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Glass in building — Laminated solar photovoltaic glass for use in buildings

Verre dans la construction — Verre feuilleté photovoltaïque pour utilisation dans les bâtiments

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Foreword

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This document was prepared by Technical Committee ISO/TC 160, *Glass in building*, Subcommittee SC 1, *Product considerations*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Glass in building — Laminated solar photovoltaic glass for use in buildings

1 Scope

This document specifies requirements of appearance, durability and safety, test methods and designation for laminated solar photovoltaic (PV) glass for use in buildings.

This document is applicable to building-integrated photovoltaics (BIPV). Building-attached photovoltaics (BAPV) can refer to this document.

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.

ISO 3290-1, *Rolling bearings — Balls — Part 1: Steel balls*

ISO 12543-1, *Glass in building — Laminated glass and laminated safety glass — Part 1: Definitions and description of component parts*

ISO 12543-2:2011, *Glass in building — Laminated glass and laminated safety glass — Part 2: Laminated safety glass*

ISO 12543-3, *Glass in building — Laminated glass and laminated safety glass — Part 3: Laminated glass*

ISO 12543-4:2011, *Glass in building — Laminated glass and laminated safety glass — Part 4: Test methods for durability*

ISO 12543-5, *Glass in building — Laminated glass and laminated safety glass— Part 5: Dimensions and edge finishing*

ISO 12543-6:2011, *Glass in building — Laminated glass and laminated safety glass — Part 6: Appearance*

ISO 29584, *Glass in building — Pendulum impact testing and classification of safety glass*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12543-1, ISO 12543-2, ISO 12543-3, ISO 12543-4, ISO 12543-5, ISO 12543-6, IEC/TS 61836 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
laminated solar PV glass
laminated glass that integrates the function of photovoltaic power generation

Note 1 to entry: This term covers both laminated glass (see ISO 12543-3) and laminated safety glass (see ISO 12543-2).

3.2
interlayer
layer of material acting as an adhesive and separator between either piles of glass or between piles of glass and electrical components, which it can embed

Note 1 to entry: Different interlayer materials may be combined within one PV composition.

EXAMPLE Electrical components such as solar cells, interconnectors, diodes or cables.

3.3
termination
component that extracts power from *laminated solar PV glass* (3.1)

3.4
insulating strip
material that is used for the insulating treatment of electrical circuit connection parts

3.5
building-integrated photovoltaics
BIPV
photovoltaic materials that are designed to be a component of the building envelope

Note 1 to entry: If the BIPV material is removed, it has to be replaced by an appropriate building material.

EXAMPLE The building envelope would comprise the roof, skylights or facades.

3.6
building-attached photovoltaics
BAPV
photovoltaic materials that are simply attached to the building

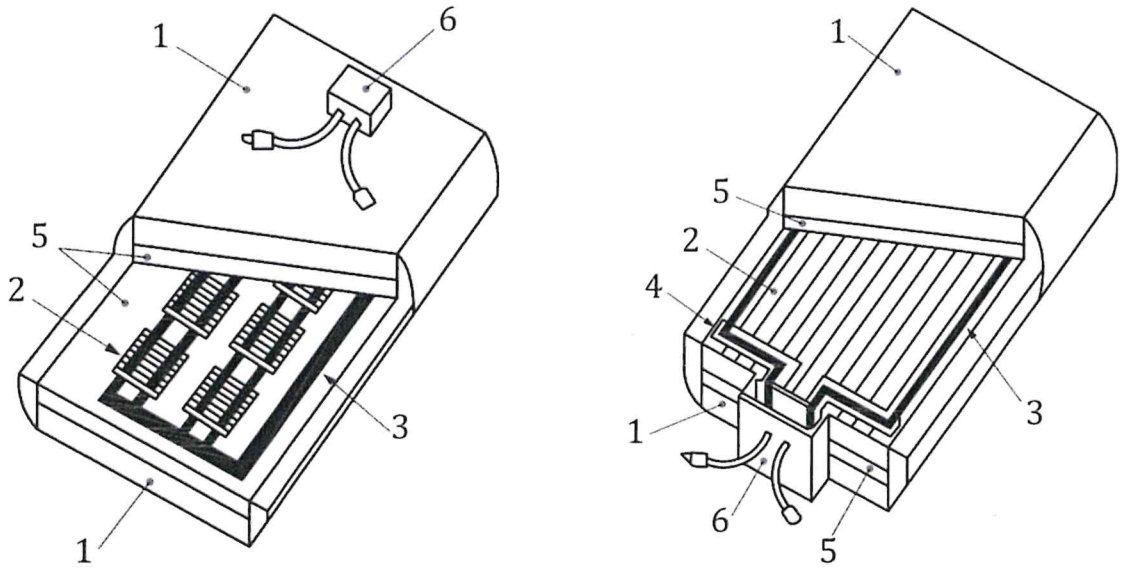
Note 1 to entry: If the BAPV material is removed, it may not be replaced by another building material.

4 Description of components

4.1 General

Laminated solar PV glass shall be manufactured from the combinations of one or more sheets of glass, solar cell, interlayers, interconnector and termination. Figure 1 shows examples of laminated solar PV glass for use in buildings.

NOTE Drawings are not to scale. The description of components in this clause is not exhaustive. Not all components need to be present.



a) Crystalline silicon type laminated solar PV glass **b) Thin-film type laminated solar PV glass**

Key

1 glass
2 solar cell (a: crystalline silicon solar cell; b: thin-film solar)
3 interconnector
4 insulating strip
5 interlayer
6 termination

Figure 1 — Example configurations of laminated solar PV glass in buildings

The glass, interlayer and other component materials are subject to standardization. If materials are not subject to standardization, they should be subject to the manufacturer's specification. These specifications are usually subject to the manufacturer's own quality procedure for factory production control or quality assurance system.

4.2 Types of glass

The type of glass used in laminated solar PV glass may be as follows (see ISO 16293-1):

— float glass;

— patterned glass.

The glass may also be as follows:

— clear, tinted or coated;

— transparent, translucent or opaque;

— annealed, heat strengthened, tempered or chemically strengthened;

— surface-treated (e.g. by sandblast or acid etched).

The layer of glass that faces the sunlight directly shall be transparent or translucent.

NOTE Glass compositions and types are subject to product standards.

4.3 Typical types of solar cells

Typical types of solar cells used in laminated glass may be as follows:

— crystalline silicon solar cell;

— thin-film solar cell.

Typical types of thin-film solar cell include but are not limited to the following:

— amorphous silicon (a-Si) or microcrystalline silicon (uc-Si);

— copper indium gallium selenide (CIGS), or copper zinc tin sulfide (CZTS);

— cadmium telluride (CdTe);

— dye-sensitized solar cell (DSSC or DSC);

— organic solar cell.

NOTE The terms, a-Si, uc-Si, CIGS, CZTS, CdTe, DSSC and DSC are commonly used in the photovoltaic industry.

4.4 Interlayer

Typical types of interlayers are as follows:

— polyvinyl butyral (PVB);

— ethylene vinyl acetate (EVA);

— ionomer;

— silicone;

— liquid resin;

— olefin.

4.5 Interconnector

Materials with suitable conductivity of electricity, and suitable weldability or solderability, typical type of interconnector, such as copper and aluminium, should be selected and used.

4.6 Insulating strip

Polyethylene terephthalate (PET) and other materials with suitable electrical insulation should be selected and used to provide the sole insulation between a live part and an accessible metal part or between uninsulated live parts not of the same potential.

The strip should be of adequate thickness and of a material appropriate for the application, as given in IEC 61730-1.

4.7 Termination

Terminal consists of junction box (see IEC 62790), cable and connector.

5 Requirements

5.1 General

The requirements of laminated solar PV glass shall be in accordance with those listed in Table 1.

Table 1 — Technical requirements and test methods

Item		Requirement	Test method
Appearance and dimensions	Appearance	5.2	7.2
	Dimensions and edge finishing	5.3	—
Durability	High temperature test	5.4	7.3
	Damp heat test	5.5	7.4
	Radiation test	5.6	7.5
	Thermal cycling test	5.7	7.6
	Humidity freeze test	5.8	7.7
	Measurement of nominal module operating temperature (NMOT)	5.9	7.8
	Hot-spot endurance test	5.10	7.9
Safety	Impact test	5.11	ISO 29584
	Ball drop test	5.12	7.10
	Insulation test	5.13	7.11
	Wet leakage current test	5.14	7.12
	Robustness of terminations test	5.15	7.13

For curved or oversized laminated solar PV glass, the appearance, dimensions and technical requirements should be agreed with the manufacturer.

5.2 Appearance

5.2.1 Major visual defects

The following are considered to be major visual defects and shall not be permitted:

a) broken, cracked or torn external surfaces, including front glass, back glass and terminations;

b) bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the installation and/or operation of the module would be impaired;

c) voids in or visible corrosion of visible surfaces, extending over more than 10 % of any cell area;

d) visible corrosion of output connections, interconnections and busbars;

e) bubbles or delamination forming a continuous path between any part of the electrical circuit and the edge of the pane, or which exhibits significant growth during the testing and will, if testing is continued, reach such a condition;

f) haze and cloudiness in the main area;

g) creases and streaks introduced into interlayer in the main area;

h) evidence of any molten, burned or broken solar cell, diode or active PV component;

i) loss of mechanical integrity, to the extent that the installation and/or operation of the pane would be impaired;

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

NOTE 1 Major visual defects given in a), b), c), e), h), i) and j) are consistent with IEC 61215-1:2016, 8a), 8b), 8h), 8c), 8e), 8f) and 8g) respectively.

NOTE 2 Major visual defects given in f) and g) are consistent with ISO 12543-2 and ISO 12543-6, respectively.

5.2.2 Defects in the main area

For the purpose of product quality, permissible spots and linear defects in the main area shall be in accordance with ISO 12543-6:2011, 8.1 and 8.2.

5.2.3 Defects in the edge area

When inspected in accordance with the test method given in 7.2, defects in the edge area shall be in accordance with ISO 12543-6:2011, Clause 5 and Clause 9.

5.3 Dimensions and edge finishing

The dimensions and edge finishing of laminated solar PV glass shall be in accordance with ISO 12543-5.

The distance between the edge of the outermost solar cells and the edge of the pane should be subject to the manufacturer's specification.

5.4 High temperature test

Laminated solar PV glass shall be tested in accordance with 7.3.

No major visual defects (i.e. bubbles, delamination, haze and cloudiness) shall be found in three test specimens.

Even if faults are found in only one test specimen, three new test specimens shall be retested and evaluated. No major visual defects shall be found in any of these three test specimens.

5.5 Damp heat test

Laminated solar PV glass shall be tested in accordance with 7.4.

The requirements are as follows:

— no evidence of major visual defects as given in 5.2.1;

— other requirements shall be in accordance with MQT13 of IEC 61215-2:2016.

If the requirements are not met by only one test specimen, three new test specimens shall be tested and evaluated. No fault shall be found in any of these three test specimens.

5.6 Radiation test

Laminated solar PV glass shall be tested in accordance with 7.5.

The requirements are as follows:

— no evidence of major visual defects as given in 5.2.1;

— other requirements shall be in accordance with ISO 12543-2:2011, 5.3.

5.7 Thermal cycling test

Laminated solar PV glass shall be tested in accordance with 7.6.

The requirements are as follows:

— no evidence of major visual defects as given in 5.2.1;

— other requirements shall be in accordance with MQT11 of IEC 61215-2:2016.

5.8 Humidity freeze test

Laminated solar PV glass shall be tested in accordance with 7.7.

The requirements are as follows:

— no evidence of major visual defects as given in 5.2.1;

— other requirements shall be in accordance with MQT12 of IEC 61215-2:2016.

5.9 Measurement of NMOT

The nominal module operating temperature (NMOT) of the product shall be measured in accordance with 7.8.

5.10 Hot-spot endurance test

The laminated solar PV glass shall be tested in accordance with 7.9.

The requirements are as follows:

— no evidence of major visual defects as given in 5.2.1;

— other requirements shall be in accordance with MQT09 of IEC 61215-2:2016.

5.11 Impact test

Laminated solar PV glass shall be tested in accordance with the pendulum impact test of ISO 29584 and be classified according to its resistance to impact.

5.12 Ball drop test

Laminated solar PV glass shall be tested in accordance with 7.10.

The interlayer shall not tear or be exposed due to glass breakage after the test.

If the requirements are not satisfied by more than two specimens, the product fails this test. If the requirements are not satisfied by two specimens, six new test specimens shall be retested and evaluated. The requirements shall be satisfied by all of these six test specimens.

5.13 Insulation test

Laminated solar PV glass shall be tested in accordance with 7.11.

The requirements shall be in accordance with MQT03 of IEC 61215-2:2016.

5.14 Wet leakage current test

Laminated solar PV glass shall be tested in accordance with 7.12.

The requirements shall be in accordance with MQT15 of IEC 61215-2:2016.

5.15 Robustness of terminations test

Laminated solar PV glass shall be tested in accordance with 7.13.

The requirements are as follows:

— no evidence of major visual defects as given in 5.2.1;

— the requirements shall be in accordance with MQT14 of IEC 61215-2:2016.

6 Test specimens

Test specimens shall be representative of standard production. They can also be manufactured specially to the specified sizes for testing.

Test specimens shall be 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. Test specimens shall be accompanied by the manufacturer's mounting and connection instructions, including the maximum permissible system voltage.

For crystalline silicon type, the specimens should contain at least two solar cells with interconnector.

The distance between the edge of the outmost solar cells and the edge of the pane of specially prepared specimen shall be the same as with the product.

Test specimens shall be inspected perpendicularly at a distance of 2 m in front of a white diffuse background. Only samples free of major visual defects shall be used for the test.

In carrying out the test, the operator shall strictly observe the manufacturer's handling and mounting instructions. The method of supporting the test specimen shall not cover more than one edge of the test specimen.

The numbers and sizes of specimens for different tests are listed in Table 2.

Table 2 — Number, type and size of test specimens

Test	Number	Size (mm × mm)
High temperature test	3	300 × 100 (min. size)
Damp heat test	2	300 × 100 (min. size)
Radiation test	3	300 × 150[a] (min. size) 300 × 100 (min. size)
Thermal cycling test (50 cycles)	3	
Humidity freeze test	3	
Thermal cycling test (200 cycles)	2	Product size
Hot-spot endurance test	1	Product size
Measurement of NMOT	1	Product size
Impact test	4	876 × 1 938 or the product size, whichever is smaller
Ball drop test	6	500 × 500 (min. size)

[a] The minimum size of method A for radiation test is 300 mm × 150 mm, the minimum size of method B for radiation test is 300 mm × 100 mm.

Solar cell arrangement in the laminate might affect the mechanical property of the pane. Laminated solar PV glass with different solar cell spacing should be considered as a different model.

7 Test methods

7.1 Test sequences

The laminated solar PV glass shall be divided into groups and subjected to the qualification test sequences in Figure 2. High temperature test and ball drop test are independent tests.

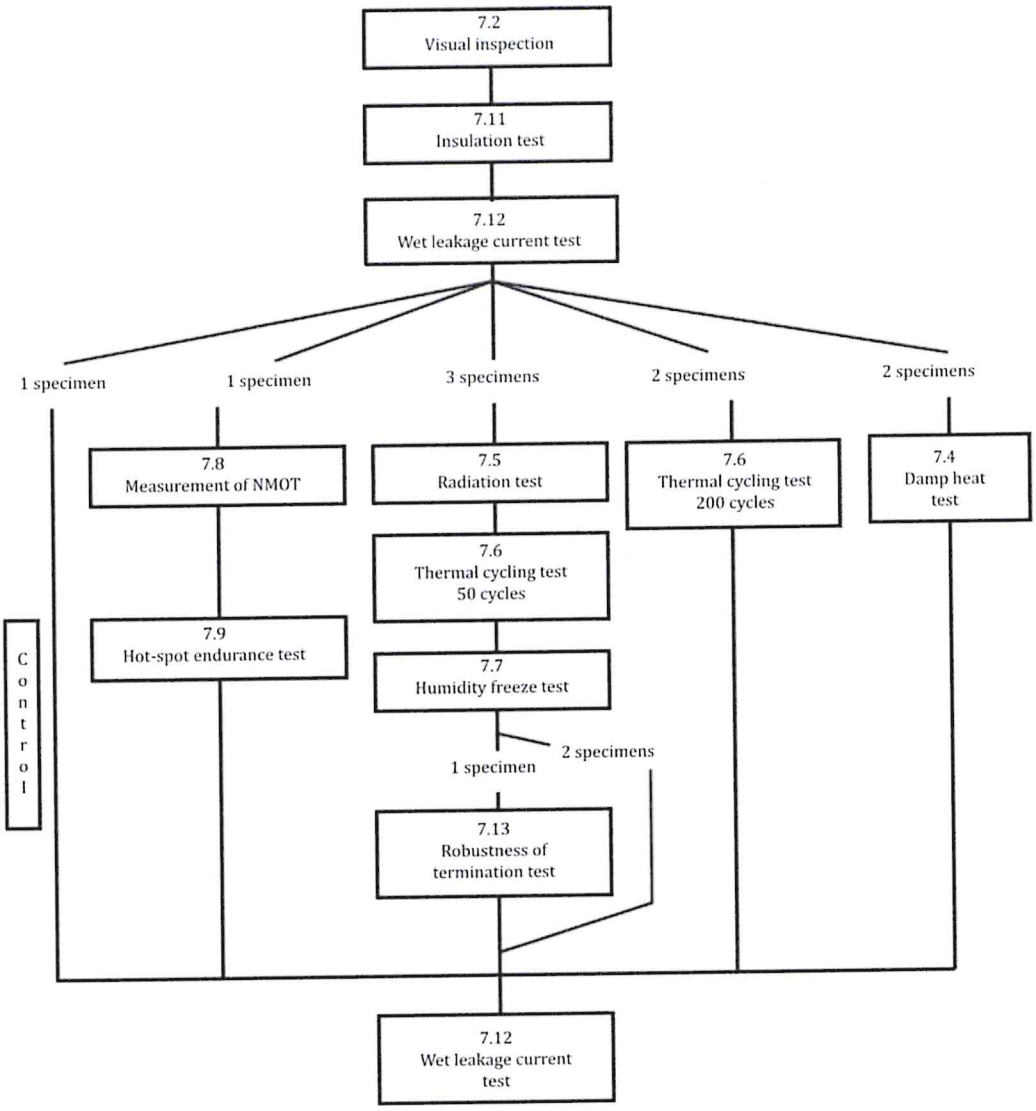


Figure 2 — Qualification test sequence of laminated solar PV glass

7.2 Visual inspection

The specimens shall be inspected perpendicularly at a distance of 2 m in front of a white diffuse background under the illumination of no less than 1 000 lux.

The size of spot defects and the width of linear defects are measured by reading with a microscope with a magnification of 10 and a precision of 0,1 mm.

7.3 High temperature test

This test is identical to ISO 12543-4:2011, Clause 5, and the procedure is given in 5.3.2.

7.4 Damp heat test

This test is identical to MQT13 of IEC 61215-2:2016.

7.5 Radiation test

This test is identical to ISO 12543-4:2011, Clause 7.

7.6 Thermal cycling test

This test is identical to MQT11 of IEC 61215-2:2016.

7.7 Humidity-freeze test

This test is identical to MQT12 of IEC 61215-2:2016.

7.8 Measurement of NMOT

This test is identical to MQT05 of IEC 61215-2:2016.

7.9 Hot-spot endurance test

This test is identical to MQT09 of IEC 61215-2:2016.

7.10 Ball drop test

7.10.1 Purpose

The test aims at evaluating the ability of the interlayer to withstand hard impact, e.g. due to falling objects of relative low weight at a high speed onto glass.

7.10.2 Specimen

The specimens shall have the same nominal thickness. A solar cell shall be in the centre of specimen. This test should be performed on six specimens.

7.10.3 Apparatus

7.10.3.1 Impactor.

Steel ball with a weight of (1 040 ± 10) g and a diameter of 63,5 mm, and steel ball with a weight of (2 260 ± 20) g and a diameter of 82,5 mm.

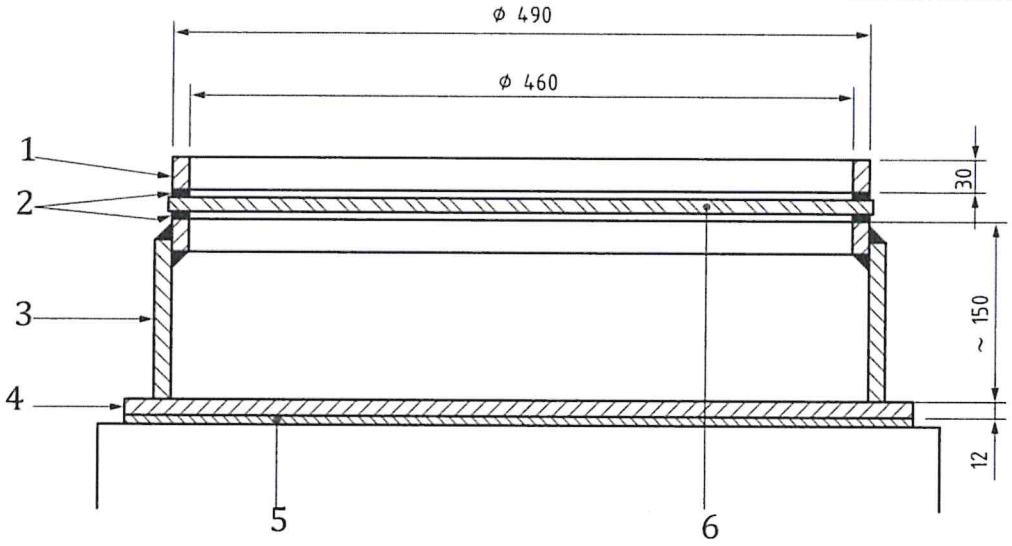
7.10.3.2 Impactor hold-release device.

The steel ball can be held, e.g. by means of an electric magnet, at a highest height of 4 800 mm above a sample. From the desired height, the ball is released in such a way that only gravity acts on it. The ball should fall within a circle of 100 mm diameter in the centre of the sample, which is positioned in accordance with Figure 3.

7.10.3.3 Specimen holder.

The specimen holder (see Figure 3) consists of two steel frames, type of St 37-2. The width of the centred edges should be 15 mm, and the centred edges should be covered with rubber strips, 15 mm width and 3 mm thick, hardness 40 ± 10 IHRD. The mass of the upper frame shall be approximately 7 kg. The equipment is mounted on a 12 mm thick steel base plate. Between the base plate and the solid support, a 3 mm rubber mat, hardness 40 ± 10 IHRD, should be used.

Dimensions in millimetres



Key

1 upper frame
2 rubber
3 lower frame
4 base plate
5 rubber interlayer
6 test specimen

Figure 3 — Assembly for ball drop test base plate, frame and specimen

7.10.4 Procedure

Place the specimens in the environment condition, preferably (23 ± 5) °C, for 4 h.

Position and release the 1 040 g ball from a height of 1 200 mm. If the glass is not broken, increase the drop height to 1 500 mm, 1 900 mm, 2 400 mm, 3 000 mm, 3 800 mm, 4 800 mm and repeat the test until the glass breaks.

If the glass is unbroken after the 1 040 g ball drops from a height of 4 800 mm, repeat the above steps using the 2 260 g ball.

If the glass is unbroken after the 2 260 g ball drops from a height of 4 800 mm, repeat the above steps using a heavier ball which is more than 2 260 g, as given in ISO 3290-1, until the glass breaks.

In case of an asymmetric product, the test shall be carried out on both sides of the specimen, using three specimens in a separate set.

7.11 Insulation test

This test is identical to MQT03 of IEC 61215-2:2016.

7.12 Wet leakage current test

This test is identical to MQT15 of IEC 61215-2:2016.

7.13 Robustness of terminations test

This test of retention of junction box is identical to MQT14.1 of IEC 61215-2:2016.

This test of cord anchorage is identical to MQT14.2 of IEC 61215-2:2016.

8 Designation

Laminated solar PV glass shall be designated by the following:

— the type of glass;

— a reference to this document, i.e. ISO TS 18178;

— the nominal thickness, in millimetres;

— the nominal width, *B*, and nominal length, *H*, in millimetres.

EXAMPLE A laminated solar PV glass with a thickness of 6,4 mm, a width of 2,0 m and a length of 1,5 m is designated as follows:

Laminated solar PV glass ISO TS 18178 6,4 2 000 × 1 500

Bibliography

[1] ISO 16293-1, *Glass in building — Basic soda lime silicate glass products — Part 1: Definitions and general physical and mechanical properties*

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

[3] IEC 61730-1, *Photovoltaic (PV) module safety qualification — Part 1: Requirements for construction*

[4] IEC 61730-2, *Photovoltaic (PV) module safety qualification — Part 2: Requirements for testing*

[5] IEC 62790, *Junction boxes for photovoltaic modules — Safety requirements and tests*

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