Deutsches Institut für Bautechnik

DIBt

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**Technical authority granting approvals and permits for construction products and construction techniques**

# General construction technique permit

Date: 3 May 2024

Reference number: I 34-1.70.3-27/24

**Number:**
**Z-70.3-270**

**Validity**
from: **3 May 2024**
to: **1 October 2026**

**Applicant:**
**Kuraray Europe GmbH**
Philipp-Reis-Straße 4
65795 Hattersheim

**Subject of decision:**
**Glazing made of laminated safety glass using the 'SentryGlas® XtraTM SG 6000' interlayer**

The subject named above is herewith granted a general construction technique permit (*allgemeine Bauartgenehmigung*).
This decision contains five pages and six annexes with nine pages.
This general construction technique permit replaces general construction technique permit no. Z-70.3-270 of 1 October 2024.

**Translation authorised by DIBt**

# I GENERAL PROVISIONS

1 The general construction technique permit confirms the fitness for application of the subject concerned within the meaning of the Building Codes of the federal states (*Landesbauordnungen*).

2 This decision does not replace the permits, approvals and certificates required by law for carrying out construction projects.

3 This decision is granted without prejudice to the rights of third parties, in particular private property rights.

4 Notwithstanding further provisions in the 'Special Provisions', copies of this decision shall be made available to the installer of the subject concerned. Furthermore, the installer of the subject concerned shall be made aware of the fact that this decision must be made available at the place of application. Upon request, copies of the decision shall be provided to the authorities involved.

5 This decision shall be reproduced in full only. Partial publication requires the consent of DIBt. Texts and drawings in promotional material shall not contradict this decision. In the event of a discrepancy between the German original and this authorised translation, the German version shall prevail.

6 This decision may be revoked. The provisions contained herein may subsequently be supplemented and amended, in particular if this is required by new technical findings.

7 This decision is based on the information and documents provided by the applicant on the subject concerned during the permit procedure. Alterations to the information on which this general construction technique permit was based are not covered by this decision and shall be notified to DIBt without delay.

# II SPECIAL PROVISIONS

## 1 Subject concerned and field of application

The subject matter of the permit is the planning, design and execution of glazing made of laminated safety glass (VSG) using the SentryGlas® Xtra™ SG 6000 interlayer from Kuraray Europe GmbH.

The field of application includes glazing in accordance with the DIN 18008[1] series of standards. The glazing may be executed with or without a static shear interaction of the laminated safety glass panes.

## 2 Provisions for planning, design and execution

### 2.1 Planning

The Technical Building Rules, particularly the DIN 18008[1] series of standards, as well as the following provisions shall be observed for planning the glazing.

The laminated safety glass shall consist of at least two flat panes and the SentryGlas® Xtra™ SG 6000 interlayer.

For glazing with laminated safety glass without a static shear interaction being applied, the composition and manufacture as well as the impact and bond behaviour of the laminated safety glass shall comply with the specifications in Annex 1. For glazing with laminated safety glass with a static shear interaction being applied, the specifications in Annex 1 on the adhesion behaviour and the shear modulus values shall additionally be fulfilled.

It shall be ensured that the glass or interlayer edges are only in contact with adjacent materials that are permanently compatible with the SentryGlas® Xtra™ SG 6000 interlayer. The relevant instructions provided by Kuraray Europe GmbH shall be observed.

### 2.2 Design

The Technical Building Rules, particularly the DIN 18008[1] series of standards, as well as the following provisions shall be observed for designing the glazing.

The typical fragmentation pattern for panes of component size required in DIN 18008-1[2], Clause 4.1.3, is guaranteed for the glass panes used in the laminated safety glass.

When designing the glazing, the bonding effect of the SentryGlas® Xtra™ SG 6000 interlayer may be taken into account for the laminated safety glass if the composition and manufacture, impact, adhesion and bond behaviour as well as the shear modulus values of the laminated safety glass are in compliance with Annex 1.

By derogation from the provisions of the DIN 18008[1] series of standards, a linear elastic behaviour of the SentryGlas® Xtra™ SG 6000 interlayer may be assumed for the laminated safety glass under the conditions specified below when verifying the ultimate limit state and serviceability limit state of vertical glazing (facades and interiors) under wind and horizontal line loads or of horizontal glazing (overhead) under snow and wind loads in order to take into account the shear interaction between the individual panes.

For single-pane glazing, the shear modulus values given in Table 1 for the respective load case and a Poisson's ratio of $\nu = 0.49$ may be used as linear elastic characteristics of the SentryGlas® Xtra™ SG 6000 interlayer.

1 DIN 18008 Glass in building – Design and construction rules
2 DIN 18008-1:2020-05 Glass in building – Design and construction rules – Part 1: Terms and general bases

For laminated safety glass with expected interlayer temperatures T > +55 °C, determined taking into account the minimum values for climatic effects in accordance with DIN 18008-1[2], Annex C, or determined taking into account the interlayer temperatures actually expected, the reduced shear modulus values $G_{red}$ given in Table 1 shall be used.

Table 1: Characteristic values applicable to single-pane glazing

| | Load case | Shear modulus G [N/mm²] | Red. shear modulus $G_{red}$ [N/mm²] | $k_{VSG}$[3] | $k_{mod}$ |
|---|---|---|---|---|---|
| Facades | Wind | 70 | 31.6 | 1.0 | 0.7 |
| | Horizontal line | 20.0 (T = 30 °C)<br>8.0 (T = 35 °C)<br>5.2 (T = 40 °C)<br>3.4 (T = 43 °C)<br>1.7 (T = 50 °C)<br>0.7 (T = 55 °C) | 0.3 | 1.0 | 0.7 |
| | Horizontal line and wind | 70 | 31.6 | 1.0 | 0.7 |
| Indoor | Wind | 70 | 31.6 | 1.0 | 0.7 |
| | Horizontal line | 20[4] | 0.3 | 1.0 | 0.7 |
| | Horizontal line and wind | 70 | 31.6 | 1.0 | 0.7 |
| Overhead use | Self-weight | 0 | 0 | 1.1 | 0.25 |
| | **Heated areas** | | | | |
| | Snow | 12 | 12 | 1.0 | 0.4 |
| | Wind and snow | 12 | 12 | 1.0 | 0.7 |
| | **Unheated areas** | | | | |
| | Snow | 30 | 30 | 1.0 | 0.4 |
| | Wind and snow | 30 | 30 | 1.0 | 0.7 |

The calculations may be geometrically linear or non-linear. The following sequence shall be observed for verification purposes:

1. Load case combinations in accordance with DIN EN 1990[5] including the associated partial safety factors and combination coefficients shall be formed.
2. The main tensile stresses in the laminated safety glass shall be calculated separately for each load component (γ-,·ψ-fold load) of the relevant load case combination. The following system assumptions shall be observed:
   - For wind, horizontal line and snow loads, a partial shear interaction in accordance with Table 1 may be used for the calculation.

3 $k_{VSG}$ Factor for laminated glass and laminated safety glass, see DIN 18008-1, Clause 8.3.9

4 Valid for a permissible interlayer temperature T of 30°C and a load time of one hour; for higher interlayer temperatures T, shear modulus values for outdoor applications shall be taken into account.

5 DIN EN 1990:2010-12 Eurocode: Basis of structural design

- For climate loads (temperature, atmospheric pressure, difference in altitude), the method specified in Clause 7.2 of DIN 18008-1[2]shall be used. The extreme cases 'without shear interaction' and 'full shear interaction' shall be considered. The more unfavourable case shall be taken.
- No shear interaction shall be considered for the calculation of the other load cases (e.g., self-weight).

3. The main tensile stresses shall then be added up for each load component for the load case combination considered.
4. The load-bearing capacity shall be verified in accordance with DIN 18008-1[2] for the relevant load case combination in consideration of the $k_{mod}$ and $k_{VSG}$ coefficients in accordance with Table 1.

### 2.3 Execution

The Technical Building Rules, particularly the DIN 18008[1] series of standards, shall be observed for executing the glazing.

The executing company shall provide a declaration of conformity in accordance with Section 16a(5) in conjunction with Section 21(2) of the Model Building Code to confirm the conformity of the construction technique with this general construction technique permit.

## 3 Provisions for use, maintenance and repair

Damaged panes shall be replaced immediately. Hazardous areas shall be sealed off immediately. When replacing the panes, it shall be ensured that solely construction products to which this general construction technique permit applies are used.

Andreas Schult
Head of Section

Drawn up by
Stöhr

## A 1.1 Composition and manufacture of the laminated safety glass

- The glass panes consist of the following glass products:
  - float glass (soda lime silicate glass) in accordance with DIN EN 572-2[1],
  - safety glass in accordance with DIN EN 12150-1[2] with a fragmentation pattern in accordance with A 1.3,
  - heat-soaked thermally toughened soda lime silicate safety glass in accordance with DIN EN 14179-1[3] or DIN 18008-2[4], Clause 4.3, 3rd bullet point, with a fragmentation pattern in accordance with A 1.3,
  - heat strengthened glass in accordance with DIN EN 1863-1[5] with a fragmentation pattern in accordance with A 1.3,
  - coated glass in accordance with DIN EN 1096-1[6] - with coatings with properties at least equivalent to black enamelled glass in terms of absorption performance and the resultant interlayer temperature,
  - patterned glass in accordance with DIN EN 572-5[7] - with compliance with the limit values for straightness (local and global warping) of the side facing the interlayer for thermally non-toughened patterned glass for heat strengthened glass in accordance with DIN EN 1863-1[5] and safety glass in accordance with DIN EN 12150-1[2].
- The minimum thickness of the SentryGlas® Xtra™ SG 6000 interlayer is 0.76 mm and the maximum thickness 3.04 mm. The product information provided by the manufacturer and the composition are deposited with DIBt, last update 21 September 2021.
- The moisture content of the film during manufacture is ≤ 0.2%, measured in accordance with **Annex 6**.
- When manufacturing laminated safety glass using coated glass products (excluding enamelled glass products), the glass panes are laminated with the SentryGlas® Xtra™ SG 6000 interlayer only on the uncoated glass surface.
- The laminated safety glass is manufactured by means of the lamination process.
- For laminated safety glass with an interlayer nominal thickness of 0.76 mm, the nominal thickness of thermally toughened glass must not exceed 8 mm.

## A 1.2 Performance values

- Impact behaviour tested in accordance with DIN EN 12600[8] (4 mm float/0.76 mm SentryGlas® Xtra™ SG 6000/4 mm float): 1(B)1.
- Impact behaviour tested in accordance with DIN EN 356[9] (4 mm float/0.76 mm SentryGlas® Xtra™ SG 6000/4 mm float): P1A.
- Impact behaviour in the ball drop test in accordance with DIN 52338[10]: no penetration of the ball from a drop height of 5.75 m
- Laminate bond strength (pummel test) tested in accordance with **Annex 2.1 and 2.2**: Pummel value ≥ 6
- Adhesion tested in accordance with **Annex 3**: smallest value $\sigma \geq 8.5$ N/mm²
- Shear modulus values tested in accordance with **Annexes 4.1 to 4.3**: see **Annex 5**

## A 1.3 Fragmentation pattern

Glass products in accordance with EN 12150-2[11] and EN 14179-2[12] must have the fragmentation pattern defined in DIN EN 12150-1[2] for test panes for each manufactured component size.

Glass products in accordance with EN 1863-2[13] with a component size of 1000 mm x 1500 mm and more must have a fragmentation pattern in which the proportion of the area made up of fragments of a non-critical size is more than four-fifths of the total area. The method for assessing the fragmentation pattern is based on DIN EN 1863-1[5], Section 8. All fragments in which a circle of diameter 120 mm can be drawn may be deemed non-critical in terms of size.

| | | |
|---|---|---|
| 1 | DIN EN 572-2:2012-11 | Glass in building – Basic soda lime silicate glass products – Part 2 – Float glass |
| 2 | DIN EN 12150-1:2019-08 | Glass in building – Thermally toughened soda lime silicate safety glass – Part 1: Definition and description |
| 3 | DIN EN 14179-1:2016-12 | Glass in building – Heat soaked thermally toughened soda lime silicate safety glass – Part 1: Definition and description |
| 4 | DIN 18008-2:2020-05 | Glass in building – Design and construction rules – Part 2: Linearly supported glazings |
| 5 | DIN EN 1863-1:2012-02 | Glass in building – Heat strengthened soda lime silicate glass – Part 1: Definition and description |
| 6 | DIN EN 1096-1:2012-04 | Glass in building – Coated glass – Part 1: Definitions and classification |
| 7 | DIN EN 572-5:2012-11 | Glass in building – Basic soda lime silicate glass products – Part 5: Patterned glass |
| 8 | DIN EN 12600:2003-04 | Glass in building – Pendulum tests – Impact test method and classification for flat glass |
| 9 | DIN EN 356:2000-02 | Glass in building – Security glazing – Testing and classification of resistance against manual attack |
| 10 | DIN 52338:2016-10 | Test methods for flat glass in building – Ball drop test for laminated glass |
| 11 | In Germany implemented by DIN EN 12150-2:2005-01. | |
| 12 | In Germany implemented by DIN EN 14179-2:2005-08. | |
| 13 | In Germany implemented by DIN EN 1863-2:2005-01. | |

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|---|---|
| Glazing made of laminated safety glass using the 'SentryGlas® XtraTM SG 6000' interlayer | Annex 1 |
| Composition and manufacture, performance values | |

## A 2 Instructions for testing the laminate bond strength (pummel test)

### A 2.1 General

- The test specimens are manufactured in compliance with the Kuraray Manual (Lamination Guidelines, 9/2021) for SentryGlas® Xtra™ SG 6000.
- The standard dimensions of the test specimens are 80 mm x 300 mm (min. 80 mm x 150 mm).
- The test specimens have the following composition: 3 mm float / 0.76 mm SentryGlas® Xtra™ SG 6000 / 3 mm float.
- Number of test specimens: at least 5.

### A 2.2 Conducting the test

- Before testing, the test specimens are equilibrated at room temperature for at least 30 minutes (25 °C ± 5 °C).
- The test specimen is held at an angle of approx. 5° to the plane of the pummel plate or placed on the striking tool so that only the edge of the unbroken glass is in contact with the plate (Fig. A 2.1).
- The test specimen is repeatedly struck with a hammer (500 g flat-head hammer) in an overlapping pattern (uniform strikes, starting at the bottom edge, overlapping half of the previous strike area, spacing approx. 20 mm) to break the glass into powdered particles. At least 6 to 10 cm of the laminate is struck (Fig. A 2.1).
- The laminate is then turned over (short end over short end) and the process is repeated. Both ends (the inside of one end and the outside of the other) are struck and read. On completion, the centre section, which contains the specimen ID, should be the only glass that has not been crushed.

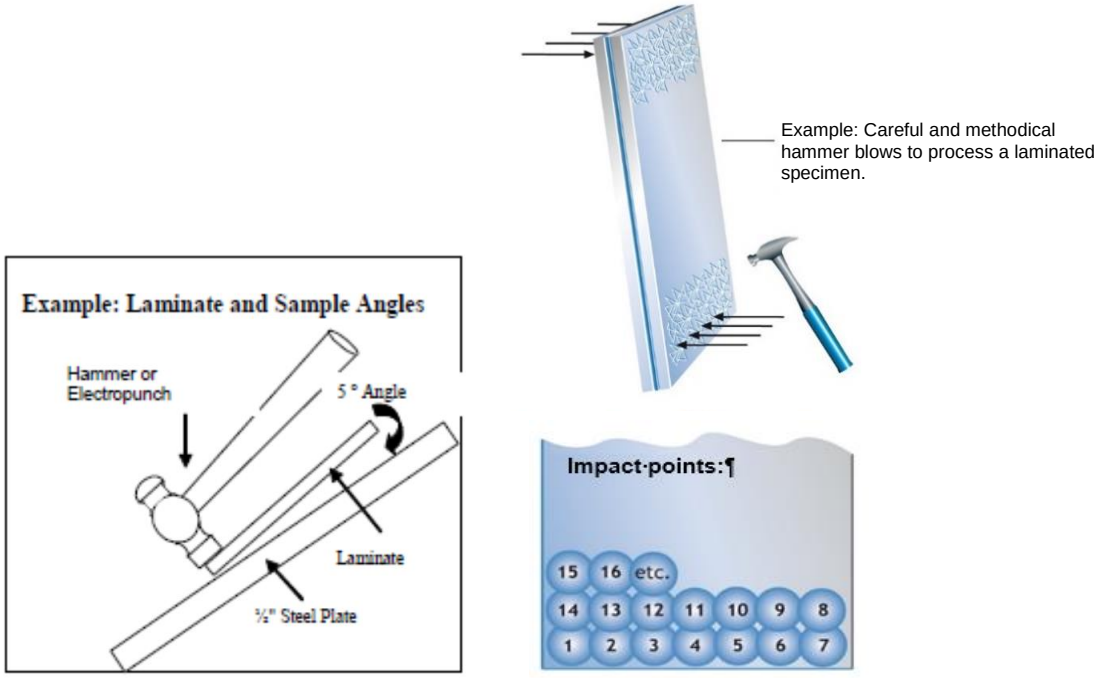


**Fig. A 2.1:** Conducting the test

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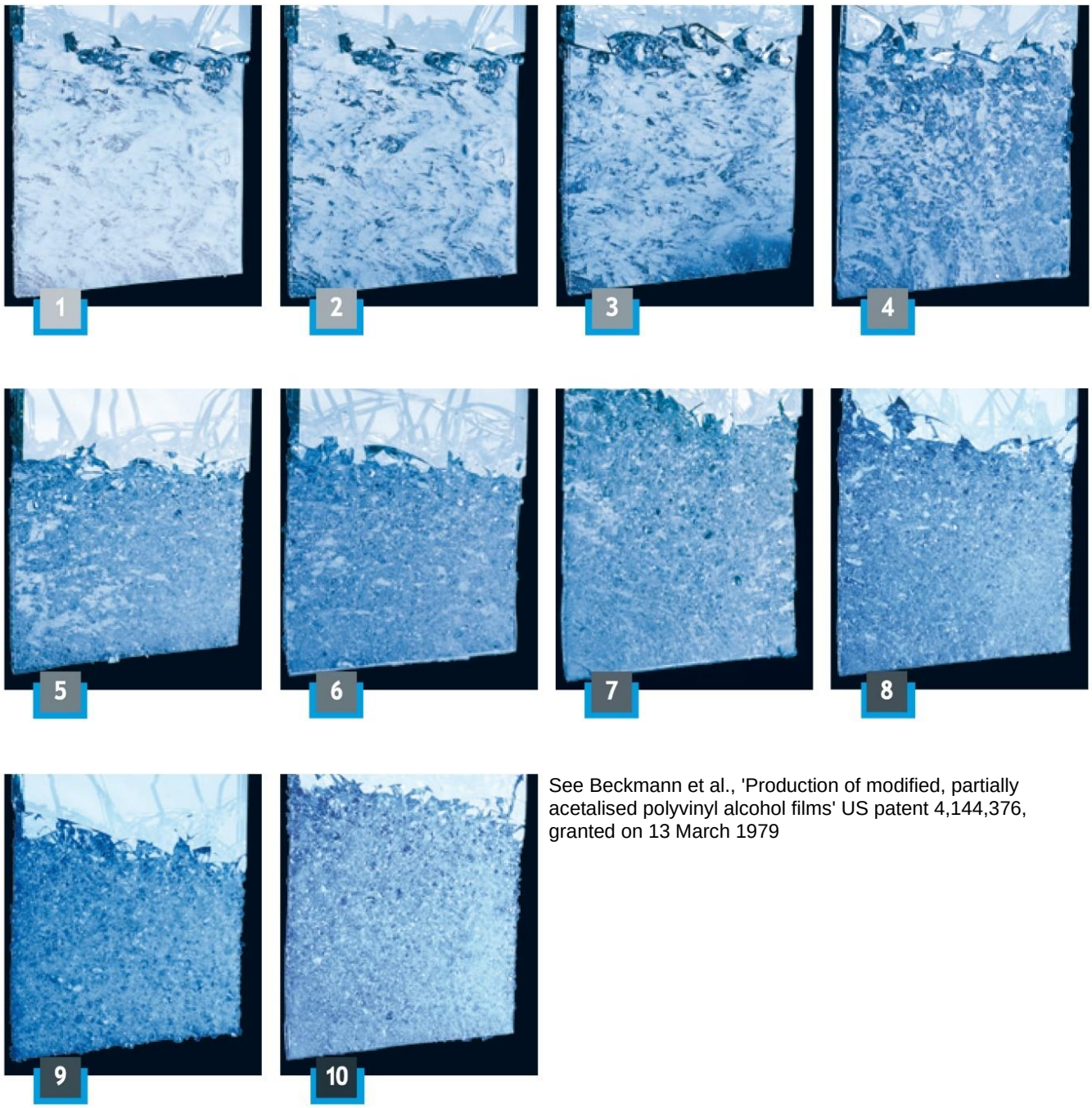
|---|---|
| Glazing made of laminated safety glass using the 'SentryGlas® XtraTM SG 6000' interlayer | Annex 2.1 |
| Instructions for testing the laminate bond strength (pummel test) | |

## A 2.3 Evaluation

- The specimens are placed on brown kraft paper, carefully compared with the reference specimens and the degree of bonding (0 to 10) is determined by comparing the specimens with the reference specimens (Fig. A 2.2).
- A pummel value of 0 means no bonding, a pummel value of 10 means very high bonding.




See Beckmann et al., 'Production of modified, partially acetalised polyvinyl alcohol films' US patent 4,144,376, granted on 13 March 1979

**Fig. A 2.2:** Reference pummel pattern

| | |
|---|---|
| Glazing made of laminated safety glass using the 'SentryGlas® XtraTM SG 6000' interlayer | Annex 2.2 |
| Instructions for testing the laminate bond strength (pummel test) | |

## A 3 Pull test instructions

### A 3.1 General

- The laminated safety glass is manufactured in accordance with the Kuraray Manual (Lamination Guidelines, 9/2021) for SentryGlas® Xtra™ SG 6000.
- Typical composition of the test specimen: 3 mm float / 0.76 mm SentryGlas® Xtra™ SG 6000 / 3 mm float
- Test specimens measuring 40 mm x 10 mm are cut out of the laminated safety glass using a suitable saw or cutting method at a distance of at least 50 mm from the edge of the laminated safety glass.
- The glass surfaces of the test specimens are thoroughly cleaned and degreased with n-pentane.
- The prepared test specimens are glued between two suitable metal test specimen holders at room temperature (23°C +/- 2°C) (Fig. A 3.1). F246 Acrylic Adhesive, Bond Master with initiator No. 5 or equivalent adhesives may be used. The adhesive should be allowed to cure for at least 24 hours.
- The test specimens must be stored at room temperature and a relative humidity of less than 60% for one week before the start of the test.
- Number of test specimens: at least 10 to determine the performance values; at least 5 for FPC.

### A 3.2 Conducting the test

- The test specimens are placed in the specimen holder of a suitable tensile testing machine (e.g., Zwick tensile tester) (Fig. A 3.2).
- The test speed is 0.50 mm/min., vertical movement at room temperature (23 °C +/- 2 °C).

### A 3.3 Evaluation

- The force/displacement curve up to the failure of the bond between SentryGlas® Xtra™ SG 6000 and glass is recorded and documented. Test specimens with adhesive bond failure to the specimen holder or cohesive failure of the glass are excluded from the evaluation.
- The recorded data is converted into a stress value $\sigma$, taking into account the dimensions of the test specimen.

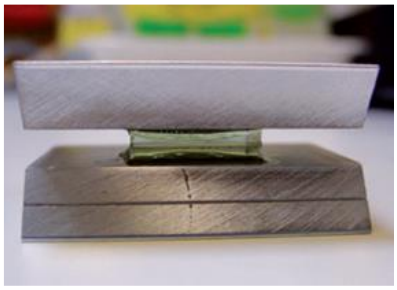
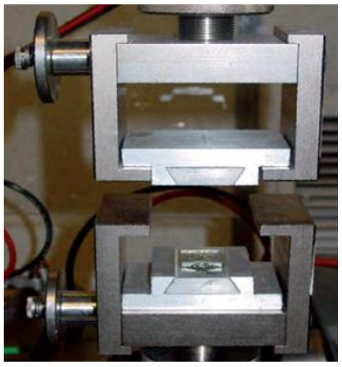


**Fig. A 3.1:** Test specimen holder



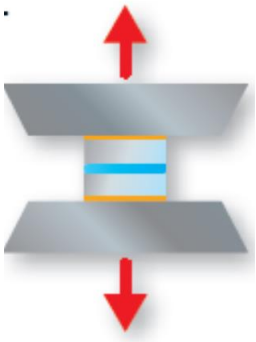


**Fig. A 3.2:** Tensile testing machine

| | |
|---|---|
| Glazing made of laminated safety glass using the 'SentryGlas® XtraTM SG 6000' interlayer | Annex 3 |
| Pull test instructions | |

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## A 4 Test instructions for determining the shear moduli G(t,T)

### A.4.1 General

Dynamic mechanical thermal analyses (DMTA) are conducted to experimentally characterise the temperature- and load duration-dependent material behaviour of polymeric interlayers. In a DMTA, the viscoelastic body is excited at a controlled temperature by means of harmonically oscillating distortion or stress and the phase-shifted stress or distortion response is measured. The time- and temperature-dependent stiffness characteristics G(t;T) can be determined by varying the excitation frequency and temperature. The measurements are taken in the rheometer.

The tests are started immediately or five days after the specimen has been installed to allow for secondary crystallisation.

To validate the DMTA, flexural creep and torsional relaxation tests are conducted on the glass/film laminate.

The procedure is described in general in DIN EN 16613[1] and the ISO 6721[2] series of standards.

### A 4.2 DMTA test description

#### A 4.2.1 Conducting the test

Table T 4.1 shows the description of the test in the rheometer. The rheometer is shown in Fig. A 4.1.

Tab. T 4.1: Test description

| | | |
|---|---|---|
| Testing machine | Rheometer | |
| Preparing the specimen | Punched out using a hole punch | |
| Specimen storage | At least 5 days dry (e.g., Steiner Chemie drying beads), room temperature | |
| Measuring system | Plate-plate system | |
| Specimen geometry | Circle: Ø 8 mm, d=0.76 mm | |
| Normal contact force | 0.1 [N] (pressure) | |
| Number of specimens | 3 | |
| | **Amplitude measurement** | **Temperature/frequency measurement** |
| Temperature | -40 °C; +100 °C | [-40 °C to +105 °C] |
| Frequencies | 0.1Hz; 1Hz; 10Hz | [0.1Hz to 10Hz] |
| Distortion amplitude | [0.01 % to 0.05 %] | 0.025 % at T [-40 °C to +65 °C];<br>0.04 % at T [70 °C to 105 °C] |

#### A 4.2.2 Rheometer test results

A 4.2.2.1 Amplitude measurement

- Storage modulus G' as a function of the applied distortion/stress amplitude
- Loss modulus G'' as a function of the applied distortion/stress amplitude
- Complex modulus G* as a function of the applied distortion/stress amplitude

[1] DIN EN 16613:2020-01 Glass in building – Laminated glass and laminated safety glass – Determination of interlayer viscoelastic properties

[2] ISO 6721 Plastics - Determination of dynamic mechanical properties

A 4.2.2.2 Temperature/frequency measurement

- Storage modulus G' as a function of frequency and temperature
- Loss modulus G'' as a function of frequency and temperature
- Complex modulus IG*I as a function of frequency and temperature
- Loss factor tan δ= G''/G' as a function of frequency and temperature

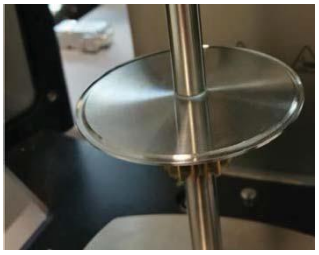

**Fig. A 4.1:** Test set-up, rheometer

### A 4.2.3 Analysis and evaluation

As long as the storage modulus, loss modulus and complex modulus from the amplitude measurement are independent of the applied distortion amplitude or stress amplitude, the material is in the linear viscoelastic range. The master curve is generated at a reference temperature of $T_{ref}$ = 20°C by the gradual displacement of the measured isothermal IG*I modulus/frequency curves horizontally along the frequency axis. The horizontal displacement factors may be approximated mathematically by the time/temperature displacement principle of William-Landel-Ferry or Arrhenius. If these do not adequately represent the displacement factors over the entire temperature range under examination, the incrementally determined displacement factors are used.

The Prony series is determined by taking into account the master curves of the storage modulus G' and the loss modulus G''.

$$G(t) = G_0 \cdot \left(1 - \sum_{i=1}^{n} g_i \left(1 - e^{-\frac{t}{\alpha_T(T,T_{ref})\cdot\tau_i}}\right)\right)$$

This series is then used to obtain the shear modulus values G(t,T), see **Annex 5**, Fig. A 5.1 and Fig. A 5.2.

## A 4.3 Test instructions for flexural creep and torsional relaxation tests

### A 4.3.1 General

- The laminated safety glass is manufactured in accordance with the Kuraray Manual (Lamination Guidelines, 9/2021) for SentryGlas® Xtra™ SG 6000.
- Composition: 4 mm float glass / 2.28 mm SentryGlas® Xtra™ SG 6000 / 4 mm float glass
- Dimensions: 1100 ± 5 mm x 360 ± 5 mm (L x W)
- Number: at least 3 test specimens per temperature.
- The test setup consists of a measuring channel for the deflection in the centre of the span and/or for the drilling angle and the torsional moment and the temperature of each glass laminate. The temperature is measured on the outside of the glass laminate.
- The test set-up and measuring points are shown in Fig. A 4.2 and A 4.3.

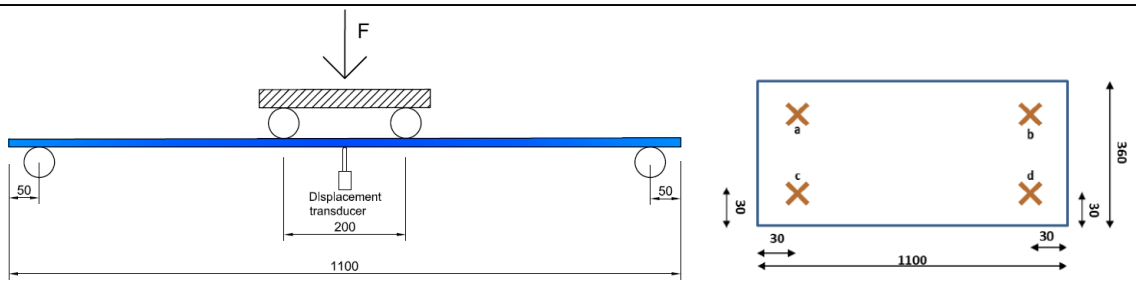


**Fig. A 4.2:** Flexural creep test and measuring points

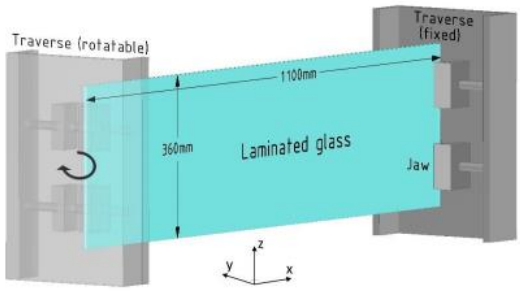


**Fig. A 4.3:** Torsional relaxation test

### A 4.3.2 Conducting the test

A 4.3.2.1 Flexural creep test

- Performed based on DIN EN 16613[1], Annex 3 or DIN EN 1288-3[2]
- Test specimen loaded such that the glass panes are loaded with at least 10 MPa
- Before applying the load, all test specimens are conditioned for 24 hours without load so that the impact of self-weight may be neglected.
- Load applied quasi-statically (100 N, 250 N and 300 N)
- Measurement at 0 °C, 23 °C, 30 °C, 50 °C and 80 °C
- Load duration at least 24 h
- Deflection in the centre of the span and the temperature of each glass element are recorded

A 4.3.2.2 Torsional relaxation test

- Specimens conditioned for 24 hours at room temperature
- Torsion angle of 2° applied in a short time, but quasi-statically
- Measurement at 23 °C and 30 °C
- Load duration at least 24 h
- Torsion angle, torsional moment and the temperature of each test specimen are recorded (staring together with conditioning).

### A 4.3.3 Evaluation

- The shear moduli are determined for different points in time and temperatures, see **Annex 5**, Fig. A 5.2.
- The shear moduli are determined as mean values from the tests.

1 DIN EN 16613:2020-01 Glass in building – Laminated glass and laminated safety glass – Determination of interlayer viscoelastic properties
2 DIN EN 1288-3:2000-09 Glass in building – Determination of the bending strength of glass – Part 3: Test with specimen supported at two points (four point bending)

| | |
|---|---|
| Glazing made of laminated safety glass using the 'SentryGlas® XtraTM SG 6000' interlayer | Annex 4.3 |
| Test instructions for determining shear moduli G(t,T) | |

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## A 5 Shear modulus values G(T,t), determined by testing

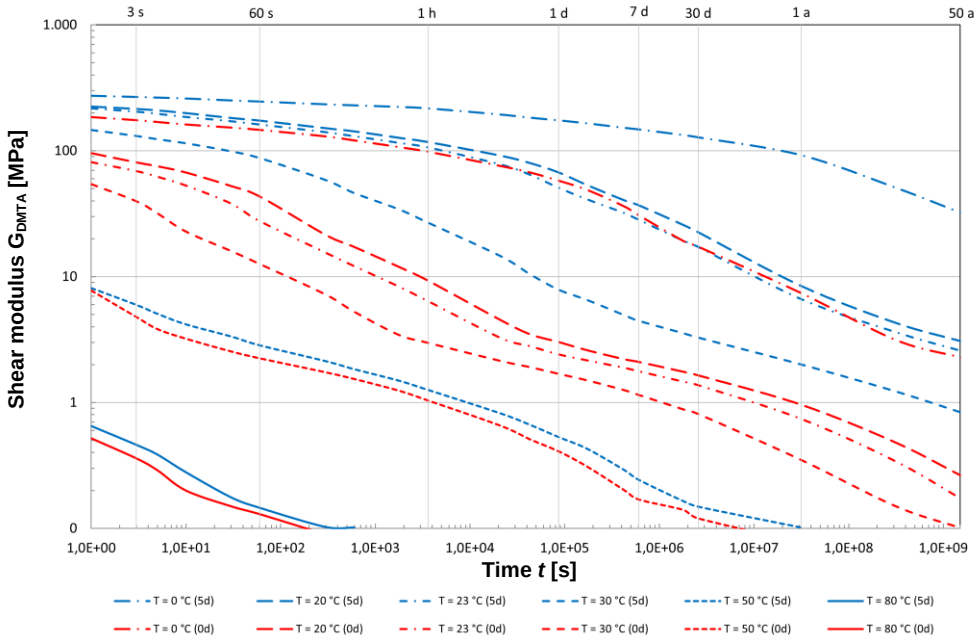


**Fig. A 5.1** Shear modulus G(T,t) from DMTA as a function of temperature T and load duration t

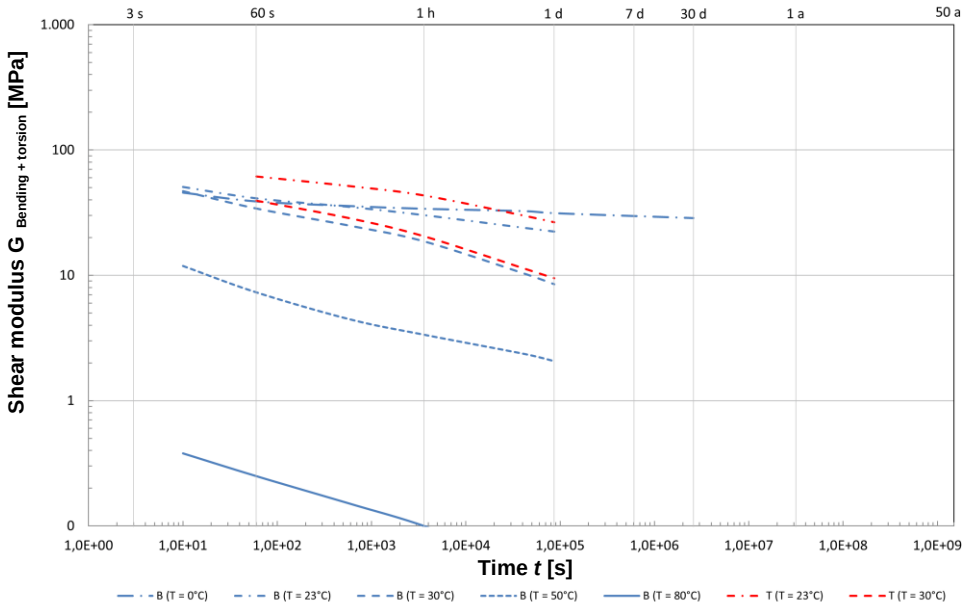


**Fig. A 5.2** Shear modulus G(T,t) from flexural creep and torsional relaxation tests as a function of temperature T and load duration t

| | |
|---|---|
| Glazing made of laminated safety glass using the 'SentryGlas® XtraTM SG 6000' interlayer | Annex 5 |
| Shear modulus G(T,t) | |

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## A 6 Principle of moisture measurement using NIR spectroscopy

### A 6.1 General principle

To determine the moisture content of the laminated film in a laminated glass specimen, a spectral scan is performed in the near infrared range of the spectrum from 1450 to 2200 nm. The absorbance caused by moisture in the specimen is in the range 1875-1950 nm and is corrected for the specimen thickness by dividing it by the absorbance caused by CH2 groups at 1730 nm.

Correlating Karl Fischer moisture analyses ('MOISTURE Standards') with this NIR ratio allows the percentage moisture content to be calculated. To calibrate and adjust the NIR spectrometer, laminated safety glass specimens with a precisely defined moisture content are prepared and provided in advance. The moisture content of these specimens ('MOISTURE STANDARDS') is determined by Karl Fischer titration (KFT).

The constants are to be determined for the glass substrates used (type of float glass and thickness) and used accordingly (note: laboratories typically work with identical base glass of the same thickness in all cases. Knowledge and experience of conducting and evaluating NIR spectroscopy are required.

### A 6.2 Conducting the test

- The NIR spectrophotometer is set up to scan the range from 1450 to 2200 nm.
- The laminated safety glass specimen is cleaned, placed in the spectrophotometer and scanned in the NIR range. A typical scan is shown in Fig. A 6.
- The CH2 absorption is measured from the horizontal tangent to the 1730 nm peak and from a second horizontal baseline to the minimum close to 1575 nm (the minima are to be defined and specified in the wavelength range).
- The moisture absorption is measured from the maximum in the range of 1875–1950 nm to the tangent between the two minima at nominally 1873 and 2087 nm.

### A 6.3 Evaluation

- The NIR ratio is the moisture absorption divided by the CH2 absorption.
- The percentage humidity is calculated using the following equation.

$$\%H_2O = \mathbf{A} * (\text{NIR ratio}) - \mathbf{B}$$

- A and B are constants that vary depending on the spectrophotometer, glass colour and glass thickness.

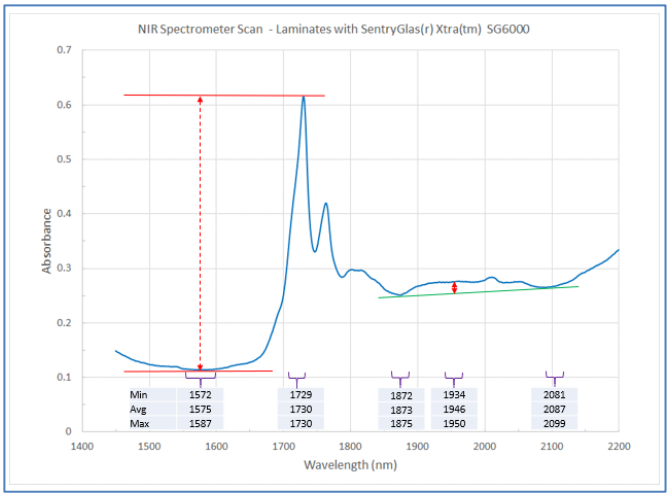


**Fig. A 6:** Typical scan

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| Glazing made of laminated safety glass using the 'SentryGlas® XtraTM SG 6000' interlayer | Annex 6 |
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