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

## Part 2:
## Centre of glazing





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# Foreword

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This document was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*.



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

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 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 can 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. In some cases, solar heat gain coefficient of the centre of glazing can be determined most accurately by a combination of calculations and measurements.

# 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:

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 7345, *Thermal performance of buildings and building components — Physical quantities and definitions*

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

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 19467:2017, *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*

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 and the following 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 http://www.electropedia.org/

**3.1**
**centre of glazing**
central area of the glazing, undisturbed by edge and frame effects

**3.2**
**off-normal irradiance**
irradiation with altitude and/or azimuth angle not equal to 0°



**3.3**
**projected area**
area of the projection of the surface of the element on to a plane parallel to the transparent or translucent part of the element

Note 1 to entry: In the case of non-parallel condition, refer to Annex D.

**3.4**
**simple fenestration system**
fenestration products having non-ventilated glazing units made from glass and/or polymers and homogeneous specular and transparent properties in optical and thermal.

Note 1 to entry: In the case of non-parallel condition, refer to Annex D.

**3.5**
**complex fenestration system**
optically and/or thermally complex fenestration products that are not described as *simple fenestration systems* (3.4)

EXAMPLE optically scattering glazing and/or shading devices and/or ventilated cavities and/or PV cells and/or solar collectors.

**3.6**
**solar wavelength range**
range of wavelengths for the incident radiation used for solar properties

Note 1 to entry: The range of wavelengths for the incident shall be as specified in ISO 9050.

## 4 Symbols

| Symbol | Quantity | Unit |
|---|---|---|
| $A$ | Area | $m^2$ |
| $f$ | Ratio of irradiation difference to distance difference | - |

| 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/(m²·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/m² |
| $I$ | Irradiance, radiant flux (power) of incident radiation (energy per unit area per unit time resulting from incident radiation) | W/m² |
| $U$ | Thermal transmittance | W/(m²·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 |
| $\tau$ | Transmittance | - |

| Subscripts | Meaning |
|---|---|
| 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, $g_{cog}$, 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.

$$g_{cog} = \frac{q_{in} - q_{in}\left(I_{net} = 0\right)}{I_{net}} \tag{1}$$

where

$I_{net}$ is the net radiant flux (power) of incident radiation, in W/m2;

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

$q_{in}(I_{net} = 0)$ 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 ($\theta_{ne} - \theta_{ni}$), in W/m$^2$.

Main differences between ISO 19467 and this document 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, $I_{net}$, shall be calculated using Formula (2), which is the area-weighted average irradiance at the external surface of the test specimen on which sensing position should be equally distributed.

$$I_{net} = \frac{\sum_{i=1}^{n} I_{net,i} \cdot A_{cog,i}}{A_{cog}} \tag{2}$$

where

$I_{net,i}$ 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 W/m$^2$;

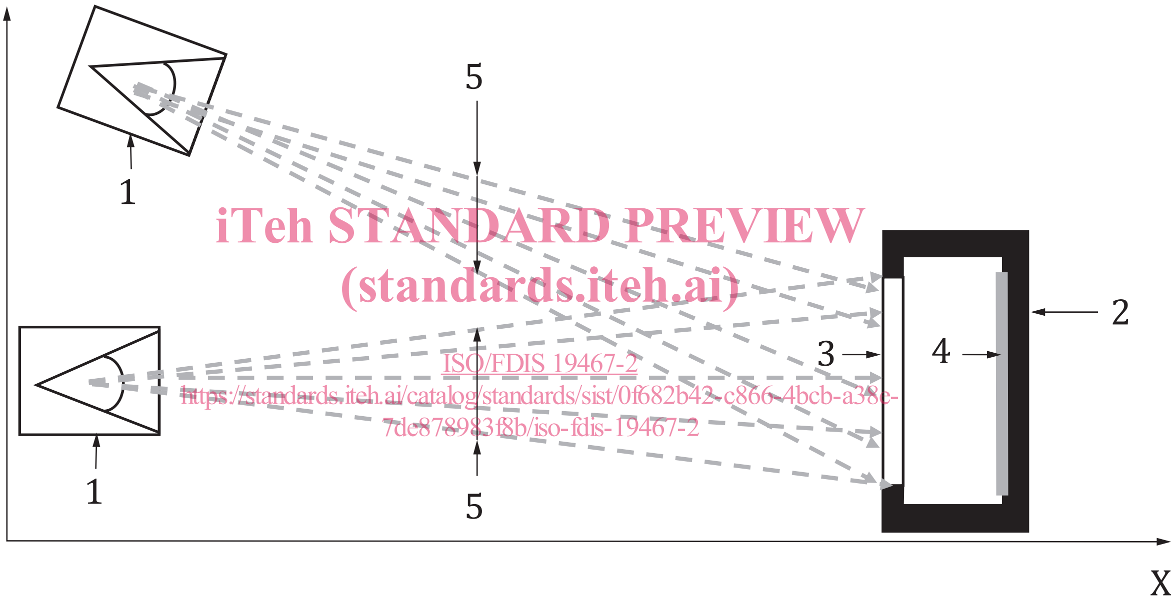
$A_{cog,i}$ is the corresponding projected area for each measurement point, *i,* in the centre of glazing along a vertical line in the plane of the test specimen, in m$^2$;

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

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

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

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, $A_{cog}$, for both the cooled plate method and the hot box method can be determined according to Annex A and Annex D, respectively.





**Key**

X x-axis

1 solar simulator (normal and off-normal)

2 metering box or insulation box

3 test specimen

4 cooling device or absorber

5 lighting generated by solar simulator

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

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). The influence of divergent irradiation on the position of $X_{ref}$ should be taken into account according to Annex C for the cooled plate method.

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

where

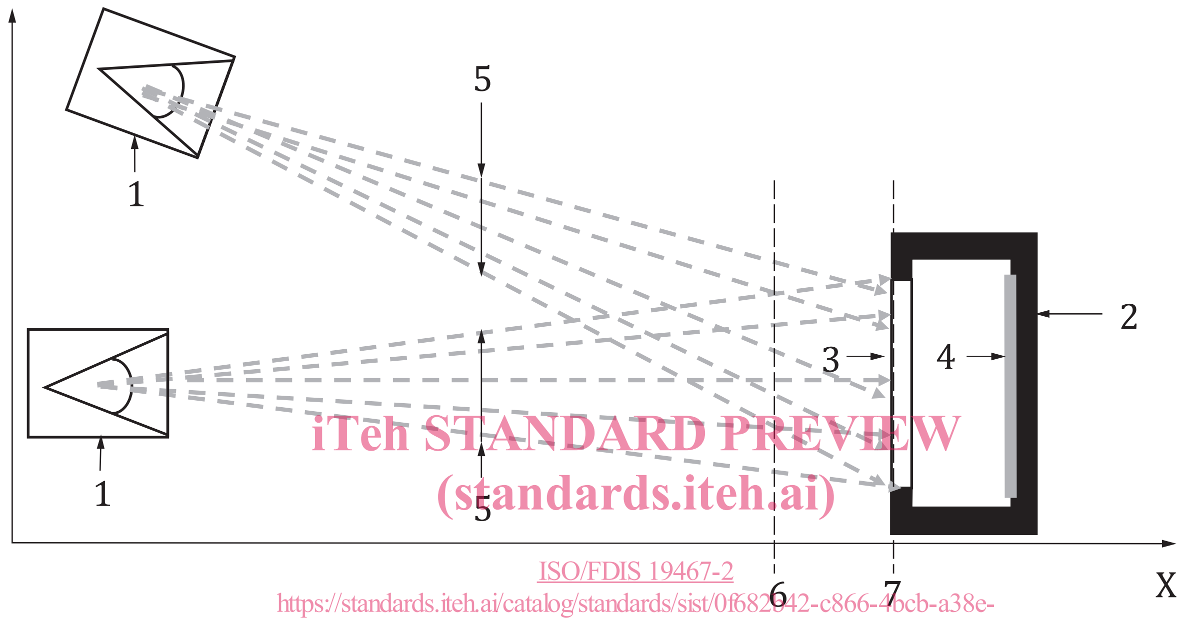
$I_{scan,i}$ is the corresponding net radiant flux (power) of incident radiation for each measurement point, $i$, at the position $x_{scan}$, in W/m$^2$;

$f$ 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 reference plane for the irradiance measurement, in m.

NOTE Directions of $x_{scan}$ and $x_{ref}$ are normal to the test specimen.






**Key**

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

$$f = \frac{\frac{I_{scan,1}}{I_{scan,2}} - 1}{x_{scan,2} - x_{scan,1}} \quad (5)$$

where

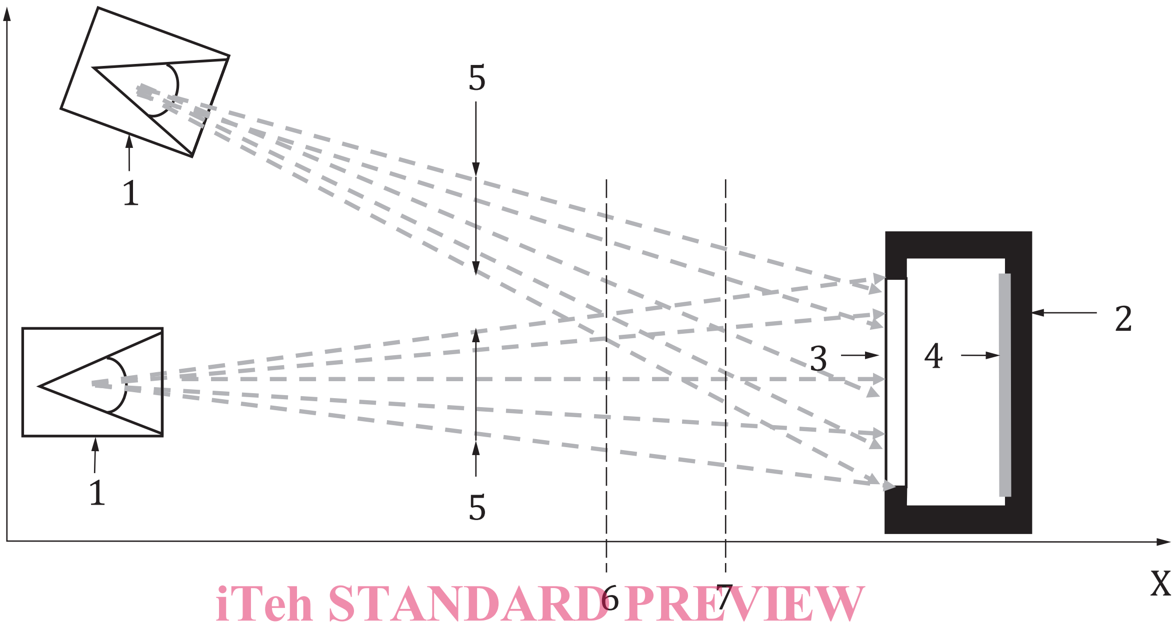
$x_{scan,1}$ is the measuring plane1 of irradiance scan in m (key 7 in Figure 3);

$x_{scan,2}$ is the measuring plane 2 of irradiance scan in m (key 8 in Figure 3);

$I_{scan,1}$ is the irradiance on the measuring plane 1, in W/m$^2$ (key 7 in Figure 3);

$I_{scan,2}$ is the irradiance on the measuring plane2, in W/m$^2$ (key 8 in Figure 3).

If the irradiance sensor cannot be put in the reference plane and f is greater than 0,07 %/mm, $f$ should be taken into account to analyse the additional uncertainty of the irradiance level due to divergence effects as shown in Figure 3 and the correction of the reference plane as described in Annex C as already mentioned before Formula (4). This additional systematic (non-statistical) error should be taken into account in the determination of the uncertainty of the *g*-value measurement.






**Key**

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

**Figure 3 — Determination of irradiance in different planes in front of the test specimen**

### 5.2.3 Calculation of $I_{net}$ with correction of reflected by the absorber

The net density of the heat flow rate of the incident radiation, $I_{net,i}$, shall be calculated using Formula (6).

$$I_{net,i} = I_{scan,i} - I_r \tag{6}$$

where $I_r$ is the density of heat flow rate of the incident radiation that is transmitted to the external side of the metering box/plate after being reflected the internal side of the metering box/plate, in W/m$^2$.

If $I_r$ is proved to be negligible ($I_r$ approximately 0), the net radiant flux (power) of incident radiation, $I_{net}$, shall be calculated using Formula (7), which results in the second term on the right side of Formula (6) to become 0.

$$I_{net,i} = I_{scan,i} \tag{7}$$

Whether $I_r$ is negligible or not shall be evaluated based on the criteria stated in ISO 19467.

## 5.3 Measurement of heat flow rates with irradiance

### 5.3.1 Hot box method

The heat flow rates with irradiance for the hot box method are shown in Figure 4.