Durability test on laminated safety glass 4.1.4 with UV-H film

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Author(s) J. van der Zwan, B.Sc.

Assignor SoaSA Technology International Ltd.
Unit E, 19/F. 2nd Wuhan Building
Jiahe Road,
Xiamen,, Fujian,
China 361012

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1 Introduction

SoaSA Technology International Ltd. has commissioned TNO Science and Industry, BU Testing and Consultancy to establish the durability of the laminated glass system laminated safety glass 4.1.4 with UV-H film according to EN 12543:1998.

If any deviation of applied materials/process/machines is encountered (and a so-called major change), re-type testing or additional tests may be required. This decision and responsibility belongs to the manufacturer. The product description is the lead for determining the window of these rules.

The following paragraphs describe the tests, the results and the conclusions.
2 Product Testing

2.1 Producer of the samples

SoaSA Technology International Ltd.
Unit E, 19/F, 2nd Wuhan Building
Jiahe Road,
Xiamen., Fujian,
China 361012

2.2 Product description

4 samples of the following description were delivered for testing in May 2006:

- Laminated safety glass, one 1 mm UV-H film between 2 sheets of 4 mm float glass.

Dimensions of the samples: 100 x 300 x 8.7 mm.

Test specimens should be representative of standard production. Test specimens should either be specially manufactured to the test size or be cut from larger panes. Test specimen with cut edges should contain at least one edge from the original pane from which it was cut. If the final product has all its edges sealed/protected then the test specimen should 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 was covered.

The samples were identified and visually inspected prior to the test at a distance between 30 cm and 50 cm in front of a white diffuse background. Only samples free of faults (bubbles, delamination, cloudiness) were used for the test.

2.3 Normative references

The EN12543-4 Standard specifies test methods in respect of resistance to high temperature, humidity and radiation for laminated glass and laminated safety glass for use in building.

This European Standard EN12543-4 incorporates by dated or undated references, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies;

EN 410 Glass in building - Determination of luminous and solar characteristics of glazing
2.4 Testing procedures

2.4.1 General

Testing the durability of laminated glass can be divided into two main groups with each two subgroups.

Laminated safety glass (EN12543-2):
- Durability of laminated safety glass and laminated safety glass with fire resistant properties
  - High temperature test
  - Humidity test 5.3.1 (exposed direct to solar radiation)
  - Radiation test
- Durability of fire resistant laminated safety glass
  - Subgroup A:
    - Humidity test 5.3.2 (not exposed to direct solar radiation)
  - Subgroup B:
    - Humidity test 5.3.1 (exposed direct to solar radiation)
    - Radiation test

Laminated glass (EN12543-3):
- Durability of laminated glass and laminated glass with fire resistant properties
  - High temperature test
  - Humidity test 5.3.1 (exposed direct to solar radiation)
  - Radiation test
- Durability of fire resistant laminated glass
  - Subgroup A:
    - Humidity test 5.3.2 (not exposed to direct solar radiation)
  - Subgroup B:
    - Humidity test 5.3.1 (exposed direct to solar radiation)
    - Radiation test

2.4.2 High temperature test

2.4.2.1 Principle
The purpose of this test is to determine whether the laminated glass and laminated safety glass will withstand exposure to high temperatures over an extended period of time without its properties becoming substantially altered. The change in properties is judged by the occurrence of bubbles, delamination and cloudiness (not discolouration).

2.4.2.2 Size and number of test specimens
The test specimens were not smaller than 300 mm x 100 mm.
2.4.2.3 Procedure

The three test specimens were heated to a temperature of $100^\circ\text{C}$ and maintained this temperature for a period of 2 h, then the test specimens were allowed to cool to room temperature. Since the test specimens had both external surfaces of glass the test was carried out by immersing the test specimens vertically in water heated up to $100^\circ\text{C}$. To avoid extreme thermal stresses leading to crack formation the specimens was heated up in two steps by first immersing it into a water bath of about $60^\circ\text{C}$ for 5 min.

2.4.2.4 Expression of results

The samples were inspected at a distance between 30 cm and 50 cm in front of a white diffuse background. The number and extent of the faults occurring in the interlayer (bubbles, delamination, cloudiness, not discolouration) were recorded for each test specimen. All faults within 15 mm from an original edge and 25 mm from a cut edge were ignored (if any).

Delamination taken as a criterion for evaluation after the high temperature and the humidity test, are defined as essentially two dimensional phenomena, in the interfaces between the glass-interlayer and interlayer-interlayer, in which area no adhesion exists.

Results will be interpreted as the following:
- Laminated safety glass in accordance with clause 4.1 of EN ISO 12543-2
- Laminated glass in accordance with clause 4.1 of EN ISO 12543-3

2.4.3 Humidity test

2.4.3.1 Principle

The purpose of this test is to determine whether the laminated glass and laminated safety glass will withstand the effects of humidity in the atmosphere over an extended period of time without its properties becoming substantially altered. The effects of the humidity to be judged are bubbles, delamination and cloudiness (not discolouration).

2.4.3.2 Size and number of test specimens

The test specimens were not smaller than 300 mm x 100 mm. There were three test specimens prepared by cutting from the delivered samples.

2.4.3.3 Procedure

Option A, Test with condensation (par. 5.3.1 EN ISO 12543-4)

Three test specimens were kept vertically for two weeks over water in a closed container. Maintain the temperature of the air in the container within the limits of $50^\circ\text{C}$.

Adequate spacing between the test specimens was provided.

Results will be interpreted as the following:
- Laminated safety glass in accordance with clause 4.1 of EN ISO 12543-2
- Laminated glass in accordance with clause 4.1 of EN ISO 12543-3
Option B, Test without condensation (par. 5.3.2 EN ISO 12534-4)

Put the three test specimen vertically for two weeks into a climate chamber and keep up the temperature within the limits of 50 °C and the relative humidity within the limits 80 ± 5%. Adequate spacing between the test specimens was provided.

Results will be interpreted as the following:
- Laminated safety glass in accordance with clause 5 of EN ISO 12543-2
- Laminated glass in accordance with clause 5 of EN ISO 12543-3

2.4.3.4 Expression of results
The samples were inspected at a distance between 30 cm and 50 cm in front of a white diffuse background. The number and extend of the faults occurring in the interlayer (bubbles, delamination, cloudiness, not discolouration) were recorded (if any) for each test specimen. All faults within 15 mm for an original edge, 25 mm from a cut edge or 10 mm from any crack were not taken into account (if any). 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 were considered.

2.4.4 Radiation test

2.4.4.1 Principle
The purpose of this test is to determine whether exposure of laminated glass or laminated safety glass to radiation over an extended period of time produces any appreciable change in its properties. The change in its properties is judged by a change in luminous transmittance and the occurrence of bubbles, delamination and cloudiness (not discolouration).

2.4.4.2 Exposure procedure to simulated solar radiation
A radiation source which emits a spectrum similar to solar radiation was used. 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 were used showing the following spectral characteristics by default:

<table>
<thead>
<tr>
<th>Range</th>
<th>Percentage</th>
<th>± Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVB (280 nm to 315 nm)</td>
<td>3% ± 1%</td>
<td></td>
</tr>
<tr>
<td>UVA (315 nm to 380 nm)</td>
<td>8% ± 1%</td>
<td></td>
</tr>
<tr>
<td>Visible range (380 nm to 780 nm)</td>
<td>18% ± 1%</td>
<td></td>
</tr>
<tr>
<td>IRA (780 nm to 1400 nm)</td>
<td>24% ± 2%</td>
<td></td>
</tr>
<tr>
<td>IRB (1400 nm to 2600 nm)</td>
<td>27% ± 4%</td>
<td></td>
</tr>
<tr>
<td>IRC (&gt; 2600 nm)</td>
<td>20% ± 3%</td>
<td></td>
</tr>
</tbody>
</table>

2.4.4.3 Test conditions
The exposure time for the radiation test was 2000 h. The temperature of the test specimen was maintained at 45°C ± 5°C. The lamps were replaced when their irradiance level in the UVA decreases by more than 50%. The total irradiance level in the plane of the test samples was 900 W/m² ± 100 W/m².
2.4.4.4 **Arrangement of test apparatus**

The test samples were 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 was 400 mm and the air space behind the array was 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 did not exceed the area of the lamp array $A$ given by the relation $A = n \times l_1^2$ where $n =$ number of lamps and $l_1 =$ distance between the axes of neighbouring lamps.

As radiation sources OSRAM lamps type Ultra-Vitalux 300 W were used. 16 lamps were arranged in a square of 4 x 4 lamps with a distance of $l_1 = 250$ mm between the lamps forming a radiation field of 1 m x 1 m. The lamp array was framed by an stainless steel sides width $l_3 = 1000$ mm with a specular reflective surface. The distance between these sides and the outer row of lamps on each side is $l_4 = 125$ mm. The angle $\alpha$ 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 $l_2 = 1100$ mm forming an area of 1 m x 1 m (see figure 1).

![Figure 1: Arrangement for the radiation test](image-url)

1 lamps  
2 aluminium foil  
3 test specimens vertically mounted
2.4.4.5  *Size and number of test specimens*

The size of the test specimens were 350 mm x 190 mm.

2.4.4.6  *Procedure*

When needed according to 6.5, the luminous transmittance was determined of the three test specimens before exposure according to EN 410.

The test specimens were orientated so that, if there is a designated outer surface, it faces the lamp array. Asymmetric laminated glass, which does not have a specific designated outer surface, should be tested both ways round. After exposure, the luminous transmittance of each test specimen was measured once again according to EN 410.

2.4.4.7  *Expression of results*

The samples were inspected at a distance between 30 cm and 50 cm in front of a white diffuse background. The number and extent of delamination occurring in the interlayer for each test specimen was reported (if any). All delamination within 15 mm from an original edge or 25 mm from a cut edge are not taken into account.
3 Results

3.1 High temperature test

Type of glass: Laminated safety glass
Structure of the glass: (nominal thickness of the individual constituents (mm))

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Type of test</th>
<th>Fire resistant laminated safety glass y/n</th>
<th>Indoor / outdoor use?</th>
<th>Dimensions</th>
<th>Nominal thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV – H 3</td>
<td>High Temperature</td>
<td></td>
<td>outdoor</td>
<td>100 x 300</td>
<td>4.1.4</td>
</tr>
<tr>
<td>UV – H 5</td>
<td>High Temperature</td>
<td></td>
<td>outdoor</td>
<td>100 x 300</td>
<td>4.1.4</td>
</tr>
<tr>
<td>UV – H 7</td>
<td>High Temperature</td>
<td></td>
<td>outdoor</td>
<td>100 x 300</td>
<td>4.1.4</td>
</tr>
</tbody>
</table>

Sample characteristics:

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Type of test</th>
<th>Cut or on size production</th>
<th>Edge type</th>
<th>Edge protection</th>
<th>Supported edge marked y/n</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV – H 3</td>
<td>High Temperature</td>
<td>C</td>
<td>arissed</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>UV – H 5</td>
<td>High Temperature</td>
<td>C</td>
<td>arissed</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>UV – H 7</td>
<td>High Temperature</td>
<td>C</td>
<td>arissed</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

For each test specimen the number and size of the bubbles, delamination and cloudiness occurring (not discolouration):

Results

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Results</th>
<th>Bubbles y/n</th>
<th>Size of bubbles</th>
<th>Delamination y/n</th>
<th>Cloudiness y/n</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV – H 3</td>
<td>High Temperature</td>
<td>N</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>UV – H 5</td>
<td>High Temperature</td>
<td>N</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>UV – H 7</td>
<td>High Temperature</td>
<td>N</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>
3.2 Humidity test

Type of glass: Laminated glass or Laminated safety glass
Structure of the glass: (nominal thickness of the individual constituents (mm))
Test Procedure: Test with condensation (5.3.1) or Test without condensation (5.3.2)

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Type of test</th>
<th>Fire resistant laminated safety glass y/n</th>
<th>Indoor / outdoor use?</th>
<th>Dimensions</th>
<th>Nominal thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV – H 2</td>
<td>5.3.2</td>
<td></td>
<td>outdoor</td>
<td>100 x 300</td>
<td>4.1.4</td>
</tr>
<tr>
<td>UV – H 4</td>
<td>5.3.2</td>
<td></td>
<td>outdoor</td>
<td>100 x 300</td>
<td>4.1.4</td>
</tr>
<tr>
<td>UV – H 8</td>
<td>5.3.2</td>
<td></td>
<td>outdoor</td>
<td>100 x 300</td>
<td>4.1.4</td>
</tr>
</tbody>
</table>

Sample characteristics:

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Cut or on size production</th>
<th>Edge type</th>
<th>Edge protection</th>
<th>Supported edge marked y/n</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV – H 2</td>
<td>C</td>
<td>arrissed</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>UV – H 4</td>
<td>C</td>
<td>arrissed</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>UV – H 8</td>
<td>C</td>
<td>arrissed</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

For each test specimen the number and size of the bubbles, delamination and cloudiness occurring (not discolouration): Note: In the case of fire resistant laminated safety glass and fire resistant laminated glass only (if any) delamination was given.

Results

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Bubbles y/n</th>
<th>Size of bubbles</th>
<th>Delamination y/n</th>
<th>Cloudiness y/n</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV – H 2</td>
<td>N</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>UV – H 4</td>
<td>N</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>UV – H 8</td>
<td>N</td>
<td>0</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>
3.3 Radiation test

Type and structure of the laminated glass or laminated safety glass, with nominal thickness of the individual constituents in millimetres

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Type of test</th>
<th>Fire resistant laminated safety glass</th>
<th>Indoor / outdoor use?</th>
<th>Dimensions</th>
<th>Nominal thickness</th>
<th>asymmetrical y/n</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV – H 1</td>
<td>Ultravitalux</td>
<td>outdoor</td>
<td></td>
<td>100 x 300</td>
<td>4.1.4</td>
<td>N</td>
</tr>
<tr>
<td>UV – H 6</td>
<td>Ultravitalux</td>
<td>outdoor</td>
<td></td>
<td>100 x 300</td>
<td>4.1.4</td>
<td>N</td>
</tr>
<tr>
<td>UV – H 9</td>
<td>Ultravitalux</td>
<td>outdoor</td>
<td></td>
<td>100 x 300</td>
<td>4.1.4</td>
<td>N</td>
</tr>
</tbody>
</table>

Type of test specimens including cut or special manufacture; type of edge; edge protection, face to radiation source;

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Type of test</th>
<th>Cut or on size production</th>
<th>Edge type</th>
<th>Edge protection</th>
<th>Supported edge marked y/n</th>
<th>side facing radiation source</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV – H 1</td>
<td>Ultravitalux</td>
<td>on size</td>
<td>arrissed</td>
<td>N</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>UV – H 6</td>
<td>Ultravitalux</td>
<td>on size</td>
<td>arrissed</td>
<td>N</td>
<td>Y</td>
<td>-</td>
</tr>
<tr>
<td>UV – H 9</td>
<td>Ultravitalux</td>
<td>on size</td>
<td>arrissed</td>
<td>N</td>
<td>Y</td>
<td>-</td>
</tr>
</tbody>
</table>

For products with initial light transmittance > 20%: for each test specimen the percentage difference in the light transmittance before and after radiation; for products with initial light transmittance ≤ 20%: for each test specimen the actual difference in light transmittance before and after radiation; In the case of fire resistant laminated glass and fire resistant laminated safety glass this difference has not to be given. Also the presence of delamination is given (if any);

<table>
<thead>
<tr>
<th>Sample Code</th>
<th>Type of test</th>
<th>initial LT</th>
<th>&gt; 20%?y/n</th>
<th>LT after exposure</th>
<th>delamination y/n</th>
<th>Report value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV – H 1</td>
<td>Ultravitalux</td>
<td>0.866</td>
<td>Y</td>
<td>0.848</td>
<td>N</td>
<td>0.018</td>
</tr>
<tr>
<td>UV – H 6</td>
<td>Ultravitalux</td>
<td>0.866</td>
<td>Y</td>
<td>0.849</td>
<td>N</td>
<td>0.017</td>
</tr>
<tr>
<td>UV – H 9</td>
<td>Ultravitalux</td>
<td>0.868</td>
<td>Y</td>
<td>0.846</td>
<td>N</td>
<td>0.022</td>
</tr>
</tbody>
</table>
4 Signature

Eindhoven, November 2006

J. van der Zwan B.Sc
Author

K.K. Pahnke, M.Sc.
Head of Department