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Calculation of the impact of daylight utilization on the net and final energy demand for lighting

Calcul de l'effet d'utiliser la lumière du jour à la demande énergétique net et finale pour l'éclairage

ICS 91.160.01

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Contents

Page

Tables

Figures

Foreword

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ISO 10916 was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*.

Introduction

This ISO Standard is part of a set of standards allowing to rate the overall energetic performance of buildings. Facades and rooflights have a key impact on the buildings energy balance. This ISO Standard supports the daylighting and lighting energy related analysis and optimization of façade and rooflight systems. It was therefore specifically devised to establish conventions and procedures for the estimation of daylight penetrating buildings through vertical facades and rooflights as well as on the energy consumption for electric lighting as a function of daylight provided in indoor spaces.

Calculation of the impact of daylight utilization on the net and final energy demand for lighting

1 Scope

This ISO standard defines the calculation methodology for determining the monthly and annual amount of usable daylight penetrating non-residential buildings through vertical facades and rooflights and the impact thereof on the energy demand for electric lighting. The standard can be used for existing buildings and the design of new and renovated buildings.

The standard provides the overall lighting energy balance equation relating the installed power density of the electric lighting system with daylight supply and lighting controls (proof calculation method).

The determination of the installed power density is not in the scope of this method, neither are controls relating for instance to occupancy detection. Provided the determination of the installed power density and control parameters using external sources the internal loads by lighting and the lighting energy demand itself can be calculated. The energy demand for lighting and internal loads by lighting can then be taken into account in the overall building energy balance calculations:

— heating,

— ventilation,

— climate regulation and control (including cooling and humidification) and

— heating the domestic hot-water supply

of buildings.

For estimating the daylight supply and rating daylight dependent artificial lighting control systems a simple table based calculation approach is provided. The simple method describes the division of a building into zones as required for daylight illumination-engineering purposes, as well as considerations on the way in which daylight supplied by vertical façade systems and rooflights is utilized and how daylight dependent lighting control systems effect energy demand. Dynamic vertical facades with optional shading and light redirection properties are considered, i.e. allowing a separate optimization of façade solutions under direct insolation and under diffuse skies. For rooflighting systems standard static solutions like shed rooflights and continous rooflights are considered. The method is applicable for different latitudes and climates. For standard building zones (utilizations) operation times are provided.

For detailed computer based analysis (comprehensive calculation) minimum requirements are specified.

To support overall building performance assessment additional daylight performance indicators on the overall building level are provided.

2 Normative references

No normative references apply.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
ballast
unit inserted between the supply and one or more discharge lamps which by means of inductance, capacitance, or a combination of inductance and capacitance, serves mainly to limit the current of the lamp(s) to the required value

3.2
control system
various types of electrical and electronic systems:

— used to control and regulate;

— systems to protect against solar radiation and/or glare;

— artificial lighting in relation to the currently available daylight;

— used to detect and record the presence of occupants.

3.3
daylight factor [D]
ratio of the illuminance at a point on a given plane due to the light received directly and indirectly from a sky of assumed or known luminance distribution, to the illuminance on a horizontal plane due to an unobstructed hemisphere of this sky, where the contribution of direct sunlight to both illuminances is excluded

Unit: 1

3.4
electrical power of artificial lighting system [P]
the total electrical power consumption of the lighting system in the considered space

3.5
illuminance [E]
quotient of the luminous flux incident on an element of the surface containing the point, by the area of that element

Unit: lx = lm × m^{-2}

3.6
lamp
source made in order to produce optical radiation, usually visible

3.7
light reflectance
ratio of the reflected luminous flux to the incident luminous flux in the given conditions

Unit: 1

3.8
light transmittance
ratio of the transmitted luminous flux to the incident luminous flux in the given conditions

Unit: 1

3.9
luminaire
apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except the lamps themselves, all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply

3.10
luminous exposure
quotient of quantity of light dQ_v incident on an element of the surface containing the point over the given duration, by the area dA of that element

Unit: lx × s = lm × s × m^{-2}

3.11
luminous flux [Φ]
quantity derived from the radiant flux, Φ_e, by evaluating the radiation according to its action upon the CIE standard photometric observer

Unit: lm

3.12
maintained illuminance [$\overline{E}_m$]
value below which the average illuminance over the specified surface is not allowed to fall

Unit: lx = lm × m^{-2}

3.13
obstruction
anything outside the window which prevents the direct view of part of the sky

3.14
Rooflight
daylight opening on the roof or on a horizontal surface of a building

3.15
task area
partial area in the work plane in which the visual task is carried out

3.16
visual task
visual elements of the work being done

4 Symbols, indices and abbreviated terms

For the purposes of this document, the following symbols and units apply.

4.1 Symbols

Symbol	Quantity	Unit
τ	light transmittance	—
ρ	Light reflectance	—
φ	luminous flux	lm
η	efficiency	—
a	depth	m
A	area	m^2
b	width	m
bf	occupancy factor	—
C	correction factor	—
D	daylight factor	%
$\overline{E}_m$	maintained illuminance	lx
f, F	factors	—
h	height	m
k	space index	—
k	correction factor	—
J	counter for number of areas being evaluated	—
N	counter for number of zones	—
p	area-specific power	W/m^2
t	time	h
v	distribution key	—
wi	light-well index	—

4.2 Indices

ext	external, outdoors	ND	no daylight
A	absence	Night	night-time
At	atrium, atrium	O	occupancy
c	control	rel	relative
Ca	Carcass opening	Rd	room depth, space depth
D	daylight	s	transparent or translucent surface of the daylight aperture
D65	standard lightsource D65	s	supply
Day	day-time	SA	sun-shading activated
eff	effective, root-mean-square	Sh	shading, obstruction
ext	external, outdoors	SNA	sun-shading not activated
GDF	glazed curtain wall, glazed double façade	t	building use (operating) time
hf	horizontal fin or projection	Ta	task area
i,j,n	serial counter indices	Tr	transparency
Li	lintel	u	lower
In	internal courtyard	vf	vertical fin or projection
lsh	linear shading		

5 Proof calculation method

5.1 Energy demand for lighting as function of daylight

The final energy demand for lighting purposes is $Q_{\mathrm{l,f}}$ to be determined for a total of N building zones which can be subdivided into J evaluation areas:

$$Q_{\mathrm{l,f}} = \sum_{n=1}^{N} \sum_{j=1}^{J} Q_{\mathrm{l,b},n,j} \tag{1}$$

The energy demand of any one evaluation area j is calculated by applying the following Formulae:

$$Q_{\mathrm{l,n},j} = p_j \; F_{\mathrm{c},j} \left[A_{\mathrm{D},j} \left(t_{\mathrm{eff,Day,D},j} + t_{\mathrm{eff,Night},j} \right) + A_{\mathrm{ND},j} \left(t_{\mathrm{eff,Day,ND},j} + t_{\mathrm{eff,Night},j} \right) \right] \tag{2}$$

where

$$A_j = A_{\mathrm{D},j} + A_{\mathrm{ND},J} \tag{3}$$

applies to the total area of the respective evaluation area,