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TNO report

TQS-RAP-07-

Noval Glass Group LTD

EN - ISO 12543 Glass in building - Laminated glass and laminated safety glass

Durability testing

Laminated glass (33.2)

Date	October 2007
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The classification designation Ongerubriceerd is equivalent to Unclassified, Stg. Confidentieel is equivalent to Confidential and Stg. Geheim is equivalent to Secret.

Contents

1 Introduction

Noval Glass Group LTD has commissioned TNO Quality Services BV with the assessment of the performance of the ITT testing as specified in the product standard EN – ISO 12543.

The ITT is part of the standard of a series of interrelated parts:

EN ISO 12543-1: Glass in building - Laminated glass and laminated safety glass - Part 1: Definitions and description of component parts
EN ISO 12543-2: Glass in building - Laminated glass and laminated safety glass - Part 2: Laminated safety glass
EN ISO 12543-3: Glass in building - Laminated glass and laminated safety glass - Part 3: Laminated glass
EN ISO 12543-4: Glass in building - Laminated glass and laminated safety glass - Part 4: Test methods for durability
EN ISO 12543-5: Glass in building - Laminated glass and laminated safety glass - Part 5: Dimensions and edge finishing
EN ISO 12543-6: Glass in building - Laminated glass and laminated safety glass - Part 6: Appearance
EN 14449 Glass in building - Laminated glass and laminated safety glass - FPC and Evaluation of Conformity

The responsibility to comply to the above standards lies at the manufacturer. The task of the Notified Test Body is limited to the assessment of the ITT.

The product description "**Laminated Glass Products**" was supplied by the manufacturer and shall be added to this initial type test report by the manufacturer. It was to the manufacturer's responsibility that the samples delivered for initial type test are representative to the production and normal production deviations were included in the delivered test samples.

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 Experimental

2.1 Producer of the samples

Noval Glass Group LTD

No.33 Shandong Road, Qingdao P.R.China

Production plant of the sampels	***: Noval Glass Group LTD***
Sampling date	***: 01-08-2007***
Line ID where the samples are made	***: Laminating working area***

2.2 Product description

Three samples per test and per configuration of the following descriptions were delivered for testing:

- 3 mm glass – 0.38 mm interlayer - 0.38 mm interlayer – 3 mm glass

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 Tests

2.3.1 General

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

Laminated safety glass (EN – ISO 12543-2):

- 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 (EN – ISO 12543-3):

- 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

2.3.2 *High temperature test*

2.3.2.1 *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).

2.3.2.2 *Size and number of test specimens*

The test specimens were not smaller than 300 mm x 100 mm.

2.3.2.3 *Procedure*

The three test specimens were heated to a temperature of 100^{0}_{-3} °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^{0}_{-3} °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°C for 5 min.

2.3.2.4 *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

2.3.3 *Humidity test*

2.3.3.1 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).

2.3.3.2 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.

2.3.3.3 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^{+2}_{0} °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^{+2}_{0} °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 5of EN ISO 12543-3

2.3.3.4 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.

2.3.4 Radiation test

2.3.4.1 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).

2.3.4.2 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:

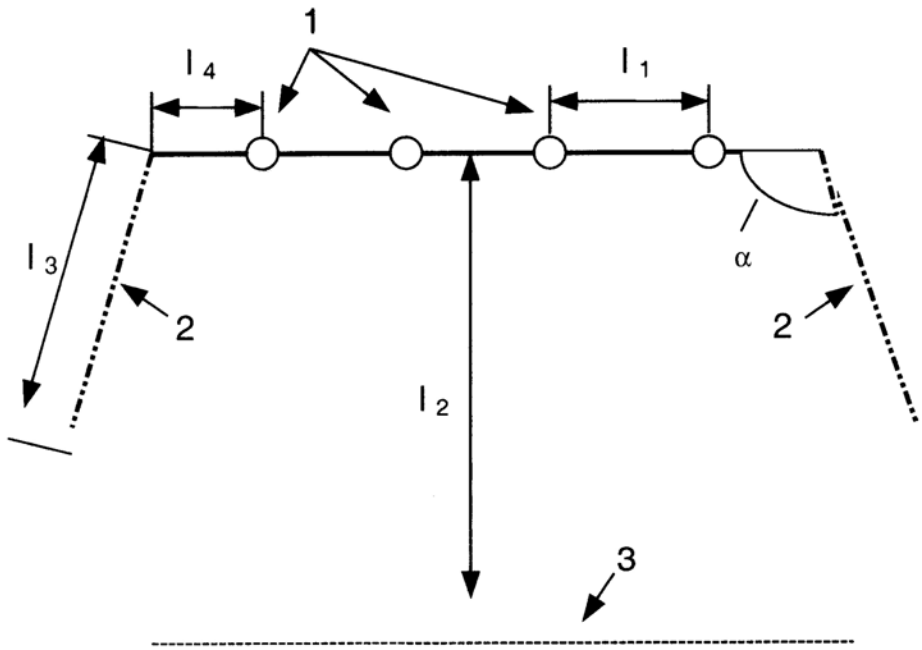
UVB	(280 nm to 315 nm)	3% ± 1%
UVA	(315 nm to 380 nm)	8% ± 1%
Visible range	(380 nm to 780 nm)	18% ± 1%
IRA	(780 nm to 1400 nm)	24% ± 2%
IRB	(1400 nm to 2600 nm)	27% ± 4%
IRC	(> 2600 nm)	20% ± 3%

2.3.4.3 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.

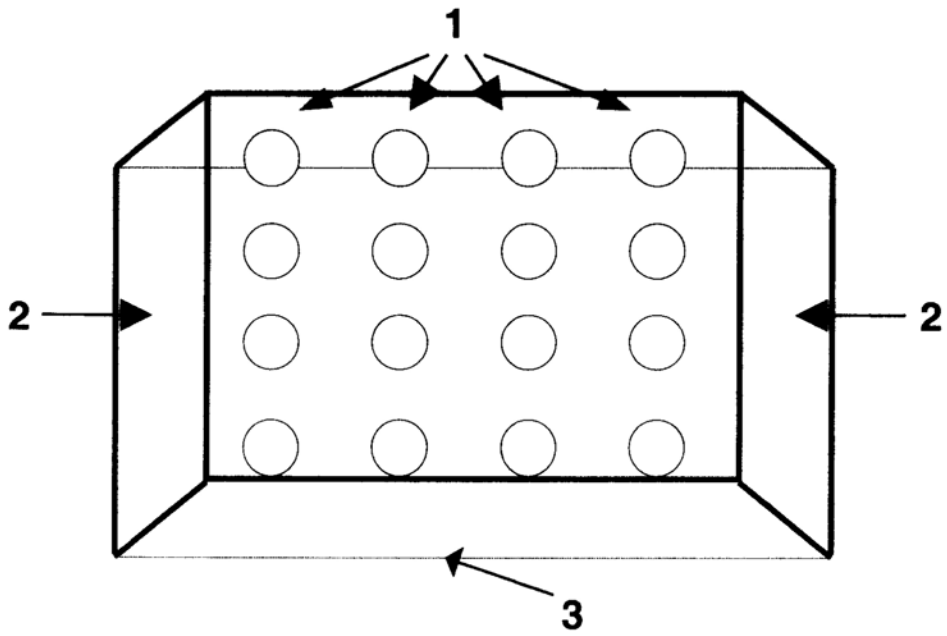
2.3.4.4 Arrangement of test apparatus

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 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 = 1100 mm forming an area of 1 m x 1 m (see figure 1).



1 lamps
2 aluminium foil
3 test specimens vertically mounted

Figure 1: Arrangement for the radiation test



1 lamps
2 aluminium foil
3 plane of test specimens

Figure 2: Arrangement for the radiation test (cross sectional view)

2.3.4.5 Size and number of test specimens

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

2.3.4.6 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.

2.3.4.7 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 General

All samples have been tested by the China Safety Global Certification Center (CSGC) which is an approved test body and appointed by Certification and Accrediation of the P.R China (CNCA) and accredited by China National Accrediation Board for Certifiers (CNAB).

3.2 High temperature test

Type of specimens: 3mm glass +0.38 mm interlayer+0.38 mm interlayer + 3mm glass
Dimensions test specimens: 300x300x6.76 mm
Production Line: Laminating working area

Sample Code	Type of test	Fire resistant laminated safety glass y/n	Indoor / outdoor use?	Dimensions	Nominal thickness
1	High temperature	N	NA	300X300	6.76
2	High temperature	N	NA	300X300	6.76
3	High temperature	N	NA	300X300	6.76

Sample Code	Type of test	Cut or on size production	Edge type	Edge protection	Supported edge marked Y/N
1	High temperature	Cut	Ground edge	NA	N
2	High temperature	Cut	Ground edge	NA	N
3	High temperature	Cut	Ground edge	NA	N

Sample Code	Results	Bubbles Y/N	Sides of bubbles	Delamination Y/N	Cloudiness Y/N
1	High temperature	N	NA	N	N
2	High temperature	N	NA	N	N
3	High temperature	N	NA	N	N

3.3 Humidity test

Type of specimens: 3mm glass +0.38 mm interlayer+0.38 mm interlayer + 3mm glass
Dimensions test specimens: 300x300x6.76 mm
Production Line: Laminating working area

Sample Code	Type of test	Fire resistant laminated safety glass y/n	Indoor / outdoor use?	Dimensions	Nominal thickness
4	5.3.1	N	NA	300X300	6.76
5	5.3.1	N	NA	300X300	6.76
6	5.3.1	N	NA	300X300	6.76

Sample Code	Sample characteristic	Cut or on size production	Edge type	Edge protection	Supported edge marked Y/N
4	5.3.1	Cut	Ground	N	N
5	5.3.1	Cut	Ground	N	N
6	5.3.1	Cut	Ground	N	N

Sample Code	Results	Bubbles Y/N	Sides of bubbles	Delamination Y/N	Cloudiness Y/N
4	5.3.1	N	NA	N	N
5	5.3.1	N	NA	N	N
6	5.3.1	N	NA	N	N

3.4 Radiation test

Type of specimens: 3mm glass +0.38 mm interlayer+0.38 mm interlayer + 3mm glass
Dimensions test specimens: 300x300x6.76 mm
Production Line: Laminating working area

Sample Code	Type of test	Fire resistant laminated safety glass y/n	Indoor / outdoor use?	Dimensions	Nominal thickness	Asymmetrical Y/N
7	Ultravitalux	N	NA	300X300	6.76	N
8	Ultravitalux	N	NA	300X300	6.76	N
9	Ultravitalux	N	NA	300X300	6.76	N

Sample Code	Type of test	Cut or on size production	Edge type	Edge protection	Supported edge marked Y/N	Side facing radiation source	Delamination Y/N
7	Ultravitalux	Cut	Ground	N	N	NA	N
8	Ultravitalux	Cut	Ground	N	N	NA	N
9	Ultravitalux	Cut	Ground	N	N	NA	N

Sample Code	Type of test	Initial LT	>20%? Y/N	LT after exposure	Delamination Y/N	Report value
7	Ultravitalux	87.60%	Y	85.10%	N	2.85%
8	Ultravitalux	87.90%	Y	85.13%	N	3.15%
9	Ultravitalux	87.90%	Y	85.11%	N	3.17%

4 Conclusion

All aspects are checked to establish if the product of Noval Glass Group LTD conforms to the definition of laminated glass.

The high temperature, humidity and radiation test ***fulfil*** the requirements mentioned in EN ISO 12543 and EN14449 for laminated glass and laminated safety glass products.

When and if changes are made in production method and/or equipment, assessment according the EN ISO12543 and EN14449 shall be reconsidered and re-test shall be done when the changes can lead to different toughening of the glass. The decision and responsibility lies at the producer.

5 Signature

Eindhoven, October 2007

TNO Quality Services BV

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Summary of report **Date: 10-23-2007**

EN ISO 12543-4
Laminated glass and laminated safety glass

for details, see test report

Producer: Noval Glass Group LTD
No.33 Shandong Road, Qingdao P.R.China

Under responsibility of: Noval Glass Group LTD
No.33 Shandong Road, Qingdao P.R.China.

Product:

Laminated Glass

(33.2 configuration)

Test Result:

PASS

The tested samples are complying with the requirements of EN ISO 12543-4.

Signature:

L. van der Ven - le Comte
Project leader

A.J. Piers
Programme leader