UL 62915

STANDARD FOR SAFETY

Technical Specification for Photovoltaic (PV) Modules – Type Approval, Design And Safety Qualification – Retesting

Technical Specification for Photovoltaic (PV) Modules – Type Approval, Design And Safety Qualification – Retesting, UL 62915

First Edition, Dated March 23, 2022

Summary of Topics

First Edition of the UL IEC-Based Technical Specification for Photovoltaic (PV) Modules – Type Approval, Design and Safety Qualification – Retesting, UL 62915. UL 62915 is an adoption of IEC 62915 (First Edition, issued May 2018). Please note that the National Difference document incorporates all of the U.S. national differences for UL 62915.

The requirements are substantially in accordance with Proposal(s) on this subject dated August 20, 2021 and February 18, 2022.

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MARCH 23, 2022

ANSI/UL 62915-2022

UL 62915

Technical Specification for Photovoltaic (PV) Modules – Type Approval, Design And Safety Qualification – Retesting

First Edition

March 23, 2022

This ANSI/UL Standard for Safety consists of the First Edition.

The most recent designation of ANSI/UL 62915 as an American National Standard (ANSI) occurred on March 23, 2022. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, or Preface. The National Difference Page and IEC Foreword are also excluded from the ANSI approval of IEC-based standards.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

No Text on This Page

CONTENTS

No Text on This Page

PREFACE

This UL Standard is based on IEC Publication 62915: First edition Photovoltaic (PV) modules – Type approval, design and safety qualification – Retesting. IEC publication IEC 62915 is copyrighted by the IEC.

Note – Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

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NATIONAL DIFFERENCES

National Differences from the text of International Electrotechnical Commission (IEC) Publication 62915, copyright 2018, are indicated by notations (differences) and are presented in bold text.

There are five types of National Differences as noted below. The difference type is noted on the first line of the National Difference in the standard. The standard may not include all types of these National Differences.

DR – These are National Differences based on the **national regulatory requirements**.

D1 – These are National Differences which are based on **basic safety principles and requirements**, elimination of which would compromise safety for consumers and users of products.

D2 – These are National Differences from IEC requirements based on existing **safety practices**. These requirements reflect national safety practices, where empirical substantiation (for the IEC or national requirement) is not available or the text has not been included in the IEC standard.

DC – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

DE – These are National Differences based on **editorial comments or corrections**.

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

Addition / Add - An addition entails adding a complete new numbered clause, subclause, table, figure, or annex. Addition is not meant to include adding select words to the base IEC text.

Modification / Modify - A modification is an altering of the existing base IEC text such as the addition, replacement or deletion of certain words or the replacement of an entire clause, subclause, table, figure, or annex of the base IEC text.

Deletion / Delete - A deletion entails complete deletion of an entire numbered clause, subclause, table, figure, or annex without any replacement text.

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FOREWORD

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PHOTOVOLTAIC (PV) MODULES – TYPE APPROVAL, DESIGN AND SAFETY QUALIFICATION – RETESTING

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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6) All users should ensure that they have the latest edition of this publication.

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The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

• the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or

• the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62915, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this technical specification is based on the following documents:

Enquiry draft	Reports on voting
82/1331/DTS	82/1378A/RVDTS

Full information on the voting for the approval of this technical specification 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.

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

• transformed into an International standard,

• reconfirmed,

• withdrawn,

• replaced by a revised edition, or

• amended. A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

PHOTOVOLTAIC (PV) MODULES – TYPE APPROVAL, DESIGN AND SAFETY QUALIFICATION – RETESTING

1 Scope

This document sets forth a uniform approach to maintain type approval, design and safety qualification of terrestrial PV modules that have undergone, or will undergo modification from their originally assessed design.

Changes in material selection, components and manufacturing process can impact electrical performance, reliability and safety of the modified product. This document lists typical modifications and the resulting requirements for retesting based on the different test standards. It provides assistance; at some level engineering judgement may be needed.

The test sequences are selected to identify adverse changes to the modified product.

Those products successfully following the herein defined test sequences are considered to be compliant with the standard against which they have originally been assessed in a full qualification.

The number of samples to be included in the retesting program and the pass/fail criteria are listed in the referenced standards IEC 61215 and IEC 61730.

Tests required by changes from previous to new standard editions of IEC 61215 and IEC 61730 are not covered by this document and are evaluated separately.

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 61215 (all parts), *Terrestrial photovoltaic (PV) modules – Design qualification and type approval*

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

IEC 61215-2:2016, *Terrestrial photovoltaic (PV) modules – Design qualification and type approval – Part 2: Test procedures*

IEC 61730 (all parts), *Photovoltaic (PV) module safety qualification*

IEC 61730-1:2016, *Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction*

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

IEC 62790, *Junction boxes for photovoltaic modules – Safety requirements and tests*

2DV DR *Addition of the following:*

UL 969, *Marking and Labeling Systems*

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

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

UL 61730-1, *Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction*

UL 61730-2, *Photovoltaic (PV) module safety qualification – Part 2: Test requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61215-1, IEC 61215-2, IEC 61730-1 and IEC TS 61836, as well as 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
different material
material that differs in its chemical composition, type designation, or specification from the material it replaces

3.2
nominal value
value of a quantity used to designate and identify a component, device, equipment, or system

[SOURCE IEC 60050-151:2001, 151-16-09]

3.3
tolerance
permitted deviation of declared nominal value

4 Retesting

4.1 General

This clause is separated into one subclause each for crystalline silicon and for thin-film technologies. The document is organized by major modification headings with specific supporting examples and parenthetical reference to the specific clauses of the relevant IEC standards.

Any change in the design, materials, components, material combinations, manufacturers or processing of the PV module type family from the last tested version may require a repetition of some or all of the qualification tests according to the clauses that follow in order to maintain type and safety approval. For any change in material specification, including, e.g., electrical, optical, mechanical properties, the nominal values and tolerances shall be considered. For any assessment of a new thickness or dimension, the initially tested thickness or dimension shall be used as reference. Any variation of a parameter may be assessed as change if the new value is out of the tolerance from the nominal value of this parameter.

Materials in direct contact with each other shall be tested in all applicable combinations. The required test items shall be selected only from those tests which are applicable for change of both materials. An example for an assessment procedure is given in Annex A, Clause A.4.

The number of samples to be included in the retesting program and the pass criteria are to be taken from the relevant clause/subclause of the referenced standards (‘pass criteria’).

Each PV module delivered for retesting shall be subjected to electrical stabilisation (MQT 19), as applicable by the relevant type approval standard.

All initial measurements as listed in the referenced standards shall be performed before the specific tests, e.g. tests MQT 01 / 03 / 06.1 / 15 / 19 for an IEC 61215 retest program.

Any scenario including a change in the optical path or electric circuitry that requires retesting as defined hereinafter shall include an STC output power measurement (MQT 06.1). The measured stabilized power, open-circuit voltage and short-circuit current shall be assessed against the rating (Gate No. 1), and the relative change in output power shall be assessed (Gate No. 2) according to the pass criteria laid down in the standard (see IEC 61215-1:2016, 7.2).

Final diagnostic measurements are listed in the referenced test procedure; as a minimum the same tests as performed initially shall be performed.

The Durability of markings (MST 05) and the Sharp edge test (MST 06) need to be considered in general for all design changes which may impact the results of these tests.

If multiple tests from a test sequence are required, they shall be done in the sequence prescribed by the referenced standard.

Changes in the PV module design might require assessment against IEC 61730-1 (requirements for construction) besides the indicated test programs.

Required tests in this Clause 4 are written for combined IEC 61215 (all parts) and IEC 61730 (all parts) evaluations. For simplification, the term “all parts” is omitted in the following. For single IEC 61730 evaluations, care has to be taken that tests listed herein for IEC 61215 may also be referenced and required by IEC 61730 to ensure compliance.

4.1DV.1 D1 *Modification by replacing the 11th paragraph with the following:*

Changes in the PV module design require assessment against UL 61730-1 (requirements for construction) besides the indicated test programs.

4.1DV.2 DR *Modification throughout the entire standard:*

Replace all references to IEC 61215-1 with UL 61215-1, references to IEC 61215-2 with UL 61215-2, references to IEC 61730-1 with UL 61730-1, and references to IEC 61730-2 with UL 61730-2.

4.2 Test programs for crystalline silicon PV modules

NOTE See Table A.1 for a summary of the retest requirements for crystalline silicon PV modules.

4.2.1 Modification to frontsheet

A change from glass to non-glass or vice-versa requires a full qualification.

For the following modifications:

• Different material, i.e. any change in specification of the material or any of its layers

• Glass: reduction of thickness by more than 10 %; non-glass: change of thickness by more than 20 % of any one of the individual layers (while maintaining the required minimum distance through insulation)

• For glass, if there is a reduction in the strengthening process (for example retest if change is from tempered glass to heat strengthened or annealed)

• Different surface treatment, e.g. any coating on frontsheet (inside or outside)

• Change of amount of adhesives, primers or other additives

• Addition or removal of adhesives, primers or additives

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09) if change in material, heat strengthening process or if thickness is reduced

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12) / Retention of junction box on mounting surface (MQT 14.1) (can be omitted for glass with identical UV cut-off)

• Damp heat test (MQT 13) if non-glass or if surface treatment is added/changed (inside or outside)

• Static mechanical load test (MQT 16) (can be omitted for different inside and outside surface treatments that do not impair mechanical strength)

• Hail test (MQT 17) (can be omitted for different surface treatment on the inside)

Repeat for IEC 61730:

• Insulation thickness test (MST 04) if non-glass

• Cut susceptibility test (MST 12) if non-glass

• Impulse voltage test (MST 14) if reduced thickness or if change in material

• Temperature test (MST 21) if non-glass and change in material

• Ignitability test (MST 24) if non-glass

• Module breakage test (MST 32) (can be omitted for different surface treatments that do not impair mechanical strength)

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint (not for reduction of thickness, not for different outer surface treatment and not for change in glass strengthening process)

• Materials creep test (MST 37) (not for reduction of thickness and not for different outside surface treatment)

• Sequence B if non-glass

• Sequence B1 if design qualified for pollution degree 1 (not for reduction of thickness, not for different surface treatment and not for change in glass strengthening process)

For increased thickness, the Materials creep test (MST 37) is required.

4.2.1DV DR *Modification:*

4.2.1DV.1 For the list under "For the following modifications", add the following footnote:

• Different material[1], i.e. any change in specification of the material or any of its layers

[1] NOTE The default position is that a different supplier means different material, for any material. The burden of proof of equivalency is up to the manufacturer and supplier of material, through acceptable results of test and evaluation.

4.2.1DV.2 For the list under "Repeat for IEC 61730", add and delete in accordance with the following:

(Delete) • Insulation thickness test (MST 04) if non-glass

(Delete) • Ignitability test (MST 24) if non-glass

(Add) • Fire Test (MST 23) if change in material or heat strengthening process if glass.

4.2.2 Modification to encapsulation system

For the following modifications:

• Different material

• Different type or change in amount of additive or different chemical composition of encapsulant

• Different manufacturer of encapsulant

• Different encapsulation process (e.g. curing degree, temperature/pressure profile)

• Reduction in thickness of total encapsulation by more than 20 % prior to processing (thickness can also be expressed in density, e.g. in g/cm^3)

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12)

• Damp heat test (MQT 13)

• Hail test (MQT 17) if frontsheet is polymeric

Repeat for IEC 61730:

• Cut susceptibility test (MST 12) if frontsheet or backsheet is polymeric

• Impulse voltage test (MST 14) if reduced thickness or if change in material

• Module breakage test (MST 32) if material composition changes

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes encapsulant as a part of a qualified cemented joint

• Materials creep test (MST 37)

• Sequence B (only for different material or reduction in thickness)

• Sequence B1 if design qualified for pollution degree 1

4.2.2DV DR *Modification:*

4.2.2DV.1 For the list under "For the following modifications" add the following footnote:

• Different material[1]

4.2.2DV.2 For the list under "Repeat for IEC 61730", add the following:

• Fire Test (MST 23) if different material[1], and for change in thickness by more than 20 %

[1] NOTE The default position is that a different supplier means different material, for any material. The burden of proof of equivalency is up to the manufacturer and supplier of material, through acceptable results of test and evaluation.

4.2.3 Modification to cell technology

For the following modifications:

• Metallization material composition (e.g. paste)

• Change in busbar metallization area by more than 20 %

• Change in number of busbars

• Change in anti-reflective coating

• Semiconductor layer material

• Change in crystallization process (e.g. mono- vs. poly-crystalline)

• Change of manufacturing site of the solar cells not under the same quality management system

• Use of cells from a different manufacturer

• Change in nominal cell thickness greater than 10 %

• Different size of cell or use of cut cells (e.g. halved)

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• Thermal cycling test, 200 cycles (MQT 11)

• Damp heat test (MQT 13) (may be omitted if outer surface of cell is chemically identical (metallization and AR coating))

• Static mechanical load test (MQT 16) for reduction of cell thickness only

Repeat for IEC 61730:

• Temperature test (MST 21)

• Reverse current overload test (MST 26)

4.2.3DV D1 ***Modification of the list under "For the following modifications" by adding the following:***

• Change in cell technology (such as screen print, PERC, HIT, tandem cells).

4.2.4 Modification to cell and string interconnect material or technique

For the following modifications:

• Different material (e.g. alloy, chemistry and core)

• Change in mechanical properties by more than 10 % of tensile strength, yield strength and elongation

• Change in thickness by more than 10 %

• Change in (total) cross-section of interconnect material (e.g., more busbars / more busbars with less width)

• Different bonding technique

• Change in the number of interconnect or bonding points or decrease in bonding area per contact point

• Different length of interconnect material between last bond on one cell and first bond on the adjacent cell

• Different solder material, flux or conductive adhesive

• Change in insulation tape (thickness, material, manufacturer)

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09) for changes in bonding technique, interconnect material, solder material, flux or conductive adhesive

• Thermal cycling test, 200 cycles (MQT 11)

• Damp heat test (MQT 13) for changes in material

Repeat for IEC 61730:

• Reverse current overload test (MST 26)

4.2.5 Modification to backsheet

A change from glass to non-glass or vice-versa requires a full qualification.

For the following modifications:

• Different material, i.e. any change in specification of the material or any of its layers

• Glass: reduction of thickness by more than 10 %; non-glass: change of thickness by more than 20 % of any one of the individual layers (while maintaining the required minimum distance through insulation)

• For glass, if there is a reduction in the strengthening process (e.g. retest if change is from tempered to heat strengthened or annealed glass)

• Different surface treatments (inside or outside)

• Change of amount of adhesives, primers or other additives

• Addition or removal of adhesives, primers or additives

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09) for glass if change in heat strengthening process or if thickness is reduced

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12) / Retention of junction box on mounting surface (MQT 14.1) (can be omitted for glass with identical UV cut-off; not for glass change). MQT 14.1 can be omitted if junction box is mounted on frontsheet.

• Damp heat test (MQT 13) if non-glass or if surface treatment is added/changed (inside or outside).

• Static mechanical load test (MQT 16) if glass (including change in manufacturer) or if mounting depends on adhesion to backsheet

• Hail test (MQT 17) if rigidity depends on backsheet

Repeat for IEC 61730:

• Insulation thickness test (MST 04) if non-glass

• Cut susceptibility test (MST 12) if non-glass

• Impulse voltage test (MST 14) if reduced thickness or if change in material

• Temperature test (MST 21) if non-glass and if change in material

• Ignitability test (MST 24) if non-glass

• Module breakage test (MST 32) if glass (can be omitted for different surface treatments that do not impair mechanical strength)

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint and if backsheet is part of it

• Materials creep test (MST 37) (not for reduction of thickness and not for different outside surface treatment)

• Sequence B if non-glass

• Sequence B1 if design qualified for pollution degree 1

For increased thickness, the Materials creep test (MST 37) is required.

Additionally, in case of colour change of backsheet potentially resulting in higher PV module operating temperatures, consider repetition of the Temperature test (MST 21), if applicable.

4.2.5DV DR *Modification:*

4.2.5DV.1 For the list under "For the following modifications", add the following footnote:

• Different material[1], i.e. any change in specification of the material or any of its layers

[1] NOTE The default position is that a different supplier means different material, for any material. The burden of proof of equivalency is up to the manufacturer and supplier of material, through acceptable results of test and evaluation.

4.2.5DV.2 For the list under "Repeat for IEC 61730", add and delete in accordance with the following:

(Delete) • Insulation thickness test (MST 04) if non-glass

(Delete) • Ignitability test (MST 24) if non-glass

(Add) • Fire Test (MST 23) if non-glass or change heat strengthening process if glass.

4.2.6 Modification to electrical termination

Components for electrical terminations such as junction box, cables and connectors shall meet the relevant IEC standards referenced in IEC 61730-1. Their combination with other components and materials shall be tested either on PV module level or on component level. A change in component combination may result in the following PV module tests in addition to tests listed in the relevant component standards.

For the following modifications:

• Different material

• Different design (e.g., different dimensions, changed positions, number of junction boxes)

• Different potting material

• Different method of mechanical attachment / securement (e.g. adhesive change)

• Different method of electrical attachment (e.g. solder, crimping, brazing, etc.)

Repeat for IEC 61215:

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12) / Robustness of terminations test (MQT 14.1 and 14.2) (UV preconditioning test can be omitted for change in potting material or in case junction box is not directly exposed to sunlight; Test of cord anchorage (MQT 14.2) can be omitted for change in mechanical attachment of junction box; Retention of junction box on mounting surface (MQT 14.1) can be omitted for change in electrical attachment of cables)

• Thermal cycling test, 200 cycles (MQT 11) only for change in electrical attachment

• Damp heat test (MQT 13)

• Bypass diode thermal test (MQT 18) (not required for change of any attachment)

Repeat for IEC 61730:

• Accessibility test (MST 11)

• Temperature test (MST 21) if change in potting material or adhesive

• Ignitability test (MST 24) only for change of adhesive

• Reverse current overload test (MST 26) (not for change of adhesive)

• Screw connections test (MST 33) if applicable

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint (only for mechanical attachment of junction box)

• Materials creep test (MST 37) only for change of adhesive or for increased weight of electrical termination

• Sequence B only for change of adhesive

• Sequence B1 if design qualified for pollution degree 1

4.2.6DV DR *Modification of the list under "Repeat for IEC 61730" by deleting the following bullet:*

• Ignitability test (MST 24) only for change of adhesive

4.2.7 Modification to bypass diode

For bypass diodes mounted within the junction box, requirements of IEC 62790 need to be fulfilled.

For bypass diodes not mounted within the junction box, the following applies:

For the following modifications:

• Lower rating of diode current or diode junction temperature

• Different number of bypass diodes per PV module

• Different type of bypass diode

• Different manufacturer of bypass diode

• Different mounting method (physical configuration, soldering material, bonding process, soldering temperature or process)

Repeat for IEC 61215:

• Thermal cycling test, 200 cycles (MQT 11) only for different mounting method

• Bypass diode thermal test (MQT 18)

Repeat for IEC 61730:

• Reverse current overload test (MST 26) only for different mounting method

4.2.7DV D1 *Modification in accordance with the following:*

Delete first 2 sentences that begin with "For bypass diodes"

4.2.8 Modification to electrical circuitry

For the following modifications:

• Modifications to the interconnection circuitry (e.g. more cells per bypass diode or rerouting of output leads)

• Reconfiguration of PV module operating voltage/current (e.g. serial/parallel connection of cells)

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09) only if more cells per bypass diode

• Thermal cycling test, 200 cycles (MQT 11) if there are internal conductors behind the cells

• Bypass diode thermal test (MQT 18) if the short circuit current increases by >10 %

Repeat for IEC 61730:

• Insulation thickness test (MST 04) for rerouting of output leads

• Reverse current overload test (MST 26) (only for increase in PV module operating voltage/current by 10 % or more)

4.2.8DV D2 ***Modification of the list under "Repeat for IEC 61730" by deleting the following bullet:***

• Insulation thickness test (MST 04) for rerouting of output leads

4.2.9 Modification to edge sealing

For the following modifications:

• Different material

• Different thickness or width

Repeat for IEC 61215:

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12) if edge sealing is outer enclosure

• Damp heat test (MQT 13)

Repeat for IEC 61730:

• Impulse voltage test (MST 14)

• Ignitability test (MST 24) (not for different thickness or width)

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint

• Sequence B (not for different thickness or width)

• Sequence B1 if design qualified for pollution degree 1

4.2.9DV DR ***Modification of the list under "Repeat for IEC 61730" by deleting the following bullet:***

• Ignitability test (MST 24) (not for different thickness or width)

4.2.10 Modification to frame and/or mounting structure

For the following modifications:

• Shape and/or cross-section of frame

• Reduction of surface area in contact between laminate and frame per linear dimension

• Different material including adhesive or mounting material

• Different mounting method (as defined in installation manual)

• Change in frame corner design

• Change in frame adhesive

• Change from framed to frameless PV module or vice versa

Repeat for IEC 61215:

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12) if mounting relies on adhesive or polymeric framing material

• Thermal cycling test, 200 cycles (MQT 11) if mounting relies on adhesive or polymeric framing material

• Damp heat test (MQT 13) if mounting relies on adhesive or polymeric framing material or if change from framed to frameless PV module or vice versa

• Static mechanical load test (MQT 16)

• Hail test (MQT 17) if polymeric frame / frontsheet or if change from framed to frameless PV module

Repeat for IEC 61730:

• Continuity test of equipotential bonding (MST 13) if change in method of assembly (can be omitted if change in adhesive)

• Ignitability test (MST 24) for polymeric frames

• Module breakage test (MST 32)

• Screw connections test (MST 33) if applicable

• Material creep test (MST 37) if creep is not prevented by frame or other support anymore

• Sequence B for polymeric frames

In case of change of frame manufacturer or mounting system manufacturer (same material specifications and design) no tests are required.

4.2.10DV DR *Modification:*

4.2.10DV.1 For the list under "For the following modifications", add new bullet:

• Changes in the frame coating, surface treatment or surface treatment thickness by more than 25 % (only IEC 61730 retest of the Continuity test of equipotential bonding (MST 13))

4.2.10DV.2 For the list under "Repeat for IEC 61730", add and delete in accordance with the following:

(Delete) • Ignitability test (MST 24) for polymeric frames

(Add) • Fire Test (MST 23) (for polymeric frame or change from framed to unframed or vice versa)

4.2.11 Change in PV module size

For increase by more than 20 % of length, width or area

Repeat for IEC 61215:

• Thermal cycling test, 200 cycles (MQT 11)

• Damp heat test (MQT 13)

• Static mechanical load test (MQT 16)

• Hail test (MQT 17) if non-tempered glass or if non-glass

Repeat for IEC 61730:

• Module breakage test (MST 32)

4.2.12 Higher or lower output power (by 10 % or more) with the identical design and size and using the identical cell process

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• Thermal cycling test, 200 cycles (MQT 11) if short-circuit current is increased by more than 10 %

• Bypass diode thermal test (MQT 18) if short-circuit current is increased by more than 10 %

For performance at STC (MQT 06.1) see 4.1.

Repeat for IEC 61730:

• Reverse current overload test (MST 26)

4.2.13 Increase of over-current protection rating

Repeat for IEC 61730:

• Continuity test of equipotential bonding (MST 13)

• Reverse current overload test (MST 26)

4.2.14 Increase of system voltage

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12)

• Thermal cycling test, 200 cycles (MQT 11)

• Damp heat test (MQT 13)

Repeat for IEC 61730:

• Insulation thickness test (MST 04)

• Accessibility test (MST 11)

• Cut susceptibility test (MST 12) if non-glass

• Continuity test of equipotential bonding (MST 13)

• Impulse voltage test (MST 14)

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint

• Sequence B

4.2.14DV D2 ***Modification of the list under "Repeat for IEC 61730" by deleting the following bullet:***

• Insulation thickness test (MST 04)

4.2.15 Change in cell fixing tape

For the following modifications:

• Different material

• Different manufacturer

Repeat for IEC 61215:

• Humidity freeze test (MQT 12)

4.2.15DV D1 *Modification of the title for 4.2.15 by replacing it with the following:*

Change in cell fixing tape or internal insulation tape (for all types of modules)

4.3 Test programs for thin-film PV modules

NOTE See Table A.2 for a summary of the retest requirements for thin-film PV modules.

4.3.1 Modification to frontsheet

A change from glass to non-glass or vice-versa requires a full qualification.

For the following modifications:

• Different material, i.e. any change in specification of the material or any of its layers

• Glass: reduction of thickness by more than 10 %; non-glass: change of thickness by more than 20 % of any one of the individual layers (while maintaining the required minimum distance through insulation)

• For glass, if there is a reduction in the strengthening process (for example retest if change is from tempered glass to heat strengthened or annealed)

• Different surface treatment, e.g. any coating on frontsheet (inside or outside)

• Change of amount of adhesives, primers or other additives

• Addition or removal of adhesives, primers or additives

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09) if change in material, heat strengthening process or if thickness is reduced

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12) / Retention of junction box on mounting surface (MQT 14.1) (can be omitted for glass with identical UV cut-off)

• Damp heat test (MQT 13) if non-glass or if cell material is deposited on glass or if surface treatment is added/changed (inside or outside)

• Static mechanical load test (MQT 16) (can be omitted for different inside and outside surface treatment that do not impair mechanical strength)

• Hail test (MQT 17) (can be omitted for different surface treatment on the inside)

Repeat for IEC 61730:

• Insulation thickness test (MST 04) if non-glass

• Cut susceptibility test (MST 12) if non-glass

• Impulse voltage test (MST 14) if reduced thickness or if change in material

• Temperature test (MST 21) if non-glass and change in material

• Ignitability test (MST 24) if non-glass

• Module breakage test (MST 32) (can be omitted for different surface treatments that do not impair mechanical strength)

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint (not for reduction of thickness, not for different outer surface treatment and not for change in glass strengthening process)

• Materials creep test (MST 37) (not for reduction of thickness and not for different outside surface treatment)

• Sequence B if non-glass

• Sequence B1 if design qualified for pollution degree 1 (not for reduction of thickness, not for different surface treatment and not for change in glass strengthening process)

For increased thickness, the Materials creep test (MST 37) is required.

4.3.1DV DR *Modification:*

4.3.1DV.1 For the list under "For the following modifications", add the following footnote:

• Different material[1], i.e. any change in specification of the material or any of its layers

[1] NOTE The default position is that a different supplier means different material, for any material. The burden of proof of equivalency is up to the manufacturer and supplier of material, through acceptable results of test and evaluation.

4.3.1DV.2 For the list under "Repeat for IEC 61730", add and delete in accordance with the following:

(Delete) • Insulation thickness test (MST 04) if non-glass

(Delete) • Ignitability test (MST 24) if non-glass

(Add) • Fire Test (MST 23) if change in material or heat strengthening process if glass.

4.3.2 Modification to encapsulation system

For the following modifications:

• Different material

• Different type or change in amount of additive or different chemical composition of encapsulant

• Different manufacturer of encapsulant

• Different encapsulation process (e.g. curing degree, temperature/pressure profile)

• Reduction in thickness of total encapsulation by more than 20 % prior to processing (thickness can also be expressed in density, e.g. in g/cm^3)

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12)

• Damp heat test (MQT 13)

• Hail test (MQT 17) if frontsheet is polymeric

Repeat for IEC 61730:

• Cut susceptibility test (MST 12) if frontsheet or backsheet is polymeric

• Impulse voltage test (MST 14) if reduced thickness or if change in material

• Module breakage test (MST 32) if material composition changes

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes encapsulant as a part of a qualified cemented joint

• Materials creep test (MST 37)

• Sequence B (only for different material or reduction in thickness)

• Sequence B1 if design qualified for pollution degree 1

4.3.2DV DR *Modification:*

4.3.2DV.1 For the list under "For the following modifications", add the following footnote:

• Different material[1]

4.3.2DV.2 For the list under "Repeat for IEC 61730", add the following:

• Fire Test (MST 23) if different material[1]

[1] NOTE The default position is that a different supplier means different material, for any material. The burden of proof of equivalency is up to the manufacturer and supplier of material, through acceptable results of test and evaluation.

4.3.3 Modification to front contact (e. g. TCO)

For the following modifications:

• Different manufacturer

• Different material, reduction in material purity

• Change in production process

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12)

• Damp heat test (MQT 13)

Repeat for IEC 61730:

• Impulse voltage test (MST 14)

• Reverse current overload test (MST 26)

The use of process gases or targets from different suppliers, but same minimum purities does not require retesting.

4.3.4 Modification to cell technology

For the following modifications:

• Change in cell structure (modification of any layer / additional layer / change of overall cell thickness > 10 %)

• Reduction in process gas purity (including mixing ratios)

• Change in source or target material or reduction in target purity

• Change in doping material composition

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• Damp heat test (MQT 13)

Repeat for IEC 61730:

• Temperature test (MST 21)

• Reverse current overload test (MST 26)

A change in the semiconductor material/technology requires a full qualification.

4.3.4DV D1 ***Modification of the list under "For the following modifications" by adding the following:***

• Change in cell material/technology (perovskites, CIGs, a-Si, CdTe)

4.3.5 Modification to cell layout

For the following modifications:

• Change in number of cells (given that the output power increases by > 10 %)

• Change in serial/parallel connection

• Change in number of cross-scribes

• Change in cell width > 10 %

• Change in patterning technology (e.g. laser vs. mechanical)

• Increase in number of cells per bypass diode

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• Bypass diode thermal test (MQT 18) if the short-circuit current increases by > 10 %

Repeat for IEC 61730:

• Reverse current overload test (MST 26)

4.3.6 Modification to back contact

For the following modifications:

• Different manufacturer

• Different material, reduction in material purity

• Change in production process

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12)

• Damp heat test (MQT 13)

Repeat for IEC 61730:

• Impulse voltage test (MST 14)

• Reverse current overload test (MST 26)

The use of process gases or targets from different suppliers, but same minimum purities does not require retesting.

4.3.7 Modification to edge deletion

For the following modifications:

• Process (e.g. laser vs. mechanical process)

• Reduction in width (edge distance)

Repeat for IEC 61215:

• Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12)

• Damp heat test (MQT 13)

Repeat for IEC 61730:

• Impulse voltage test (MST 14)

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint

• Sequence B1 if design qualified for pollution degree 1

4.3.8 Modification to interconnect material or technique

For the following modifications:

• Different material (e.g. alloy, chemistry and core)

• Change in mechanical properties by more than 10 % of tensile strength, yield strength and elongation

• Change in thickness by more than 10 %

• Change in (total) cross-section of interconnect material by more than 10 %

• Different bonding technique

• Different bonding material (e.g. adhesive)

• Change in the number of interconnect or bonding points or decrease in bonding area per contact point

• Change in contact layout (e.g. position of cross connectors or internal conductors behind the cells)

• Change in insulation tape (thickness, material, manufacturer)

Repeat for IEC 61215:

• Thermal cycling test, 200 cycles (MQT 11)

• Damp heat test (MQT 13) for changes in material

Repeat for IEC 61730:

• Reverse current overload test (MST 26)

4.3.9 Modification to backsheet

A change from glass to non-glass or vice-versa requires a full qualification.

For the following modifications:

• Different material, i.e. any change in specification of the material or any of its layers

• Glass: reduction of thickness by more than 10 %; non-glass: change of thickness by more than 20 % of any one of the individual layers (while maintaining the required minimum distance through insulation)

• For glass, if there is a reduction in the strengthening process (e.g. retest if change is from tempered to heat strengthened or annealed glass)

• Different surface treatments (inside or outside)

• Change of amount of adhesives, primers or other additives

• Addition or removal of adhesives, primers or additives

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09) for glass if change in heat strengthening process or if thickness is reduced

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12) / Retention of junction box on mounting surface (MQT 14.1) (can be omitted for glass with identical UV cut-off; not for glass change). MQT 14.1 can be omitted if junction box is mounted on frontsheet.

• Damp heat test (MQT 13) (if non-glass or if cells are deposited on back glass; not for glass change) or if surface treatment is added/changed (inside or outside).

• Static mechanical load test (MQT 16) if glass (including change in manufacturer) or if mounting depends on adhesion to backsheet

• Hail test (MQT 17) if rigidity depends on backsheet

Repeat for IEC 61730:

• Insulation thickness test (MST 04) if non-glass

• Cut susceptibility test (MST 12) if non-glass

• Impulse voltage test (MST 14) if reduced thickness or if change in material

• Temperature test (MST 21) if non-glass and if change in material

• Ignitability test (MST 24) if non-glass

• Module breakage test (MST 32) if glass (can be omitted for different surface treatments that do not impair mechanical strength)

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint and if backsheet is part of it

• Materials creep test (MST 37) (not for reduction of thickness and not for different outside surface treatment)

• Sequence B if non-glass

• Sequence B1 if design qualified for pollution degree 1

For increased thickness, the Materials creep test (MST 37) is required.

Additionally, in case of colour change of backsheet potentially resulting in higher PV module operating temperatures, consider repetition of the Temperature test (MST 21), if applicable.

4.3.9DV DR *Modification*

4.3.9DV.1 For the list under "For the following modifications", add the following footnote:

• Different material[1], i.e. any change in specification of the material or any of its layers

[1] NOTE The default position is that a different supplier means different material, for any material. The burden of proof of equivalency is up to the manufacturer and supplier of material, through acceptable results of test and evaluation.

4.3.9DV.2 For the list under "Repeat for IEC 61730", add and delete in accordance with the following:

(Delete) • Insulation thickness test (MST 04) if non-glass

(Delete) • Ignitability test (MST 24) if non-glass

(Add) • Fire Test (MST 23) if non-glass or change heat strengthening process if glass.

4.3.10 Modification to electrical termination

Components for electrical terminations such as junction box, cables and connectors shall meet the relevant IEC standards referenced in IEC 61730-1. Their combination with other components and materials shall be tested either on PV module level or on component level. A change in component

combination may result in the following PV module tests in addition to tests listed in the relevant component standards.

For the following modifications:

• Different material

• Different design (e.g., different dimensions, changed positions, number of junction boxes)

• Different potting material

• Different method of mechanical attachment / securement (e.g. adhesive change)

• Different method of electrical attachment (e.g. solder, crimping, brazing, etc.)

Repeat for IEC 61215:

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12) / Robustness of terminations test (MQT 14.1 and 14.2) (UV preconditioning test can be omitted for change in potting material or in case junction box is not directly exposed to sunlight; Test of cord anchorage (MQT 14.2) can be omitted for change in mechanical attachment of junction box; Retention of junction box on mounting surface (MQT 14.1) can be omitted for change in electrical attachment of cables)

• Thermal cycling test, 200 cycles (MQT 11) only for change in electrical attachment

• Damp heat test (MQT 13)

• Bypass diode thermal test (MQT 18) (not required for change of any attachment)

Repeat for IEC 61730:

• Accessibility test (MST 11)

• Temperature test (MST 21) if change in potting material or adhesive

• Ignitability test (MST 24) only for change of adhesive

• Reverse current overload test (MST 26) (not for change of adhesive)

• Screw connections test (MST 33) if applicable

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint (only for mechanical attachment of junction box)

• Materials creep test (MST 37) only for change of adhesive or of junction box

• Sequence B only for change of adhesive

• Sequence B1 if design qualified for pollution degree 1

4.3.10DV DR *Modification of the list under "Repeat for IEC 61730" by deleting the following bullet:*

• Ignitability test (MST 24) only for change of adhesive

4.3.11 Modification to bypass diode

For bypass diodes mounted within the junction box, requirements of IEC 62790 need to be fulfilled.

For bypass diodes not mounted within the junction box, the following applies:

For the following modifications:

• Lower rating of diode current or diode junction temperature

• Different number of bypass diodes per PV module

• Different type of bypass diode

• Different manufacturer of bypass diode

• Different mounting method (physical configuration, soldering material, bonding process, soldering temperature or process)

Repeat for IEC 61215:

• Thermal cycling test, 200 cycles (MQT 11) only for different mounting method

• Bypass diode thermal test (MQT 18)

• Reverse current overload test (MST 26) only for different mounting method

4.3.11DV D1 *Modification in accordance with the following:*

Delete first 2 sentences that begin with "For bypass diodes"

4.3.12 Modification to edge sealing

For the following modifications:

• Different material

• Different thickness or width

Repeat for IEC 61215:

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12) if edge sealing is outer enclosure

• Damp heat test (MQT 13)

Repeat for IEC 61730:

• Impulse voltage test (MST 14)

• Ignitability test (MST 24) (not for different thickness or width)

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint

• Sequence B (not for different thickness or width)

• Sequence B1 if design qualified for pollution degree 1

4.3.12DV DR *Modification of the list under "Repeat for IEC 61730" by deleting the following bullet:*

• Ignitability test (MST 24) (not for different thickness or width)

4.3.13 Modification to frame and/or mounting structure

For the following modifications:

• Shape and/or cross-section of frame

• Reduction of surface area in contact between laminate and frame per linear dimension

• Different material including adhesive or mounting material

• Different mounting method (as defined in installation manual)

• Change in frame corner design

• Change in frame adhesive

• Change from framed to frameless PV module or vice versa

Repeat for IEC 61215:

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12) if mounting relies on adhesive or polymeric framing material

• Thermal cycling test, 200 cycles (MQT 11) if mounting relies on adhesive or polymeric framing material

• Damp heat test (MQT 13) if mounting relies on adhesive or polymeric framing material or if change from framed to frameless PV module or vice versa

• Static mechanical load test (MQT 16)

• Hail test (MQT 17) if polymeric frame / frontsheet or if change from framed to frameless PV module

Repeat for IEC 61730:

• Continuity test of equipotential bonding (MST 13) if change in method of assembly (can be omitted if change in adhesive)

• Ignitability test (MST 24) for polymeric frames

• Module breakage test (MST 32)

• Screw connections test (MST 33) if applicable

• Material creep test (MST 37) if creep is not prevented by frame or other support anymore

• Sequence B for polymeric frames

In case of change of frame manufacturer or mounting system manufacturer (same material specifications and design) no tests are required.

4.3.13DV DR *Modification:*

4.3.13DV.1 For the list under "For the following modifications", add new bullet:

• Changes in the frame coating, surface treatment or surface treatment thickness by more than 25 % (only requiring 61730 retest of the Continuity test of equipotential bonding (MST 13))

4.3.13DV.2 For the list under "Repeat for IEC 61730", add and delete in accordance with the following:

(Delete) • Ignitability test (MST 24) for polymeric frames

(Add) • Fire Test (MST 23) (for polymeric frame or change from framed to unframed or vice versa)

4.3.14 Change in PV module size

For increase by more than 20 % of length, width or area

Repeat for IEC 61215:

• Thermal cycling test, 200 cycles (MQT 11) if change in interconnection layout (e.g. longer cross-connectors)

• Damp heat test (MQT 13)

• Static mechanical load test (MQT 16)

• Hail test (MQT 17) if non-tempered glass or if non-glass

Repeat for IEC 61730:

• Reverse current overload test (MST 26)

• Module breakage test (MST 32)

4.3.15 Higher or lower output power (by 10 % or more) with the identical design and size

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• Thermal cycling test, 200 cycles (MQT 11) if short-circuit current is increased by more than 10 %

• Bypass diode thermal test (MQT 18) if short-circuit current is increased by more than 10 %

• For performance at STC (MQT 06.1) see 4.1.

Repeat for IEC 61730:

• Reverse current overload test (MST 26)

4.3.16 Increase of over-current protection rating

Repeat for IEC 61730:

• Continuity test of equipotential bonding (MST 13)

• Reverse current overload test (MST 26)

4.3.17 Increase of system voltage

Repeat for IEC 61215:

• Hot-spot endurance test (MQT 09)

• UV preconditioning test (MQT 10) / Thermal cycling test, 50 cycles (MQT 11) / Humidity freeze test (MQT 12)

• Thermal cycling test, 200 cycles (MQT 11)

• Damp heat test (MQT 13)

• Insulation thickness test (MST 04)

• Accessibility test (MST 11)

• Cut susceptibility test (MST 12) if non-glass

• Continuity test of equipotential bonding (MST 13)

• Impulse voltage test (MST 14)

• Peel test (MST 35) or Lap shear strength test (MST 36) if design includes cemented joint

• Sequence B

4.3.17DV D2 *Modification of the list under "Repeat for IEC 61730" by deleting the following bullet:*

• Insulation thickness test (MST 04)

5DV D1 *Modification by adding the following new Clauses 5.1DV and 5.2DV:*

5.1DV Qualification of new factory

For a change in the factory where the modules are manufactured:

Repeat for UL 61730:

• Humidity Freeze (MST 52)

• Temperature Cycling, 200 cycles (MST 51)

5.2DV Change in Module Label unless already qualified to UL 969 for the substrate to which it is adhered.

For the following modifications:

• Change in material

• Change in adhesive

• Change in ink

• Change the component or the material of the component that the label is adhered to unless qualified to UL 969, in which case only the humidity freeze test (MST 52) is required.

Repeat for UL 61730:

• Sequence B on either a full sized module, or to a coupon with similar rigidity as the full sized module and with the same material layer to which the label is affixed

Annex A
(informative)

A.1 Required retests for crystalline silicon PV modules, tabular overview

Table A.1

Required retests for crystalline silicon PV modules

	IEC test	Hot-spot endurance test	UV preconditioning test	Thermal cycling test (50)	Thermal cycling test (200)	Humidity-freeze test	Damp heat test	Retention of junction box on mounting surface	Test of cord anchorage	Static mechanical load test	Hail test	Bypass diode testing	Insulation thickness test	Accessibility test	Cut susceptibility test	Continuity test of equipotential bonding	Impulse voltage test	Temperature test	Ignitability test	Reverse current overload test	Module breakage test	Screw connections test	Peel test	Lap shear strength test	Materials creep test	Sequence B	Sequence B1
	IEC test No.	MQT 09	MQT 10	MQT 11	MQT 11	MQT 12	MQT 13	MQT 14.1	MQT 14.2	MQT 16	MQT 17	MQT 18	MST 04	MST 11	MST 12	MST 13	MST 14	MST 21	MST 24	MST 26	MST 32	MST 33	MST 35	MST 36	MST 37	MST 52-54	MST 52/55/56
Sub-clause	Modification (short term)																										
4.2.1	Frontsheet	▒	▒	▒		▒	▒	▒		▒	▒		▒		▒		▒	▒	▒		▒		▒	▒	▒	▒	▒
4.2.2	Encapsulation	■	■	■		■	■				▒						▒				▒		▒	▒	■	▒	▒
4.2.3	Cell	■			■		▒			▒								■		■							
4.2.4	Interconnection	▒			■		▒													■							
4.2.5	Backsheet	▒	▒	▒		▒	▒	▒		▒	▒		▒		▒		▒	▒	▒		▒		▒	▒	▒	▒	▒
4.2.6	El. termination		▒	■	▒	■	■	▒	▒			▒		■				▒	▒	▒		■	▒	▒	▒	▒	▒
4.2.7	Diode				▒							■								▒							
4.2.8	Circuitry	▒			▒								▒							▒							
4.2.9	Edge sealing		▒	▒		▒	■										■		▒				▒	▒		▒	▒
4.2.10	Frame		▒	▒	▒	▒	▒			■	▒					▒			▒		■	■			▒	▒	
4.2.11	Module size				■		■			■	▒										■						
4.2.12	Output power	■			▒							▒								■							
4.2.13	Reverse current															■				■							
4.2.14	System voltage	■	■	■	■	■	■						■	■	■	■	■						▒	▒		■	
4.2.15	Cell fixing tape					■																					
■	Test necessary																										
▒	If applicable. Check detailed specification in 4.2.																										

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