SLOVENSKI STANDARD
oSIST prEN 16613:2024

01-april-2024

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 viskoelastischen Eigenschaften von Zwischenschichten

Verre dans la construction - Verre feuilleté et verre feuilleté de sécurité - Détermination des propriétés viscoélastiques des intercalaires

Ta slovenski standard je istoveten z: **prEN 16613**

ICS:

81.040.20 Steklo v gradbeništvu Glass in building

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prEN 16613

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ICS 81.040.20

Will supersede EN 16613:2019

English Version

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 viscoélastiques des intercalaires

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

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 129.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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

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Contents

Page

European foreword

This document (prEN 16613:2024) has been prepared by Technical Committee CEN/TC 129 “Glass in building”, the secretariat of which is held by NBN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 16613:2019.

prEN 16613:2024 includes the following significant technical changes with respect to EN 16613:2019:

a) The test procedure focuses on a parallel-plate oscillation rather than tensile vibration.

b) A more detailed description of the test procedure is provided comprising four subsequent steps.

c) Annex A has been reviewed and is used for non-isotropic and multilayer interlayer materials as well as step four in the main test procedure. It provides the methods to calculate the effective thickness, shear transfer coefficient ω, the coupling factor η and the interlayer shear modulus G_{int}.

d) Annex C details the procedure to obtain the master curve and the Prony parameters.

e) The new Annex D will help determine mechanical properties used for calculation of noise reduction.

f) Annex E provides guidance for a precise geometrical assessment of a deflected specimen.

Introduction

The purpose of this document is to provide viscoelastic properties of interlayer materials for structural design of laminated glass.

In addition, it provides a method to calculate interlayer mechanical properties at different frequencies that can be used for calculation of sound reduction indices.

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 or laminated safety glass. The shear characteristics of interlayers are needed to design laminated glass in accordance with EN 16612:2019 and CEN/TS 19100 series.

Parameters of the Prony series, widely used in numerical simulation, can be derived from the measurements in Annex C.

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 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 6721-6, *Plastics — Determination of dynamic mechanical properties — Part 6: Shear vibration — Non-resonance method*

ISO 6721-7, *Plastics — Determination of dynamic mechanical properties — Part 7: Torsional vibration — Non-resonance method*

ISO 6721-10, *Plastics — Determination of dynamic mechanical properties — Part 10: Complex shear viscosity using a parallel-plate oscillatory rheometer*

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

EN 16612:2019, *Glass in building - Determination of the lateral load resistance of glass panes by calculation*

ISO 18437-6, *Mechanical vibration and shock — Characterization of the dynamic mechanical properties of visco-elastic materials — Part 6: Time-temperature superposition*

CEN/TS 19100-2:2021, *Design of glass structures - Part 2: Design of out-of-plane loaded glass components*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 6721-1:2019 and ISO 18437-6 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp/

— IEC Electropedia: available at https://www.electropedia.org/

3.1
glass transition temperature
T_g
interval of temperature in which a material changes from a rubbery state to a solid state or vice versa

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

3.3
vitreous polymer
polymer presenting a glass transition temperature Tg in the range of building applications

3.4
relaxation modulus
G_{int}
ratio of the time-dependent stress to an imposed constant strain

3.5
complex modulus
ratio of dynamic stress and dynamic strain of a viscoelastic material that is subjected to a sinusoidal vibration

3.6
storage modulus
real part of the complex modulus

3.7
loss modulus
imaginary part of the complex modulus

3.8
phase angle
phase difference between the dynamic stress and the dynamic strain in a viscoelastic material subjected to a sinusoidal oscillation (δ)

Note 1 to entry: See Figure 2.

Note 2 to entry: The phase angle is expressed in radians (rad).

Note 3 to entry: In a dynamic experiment, it is the angle between the complex modulus G^* and the projection of its elastic part, the storage modulus part G'.

3.9
loss factor
tangent of the phase angle, also expressed as the ratio of the dynamic loss modulus G'' over the dynamic storage modulus G'

Note 1 to entry: See Figure 1.

Note 2 to entry: The loss factor is expressed as a dimensionless number.

3.10
shift factor
value (positive or negative) of the horizontal displacement of each DMA curve along the frequency axis to form the master curve

3.11
master curve
curve obtained by shifting isothermal DMA curves measured at different frequencies and a selected reference temperature

3.12
Time-Temperature-Superposition
principle which enables prediction of material behaviour outside the testable range

3.13
Prony series
formula that allows calculation of the shear modulus based on Prony parameters

3.14
Prony parameters
parameters to evaluate the shear relaxation modulus from the Prony series, including the normalized moduli g_i, relaxation times τ_i and the initial shear modulus G_0

4 Symbols and abbreviations

$a(T)$	Temperature dependent, horizontal shift factor in the time-temperature superposition principle
b	Width of the test specimen
b_{ave}	Average width of the plate
l_{cor}	Corrected distance between supporting rollers in case of bent glass plate
l_{red}	Reduction of the span per each supporting roller
C_1, C_2	Empirical constants of the WLF-TTS visco-elastic formula
d	Distance of the mid-plane of the glass plies from the mid-plane of the laminated glass composed of two plies of the same thickness
d_1	Distance of the mid-plane of the glass ply 1 from the mid-plane of the laminated glass
d_2	Distance of the mid-plane of the glass ply 2 from the mid-plane of the laminated glass
d_3	Distance of the mid-plane of the glass ply 3 from the mid-plane of the laminated glass
D_{abs}	Flexural stiffness at “no shear” condition
D_{full}	Flexural limit at “full shear” condition
D_i	Flexural stiffness of the glass ply *i*
DMTA	Dynamic Mechanical Thermal Analysis (-TS: temperature sweep, -AS: amplitude sweep, -TFS: temperature-frequency sweep)

DSC	Differential Scanning Calorimetry
e_{dl}	Deflection under self weight
e_f	Deflection under applied load
EET	Enhanced Effective Thickness method
E	Young's modulus of glass
E_a	Activation energy
E_{int}	Young's modulus of the interlayer material
f	Frequency
F	Four point bend test load
g_i	Normalized shear moduli
G^*, $\|G^*\|$	Shear complex modulus
G'	Shear storage modulus
G''	Shear loss modulus
G_0	Initial shear modulus (at a time 0)
G_∞	Equilibrium modulus (at infinite time)
G_{int}	Shear relaxation modulus of the interlayer material
h	Thickness of glass pane of laminated glass composed of n plies of the same thickness
h_1	Nominal thickness of pane 1 of an insulating glass unit or ply 1 of a laminated glass
h_2	Nominal thickness of pane 2 of an insulating glass unit or ply 2 of a laminated glass
h_3	Nominal thickness of pane 3 of an insulating glass unit or ply 3 of a laminated glass
$h_{ef,\sigma}$	Effective thickness of laminated glass for calculation of stress
$h_{ef,w}$	Effective thickness of laminated glass for calculation of deflection
$h_{ef,wt}$	Effective thickness of laminated glass deflecting under load
h_i	Nominal thickness of pane i of an insulating glass unit or ply *i* of a laminated glass
h_{int}, $h_{int,1}$, $h_{int,2}$	Thickness of the interlayer
l_b	Distance between centre lines of bending rollers
l	Distance between centre lines of supporting rollers
l_{cor}	Corrected distance between supporting rollers in case of bent glass plate
l_{red}	Reduction of the span per each supporting roller
n	Number of plies (only in Annex A) and number of spring-damper elements (only in Annex C)
p	Self weight of the plate

$P_{r,j}$	is the polynomial coefficient of the shear storage modulus of degree *j*, with *j* ranging from 0 to 7;
$P_{i,j}$	is the polynomial coefficient of the shear loss modulus of degree *j*, with *j* ranging from 0 to 7;
r	Radius of the curved glass deflected under self weight
r_r	Radius of the roller
R	Universal glass constant
t	Load duration
t_r	Time needed to apply load
T	Temperature in °C
T_c	Crystallization temperature
T_g	Glass transition temperature
T_k	Temperature in Kelvin
T_m	Melting temperature
T_r	Reference temperature
$T_{k,r}$	Reference temperature in Kelvin
TTS	Time-temperature-superposition
ν_{int}	Poisson's number of the interlayer material
ν	Poisson's number of glass material
WLF-TTS	Williams-Landel-Ferry TTS
x	Axis *x* illustrating the horizontal position of the test specimen
x_{F1}	Distance between the first supporting roller and the first bending roller
x_{F2}	Distance between the first supporting roller and the second bending roller
y	Axis *y* illustrating vertical displacement
$y_{c,g}$	Deflection under self weight
y'_{dl}	Angular deformation under self weight
y'_p	Angular deformation under two punctual loads
y'_r	Formula of the curvature of the support roller
y'_t	Total angular deformation under self weight and punctual loads
y_{tot}	Total deflection under self weight and applied load
$y_{tot,m}$	Total measured deflection under self weight and applied load
β	Scaling factor
δ	Phase angle
η	Coupling coefficient used in Annex A (EET)
η	Coefficient of viscosity used in Annex C (Maxwell model)