SLOVENSKI STANDARD
SIST EN 16613:2020

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Steklo v gradbeništvu - Lepljeno steklo in lepljeno varnostno steklo - Določevanje mehanskih lastnosti vmesnih slojev

Glass in building - Laminated glass and laminated safety glass - Determination of interlayer viscoelastic properties

Glas im Bauwesen - Verbundglas und Verbundsicherheitsglas - Bestimmung der mechanischen Eigenschaften von Zwischenschichten

Verre dans la construction - Verre feuilleté et verre feuilleté de sécurité - Détermination des propriétés mécaniques d'un intercalaire

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81.040.20 Steklo v gradbeništvu Glass in building

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Glass in building - Laminated glass and laminated safety glass - Determination of interlayer viscoelastic properties

Verre dans la construction - Verre feuilleté et verre feuilleté de sécurité - Détermination des propriétés mécaniques d'un intercalaire

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (EN 16613:2019) has been prepared by Technical Committee CEN/TC 129 "Glass in building", the secretariat of which is held by NBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2020 and conflicting national standards shall be withdrawn at the latest by April 2020.

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Introduction

The purpose of this document is to provide the viscoelastic properties of interlayer materials in order that calculations for the load resistance of laminated glass panes can be undertaken.

In addition, this document includes a procedure for categorizing the interlayer materials into families, which can be associated with shear transfer coefficients which are used in a simplified calculation method according to EN 16612.

1 Scope

This document specifies a test method for determining the mechanical viscoelastic properties of interlayer materials. The interlayers under examination are those used in the production of laminated glass and/or laminated safety glass. The interlayer viscoelastic properties are needed in order to determine the load resistance of laminated glass.

From the tensile modulus in particular conditions of temperature and load duration, an interlayer can be placed into a family that relates to a specific interlayer shear transfer coefficient, ω. This value can be used in the simplified calculation method described in EN 16612.

Informative Annex D explains the background to the determination of families relating to a specific interlayer shear transfer coefficient.

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.

EN 1288-3, *Glass in building - Determination of the bending strength of glass - Part 3: Test with specimen supported at two points (four point bending)*

EN 16612, *Glass in building – Determination of the lateral load resistance of glass panes by calculation*

EN ISO 6721-1, *Plastics — Determination of dynamic mechanical properties — Part 1: General principles (ISO 6721-1)*

ISO 6721-4, *Plastics — Determination of dynamic mechanical properties — Part 4: Tensile vibration — Non-resonance method*

ISO 6721-11, *Plastics — Determination of dynamic mechanical properties — Part 11: Glass transition temperature*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
glass transition temperature
interval of temperature in which a material changes from a rubbery state to a glassy solid state

3.2
interlayer shear transfer coefficient
coefficient between 0 and 1 describing the ability of an interlayer material to transfer shear forces between the glass plies of a laminated glass plate when submitted to bending

3.3
stiffness family
group of interlayers having similar properties for the temperature range and load durations considered

3.4
vitreous polymer
polymer presenting a glass transition temperature in the range of building applications

4 Symbols and abbreviations

b	Width of the test specimen
C_1, C_2	Parameters in the Williams–Landel–Ferry (WLF) viscoelastic formula
e	Thickness of the test specimen
E_G	Young's Modulus of glass
E_L	Young's Modulus of the interlayer material
f	Frequency
F	Four point bend test load
G_L	Shear modulus of the interlayer material
h_k	Nominal thickness of ply k of a laminated glass
$h_{m;k}$	Distance of the mid-plane of the glass ply k from the mid-plane of the laminated glass
h_{mono}	Equivalent thickness of monolithic glass for a laminated glass deflecting under load
H	Height of the test specimen
L_B	Distance between centre lines of the bending rollers
L_S	Distance between centre lines of the supporting rollers
Q	Self-weight area density of four point bend test specimen
t	Load duration
T	Temperature
T_g	Glass transition temperature
T_{ref}	Reference temperature
w	Measured deflection of four point bend test specimen
$\alpha(T)$	Temperature transformation parameter in the WLF viscoelastic formula (known as the 'shift factor')
μ	Poisson's number of the interlayer material
ω	Interlayer shear transfer coefficient

5 Selection of testing procedure

5.1 Isotropic interlayer materials

A practical method for testing isotropic interlayer materials is to undertake a tensile test which can be used to determine the shear modulus using the following relationship:

$$G_L = \frac{E_L}{2(1+\mu)} \quad (1)$$

where

μ is the Poisson's number of the interlayer (μ can be taken as 0,49 for an isotropic interlayer).

This leads to the approximation.

$$E_L \approx 3G_L \quad (2)$$

A typical test piece for testing isotropic interlayers according to ISO 6721-4 is shown in Figure 1.

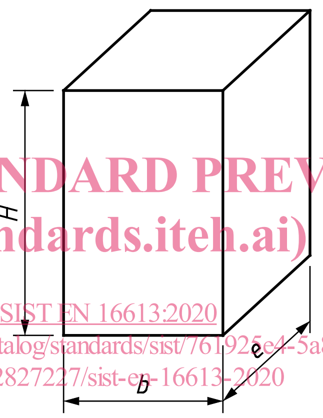

Figure 1 — Dimensions of the isotropic interlayer test piece used for tensile test

Typical dimensions of the test piece are:

- *H* = 10 mm
- *b* = 5 mm
- *e* approximately 2,3 mm (equivalent to stacking 6 plies of interlayer each with nominal thickness of 0,38 mm).

5.2 Non-isotropic interlayer materials

In the case of interlayers which are not isotropic materials (an example is the acoustic tri-layer PVB), these cannot be assessed by the method shown in 5.1.

For these interlayer materials, the relevant interlayer properties can be determined by calculation from the results of bending tests. A method for doing this is given in Annex A.

5.3 Interlayers which cannot be formed into small test pieces

There are some interlayers which cannot be formed into test pieces like those described in 5.1 or which are not stable with exposed edges in such small sizes.

For these interlayer materials, the relevant interlayer properties can be determined by calculation from the results of bending tests. A method for doing this is given in Annex A.

6 Test procedure

6.1 General

The method uses the tests described in ISO 6721-1, ISO 6721-4, and ISO 6721-11. ISO 6721-1 gives an overview of the principles of these tests.

It shall be ensured that the testing regime (temperature, frequency) is within the linear-viscoelastic region of behaviour, by undertaking amplitude sweeps.

6.2 Test specimens

The test specimens shall be manufactured from samples representative of normal interlayer material production. The test specimens shall be processed under normal laminating conditions (see Annex B).

For the purposes of the test, the thickness, *e*, of the test specimens should be not less than 2,2 mm thick and not more than 4,0 mm thick. The layering and stacking of the interlayer material to achieve an appropriate thickness shall be representative of normal production processes.

The test specimen size and tolerances on dimensions shall be determined according to the requirements of ISO 6721-4.

Two sets of test specimens are required. One set is used for determining the glass transition temperature, T_g, (see 6.3.1). The other set is used for the evaluation of the $E_L(T_{ref},f)$ curve (see 6.3.2, 6.4).

6.3 Test method

6.3.1 Glass transition temperature, T_g

Initial tests shall be conducted on at least three test specimens according to ISO 6721-11 to determine the glass transition temperature of the interlayer material. This is used to refine the temperatures assessed in 6.3.2.

NOTE If the interlayer material is not a vitreous polymer, it may not be possible to determine a glass transition temperature.

6.3.2 Determination of $E_L(T, f)$

A series of tests shall be conducted according to ISO 6721-4 to evaluate $E_L(T,f)$ for a range of frequencies, f, and a range of temperatures, T, sufficient to define the interlayer modulus, E_L.

The test temperatures shall be selected as follows.

(a) If a glass transition temperature has been determined:

- One test temperature is the glass transition temperature, T_g, determined in 6.3.1
- One test temperature is (T_g −3) °C;
- One test temperature is (T_g +3) °C;
- One test temperature is 20 °C;
- Other test temperatures shall be selected to give coverage of the temperature range, −20 °C to +60 °C;
- A minimum of 15 different test temperatures shall be used.

(b) If a glass transition temperature has not been determined:

- One test temperature is 20 °C;
- One test temperature is 17 °C;
- One test temperature is 23 °C;
- Other test temperatures shall be selected to give coverage of the temperature range, −20 °C to +60 °C;
- A minimum of 15 different test temperatures shall be used.

The frequencies to be tested at each temperature should cover the range 0,1 Hz to at least 100 Hz, testing at least 24 frequencies evenly spread through the range.

6.4 Determination of $E_L(T_{ref}, f)$

The results obtained from 6.3.2 are used to determine a master curve for $E_L(T_{ref}, f)$ for the interlayer at the reference temperature, T_{ref}, at any frequency (see Figure 2). By curve fitting to the results obtained from 6.3.2, the parameters C_1 and C_2 in the WLF viscoelastic formula [1] are evaluated:

$$\alpha(T) = 10^{\left[\frac{-C_1\left(T-T_{ref}\right)}{C_2+\left(T-T_{ref}\right)}\right]} \tag{3}$$

NOTE This curve fitting can be done by any appropriate method. Software to perform this task can be built into the test machine.