
**Glass in building — Vacuum
insulating glass —**

**Part 1:
Basic specification of products and
evaluation methods for thermal and
sound insulating performance**

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Verre dans la construction — Vitrage isolant à lame de vide —

*Partie 1: Spécification de base des produits et méthodes d'évaluation
des performances d'isolation thermique et acoustique*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document consists of basic information about the product specification and evaluation methods for thermal and sound insulating performance of vacuum insulating glass. Test methods of vacuum insulating glass for the evaluation of performance under temperature differences are to be the subject of ISO 19916-3¹⁾.

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Glass in building — Vacuum insulating glass —

Part 1:

Basic specification of products and evaluation methods for thermal and sound insulating performance

1 Scope

This document specifies product specification for vacuum insulating glass. It also specifies evaluation methods for thermal and sound insulating performance and evaluation methods for thermal insulation durability.

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.

ISO 717-1, *Acoustics — Rating of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation*

ISO 8301, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Heat flow meter apparatus*

ISO 8302, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Guarded hot plate apparatus*

ISO 9050:2003, *Glass in building — Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors*

ISO 10140-2:2010, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 2: Measurement of airborne sound insulation*

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

ISO 12543-4:2011, *Glass in building — Laminated glass and laminated safety glass — Part 4: Test methods for durability*

ISO 20492-1:2008, *Glass in buildings — Insulating glass — Part 1: Durability of edge seals by climate tests*

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:

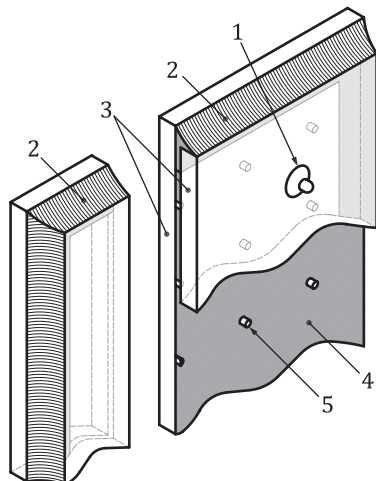
- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 vacuum insulating glass

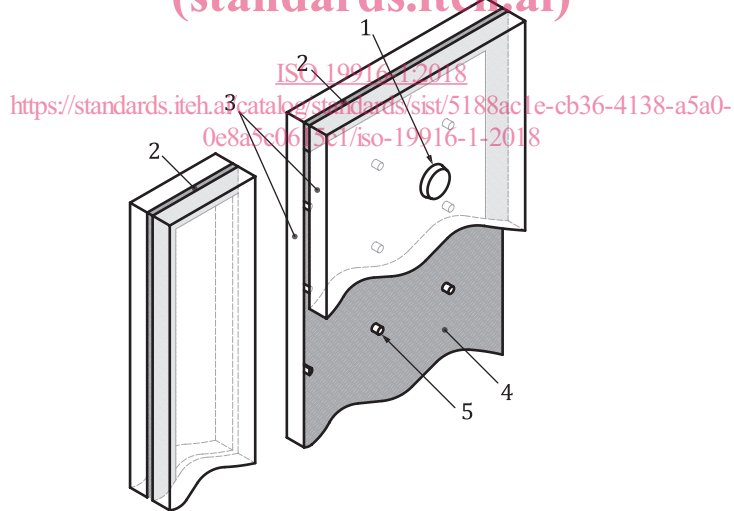
assembly consisting of at least two panes of glass, separated by an array of pillars, hermetically and durably sealed along the periphery, whereby the gaps between the glass panes are under vacuum

Note 1 to entry: The absolute pressure inside the vacuum insulating glass should be 1 Pa or lower.

Note 2 to entry: Examples of vacuum insulating glass are given in [Figure 1](#) a) and b). The difference between the two examples lies in the structure of edge seal and evacuation port.



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a) Example 1
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b) Example 2

Key

- 1 evacuation port
- 2 periphery sealing
- 3 glass pane
- 4 low-E coating
- 5 pillar

Figure 1 — Examples of vacuum insulating glass

3.2 pillar

small spacer aligned across the whole area of glass sheet such that it maintains a gap between two glass sheets

3.3 edge seal

hermetic sealing at the periphery of two glass sheets to maintain vacuum between them

Note 1 to entry: The terms “weld” and “welding” can be used instead of “seal” and “sealing” respectively, dependent upon the processing method.

3.4 evacuation port

structure through which the gas between the glass sheets is evacuated during the production process

Note 1 to entry: This is typically a small glass tube that is sealed following evacuation of air from the gap between the glass sheets.

Note 2 to entry: The evacuation port may be located on the glass sheet or at the glass edge.

3.5 getter

material which has the ability to absorb outgas in the gap between the glass sheets

3.6 displacement

misalignment at any one edge of the constituent glass panes making up the vacuum insulating glass

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4 Description of components ISO 19916-1:2018

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4.1 Glass types and characteristics

The dimensions of each pane of glass can be the same or can be different.

The type of glass used for vacuum insulating glass may be:

- float glass, in accordance with ISO 16293-2;
- polished wired glass, in accordance with ISO 16293-3;
- thermally tempered glass, in accordance with ISO 12540;
- heat strengthened glass;
- heat soaked tempered glass, in accordance with ISO 20657;
- chemically strengthened glass;
- laminated glass, in accordance with ISO 12543-3;
- laminated safety glass, in accordance with ISO 12543-2;
- patterned glass, in accordance with ISO 16293-5;
- coated glass, in accordance with ISO 11479-1.

The glass may also be:

- clear or tinted;
- transparent, translucent or opaque;

— surface treated by sandblasting or acid etching.

4.2 Pillars

Pillars may be manufactured from glass, solder glass, ceramics, metal or plastics.

4.3 Edge seal

Edge seal shall consist of an appropriate hermetic sealing material (including glass sheet fusion bonding structure).

Edge seal material may be manufactured from glass, solder glass, ceramics, metal or plastics.

4.4 Evacuation port

A hermetically-sealed evacuation port may be utilized.

Hermetically-sealed evacuation port material may be manufactured from glass, solder glass, ceramics, metal or plastics.

4.5 Getter

A getter material may be present in the vacuum layer.

Getter material may be selected depending on manufacturing process of vacuum insulating glass and characteristics of outgassing absorption required.

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5 Optical and thermal properties

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5.1 Optical properties

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Optical properties of vacuum insulating glass shall be evaluated according to ISO 9050. The properties are as follows:

- the spectral transmittance, the spectral external reflectance and the spectral internal reflectance;
- the light transmittance, the external light reflectance and the internal light reflectance;
- the solar direct transmittance and the solar direct reflectance;
- the UV-transmittance, the CIE damage factor and the skin damage factor;
- the general colour rendering index.

NOTE It is assumed that the effect of the pillars on these optical properties is negligible, because the effect does not appear in the rounded values of these properties when the ratio of pillar area to the pillar array interval area is less than 1 %.

5.2 U-value (thermal transmittance)

5.2.1 Determination of the U-value

An outline of the determination procedure is shown in [Figure 2](#).

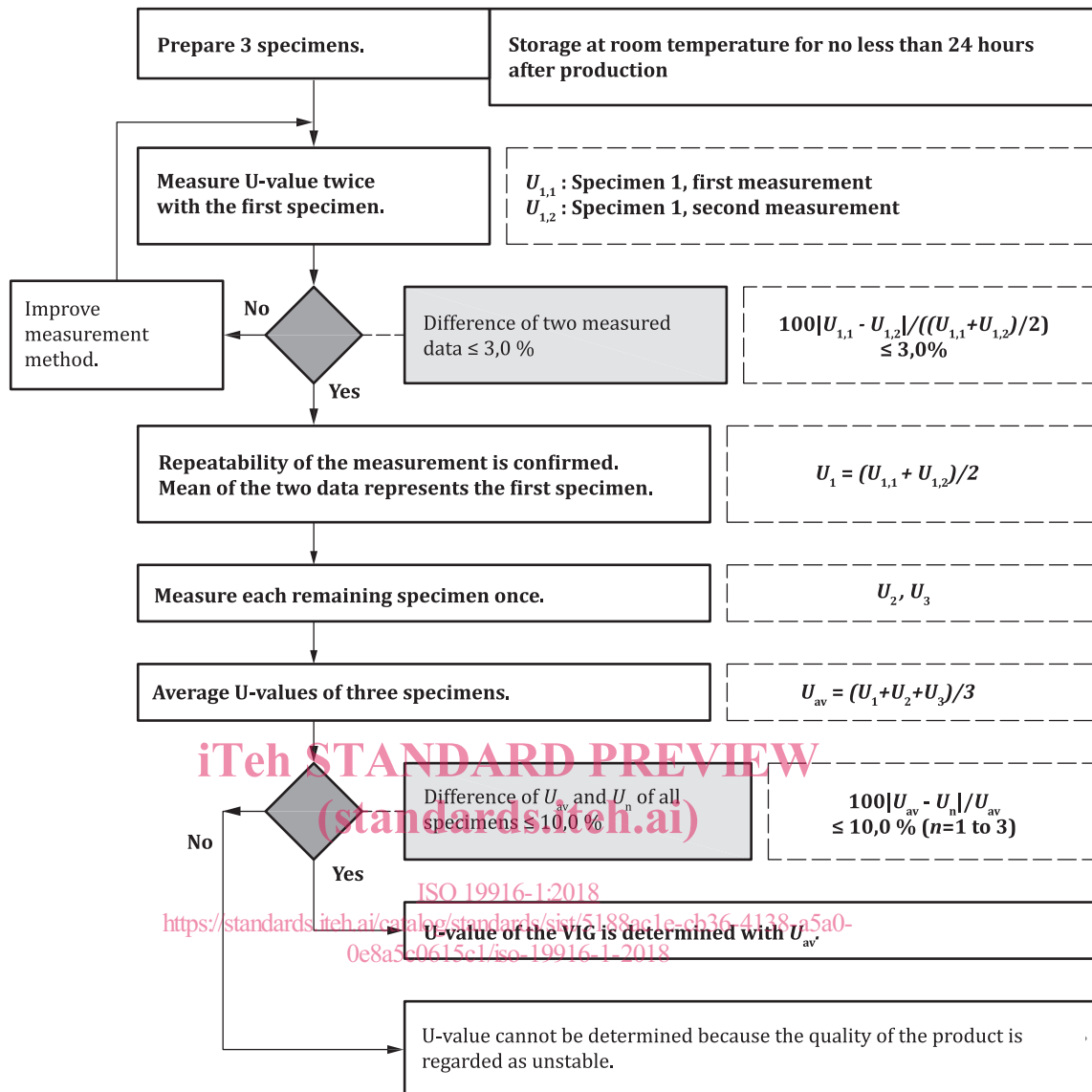


Figure 2 — Flowchart of the measurement procedure

The determination of the U-value of three vacuum insulating glass specimens shall be carried out in accordance with [Annex A](#).

The test specimen dimensions shall meet the requirements of [A.4](#).

The measurements shall be conducted after storage of specimens at room temperature for no less than 24 h after production.

Measurement A described in [A.5](#) of [Annex A](#) shall be conducted twice with the first test specimen in a group having the same specification. The percentage difference of the two results shall be no more than 3,0 % as in [Formula \(1\)](#).

$$100|U_{1,1} - U_{1,2}| / ((U_{1,1} + U_{1,2}) / 2) \leq 3,0\% \quad (1)$$

where

$U_{1,1}$ is the first measured U-value of the first test specimen;

$U_{1,2}$ is the second measured U-value of the first test specimen.

If the percentage difference in the two results of U-value with the first specimen is more than 3,0 %, the measurement method and condition should be improved. After the improvements, the measurement should be repeated.

The U-value of the first test specimen shall be determined as mean value of the two results.

The U-value of the remaining specimens in the group having the same specification shall be measured once respectively.

The average of the measured U-value on three specimens, U_{av} , shall be calculated using [Formula \(2\)](#).

$$U_{av} = (U_1 + U_2 + U_3)/3 \quad (2)$$

where

U_{av} is the average of U-value of all specimens [$W/(m^2 \cdot K)$];

U_n is the measured U-value of the specimen ($n = 1$ to 3) [$W/(m^2 \cdot K)$].

U_{av} shall be stated to two decimal places. If U_n is measured to more than 3 decimal places, then the value shall be truncated to 3 decimal places.

The percentage deviation between U_{av} and U-value of each specimen shall be calculated using [Formula \(3\)](#).

$$U_{dev,n} = 100 (| U_{av} - U_n | / U_{av}) \quad (3)$$

If $U_{dev,n}$ ($n = 1$ to 3) does not exceed 10,0 % for all specimens, the U-value of the vacuum insulating glass can be determined as U_{av} , which shall be stated to two decimal places.

If $U_{dev,n}$ ($n = 1$ to 3) exceeds 10,0 % for one or more specimens, the U-value of the vacuum insulating glass cannot be determined, because the quality of the relevant set of test specimens is regarded as unstable.

NOTE It is possible to determine the U-value of vacuum insulating glass by calculation only. This method is provided in [Annex C](#) for information.

5.2.2 Test report

The test report shall contain the following elements:

- a) identification of the specimens:
 - specimen description (e.g. manufacturer's name, product name or other reference, etc.),
 - length (mm),
 - width (mm),
 - nominal thickness (mm);
- b) for each buffer plate:
 - material,
 - nominal thickness (mm);
- c) measurement and calculation results:
 - mean surface temperature of the heating and cooling plates ($^{\circ}C$),
 - thermal resistance of the two buffer plates [$(m^2 \cdot K)/W$],

- internal heat transfer coefficient, h_i , and external heat transfer coefficient, h_e [$W/(m^2 \cdot K)$], if non-standardized values have been used,
 - thermal resistance of the vacuum insulating glass [$(m^2 \cdot K)/W$], rounded to two decimal places,
 - U-value of the vacuum insulating glass [$W/(m^2 \cdot K)$], rounded to two decimal places;
- d) any deviations from this document which can have affected the result;
- e) description of the test equipment, including:
- manufacturer's name and model, if using a commercially-available equipment,
 - dimensions of metering area (mm),
 - dimensions of hot and cold plates (mm).

5.2.3 Calculation method for U-value of vacuum insulating glass with different glass thickness

There may be cases where only the nominal thickness of one or more panes of glass in the vacuum insulating glass are different from that for which the U-value was previously determined. In such cases, the U-value should be calculated following the procedure below, using the measured thermal resistance in accordance with [Annex A](#).

The thermal resistance of the vacuum insulating glass comprising glass of different thickness, R' , can be calculated using [Formula \(4\)](#).

$$R' = R + r_g \times (\Sigma d_2 - \Sigma d_1) \quad (4)$$

where

- R' is the thermal resistance of the vacuum insulating glass with glass of different thickness [$(m^2 \cdot K)/W$];
- R is the measured thermal resistance of the vacuum insulating glass [$(m^2 \cdot K)/W$];
- r_g is the thermal resistivity of glass ($m \cdot K/W$): $r_g = 1$ ($m \cdot K/W$);
- Σd_2 is the total nominal thickness of glass sheets in the vacuum insulating glass with glass of different nominal thickness (m);
- Σd_1 is the total nominal thickness of glass sheets in the vacuum insulating glass measured (m).

The U-value of the vacuum insulating glass with glass of different thickness, U' , can be calculated using [Formula \(5\)](#).

$$1/U' = R' + 1/h_e + 1/h_i \quad (5)$$

where

- U' is the U-value of the vacuum insulating glass with different thickness of panes of glass [$W/(m^2 \cdot K)$]
- h_e and h_i are as defined in [Annex A](#).

NOTE [Formula \(4\)](#) is derived from [Formula \(6\)](#) and [Formula \(7\)](#) as follows.

The thermal resistance of the vacuum layer, R_v , can be calculated using [Formula \(6\)](#).

$$R_v = R - r_g \times \Sigma d_1 \quad (6)$$