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## Thermal Performance of windows and doors — Determination of solar heat gain coefficient using solar simulator —

### Part 2: Centre of glazing

ICS: 91.060.50; 91.120.10

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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](http://www.iso.org/directives)).

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A list of all parts in the ISO 19467 series can be found on the ISO website.

## Introduction

This document is designed to provide solar heat gain coefficient values of the centre of glazing in fenestration systems by standardized measurement method. The terms solar heat gain coefficient (SHGC), total solar energy transmittance (TSET), solar factor and  $g$ -value are all used to describe the same quantity. Small differences might be caused by different reference conditions (e.g. differences in the reference solar spectrum). In this document, solar heat gain coefficient is used.

The solar heat gain coefficient of a complex fenestration system may depend on the direction of the incident radiation. It also might be influenced by other factors, e.g. window frame. In order to avoid the complexity and to enable the measurement of off-normal irradiation, this document focuses on the centre of glazing in fenestration systems.

This document specifies standardized apparatus and criteria. The solar heat gain coefficient measuring apparatus applied in this document includes solar simulator, climatic chamber, and metering box. Solar heat gain coefficient values of the centre of glazing in fenestration systems with or without shading devices shall be determined more precisely by means of combination between calculation and measurement.

This part of ISO 19467 should be read together with ISO 19467:2017 *Thermal performance of windows and doors — Determination of solar heat gain coefficient using solar simulator*.

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# Thermal Performance of windows and doors — Determination of solar heat gain coefficient using solar simulator —

## Part 2: Centre of glazing

### 1 Scope

This document specifies a method to measure the solar heat gain coefficient for the centre of glazing in fenestration systems (e.g. complete windows, doors or curtain walls with or without shading devices) for normal and off-normal irradiation on the surface.

This document applies to the centre of glazing in fenestration systems which might consist of:

- a) various types of glazing (e.g. glass or plastic; single or multiple glazing; with or without low emissivity coatings, and with spaces filled with air or other gases; opaque or transparent glazing);
- b) various types of shading devices (e.g. blind, screen, film or any attachment with shading effects);
- c) various types of active solar fenestration systems (e.g. building-integrated PV systems (BIPV) or building-integrated solar thermal collectors (BIST)).

This document does not include: [ISO/DIS 19467-2](https://standards.iteh.ai/catalog/standards/sist/0f682b42-c866-4bcb-a38e-425194444444/iso-dis-19467-2)

- a) shading effects of building elements (e.g. eaves, sleeve wall, etc.);
- b) shading effects of fenestration attachments with overhang structures (e.g., awning, etc.) or similar;
- c) shading effects of non-glazing elements in fenestration systems (e.g. window frame, etc.);
- d) heat transfer caused by air leakage between indoors and outdoors;
- e) ventilation of air spaces in double and coupled windows;
- f) thermal bridge effects at the joint between the glazing and the rest of the fenestration parts (e.g. window frame, etc.).

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

ISO 9845-1, *Solar energy — Reference solar spectral irradiance at the ground at different receiving conditions — Part 1: Direct normal and hemispherical solar irradiance for air mass 1,5*

ISO 12567-1, *Thermal performance of windows and doors — Determination of thermal transmittance by the hot-box method — Part 1: Complete windows and doors*

ISO 15099, *Thermal performance of windows, doors and shading devices — Detailed calculations*

ISO 19467, *Thermal performance of windows and doors — Determination of solar heat gain coefficient using solar simulator*

ISO 52016-1, *Energy performance of buildings — Energy needs for heating and cooling, internal temperatures and sensible and latent heat loads — Part 1: Calculation procedures*

ISO 52022-3, *Energy performance of buildings — Thermal, solar and daylight properties of building components and elements — Part 3: Detailed calculation method of the solar and daylight characteristics for solar protection devices combined with glazing*

IEC 60904-9, *Photovoltaic devices — Part 9: Solar simulator performance requirements*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345, ISO 9050, ISO 9288, ISO 12567-1, ISO 15099, ISO 19467, ISO 52016-1 and IEC 60904-9 apply. In addition to the typical terms and definitions above, specified terms and definitions for this document are followed.

#### 3.1 centre of glazing

centre of glazing is the area undisturbed by edge and frame effect.

#### 3.2 off-normal irradiance

off-normal irradiance is the condition where the altitude angle and/or azimuth angle of incident radiation is not equal to 0°. For off-normal irradiance, altitude angle and azimuth angle shall be specified.

#### 3.3 projected area

the area of the projection of the surface of the element on to a plane parallel to the transparent or translucent part of the element.

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Note 1 to entry: In the case of non-parallel condition, refer [Annex D](#).

#### 3.4 simple fenestration system

optically and thermally simple fenestration systems are fenestration products having homogeneous specular and transparent properties with non-ventilated cavities, e.g., glazing units made from glass and/or polymers, with or without coating.

#### 3.5 complex fenestration system

optically and/or thermally complex fenestration systems (CFS) are fenestration products that are not described as simple fenestration systems, e.g., optically scattering glazing and/or shading devices and/or ventilated cavities and/or PV cells and/or solar collectors.

#### 3.6 solar wavelength range

solar wavelength range is the range defined in ISO 9050 used for solar properties.

### 4 Symbols and subscripts

Table 1 — Symbols and units

Symbol	Quantity	Unit
$A$	Area	m <sup>2</sup>
$f$	Ratio of irradiation difference to distance difference	-



Table 1 (continued)

Symbol	Quantity	Unit
$g$	Solar heat gain coefficient (also known as total solar energy transmittance, solar factor or g-value)	—
$h$	Surface coefficient of heat transfer	W/(m <sup>2</sup> ·K)
$H$	Height	m
$q$	Density of heat flow rate (energy per unit area per unit time resulting from radiative and/or convective and/or conductive heat transfer)	W/m <sup>2</sup>
$I$	Irradiance, radiant flux (power) of incident radiation (energy per unit area per unit time resulting from incident radiation)	W/m <sup>2</sup>
$U$	Thermal transmittance	W/(m <sup>2</sup> ·K)
$W$	Width	m
$x$	Distance or position	m
$\theta$	Celsius temperature	°C
$\Phi$	Heat flow rate (energy per unit time resulting from radiative and/or convective and/or conductive heat transfer)	W

Table 2 — Subscriptions and abbreviations

Subscripts	Significance
B	Planes of peripheral wall of the metering box
C	Cooling device
cog	Centre of glazing
ex	External
F	Internal fan
H	Heating device
$i$	Number (Index)
in	Internal
INS	Insulation
N	Without irradiance
net	Net (Resulting quantity)
ne	Environmental external
ni	Environmental internal
P	Surround panel
r	Reflection
ref	Reference
scan	Scan
si	Internal surface
se	External surface

## 5 Principle

### 5.1 General

The solar heat gain coefficient for the centre of glazing in fenestration systems,  $g_{\text{cog}}$ , can be determined according to the same principle described in ISO 19467. Therefore, it shall be calculated using [Formula \(1\)](#) with or without shading devices.

$$g_{\text{cog}} = \frac{q_{\text{in}} - q_{\text{in}}(I_{\text{net}}=0)}{I_{\text{net}}} \quad (1)$$

where

$I_{\text{net}}$  is the net radiant flux (power) of incident radiation, in W/m<sup>2</sup>;

$q_{\text{in}}$  is the net density of heat flow rate through the test specimen in the centre of glazing with irradiance, in W/m<sup>2</sup>;

$q_{\text{in}}(I_{\text{net}}=0)$  is the net density of heat flow rate through the test specimen in the centre of glazing due to thermal transmission without irradiance when the temperature difference between internal side and external side is  $(\theta_{\text{ne}} - \theta_{\text{ni}})$ , in W/m<sup>2</sup>.

Main differences between ISO 19467 and this standard are as follows:

- this measurement deals with not the complete fenestration systems but the centre of glazing in fenestration systems;
- irradiance can be emitted also from off-normal incidence (see [5.2](#));
- not only “hot-box method” but also “cooled plate method” are adopted (see [5.3](#), [5.4](#), and [5.5](#)).

### 5.2 Measurement of the irradiance

#### 5.2.1 General

The determination of the net radiant flux (power) of incident radiation of the centre of glazing in fenestration systems involves three stages. The first stage is to scan the irradiation. The second stage is to take the irradiation divergence by distance between test specimen and lamp into account. The third stage is to calculate the net radiant flux (power) of the incident radiation in the solar wavelength range.

#### 5.2.2 Determination of the net radiant flux (power) of incident radiation

Since the solar simulator cannot provide ideally parallel incident radiation to the test specimen, the irradiance depends on the distance between the solar simulator and each part of the test specimen and is not ideally homogeneous on the surface of the test specimen as shown in [Figure 1](#). In order to take into account the inhomogeneity of the irradiance, net radiant flux (power) of incident radiation,  $I_{\text{net}}$ ,

shall be calculated using [Formula \(2\)](#) which is the area-weighted average irradiance at the external surface of the test specimen.

$$I_{\text{net}} = \frac{\sum_{i=1}^n I_{\text{net},i} \cdot A_{\text{cog},i}}{A_{\text{cog}}} \quad (2)$$

where

$I_{\text{net},i}$  is the corresponding net radiation flux (power) of incident radiation for each measurement point,  $i$ , along a vertical line in the plane of the test specimen, in  $\text{W}/\text{m}^2$ ;

$A_{\text{cog},i}$  is the corresponding projected area for each measurement point,  $i$ , in the centre of glazing along a vertical line in the plane of the test specimen, in  $\text{m}^2$ ;

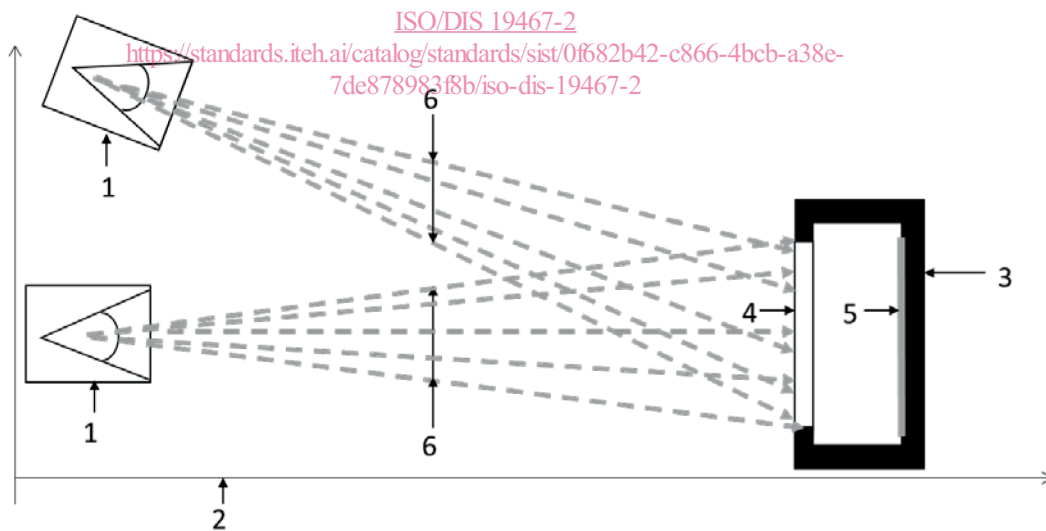
$A_{\text{cog}}$  is the projected area of the centre of glazing in the test specimen, in  $\text{m}^2$ .

NOTE Equal distribution of the sensing positions should be used.

The projected area of the centre of glazing in the test specimen,  $A_{\text{cog}}$ , shall be identical to the sum of the projected area for each measurement point,  $A_{\text{cog},i}$ , as shown in [Formula \(3\)](#).

$$A_{\text{cog}} = \sum_{i=1}^n A_{\text{cog},i} \quad (3)$$

Sensors shall be in the centre of each divided area. More information is given in [Annex B](#). The projected area of the centre of glazing in the test specimen,  $A_{\text{cog}}$ , for both the cooled plate method and the hot box method can be determined according to [Annex A](#) and [Annex D](#), respectively.



#### Key

- |   |   |   |                                       |
|---|---|---|---------------------------------------|
| 1 | solar simulator (normal and off-normal) | 4 | test specimen                         |
| 2 | x-axis                                  | 5 | cooling device or absorber            |
| 3 | metering box or insulation box          | 6 | lighting generated by solar simulator |

**Figure 1 — Influence of beam divergence of the incident irradiation**

As already stated, solar simulators do not provide ideally parallel radiation, therefore the irradiance depends on the distance from the solar simulator. The individual layers of the test specimen and the absorber in the case of cooled plate method are thus irradiated with slightly different irradiance values as shown in [Figure 2](#).

The irradiance may also be determined in a different plane in front of the test specimen. In this case,  $I_{net,i}$  shall be calculated using [Formula \(4\)](#).

$$I_{net,i} = I_{scan,i} (1 + f(x_{scan} - x_{ref})) \tag{4}$$

where

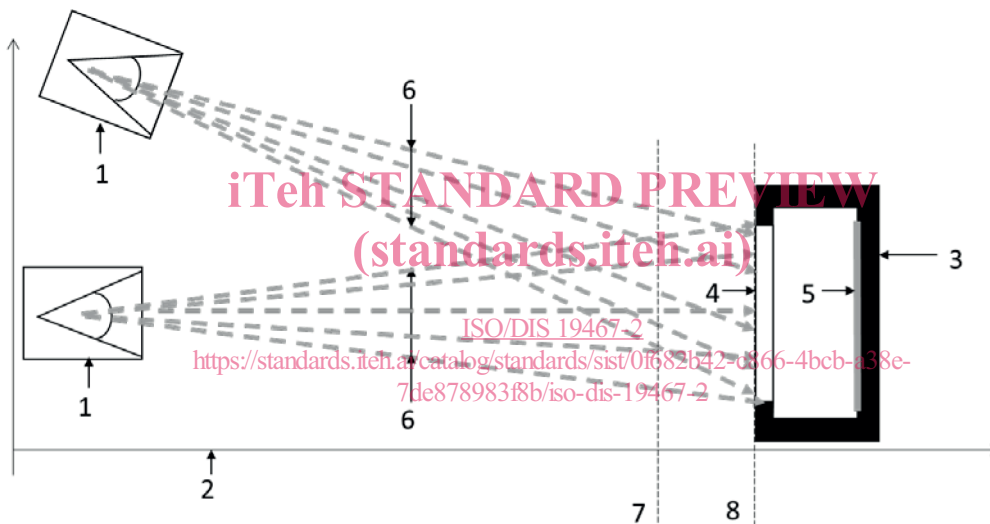
$I_{scan,i}$  is the corresponding net radiant flux (power) of incident radiation for each measurement point,  $i$ , at the position  $x_{scan}$ , in  $W/m^2$ ;

$f$  is the variation ratio of the irradiance, in  $m^{-1}$ ;

$x_{scan}$  is the distance between the solar simulator and the scanning radiometer, in m;

$x_{ref}$  is the distance between the solar simulator and the external surface of the test specimen (reference plane for the irradiance measurement), in m.

NOTE Direction of  $x_{scan}$  and  $x_{ref}$  should be normal to the test specimen.



**Key**

- |   |   |
|---|---|
| 1 solar simulator (normal and off-normal) | 5 cooling device or absorber                            |
| 2 x-axis                                  | 6 lighting projected by solar simulator                 |
| 3 metering box or insulation box          | 7 measuring plane of irradiance scan ( $x_{scan}$ )     |
| 4 test specimen                           | 8 measuring plane of reference irradiance ( $x_{ref}$ ) |

**Figure 2 — Determination of reference irradiance when the sensor cannot be put in the plane of reference irradiance**

In order to take into evaluate the variation of the irradiance level from the distance of the absorber, the criterion  $f$  might be used according to [Formula \(5\)](#).

$$f = \frac{\frac{I_{scan,1}}{I_{scan,2}} - 1}{x_{scan,2} - x_{scan,1}} \tag{5}$$

where