of multiple bins of power classes within the boundaries given in future IEC TS 62915 at least 2 modules each, from the lower end, median and higher end power class shall be used for testing. If median power class does not exist the next higher class shall be used.

If qualification of a single power class shall be extended to further bins of power classes within the boundaries given in IEC TS 62915 at least 2 modules each, from the lower end, median and higher end power class shall be used for label verification (see Gate No. 1 in 7.2.1).

It is advisable to provide additional spare samples meeting the same output power requirements.

If applicable, the test samples shall be used to represent a group of products, or variations in the materials, or production processes used to produce the modules. The additional samples required for the test programme are then derived from IEC TS 62915.

5 Marking and documentation

5.1 Name plate

Each module shall include the following clear and indelible markings:

a) name, registered trade name or registered trade mark of manufacturer;
b) type or model number designation;

c) serial number (unless marked on other part of product);

d) date and place of manufacture; alternatively serial number allowing to trace the date and place of manufacture;

e) maximum system voltage;

f) class of protection against electrical shock;

g) voltage at open-circuit or V_{oc} including tolerances;

h) current at short-circuit or I_{sc} including tolerances;

i) module maximum power or P_{max} including tolerances.

All electrical data shall be shown as relative to standard test conditions (1 000 W/m^2, 25 °C, AM 1,5 according to IEC TS 61836).

International symbols shall be used where applicable.

Compliance of marking is checked by inspection and MQT 06.1.

5.2 Documentation

5.2.1 Minimum requirements

Modules shall be supplied with documentation describing the methods of electrical and mechanical installation as well as the electrical ratings of the module. The documentation shall state the class of protection against electrical shock under which the module has been qualified and any specific limitations required for that class. The documentation shall assure that installers and operators receive appropriate and sufficient documentation for safe installation, use, and maintenance of the PV modules.

NOTE It is considered to be sufficient that one set of documentation is supplied with the module shipping unit.

5.2.2 Information to be given in the documentation

a) all information required under 5.1 e) to i);

b) reversed current rating in accordance to IEC 61730-2;

   – overcurrent protection device type and rating are e.g. given in IEC 60269-6. Overcurrent protection devices with a 1 h, 1,35 I_n overload rating, where I_n is the rated value of the overcurrent protection device, are recommended.

   – maximum series/parallel module configurations is recommended;

c) manufacturer's stated tolerance for V_{oc}, I_{sc} and maximum power output under standard test conditions;

d) temperature coefficient for voltage at open-circuit;

e) temperature coefficient for maximum power;

f) temperature coefficient for short-circuit current.

All electrical data mentioned above shall be shown as relative to standard test conditions (1 000 W/m^2, 25 °C, AM 1,5 according to IEC TS 61836). Moreover the following parameters shall be specified:

g) nominal module operating temperature (NMOT);

h) performance at NMOT (MQT 06.2);

i) performance at low irradiance (MQT 07).

International symbols shall be used where applicable.

Compliance is checked by inspection and MQT 04 through MQT 07.

The electrical documentation shall include a detailed description of the electrical installation wiring method to be used. This description shall include:

j) the minimum cable diameters for modules intended for field wiring;

k) any limitations on wiring methods and wire management that apply to the wiring compartment or box;

l) the size, type, material and temperature rating of the conductors to be used;

m) type of terminals for field wiring;

n) specific PV connector model/types and manufacturer to which the module connectors shall be mated;

o) the bonding method(s) to be used (if applicable); all provided or specified hardware shall be identified in the documentation;

p) the type and ratings of bypass diode to be used (if applicable);

q) limitations to the mounting situation (e.g., slope, orientation, mounting means, cooling);

r) a statement indicating the fire rating(s) and the applied standard as well as the limitations to that rating (e.g., installation slope, sub structure or other applicable installation information);

s) a statement indicating the design load per each mechanical means for securing the module as evaluated during the static mechanical load test according to MQT 16. At discretion of the manufacturer the test load and/or the safety factor γ_m may be noted, too.

To allow for increased output of a module resulting from certain conditions of use, the installation instructions shall include relevant parameters specified by manufacturer or the following statement or the equivalent:

"Under normal conditions, a photovoltaic module is likely to experience conditions that produce more current and/or voltage than reported at standard test conditions. Accordingly, the values of I_{SC} and V_{OC} marked on this module should be multiplied by a factor of 1,25 when determining component voltage ratings, conductor current ratings, and size of controls connected to the PV output."

5.2.3 Assembly instructions

These shall be provided with a product shipped in subassemblies, and shall be detailed and adequate to the degree required to facilitate complete and safe assembly of the product.

6 Testing

It is requested that the test laboratory uses a control module to be able to detect drifts in their measurement results.

The modules shall be divided into groups and subjected to the qualification test sequences in Figure 1. Qualification test sequences are to be carried out in the order specified. The MQT designations in the boxes refer to the corresponding test definitions in Part 2 of this standard. Technology specific test details are listed in the respective parts of this standard.

Intermediate measurements of maximum power (MQT 02) and insulation test (MQT 03) are not necessary, but they may be used to track changes.

Any single tests executed independently of a test sequence, e.g., on special test samples for MQT 09 and MQT 18, shall be preceded by the initial tests of MQT 01, MQT 02, MQT 03, and MQT 15 as appropriate.

In carrying out the tests, the tester shall strictly observe the manufacturer's handling, mounting, and connection instructions. Sequence A may be omitted if the module type has

been tested according to IEC 61853-1. In this case the relevant test results from IEC 61853-1 shall be stated or referenced in the final report.

Test conditions are summarized in Table 1. The test levels in Table 1 are the minimum levels required for qualification. If the laboratory and the module manufacturer agree, the tests may be performed with increased severities. In this case this shall be noted in the test report.

7 Pass criteria

7.1 General

If two or more modules fail to meet the following test criteria, the design shall be deemed not to have met the qualification requirements. Should one module fail any test, two additional modules meeting the requirements of Clause 4 shall be subjected to the entire series of tests of the respective test sequence.

If one or both of these modules also fail, the design shall be deemed not to have met the qualification requirements. If, however, both modules pass the test sequence, the design shall be judged to have met the qualification requirements.

A module design shall be judged to have passed the qualification tests and therefore to be approved according to this standard, if each test sample meets all of the following criteria.

7.2 Power output and electric circuitry

7.2.1 Verification of rated label values → Gate No. 1

All modules shall be stabilized following method MQT 19.1 from IEC 61215-2 (for technology specific requirements see sub-parts of IEC 61215-1). After stabilization the modules shall be measured in accordance with MQT 6.1 (P_{max}(Lab)). After the stabilization procedure all modules shall be within the power rating of the name plate (P_{max}(NP)) including stated measurement uncertainty m_1. Therefore, the following criterion shall be met:

P_{max} Verification:

Each individual module shall meet the following criterion:

$$P_{\mathrm{max}}(\mathrm{Lab}) \cdot \left(1 + \frac{|m_1|\,[\%]}{100}\right) \geq P_{\mathrm{max}}(\mathrm{NP}) \cdot \left(1 - \frac{|t_1|\,[\%]}{100}\right)$$

where

P_{max} (Lab) is the measured maximum STC power of each module in the stabilized state;

P_{max} (NP) is the maximum rated nameplate power of each module without tolerances;

m_1 is the measurement uncertainty in % of laboratory for P_{max} (expanded combined uncertainty (k=2), ISO/IEC Guide 98-3);

t_1 is the manufacturer's rated lower production tolerance in % for P_{max}.

For $\overline{P}_{\mathrm{max}}(\mathrm{Lab})$, the following criterion shall apply:

$$\overline{P}_{\mathrm{max}}(\mathrm{Lab}) \cdot \left(1 + \frac{|m_1|\,[\%]}{100}\right) \geq P_{\mathrm{max}}(\mathrm{NP})$$

where

$\overline{P}_{\max}(\text{Lab})$ is the arithmetic average of the measured maximum STC power of the modules in stabilized condition.

For multiple bins of power classes this formula has to be applied to each power class under investigation.

V_{OC} Verification:

Each individual module shall meet the following criterion:

$$V_{\text{oc}}(\text{Lab}) \cdot \left(1 + \frac{|m_2|\,[\%]}{100}\right) \leq V_{\text{oc}}(\text{NP}) \cdot \left(1 + \frac{|t_2|\,[\%]}{100}\right)$$

where

V_{OC} (Lab) is the measured maximum V_{OC} of each module in the stabilized state;

V_{OC} (NP) is the maximum rated nameplate V_{OC} of each module without tolerances;

m_2 is the measurement uncertainty in % of laboratory for V_{OC};

t_2 is the manufacturer's rated upper production tolerance in % for V_{OC}.

I_{SC} Verification:

Each individual module shall meet the following criterion:

$$I_{\text{sc}}(\text{Lab}) \cdot \left(1 + \frac{|m_3|\,[\%]}{100}\right) \leq I_{\text{sc}}(\text{NP}) \cdot \left(1 + \frac{|t_3|\,[\%]}{100}\right)$$

where

I_{SC} (Lab) is the measured maximum I_{SC} of each module in the stabilized state;

I_{SC} (NP) is the maximum rated nameplate I_{SC} of each module without tolerances;

m_3 is the measurement uncertainty in % of laboratory for I_{SC};

t_3 is the manufacturer's rated upper production tolerance in % for I_{SC}.

A systematic variation to either higher or lower output power will be stated in the final report.

7.2.2 Maximum power degradation during type approval testing → Gate No. 2

At the end of each test sequence or for sequence B after bypass diode test, the maximum power output drop of each module $P_{\max}$ (Lab_Gate No. 2) shall be less than 5 %, referenced to the module's initial measured output power $P_{\max}$ (Lab_Gate No. 1). Each test sample shall meet the following criterion:

$$P_{\max}(\text{Lab\_GateNo.2}) \geq 0{,}95 \times P_{\max}(\text{Lab\_GateNo.1}) \cdot \left(1 - \frac{r[\%]}{100}\right)$$

The reproducibility shall be determined for $P_{\max}$ and shall be used in the formula. The reproducibility r shall be less than stated in the technology specific parts of this standard.

The reproducibility r is verified by comparing the control module(s) from sequence A after initial stabilization (beginning of the test) and after final stabilization (end of tests from sequence B to E). The second test shall be performed after completing all tests. The following applies:

a) All modules from sequences B (after MQT 18.1), C, D and E are measured together with one control module from Sequence A.

b) If a) cannot be used due to test flow (different completion time of sequence or customer requests) restrictions the following applies:

   For each sequence B (after MQT 18.1), C, D and E one control module from sequence A shall be defined. The control module is stabilized and measured together with the modules from the applicable sequence B (after MQT 18.1), C, D or E. For each determined value r the requirement for r shall be fulfilled.

The reproducibility parameter r is not equal to the total measurement uncertainty of MQT 06.1. It is advisable that the same solar simulator is used for P_{max} (Lab_Gate No. 1) and P_{max} (Lab_Gate No. 2).

If r exceeds the technology specific limit for the control module the laboratory needs to check with its own internal reference module(s) whether the test equipment is faulty, or the module under test is responsible for the poor reproducibility, or it is not in a stable state after applied procedure MQT 19.1. If all checks confirm the measurement equipment is performing correctly, this indicates that the control module has drifted by more than the technology specific limit. In this case, proceed by using the technology specific limit for r.

7.2.3 Electrical circuitry

Samples are not permitted to exhibit an open-circuit during the tests.

7.3 Visual defects

There is no visual evidence of a major defect, as defined in Clause 8.

7.4 Electrical safety

a) The insulation test (MQT 03) requirements are met after the tests.

b) The wet leakage current test (MQT 15) requirements are met at the beginning and the end of each sequence.

c) Specific requirements of the individual tests are met.

8 Major visual defects

The purpose of the visual inspection is to detect any visual defects that may cause a risk of reliability loss, including power output.

In some instances more testing may be required to finally decide if major visual defects exist or not.

For the purpose of design qualification and type approval the following observations are considered to be major visual defects:

a) Broken, cracked, or torn external surfaces.

b) Bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the operation of the PV module would be impaired.

c) Bubbles or delaminations forming a continuous path between electric circuit and the edge of the module.

d) If the mechanical integrity depends on lamination or other means of adhesion, the sum of the area of all bubbles shall not exceed 1 % of the total module area.

e) Evidence of any molten or burned encapsulant, backsheet, frontsheet, diode or active PV component.

f) Loss of mechanical integrity to the extent that the installation and operation of the module would be impaired.

g) Cracked/broken cells which can remove more than 10 % of the cell's photovoltaic active area from the electrical circuit of the PV module.

h) Voids in, or visible corrosion of any of the layers of the active (live) circuitry of the module extending over more than 10 % of any cell.

i) Broken interconnections, joints or terminals.

j) Any short-circuited live parts or exposed live electrical parts.

k) Module markings (label) are no longer attached or the information is unreadable.

9 Report

Following type approval, a report of the qualification tests, with measured performance characteristics and details of any failures and re-tests, shall be prepared by the test agency in accordance with ISO/IEC 17025. The report shall contain the detail specification for the module. Each test report shall include at least the following information:

a) a title;

b) name and address of the test laboratory and location where the tests were carried out;

c) unique identification of the report and of each page;

d) name and address of client, where appropriate;

e) description and identification of the item tested;

f) characterization and condition of the test item;

g) date of receipt of test item and date(s) of test, where appropriate;

h) identification of test method used;

i) reference to sampling procedure, where relevant;

j) any deviations from, additions to, or exclusions from, the test method and any other information relevant to specific tests, such as environmental conditions, or the irradiation dose in kWh/m^2 at which stability is reached;

k) measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate including:

   – temperature coefficients of short-circuit current, open-circuit voltage and peak power,

   – NMOT,

   – power at NMOT, STC and low irradiance,

   – the maximum shaded cell temperature observed during the hot-spot endurance test,

   – spectrum of the lamp used for the UV preconditioning test,

   – mounting method(s) utilized in the static mechanical load test and for measurement of NMOT,

   – the positive/negative test loads and the safety factor γ_m used in the static mechanical load test,

   – hail ball diameter and velocity used in the hail test,

   – maximum power loss observed after all of the tests, and

l) any failures observed;

m) a representation of the markings of the module type including manufacturer's power tolerances;

n) a summary of results from all pass criteria defined in Clause 7 in absolute and relative change. If tendencies to either higher or lower values are observed this has to be included in the report. The used stabilization procedure (irradiance, temperature, time) needs to be stated in detail;

o) a statement of the estimated uncertainty of the test results (where relevant); state the reproducibility r from the control module that is used for Gate No. 2.

p) a signature and title, or equivalent identification of the person(s) accepting responsibility for the content of the report, and the date of issue;

q) where relevant, a statement to the effect that the results relate only to the items tested;

r) a statement that the report shall not be reproduced except in full, without the written approval of the laboratory.

10 Modifications

Changes in material selection, components and manufacturing process can impact the qualification of the modified product. Material in direct contact with each other shall be tested in all applicable combinations unless equality can be proven.

Detailed retesting requirements are defined in IEC TS 62915. The recommended test sequences have been selected to identify adverse changes to the modified product.

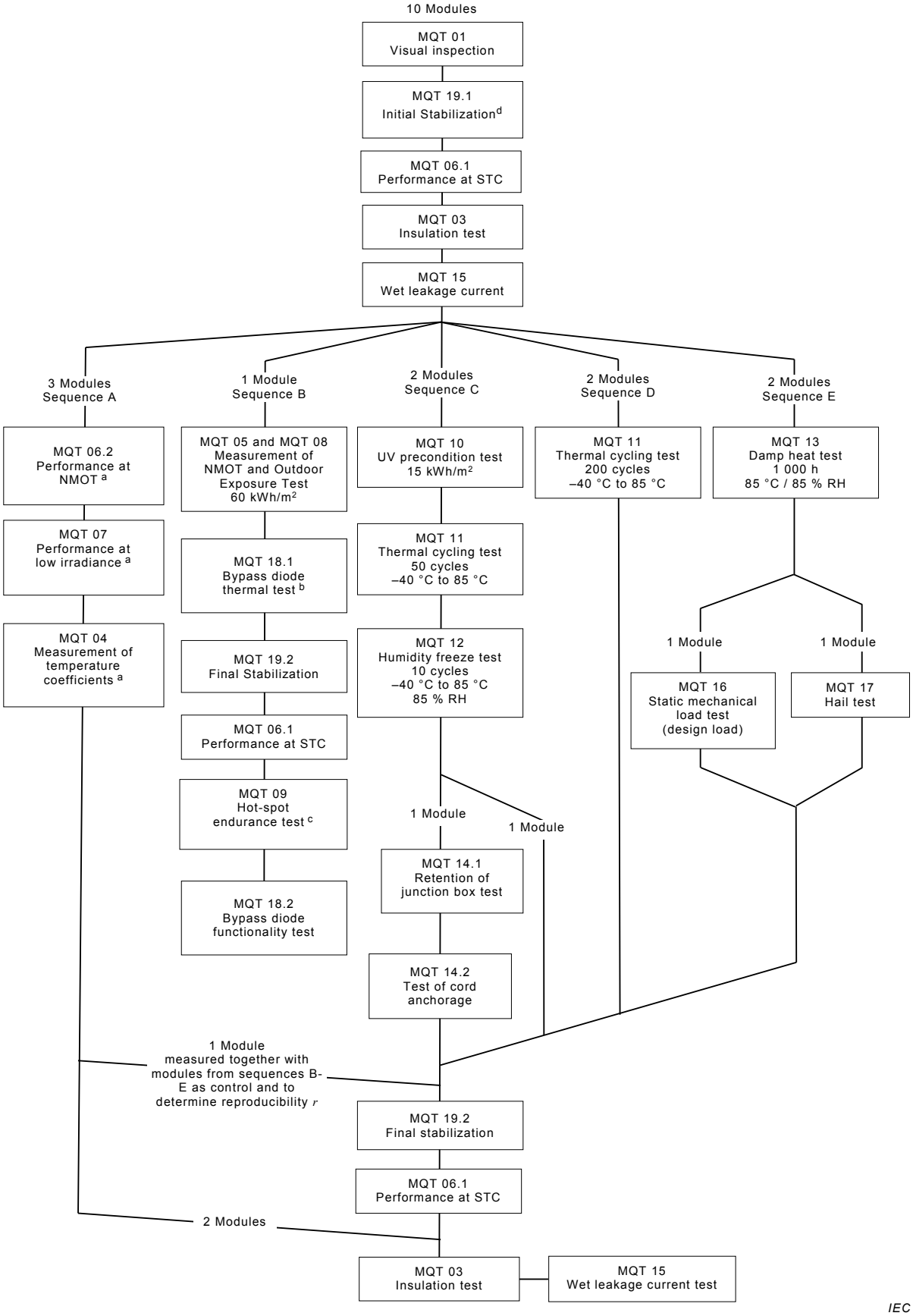
The number of samples to be included in the retesting program and the pass/fail criteria are to be taken from the relevant clauses/subclauses of this standard.

11 Test flow and procedures

For design qualification and type approval the following test flow and procedures apply. Table 1 summarizes the different tests. The full test flow is given in Figure 1. A description of the tests and test procedures is given in IEC 61215-2. Technology relevant differences will be described in the respective technology specific part of this standard.

Table 1 – Summary of test levels

Test	IEC 61215:2005 or IEC 61646:2008	Title	Test conditions
MQT 01	10.1	Visual inspection	See detailed inspection list in Clause 8
MQT 02	10.2	Maximum power determination	See IEC 60904-1
MQT 03	10.3	Insulation test	For modules with a system voltage greater than 50 V d.c., dielectric withstand at 1 000 V d.c. + twice the maximum systems voltage for 1 min, followed by insulation resistance measurement at 500 V d.c. or maximum systems voltage for 2 min. For modules with a system voltage less than 50 V d.c., the test voltages are 500 V d.c.
MQT 04	10.4	Measurement of temperature coefficients	See IEC 60891 See IEC 60904-10 for guidance (see note [a] of Figure 1)
MQT 05	10.5	Measurement of NMOT	See IEC future 61853-2 Module operating near maximum power point Total solar irradiance: 800 W/m^2 Ambient temperature: 20 °C Wind speed: 1 m/s
MQT 06	10.6	Performance at STC (MQT 06.1) and NMOT (MQT 06.2)	Cell temperature of 25 °C at STC and module temperature at NMOT Irradiance: 1 000 W/m^2 and 800 W/m^2 with IEC 60904-3 reference solar spectral irradiance distribution Requirements see Clause 7
MQT 07	10.7	Performance at low irradiance (see note [a] of Figure 1)	Cell temperature: 25 °C Irradiance: 200 W/m^2 with IEC 60904-3 reference solar spectral irradiance distribution
MQT 08	10.8	Outdoor exposure test	60 kWh/m^2 total solar irradiation
MQT 09	10.9	Hot-spot endurance test	Exposure to 1 000 W/m^2 irradiance in worst-case hot-spot condition as per the technology specific part and IEC 61215-2
MQT 10	10.10	UV preconditioning	15 kWh/m^2 total UV irradiation in the wavelength range from 280 nm to 400 nm with 3 % to 10 % UV irradiance in the wavelength range from 280 nm to 320 nm
MQT 11	10.11	Thermal cycling test	50 (Sequence C) or 200 (Sequence D) cycles from –40 °C to +85 °C with current as per technology specific part up to +80 °C
MQT 12	10.12	Humidity freeze test	10 cycles from +85 °C, 85 % RH to –40 °C with circuitry continuity monitoring
MQT 13	10.13	Damp heat test	1 000 h at +85 °C, 85 % RH
MQT 14	10.14	Robustness of termination	Test of junction box retention and cord anchorage.
MQT 15	10.15	Wet leakage current test	Test voltage increase at a rate not exceeding 500 V/s to 500 V or the maximum system voltage for the module, whichever is greater. Maintain the voltage at this level for 1 min.
MQT 16	10.16	Static mechanical load test	Three cycles of uniform load specified by the manufacturer, applied for 1 h to front and back surfaces in turn. Minimum test load: 2 400 Pa
MQT 17	10.17	Hail test	25 mm diameter ice ball at 23,0 m/s, directed at 11 impact locations
MQT 18	10.18	Bypass diode thermal test	MQT 18.1: Bypass diode thermal test: 1 h at I_{sc} and 75 °C 1 h at 1,25 times I_{sc} and 75 °C MQT 18.2: Bypass diode functionality test At 25 °C perform voltage and current measurements
MQT 19	10.19	Stabilization	Three consecutive output power measurements P1, P2 and P3 using MQT 02. STC output power is determined using procedure MQT 06.1.



[a] These tests may be omitted if IEC 61853 has been performed on this module type. Test report shall be included in the design qualification report via IEC 61215.

[b] If the bypass diodes are not accessible in the standard modules, a special sample can be prepared for the bypass diode thermal test (MQT 18.1). The bypass diode should be mounted physically as it would be in a standard

module, with lead wires attached, as required in MQT 18 of IEC 61215-2. This sample does not have to go through the other tests in the sequence.

[c] For Hot-spot endurance test on a separate module the following test sequence is permissible: MQT 01, MQT 19.1, MQT 06.1, MQT 03, MQT 15, MQT 09, and MQT 18.2.

[d] The initial stabilization MQT 19.1 may include the verification of an alternate stabilization procedure (see IEC 61215-2) for the modules of Sequence A.

Figure 1 – Full test flow for design qualification and type approval of photovoltaic modules

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BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

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