
**Glass in building — Laminated glass and
laminated safety glass —**

**Part 4:
Test methods for durability**

*Verre dans la construction — Verre feuilleté et verre feuilleté de
sécurité —*

Partie 4: Méthodes d'essai concernant la durabilité



Reference number
ISO 12543-4:2011(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 12543-4 was prepared by Technical Committee ISO/TC 160, *Glass in building*, Subcommittee SC 1, *Product considerations*.

This second edition cancels and replaces the first edition (ISO 12543-4:1998), which has been technically revised.

ISO 12543 consists of the following parts, under the general title *Glass in building — Laminated glass and laminated safety glass*:

- *Part 1: Definitions and description of component parts*
- *Part 2: Laminated safety glass*
- *Part 3: Laminated glass*
- *Part 4: Test methods for durability*
- *Part 5: Dimensions and edge finishing*
- *Part 6: Appearance*

Glass in building — Laminated glass and laminated safety glass —

Part 4: Test methods for durability

1 Scope

This part of ISO 12543 specifies test methods in respect of resistance to high temperature, humidity and radiation for laminated glass and laminated safety glass for use in building.

2 Normative references

The following referenced documents are indispensable for the application 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 9050, *Glass in building — Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors*

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

ISO 12543-2, *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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12543-1 and ISO 12543-2 apply.

4 Test specimens

Test specimens should be representative of standard production. Test specimens shall either be specially manufactured to the test size or be cut from larger panes. Test specimens with cut edges shall contain at least one edge from the original pane from which it was cut.

The original edge should be marked.

If the final product has all its edges sealed/protected, the test specimen shall also have all its edges sealed/protected.

The method of supporting the test specimen shall not cover two edges of the test specimen. If the test specimen is cut from a larger pane at least one original edge shall not be covered.

Test specimens shall be inspected prior to the test at a distance between 300 mm and 500 mm in front of a white diffuse background. Only samples free of faults (i.e. bubbles, delamination, cloudiness) shall be used for the test.

5 High-temperature test

5.1 Principle

The purpose of this test is to determine whether the laminated glass and laminated safety glass are able to withstand exposure to high temperatures over an extended period of time without their properties becoming substantially altered. The changes in properties are judged by the occurrence of bubbles, delamination and cloudiness (not discoloration).

5.2 Size and number of test specimens

The test specimens shall not be smaller than 300 mm × 100 mm. There shall be three test specimens.

5.3 Procedures

5.3.1 General

The high-temperature test may be carried out using either an oven or boiling water. The test temperature is 100 °C. The tolerances of the test temperature depend on the test method used and are as follows:

- a) Oven (100 ± 2) °C
- b) Boiling water 100 ($\begin{smallmatrix} +0 \\ -2 \end{smallmatrix}$) °C

To remove the risk of thermal breakage in the boiling water, test samples should be placed in water at 60 °C for 10 min before transferring to the water at 100 °C.

5.3.2 Procedure A

Heat the three test specimens to a temperature of 100 °C.

In an oven, the heating-up time is dependent on the load, type and thickness of the laminated glass being tested. Generally speaking, this should be assumed to be 30 min.

Maintain the test temperature for a period of 16 h.

Take the test specimens out and allow them to cool to room temperature by storing them vertically under natural convection and radiation. The assessment of the test samples may be carried out when the glass surface temperature is lower than 30 °C.

5.3.3 Procedure B

Heat the three test specimens to a temperature of 100 °C.

Heating-up time is dependent on the type and thickness of the laminated glass being tested. Generally speaking, for samples up to 11 mm thickness this should be assumed to be 30 min. For thick samples, i.e. greater than 11 mm, this shall be determined by calibration.

Maintain the test temperature for a period of 2 h.

Take the test specimens out and allow them to cool to room temperature by storing them vertically under natural convection and radiation. The assessment of the test samples may be carried out when the glass surface temperature is lower than 30 °C.

5.4 Expression of results

Inspect the samples at a distance between 300 mm and 500 mm in front of a white diffuse background.

Record the number and extent of the faults occurring in test specimen.

NOTE Bubbles, delamination, haze and cloudiness indicate faults, but discoloration does not.

Disregard all faults within 15 mm from an original edge and 20 mm from a cut edge. Individual bubbles in the immediate vicinity of inlaid wires are permissible.

Disregard a test specimen showing cracks, and perform the test on a new test specimen in its place.

5.5 Test report

The following information shall be given in the test report:

- a) reference to this part of ISO 12543, i.e. ISO 12543-4:2011;
- b) test procedure used: A (see 5.3.2) or B (see 5.3.3);
- c) type and structure of the laminated glass or laminated safety glass, with nominal thickness of the individual constituents, in millimetres;
- d) type of test specimens, including cut or special manufacture; type of edge; edge protection; dimensions;
- e) unsupported and supported edges by the test frame;
- f) for each test specimen, the number and size of the bubbles, delamination, haze or cloudiness occurring.

6 Humidity tests

6.1 Principle

The purpose of this test is to determine whether the laminated glass and laminated safety glass are able to withstand the effects of humidity in the atmosphere over an extended period of time without their properties becoming substantially altered. The effects of the humidity are judged by bubbles, delamination, haze or cloudiness.

6.2 Size and number of test specimens

The test specimens shall not be smaller than 300 mm × 100 mm. There shall be three test specimens.

6.3 Procedures

6.3.1 Test with condensation

Keep the three test specimens vertically over water in a closed container for two weeks. Maintain the temperature of the air in the container at 50^{+5}_0 °C. Adequate spacing between the test specimens shall be provided.

NOTE These conditions give a relative humidity of about 100 % and lead to water condensing on the surface of the test specimen.

6.3.2 Test without condensation

Keep the three test specimens vertically for two weeks in a climate chamber and keep the temperature of the air in the container at 50^{+5}_0 °C and the relative humidity within the limits of (80 ± 5) %. Adequate spacing between the test specimens shall be provided.

6.4 Expression of results

Inspect the samples at a distance between 300 mm and 500 mm in front of a white diffuse background.

Record the number and extent of the faults occurring in the interlayer (bubbles, delamination, haze and cloudiness) for each test specimen. Disregard all faults within 15 mm from an original edge, 20 mm from a cut edge or 10 mm from any crack. Individual bubbles in the immediate vicinity of inlaid wires are permissible.

In the case of fire-resistant laminated glass and fire-resistant laminated safety glass, only delamination shall be considered as a fault.

NOTE The interlayers of fire-resistant laminated glass and fire-resistant laminated safety glass are designed to react at high temperatures. The exposure of test specimens of those glasses to the temperature reached in the humidity test over a long period of time may create bubbles, haze and cloudiness in the interlayer which do not affect the fire-resistant properties so that only delamination will be considered.

6.5 Test report

The following information shall be given in the test report:

- a) reference to this part of ISO 12543, i.e. ISO 12543-4:2011;
- b) test procedure (6.3.1 or 6.3.2);
- c) type and structure of the laminated glass or laminated safety glass, with nominal thickness of the individual constituents, in millimetres;
- d) type of test specimens, including cut or special manufacture; type of edge; edge protection; dimensions;
- e) unsupported and supported edges by the test frame;
- f) for each test specimen, the number and size of the bubbles, delamination, haze and cloudiness occurring;
- g) In the case of fire-resistant laminated safety glass and fire-resistant laminated glass, only delamination information shall be reported.

7 Radiation tests

7.1 Principle

The purpose of this test is to determine whether exposure of laminated glass and/or laminated safety glass to radiation over an extended period of time produces any appreciable change in their properties. The change in its properties is judged by a change in luminous transmittance and the occurrence of bubbles, delamination, haze and cloudiness.

7.2 Size and number of test specimens

The size of the test specimens for method A shall not be smaller than 300 mm × 150 mm. There shall be three test specimens.

The size of the test specimens for method B shall not be smaller than 300 mm × 75 mm. There shall be three test specimens.

7.3 Simulated solar radiation methods

7.3.1 Method A

7.3.1.1 Radiation source

A radiation source that emits a spectrum similar to solar radiation shall be used.

NOTE Such a spectral distribution can be obtained by lamps which consist of a combination of a high-pressure mercury-vapour lamp with an incandescent tungsten filament.

To obtain reproducible and comparable test results suitable lamps shall show the following spectral characteristics:

— UVB	(280 nm to 315 nm)	3 % ± 1 %
— UVA	(315 nm to 380 nm)	8 % ± 1 %
— visible range	(380 nm to 780 nm)	18 % ± 1 %
— IRA	(780 nm to 1400 nm)	24 % ± 2 %
— IRB	(1 400 nm to 2 600 nm)	27 % ± 4 %
— IRC	(>2 600 nm)	20 % ± 3 %

7.3.1.2 Test conditions

The exposure time for the radiation test shall be 2 000 h.

The temperature of the test specimen shall be maintained at (45 ± 5) °C.

The lamps shall be replaced when their irradiance level in the UVA decreases by more than 50 %.

The total irradiance level in the plane of the test samples shall be (900 ± 100) W/m².

NOTE For the determination of the total irradiance level, pyranometers according to the specifications laid down in ISO 9060 and a (limited) sensitivity to the spectral range from 305 nm to 2 800 nm can be used. Using these radiation detectors, the measured irradiance level in the plane of the test samples is (730 ± 80) W/m².

7.3.1.3 Arrangement of test apparatus

The test samples are mounted vertically in front of the radiation array. The radiation array consists of lamps uniformly separated to give the optimum radiation density in the plane of the test specimens. The minimum distance between the array of the test specimens and the bottom of the test room shall be 400 mm and the air space behind the array shall be at least 500 mm (to obtain undisturbed free natural convection upwards).

In order to obtain a sufficiently uniform irradiance level, the area covered by the test specimens shall not exceed the area of the lamp array, A , in accordance with the following equation:

$$A = n \times l_1^2$$

where

n is the number of lamps;

l_1 is the distance between the axes of neighbouring lamps.

NOTE Figures A.1 and A.2 show a possible arrangement of the test apparatus.

7.3.2 Method B

7.3.2.1 Radiation source

A radiation source consisting of a medium-pressure mercury-vapour arc lamp with a tubular quartz bulb of ozone-free type shall be used. The bulb axis shall be vertical. The nominal dimensions of the lamp shall be 360 mm in length by 9,5 mm in diameter. The arc length shall be (300 ± 4) mm. The lamp shall be operated at (750 ± 50) W.

Any other source of radiation that produces the same effect as a medium-pressure mercury-vapour arc lamp may be used. To check that the effects of another radiation source are the same, a comparison shall be made by measuring the amount of energy emitted within a wavelength range of 300 nm to 450 nm, all other wavelengths being removed by the use of suitable filters. The alternative source shall then be used with these filters.

NOTE A radiation source whose radiation spectrum is comparable with the spectrum is available (see Annex A).

7.3.2.2 Test conditions

The exposure time for the radiation test shall be 2 000 h.

Place the test specimens in the test apparatus 230 mm from and parallel lengthwise to the lamp axis. Maintain the temperature of the test pieces at (45 ± 5) °C throughout the test.

7.4 Procedure

When needed according to 7.5, determine the luminous transmittance of the three test specimens before exposure, in accordance with ISO 9050.

Orientate the test specimens so that, if there is a designated outer surface, it faces the radiation source. Asymmetric laminated glass, which does not have a designated outer surface, shall be tested both ways round.

After exposure, determine the luminous transmittance of each test specimen once again, in accordance with ISO 9050.

NOTE For CEN conditions, EN 410 is used.

7.5 Expression of results

7.5.1 Laminated glass and laminated safety glass

If the initial light transmittance is greater than 65 %, compare the results of the luminous transmittance measurement of each exposed test specimen with the values obtained for the same test specimen before exposure. Express the deviation as a percentage. If the initial luminous transmittance is less than or equal to 65 %, give the difference between initial and final light transmittance.

Inspect the samples at a distance between 300 mm and 500 mm in front of a white diffuse background. Record the number and extent of delamination occurring in the interlayer for each test specimen. Disregard all delamination within 10 mm from an original edge or 15 mm from a cut edge.

7.5.2 Fire-resistant laminated glass and fire-resistant laminated safety glass

Inspect the samples at a distance between 300 mm and 500 mm in front of a white diffuse background. Record the number and extent of delamination occurring in the interlayer for each test specimen. Disregard all delamination within 10 mm from an original edge or 15 mm from a cut edge.

NOTE The interlayers of fire-resistant laminated glass and fire-resistant laminated safety glass are designed to react at high temperatures. The exposure of test specimens of those glasses to the temperature reached in the radiation test over a long period of time can create bubbles and cloudiness in the interlayer, which do not affect the fire-resistant properties so that only delamination is considered.

7.6 Test report

The following information shall be given in the test report:

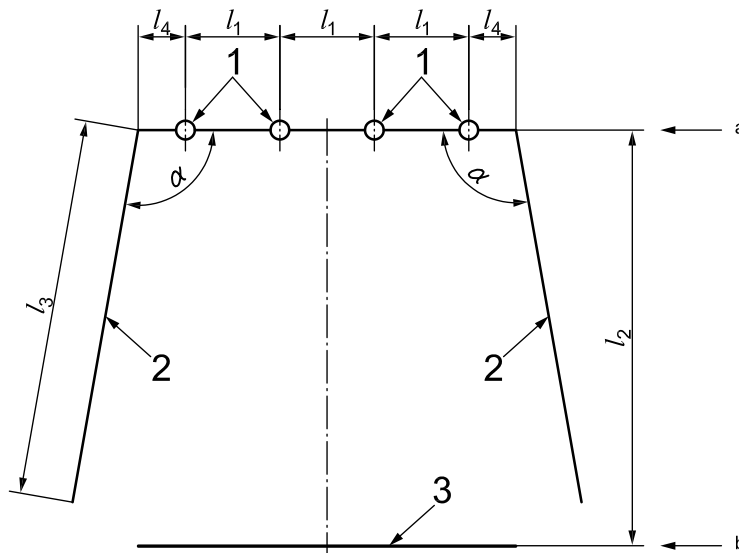
- a) reference to this part of ISO 12543, i.e. ISO 12543-4:2011;
- b) test procedure (7.3.1 or 7.3.2);
- c) type and structure of the laminated glass or laminated safety glass, with nominal thickness of the individual constituents, in millimetres;
- d) type of test specimens, including cut or special manufacture; type of edge; edge protection; dimension;
- e) specification of the radiation source;
- f) in the case of an asymmetric product, the face of the product exposed to the radiation;
- g) for products with initial light transmittance greater than 65 %: for each test specimen the percentage difference in the light transmittance before and after radiation;
- h) for products with initial light transmittance less than or equal to 65 %: for each test specimen the actual difference in light transmittance before and after radiation;
- i) in the case of fire-resistant laminated glass and fire-resistant laminated safety glass, the difference in initial light transmittance is not given;
- j) for each test specimen, the number and extent of delamination occurring.

Annex A
(informative)

**Possible arrangement of the test apparatus
for the radiation test described in 7.3.1**

As radiation sources OSRAM lamps type Ultra-Vitalux¹⁾ 300 W may be used. At least 16 lamps are arranged in a square of 4 × 4 lamps with a distance of $l_1 = 250$ mm between the lamps forming a radiation field of 1 m × 1 m.

The lamp array is framed by an aluminium foil of width $l_3 = 1\ 000$ mm with a specular reflective surface. The distance between the aluminium foil and the outer row of lamps on each side is $l_4 = 125$ mm. The angle, α , between the plane of the radiation field and the aluminium foil is 100°. The test samples are placed in a parallel plane facing the lamp array at a distance of $l_2 = 1\ 100$ mm forming an area of 1 m × 1 m (see Figures A.1 and A.2).

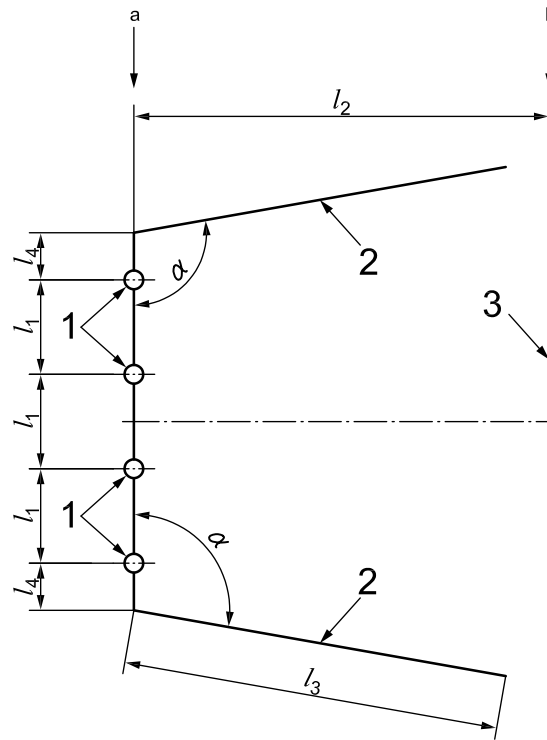


Key

- 1 lamps
- 2 aluminium foil
- 3 test specimens vertically mounted
- l_1 distance between lamps
- l_2 distance between lamps and test specimen
- l_3 width of the aluminium foil
- l_4 distance between the aluminium foil and the outer row of lamps on each side
- α angle between plane of the radiation field and the aluminium foil
- a Plane of lamp array.
- b Plane of test specimen.

Figure A.1 — Arrangement for the radiation test (plan view)

1) Ultra-Vitalux ® is the trade name of a product supplied by OSRAM in Mercuriusstraat 28, B-1930 Zaventem or in Steinerne Furt 62, D-86167 Augsburg. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

**Key**

- 1 lamps
- 2 aluminium foil
- 3 test specimens vertically mounted, area 1 m × 1 m
- l_1 distance between lamps
- l_2 distance between lamps and test specimen
- l_3 width of the aluminium foil
- l_4 distance between the aluminium foil and the outer row of lamps on each side
- α angle between plane of the radiation field and the aluminium foil
- a Plane of lamp array.
- b Plane of test specimen.

Figure A.2 — Arrangement for the radiation test (cross-sectional view)

Annex B (informative)

Lamp

Radiator Heraeus Noblelight Q 710²⁾, modified with a UV-C filter (dipped tube), for which the following operating parameters are used:

- radiation power: 740 W;
- current: 6,8 A;
- voltage: ~130 V.

2) Radiator Heraeus Noblelight Q 710 is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

Bibliography

- [1] ISO 9060, *Solar energy — Specification and classification of instruments for measuring hemispherical solar and direct solar radiation*
- [2] EN 410, *Glass in building — Determination of luminous and solar characteristics of glazing*

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