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Energy performance of fenestration systems for residential buildings — Calculation procedure

Performance énergétique des systèmes de fenêtrage pour les bâtiments résidentiels — Mode opératoire de calcul

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 18292 was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*.

Introduction

This International Standard specifies a procedure for the determination of energy rating of window and door products and other products that are installed in building envelope openings, also known as fenestration systems. To enable the fenestration industry and their clients to utilize energy performance instead of thermal transmittance to assess their products, there is a need for a simple, clear, accurate and transparent procedure that enables the energy performance of these products to be assessed using national climate data and nationally selected reference buildings.

This International Standard specifies detailed procedures for calculating the energy performance of fenestration products. In this International Standard, the energy performance is derived from thermal transmittance, solar gain, and air infiltration data obtained using standard procedures. Converting that value into an energy rating for the fenestration system is the responsibility of each country's appropriate national body. It is intended that the details of that rating system be published in a publicly available document. These procedures require the use of reference conditions, which differ between countries and can represent conditions other than actual. Allowing different reference conditions enables each country to determine its own reference values in accordance with local conditions. As long as these conditions are publicly available and the calculation is based on standardized procedures as specified in this International Standard, it is possible to calculate the energy performance of a specific product to the desired national reference conditions.

Energy performance of fenestration systems for residential buildings — Calculation procedure

1 Scope

This International Standard specifies a procedure for calculation of the energy performance of fenestration systems used in residential buildings, for rating of fenestration systems, doors and skylights, including the effects of frame, sash, glazing, and shading components. This International Standard specifies procedures for the calculation of the heating and cooling energy use in residential buildings, internal and external climatic conditions, and relevant building characteristics.

These procedures can accommodate all climatic conditions and installation details. It is the responsibility of the appropriate regulatory authority to identify the clauses of this International Standard to be applied in their area of jurisdiction and the climatic data and reference building specification(s) to be used.

2 Normative references

The following referenced documents are indispensable for the application 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 6613, *Windows and door height windows — Air permeability test*

ISO 7345, *Thermal insulation — 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 9288, *Thermal insulation — Heat transfer by radiation — Physical quantities and definitions*

ISO 10077-1, *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Part 1: General*

ISO 10077-2, *Thermal performance of windows, doors and shutters — Calculation of thermal transmittance — Part 2: Numerical method for frames*

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 12567-2, *Thermal performance of windows and doors — Determination of thermal transmittance by hot box method — Part 2: Roof windows and other projecting windows*

ISO 13790:2008, *Energy performance of buildings — Calculation of energy use for space heating and cooling*

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

ISO 15927-1, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 1: Monthly means of single meteorological elements*

ISO 15927-4, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 4: Hourly data for assessing the annual energy use for heating and cooling*

EN 410, *Glass in building — Determination of luminous and solar characteristics of glazing*

EN 1026, *Windows and doors — Air permeability — Test method*

EN 13363-1, *Solar protection devices combined with glazing — Calculation of solar and light transmittance — Part 1: Simplified method*

EN 13363-2, *Solar protection devices combined with glazing — Calculation of total solar energy transmittance and light transmittance — Part 2: Detailed calculation method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345 and ISO 9288 and the following apply.

3.1
solar heat gain
g
total solar energy transmittance (solar factor)

NOTE 1 The solar heat gain of the whole fenestration system, including glazing, frame and solar shading device, is denoted g_W.

NOTE 2 The total solar energy transmittance is also known as the solar heat gain coefficient with the acronym SHGC.

3.2
daylight potential
DP
τ_{DP}
potential of a fenestration system to supply a building with daylight

NOTE Daylight potential is not incorporated into the energy performance value.

3.3
thermal transmittance
U
heat flow rate in the steady state divided by area and by the temperature difference between the surroundings on each side of a system

[ISO 7345:1987, 2.12]

NOTE The thermal transmittance of the whole fenestration system, including glazing, frame and solar shading device, is denoted U_W.

3.4
energy performance of a fenestration system
EP
P_E
calculated annual energy need divided by area for heating and cooling caused by the fenestration system, in the reference building under the reference climatic conditions

NOTE This International Standard defines a separate energy performance value for heating and cooling conditions.

4 Symbols and units

Symbols and units used are in accordance with ISO 7345 and ISO 9288. The quantities which are specific to this International Standard are also defined in Table 1.

Table 1 — Symbols and units

Symbol	Quantity	Unit
A	area	m^2
C	effective heat capacity of a conditioned space	J/K
c	specific heat capacity	J/(kg·K)
F	factor	—
g	total solar energy transmittance of a building element	—
H	heat transfer coefficient	W/K
h	surface coefficient of heat transfer	$W/(m^2·K)$
I_{sol}	solar irradiance	W/m^2
L	overall air infiltration rate	m^3/s
P_E	annual energy performance	kWh/m^2
Q	quantity of heat	kWh
q_V	(volume) airflow rate	m^3/s
R	thermal resistance	$m^2·K/W$
T	thermodynamic temperature	K
t	time, period of time	hours
U	thermal transmittance	$W/(m^2·K)$
α	absorption coefficient of a surface for solar radiation	—
γ	tilt angle	°
Γ	heat balance ratio	—
ε	emissivity of a surface for long-wave thermal radiation	—
η	efficiency, utilization factor	—
θ	Celsius temperature	°C
κ	heat capacity per area	$J/(m^2·K)$
ρ	density	kg/m^3
r	albedo	—
σ	Stefan-Boltzmann constant ($\sigma = 5{,}67 \times 10^{-8}$)	$W/(m^2·K^4)$
τ	time constant	h
τ_{DP}	daylight potential	—
Φ	heat flow rate, thermal power	W
χ	point thermal transmittance	W/K
Ψ	linear thermal transmittance	W/(m·K)

NOTE These symbols are, where possible, the same as those in ISO 13790.

In this International Standard, the energy performance values are calculated in kilowatt hours per square metre. Users may convert these values to other units as appropriate.

The subscripts indicated in Table 2 are used.

Table 2 — Subscripts

avg	time-average	m	mass-related conductance or capacitance
base	base	nd	need
C	cooling, capacity	ob	obstacles
C,nd	cooling need, or building need for cooling	or	orientation
DP	daylight potential	p	pressure
E	energy	pre-cool	pre-cool
e	external, exterior, envelope	pre-heat	pre-heat
g	ground	ref	reference
gl	glazing, glazed element	s	designated space
gn	gains	seas	seasonal
H	heating, or horizontal	set	setpoint
H,nd	heating need, or building need for heating	sh	shading
hor	horizontal	sol	solar (heat gains)
ht	heat transfer	tr	transmission (heat transfer)
i, j, k, m, n	dummy integers	V	volume
int	internal (heat and temperature)	ve	ventilation (heat transfer)
ls	loss	w	fenestration system
m	monthly, designated month	Δ	difference

NOTE 1 These subscripts are in line with the subscripts used in ISO 13790.

NOTE 2 Variables are also defined when they appear for the first time.

5 Principle

5.1 Introduction

Energy performance of the fenestration system is expressed through energy performance indices, P_E, one representative of the heating season and one representative of the cooling season.

This procedure shall be followed for all fenestration tilt angles, γ.

The $P_{E,\,H,w}$, and $P_{E,\,C,w}$ values are the energy needs per area of the fenestration system per year, i.e. the contribution of the fenestration system to the energy needs of the reference building for heating and cooling.

$P_{E,\,H,w}$ is the fenestration heating energy performance index, expressed in kilowatt hours per square metre, while $P_{E,\,C,w}$ is the fenestration cooling energy performance index, expressed in kilowatt hours per square metre.

Different calculation procedures are possible as given in ISO 13790:

— monthly energy balance calculation method;

— seasonal energy balance calculation method;

— hourly energy balance calculation method.

The energy need of the reference building caused by the fenestration system is considered to be independent of the heating, ventilation, and air conditioning system in this International Standard.

5.2 Heating energy performance

Monthly method:

$$P_{E,\mathrm{H,w},i} = \sum_{m=1}^{12} \frac{Q_{\mathrm{H,nd,w,m},i}}{A_{\mathrm{w},i}} \tag{1}$$

Seasonal method:

$$P_{E,\mathrm{H,w},i} = \frac{Q_{\mathrm{H,nd,w,seas},i}}{A_{\mathrm{w},i}} \tag{2}$$

Hourly method:

$P_{E,\mathrm{H,w},i}$ is the annual heating energy associated with the fenestration system, expressed in kilowatt hours per square metre.

NOTE For the hourly method, separating cooling and heating components is a complex task, which can involve multiple steps; see ISO 13790:2008, 15.3.1.2.

where

$P_{E,\mathrm{H,w},i}$ is the energy performance value of the fenestration system facing orientation i for the heating season, expressed in kilowatt hours per square metre;

i is the orientation of the fenestration system, in degrees;

$A_{\mathrm{w},i}$ is the area of the (projected) fenestration system area, in square metres;

$Q_{\mathrm{H,nd,w,m}}$ is the net heat loss through the fenestration system, for the heating mode, per month, m, determined in accordance with 6.2, expressed in kilowatt hours;

$Q_{\mathrm{H,nd,w,seas}}$ is the net heat loss through the fenestration system, for the heating mode, per season, seas, determined in accordance with 6.2, expressed in kilowatt hours.

For situations where fenestration systems are placed in more than one position:

$$P_{E,\mathrm{H,w}} = \frac{\sum_i A_{\mathrm{or},i} P_{E,\mathrm{H,w,or},i}}{\sum_i A_{\mathrm{or},i}} \tag{3}$$

where $A_{\mathrm{or},i}$ is the area of the fenestration, in square metres, and at orientation i, in degrees.

5.3 Cooling energy performance

Monthly method:

$$P_{E,\mathrm{C,w},i} = \sum_{m=1}^{12} \frac{Q_{\mathrm{C,nd,w,m},i}}{A_{\mathrm{w},i}} \tag{4}$$

Seasonal method:

$$P_{E,\mathrm{C,w},i} = \frac{Q_{\mathrm{C,nd,w,seas},i}}{A_{\mathrm{w},i}} \tag{5}$$

Hourly method:

$P_{E,\text{ C,w},i}$ is the annual cooling energy associated with the fenestration systems, expressed in kilowatt hours per square metre.

NOTE For the dynamic method, separating cooling and heating components is a complex task which can involve multiple steps; see ISO 13790:2008, 15.3.1.2.

where

$P_{E,\text{ C,w},i}$ is the energy performance value of the fenestration system facing orientation i for the cooling season, expressed in kilowatt hours per square metre;

i is the orientation of the fenestration system, in degrees;

$A_{\text{w},i}$ is the area of the (projected) fenestration system area, in square metres;

$Q_{\text{C,nd,w,m}}$ is the net heat gain through the fenestration system, for the cooling mode, per month, m, determined in accordance with 6.3, expressed in kilowatt hours;

$Q_{\text{C,nd,w,seas},i}$ is the net heat gain through the fenestration system, for the cooling mode, per season, seas, determined in accordance with 6.3, expressed in kilowatt hours.

For situations where fenestration systems are placed in more than one position:

$$P_{E,\text{ C,w}} = \frac{\sum_i A_{\text{or},i} P_{E,\text{ C,w,or},i}}{\sum_i A_{\text{or},i}} \tag{6}$$

where $A_{\text{or},i}$ is the area of the fenestration system, in square metres, at orientation i, in degrees.

When calculating P_E using hourly methods, it is recommended that changes in U-values due to the exposure to actual environmental conditions and angle dependency of g-value (SHGC) be considered. It is not therefore recommended that fixed values that are used to compare products for U-value and g-value (SHGC) be used to calculate energy performance. It is necessary to use the same building assumptions and boundary conditions for both simplified and hourly calculation methods to ensure compatibility. Hourly calculation programmes need to comply with validation and verification tests as specified in the Bibliography.

6 Methodology and basic equations

6.1 General

6.1.1 Introduction

For the evaluation of the energy performance for fenestration systems, all data used shall be for the same tilt angle of either a typical situation for that fenestration system or the one given in national regulations.

The procedure presented in this International Standard includes two different parts, 6.1.2 and 6.1.3, that shall be distinguished.

6.1.2 Part 1: Preparation of the national or regional fenestration system energy rating procedures

The following actions shall be performed once only by the responsible bodies as part of the overall preparation of the national or regional fenestration system energy rating procedures:

— determination of what is to be included having regard to the climate and other factors for the country or region for which the rating scheme is being set up (e.g. whether to include heating, cooling or both, whether to define a rating for daylighting);

— the calculation of the energy use of a reference building in order to obtain the building-dependent parameters needed for the rating of the fenestration system;

— the choice of representative climate and other relevant data needed as parameters in the calculation of the energy performance of the fenestration system, including all conversions that are independent of the specifications of the fenestration system to be rated;

— establishing procedures and templates for the conversion from calculated energy performance for heating or cooling into a classification (rating);

— if appropriate, establishing procedures and templates for the conversion from the day-lighting performance of the fenestration system (characterized by a daylight potential) into a classification (rating).

6.1.3 Part 2: Calculation of the energy performance of a specific fenestration system

The user applying this International Standard shall calculate the energy performance of a specific fenestration system in accordance with the steps outlined here. The energy rating can be carried out either in a specific orientation or as a weighted average of a number of orientations.

The calculation procedure consists of four steps. Each step involves the gathering of a specific set of input data, followed by specific “pre-processing” calculations.

Figure 1 gives a detailed schematic overview of the calculation steps and the data that are needed as input; the main sources of the data are also given. The detailed procedures are given in 6.2 to 6.5. Only the general principles are provided here.

Step 1: Climate. ***Input data:*** Select appropriate nationally or regionally representative climate data, such as external temperature and the intensity of solar radiation incident on the fenestration system with given orientation and tilt.

Step 2: Building. ***Input data:*** Select appropriate data on one (or a set of) nationally specified reference building(s) and reference occupancy, including reference services (heating, cooling and ventilation) and their control.

Step 3: Fenestration system. ***Input data:*** Obtain the fenestration system properties: thermal transmittance, solar transmittance, heat transfer due to air leakage, and daylight potential.

Step 4: Calculation procedure. From the building-related data (step 2), together with the fenestration system data (step 3) and the climate data (step 1), the gain and loss utilization factors for heating and cooling respectively are calculated for monthly and seasonal methods. For the hourly method, the energy balance of the reference building is calculated each time a fenestration product is being evaluated.

Finally, with all input data available and all “pre-processing” calculations done, the energy performance of the fenestration system can be calculated for the heating mode, $P_{E,\,\mathrm{H,w}}$, and for the cooling mode, $P_{E,\,\mathrm{C,w}}$, separately. This procedure is given in Clause 5.

It may be decided at a national level to present one annual energy performance value, combining the value for heating with the value for cooling.

NOTE The energy performance value can be used as a basis for classification, using a continuous or discrete scale and benchmarks, e.g. in a way similar to EN 15217 for the energy performance classification for buildings.