SLOVENSKI STANDARD
SIST EN 673:1999

01-november-1999

Steklo v stavbah ï Doloļevanje toplotne prehodnosti (vrednost U) ï Raļunska metoda

Glass in building - Determination of thermal transmittance (U value) - Calculation method

Glas im Bauwesen - Bestimmung des Wärmedurchgangskoeffizienten (U-Wert) - Berechnungsverfahren

Verre dans la construction - Détermination du coefficient de transmission thermique, U - Méthode de calcul

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ICS:

81.040.20	Steklo v gradbeništvu	Glass in building

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EUROPEAN STANDARD

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English version

Glass in building - Determination of thermal transmittance (*U* value) - Calculation method

Verre dans la construction - Détermination du coefficient de transmission thermique, U - Méthode de calcul

Glas im Bauwesen - Bestimmung des Wärmedurchgangskoeffizienten (U-Wert) - Berechnungsverfahren

This European Standard was approved by CEN on 8 October 1997.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

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Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 129 "Glass in building", the secretariat of which is held by IBN.

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of an identical text or by endorsement, at the latest by May 1998, and conflicting national standards shall be withdrawn at the latest by May 1998.

CEN/TC 129/WG9 "Light and energy transmission, thermal insulation" prepared a working draft based on the document ISO/DIS 10292, "Thermal insulation of glazing: Calculation rules for determining the steady state *U* value of double or multiple glazing", document that was prepared by ISO/TC 160, "Glass in building".

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies a calculation method to determine the thermal transmittance of glazing with flat and parallel surfaces.
This European Standard applies to uncoated glass (including glass with structured surfaces, e.g. patterned glass), coated glass and materials not transparent in the far infrared which is the case for soda lime silicate glass products (called hereafter soda lime glass), borosilicate glass and glass ceramic. It applies also to multiple glazing comprising such glasses and/or materials. It does not apply to multiple glazing which include in the gas space sheets or foils that are far infrared transparent. The procedure specified in this European Standard determines the *U* value[1)] (thermal transmittance) in the central area of glazing.
The edge effects due to the thermal bridge through the spacer of a sealed glazing unit or through the window frame are not included. Furthermore energy transfer due to solar radiation is not taken into account.
The document for the calculation of the overall *U* value of windows, doors and shutters (see C.1) gives normative reference to the *U* value calculated for the glazing components according to this standard.
For the purpose of product comparison, a vertical position of the glazing is specified.
In addition *U* values are calculated using the same procedure for other purposes, in particular for predicting:

- heat loss through glazing;
- conduction heat gains in summer;
- condensation on glazing surfaces;
- the effect of the absorbed solar radiation in determining the solar factor (see C.2).

Reference should be made to C.4 and C.5 or other European Standards dealing with heat loss calculations for the application of glazing *U* values determined by this standard.

A procedure for the determination of emissivity is also given.

The rules have been made as simple as possible consistent with accuracy.

2 Normative references

This European Standard 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 674	Glass in building - Determination of thermal transmittance (*U* value) - Guarded hot plate method
EN 675	Glass in building - Determination of thermal transmittance (*U* value) - Heat flow meter method
prEN 1098	Glass in building - Determination of thermal transmittance (*U* value) - Calibrated and guarded hot box method

1) In some countries the symbol *k* has been used hitherto.

3 Symbols

A	constant	-
c	specific heat capacity of gas	J/(kg · K)
d	thickness of material layer (glass or alternative glazing material)	m
F	volume fraction	-
h	- heat transfer coefficient	W/(m² · K)
	- also thermal conductance	W/(m² · K)
M	number of material layers	-
n	exponent	-
N	number of spaces	-
r	thermal resistivity of glass (glazing material)	m · K/W
P	gas property	-
R_n	normal reflectance (perpendicular to the surface)	-
s	width of gas space	m
T	absolute temperature	K
U	thermal transmittance	W/(m² · K)
ΔT	temperature difference	K
ε	corrected emissivity	-
ε_n	normal emissivity (perpendicular to the surface)	-
ρ	gas density	kg/m³
σ	Stefan-Boltzmann's constant 5,67 x 10^{-8}	W/(m² · K⁴)
μ	dynamic viscosity of gas	kg/(m · s)
λ	- thermal conductivity of gas in space	W/(m · K)
	- also wavelength	μ m
ϑ	temperature on the Celsius scale	°C

Dimensionless Numbers

Gr	Grashof number	-
Nu	Nusselt number	-
Pr	Prandtl number	-

Subscripts

c	convection
e	external
i	internal
j	j-th material layer
g	gas
m	mean
n	normal
r	radiation
s	space
t	total
1;2	first, second etc.

4 Definitions

For the purposes of this standard, the following definitions apply:

4.1 *U* value: Parameter of glazing which characterizes the heat transfer through the central part of the glazing, i.e. without edge effects, and states the steady-state density of heat transfer rate per temperature difference between the environmental temperatures on each side. The *U* value is given in watts per square metre kelvin [W/(m^2 · K)].

4.2 declared value: *U* value obtained under standardized boundary conditions (see clause 8).

5 Basic formulae

The method of this standard is based on a calculation according to the following principles.

5.1 *U* value

The *U* value is given by:

$$\frac{1}{U} = \frac{1}{h_e} + \frac{1}{h_t} + \frac{1}{h_i} \qquad (1)$$

where:

h_e and h_i are the external and internal heat transfer coefficients;
h_t is the total thermal conductance of the glazing.

$$\frac{1}{h_t} = \sum_1^N \frac{1}{h_s} + \sum_1^M d_j r_j \qquad (2)$$

where:

h_s is the thermal conductance of each gas space;
N is the number of spaces;
d_j is the thickness of each material layer;
r_j is the thermal resistivity of each material (thermal resistivity of soda lime glass = 1,0 m · K/W);
M is the number of material layers.

$$h_s = h_r + h_g \qquad (3)$$

where:

h_r is the radiation conductance;
h_g is the gas conductance.

For glazing with more than one gas space the *U* value shall be found by iteration (see annex B).

5.2 Radiation conductance h_r

The radiation conductance is given by:

$$h_r = 4\sigma\left(\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1\right)^{-1} T_m^3 \qquad (4)$$

where:

σ is the Stefan-Boltzmann's constant;
T_m is the mean absolute temperature of the gas space;
ε_1 and ε_2 are the corrected emissivities at T_m.

5.3 Gas conductance h_g

The gas conductance is given by:

$$h_g = Nu\frac{\lambda}{s} \qquad (5)$$

where:

s is the width of the space;
λ is the thermal conductivity;
Nu is the Nusselt number.

$$Nu = A\,(Gr\ Pr)^n \qquad (6)$$

where:

A is a constant
Gr is the Grashof number
Pr is the Prandtl number
n is an exponent

$$Gr = \frac{9{,}81\ s^3 \Delta T \cdot \rho^2}{T_m \mu^2} \qquad (7)$$

$$Pr = \frac{\mu c}{\lambda} \qquad (8)$$

where:

ΔT is the temperature difference between glass surfaces bounding the gas space;

ρ is the density;

μ is the dynamic viscosity;

c is the specific heat capacity;

T_m is the mean temperature.

The Nusselt number is calculated from equation (6).
If *Nu* is less than 1, then the value unity is used for *Nu* in equation (5).

5.3.1 Vertical glazing

For vertical glazing:

A is 0,035
n is 0,38

5.3.2 Horizontal and angled glazing

For horizontal or angled glazing and upward heat flow the heat transfer by convection is enhanced.

This effect shall be considered by substituting the following values of *A* and *n* in equation (6).

Horizontal spaces	$A = 0,16$	$n = 0,28$
Space at 45°	$A = 0,10$	$n = 0,31$

For intermediate angles linear interpolation is satisfactory.

When the direction of heat flow is downward the convection shall be considered suppressed for practical cases and $Nu = 1$ is substituted in equation (5).

6 Basic material properties

6.1 Emissivity

The corrected emissivities ε of the surfaces bounding the enclosed spaces are required to calculate the radiation conductance h_r in equation (4).

For uncoated soda lime glass surfaces or for soda lime glass surfaces with coatings which have no effect on the emissivity, the corrected emissivity to be used is 0,837.

NOTE 1: With reasonable confidence the same value may be used for uncoated borosilicate glass and glass ceramic.

For other coated surfaces the normal emissivity ε_n shall be determined with an infrared spectrometer (see A.1 and C.6) and the corrected emissivity is determined from the normal emissivity as described in A.2.

NOTE 2: Two different definitions of emissivity should be theoretically used to describe radiation exchange between:

a) glass surfaces facing each other in glazing;
b) a glass surface facing a room.

However, in practice numerical differences are found to be negligibly small. Thus corrected emissivity describes both types of heat exchange with a sufficient approximation.

6.2 Gas properties

The properties of the gas filling the space are required.

These are: thermal conductivity λ
density ρ
dynamic viscosity μ
specific heat capacity c

The relevant values are substituted in equations (7) and (8) above for the Grashof and Prandtl numbers and the Nusselt number is determined from equation (6) above.

If the Nusselt number is greater than 1 this indicates that convection is occurring, enhancing the heat flow rate.

If the calculated value of the Nusselt number is less than 1 this indicates that heat flow in the gas is by conduction only and the Nusselt number is given the bounding value of 1. Substitution in equation (5) gives the gas conductance h_g.

Values of gas properties for a range of gases used in sealed glazing units are given in table 1.

For all practical gas mixtures the gas properties are proportioned in the ratio of the volume fractions, F_1, F_2..., with sufficient approximation:

Gas 1: F_1; Gas 2: F_2 etc.

Thus $P = P_1 F_1 + P_2 F_2$ (9)

where P represents the relevant property: thermal conductivity, density, viscosity or specific heat capacity.