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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Flat Glass Manufacturers Association of Japan (FGMAJ)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS R 3107:1998** is replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with patent rights, applications for a patent after opening to the public or utility model rights. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying any of such patent rights, applications for a patent after opening to the public or utility model rights.

Calculation of thermal transmittance of glazing

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 10292:1994**, Edition 1, with some modifications of the technical contents.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JD. The comparison table between previous and current editions of this Standard on technically significant revisions is given in Annex JE.

1 Scope

This Standard specifies the calculation of thermal transmittance through the central part of glazing¹⁾ used for building apertures (U value). The combined edge effects due to the thermal bridge of insulating glass spacer and of vacuum glass edge seal, and of the window frame are not included²⁾.

These calculations are intended to enable the heat loss through a window glass of building estimated from the thermal transmittance through the central part of glazing, together with heat losses through the opaque elements of the building, and used to determine the capacity of the heating or cooling plant.

In addition, U values for other purposes can be calculated using the same procedure, in particular for predicting:

- a) heat gains in summer by conduction;
- b) condensation on glass surfaces;
- c) seasonal heat loss through window glasses in determining overall energy use in buildings;
- d) contribution of the amount of absorbed solar radiation in determining total solar energy transmittance.

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

NOTE The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 10292:1994 *Glass in building—Calculation of steady-state U values (thermal transmittance) of multiple glazing (MOD)*

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standards and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

Note ¹⁾ Glazing is as follows.

- a) Glazing mainly manufactured from soda lime silicate glass by continuous moulding process. Glass having diffuse transmissivity, such as figured glazing, is included.

- b) Glazing in **a)** of which the surface is processed with optical coating of wavelength-selective reflection such as a heat reflecting glass in wavelength region of solar radiation, and a reflecting glass (Low-E glass) in wavelength region of thermal radiation at ambient temperature such as a low radiation glass.
- c) Laminated glass, tempered glass, heat-strengthened glass, tempered fire resistance glass, etc. intended for fragment retention, strength enhancement, etc., on which the process of **a)** or **b)** is given.
- d) Insulating glass and vacuum glass using the flat glass of **a)** to **c)**, except those containing lattice, etc. in a gas space.

Note ²⁾ When calculating the thermal transmittance of whole window, the edge effects due to the thermal bridge of insulating glass spacer and of vacuum glass edge seal, and of the window frame should be considered (see **JIS A 2102-1** ^[1]).

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this Standard. The most recent edition of the standard (including amendments) indicated below shall be applied.

JIS R 3106 *Testing method for transmittance, reflectance and emissivity of flat glass and calculation of total solar energy transmittance of glazing*

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply.

3.1

thermal transmittance, *U* value

thermal current flux at a window of building apertures per 1 K in the difference between the external temperature and the internal temperature through the central part of one sheet of flat glass, or of insulating glass or vacuum glass without edge effects, which is given in $W/(m^2 \cdot K)$

3.2

thermal conductance

thermal current flux per 1 K in temperature difference between both surfaces of glazing, or two faces across the gas space of insulating glass or across the vacuum layer of vacuum glass

3.3

thermal resistance

reciprocal of thermal conductance

Temperature difference per $1 W/m^2$ of thermal current flux generated between both surfaces of glazing, or two faces across the gas space of insulating glass or across the vacuum layer of vacuum glass.

3.4

surface heat transfer coefficient

thermal current flux per 1 K in temperature difference between the surface temperature of external side of glazing and the external temperature, or between the surface temperature of internal side of glazing and the internal temperature

NOTE In the theoretical model under this definition, the temperature of surrounding objects, sky, etc. in which the radiant heat is exchanged with the glass surface is regarded to be equal to the air temperature.

3.5

corrected emissivity

emissivity of flat glass surface in the radiant heat exchange between two faces across the gas space of insulating glass or across the vacuum layer of vacuum glass, or that between the external/internal surface of glazing of building apertures and the surrounding objects, sky, etc.

NOTE On the surface of glazing or glazing processed with optical coating, the value of emissivity changes according to the emitting angles. In general, the value of hemispherical emissivity is used in the calculation of radiant heat exchange with surrounding objects, but the value of effective emissivity is used in the radiant heat exchange between two faces across the gas space of insulating glass. In this Standard, the value converted by multiplying the measured value of normal emissivity by the corrective coefficient is called the corrected emissivity, and used for the both.

4 Symbols and subscripts

4.1 Symbols

Symbols and units for quantity used in this Standard shall be in accordance with Table 1.

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Table 1 Symbols and units

Symbol	Quantity	Unit
A	numerical value determined according to inclination angle and thermal current direction of gas space	—
c	specific heat at constant pressure of gas in gas space	$\text{J}/(\text{kg} \cdot \text{K})$
d	thickness of flat glass or middle film of laminated glass	m
Gr	Grashof number	—
h	thermal conductance or surface heat transfer coefficient	$\text{W}/(\text{m}^2 \cdot \text{K})$
N	number of gas spaces	—
Nu	Nusselt number	—
Pr	Prandtl number	—
s	thickness of gas space	m
T	absolute temperature	K
ΔT	temperature difference	K
U	thermal transmittance	$\text{W}/(\text{m}^2 \cdot \text{K})$
ε	emissivity	—
θ	temperature	$^{\circ}\text{C}$
λ	thermal conductivity	$\text{W}/(\text{m} \cdot \text{K})$
μ	viscosity of gas in gas space	$\text{N} \cdot \text{s}/\text{m}^2 = \text{kg}/(\text{m} \cdot \text{s})$
ρ	density of gas in gas space	kg/m^3
σ	Stefan-Boltzmann constant ($= 5.67 \times 10^{-8}$)	$\text{W}/(\text{m}^2 \cdot \text{K}^4)$
C	convective effect coefficient	—
K	number of sheets of constituting flat glass and middle films of laminated glass	—
n	numerical value determined according to inclination angle and thermal current direction of gas space	—
F	volumetric fraction of each gas in gas space	—
r	radius	m
l	interval	m
α	accommodation coefficient of surfaces of two sheets of glass	—
γ	ratio of specific heat	—
c_p	specific heat at constant pressure of gas	$\text{J}/(\text{kg} \cdot \text{K})$
c_v	specific heat at constant volume of gas	$\text{J}/(\text{kg} \cdot \text{K})$
R	gas constant ($= 8.313$)	$\text{J}/(\text{mol} \cdot \text{K})$
P	absolute pressure of gas	Pa
M	molar weight of gas	kg/mol
q	thermal current flux	W/m^2
J	radiant heat flux	W/m^2

4.2 Subscripts

Subscripts shall be in accordance with Table 2.

Table 2 Subscripts

Symbol	Meaning
g	gas in gas space
ext	external side
int	internal side
m	mean
n	normal
r	radiation
s	gas space
t	total
1, 2, ...	first, second, ...
k	No. of sheets of constituting flat glass or middle films of laminated glass
c	corrected
v	vacuum layer (except C_v)
p	pillar array (except C_p)
a	gas in vacuum layer
f	resin film

5 Basic formulae

5.1 General

The thermal transmittance U at the central part of glazing is obtained according to Formula (1).

$$\frac{1}{U} = \frac{1}{h_{\text{ext}}} + \frac{1}{h_t} + \frac{1}{h_{\text{int}}} \quad \text{..... (1)}$$

where, h_{ext} : surface heat transfer coefficient of external side
[W/(m²·K)]

h_{int} : surface heat transfer coefficient of internal side
[W/(m²·K)]

h_t : thermal conductance of glazing [W/(m²·K)]

The thermal conductance h_t of glazing is obtained according to Formula (2). The first term in the right side is a heat resistance of gas space, and it is taken as zero in the case of one sheet of flat glass. The second term is the thermal conductivity resistance of flat glass and middle film of laminated glass.

$$\frac{1}{h_t} = \sum_{s=1}^N \frac{1}{h_s} + \sum_{k=1}^K \frac{d_k}{\lambda_k} \quad \text{..... (2)}$$

where, h_s : thermal conductance of gas space [W/(m²·K)]

N : number of gas spaces (–)

K : number of sheets of constituting flat glass (–)

In laminated glass, the number of sheets of constituting flat glass and middle films shall be included.

d_k : thickness of constituting flat glass or thickness of middle film of laminated glass (m)

λ_k : thermal conductivity of constituting flat glass or thermal conductivity of middle film of laminated glass [W/(m·K)]

The thermal conductance of gas space h_s is obtained according to Formula (3).

$$h_s = h_r + h_g \quad \text{..... (3)}$$

where, h_r : radiation thermal conductance [W/(m²·K)]

h_g : thermal conductance by conduction and convection of gas (gas thermal conductance) [W/(m²·K)]

The thermal conductance of vacuum layer h_v is obtained in accordance with Annex JA in the case where the gas space is a vacuum layer. The thermal conductance h_s is obtained in accordance with Annex JB in the case where the gas space includes a resin film. If the gas space is a vacuum layer, $h_s = h_v$ shall apply.

5.2 Radiation thermal conductance

The radiation thermal conductance h_r of gas space is obtained according to Formula (4).

$$h_r = 4 \cdot \sigma \cdot \left(\frac{1}{\varepsilon_{c,1}} + \frac{1}{\varepsilon_{c,2}} - 1 \right)^{-1} \cdot T_m^3 \quad \text{..... (4)}$$

where, σ : Stefan-Boltzmann constant = 5.67×10^{-8} [W/(m²·K⁴)]

$\varepsilon_{c,1}, \varepsilon_{c,2}$: corrected emissivity of two glass surfaces across gas space (–) (see 6.1)

T_m : mean of absolute temperatures of two glass surfaces across gas space (K)

When the temperature of glazing is obtained in accordance with 9.4 of JIS R 3106, the mean temperature of two sheets of flat glass is taken as the mean of absolute temperatures of two glass surfaces across the gas space T_m .

NOTE If the gas in gas space has an absorption band in the wavelength region between 5 μm and 50 μm of thermal radiation at ambient temperature, the value h_r becomes smaller than that obtained according to Formula (4). However, the absorbance of the gas in gas space of ordinary insulating glass is usually small; therefore, Formula (4) shall be used also in such a case.

5.3 Gas thermal conductance

The gas thermal conductance of gas space, h_g , is obtained according to Formula (5).

$$h_g = C \cdot \frac{\lambda}{s} \quad \text{..... (5)}$$

where, s : thickness of gas space (m)

λ : thermal conductivity of gas in gas space [W/(m·K)]

C : convective effect coefficient (–)