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Hygrothermal performance of buildings – methodology and requirements

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Increasing demand of Energy efficient buildings

Energy Performance of Buildings Directive (EPBD) requires all EU countries to enhance their building regulations and to introduce energy certification schemes for buildings.

- legislation going toward to more energy efficient buildings (20-20-20 etc.)

- finding better solutions that are energy efficient

- ..

Implemention of EPBD

Building Research Institute is involveed in the project: Concerted Action 3 EPBD (2011-2015)

- Certification schemes
- Inspection of heating and air-conditioning systems
- Training of experts and inspectors
- Energy performance requirements using the cost-optimum methodology
- Towards 2020: High performance buildings / Nearly-zero energy and carbon buildings
- Compliance and control of EP requirements and certification system / Independent control system
- Effectiveness of support initiatives

Acc. to EPBC - the methodology for calculating the energy performance of buildings should take into account European standards and shall be consistent with relevant Union legislation, including Directive 2009/28/EC.

Methods for	Standards
expressing energy performance and for energy certification of buildings	EN 15217, EN 15603, EN 15459, EN 15251, EN 13829, EN 13187, EN 12599, EN 15239, EN 15240, EN 15378
calculation of system energy requirements and system efficiencies	EN 15316-1,-2,.. -4-7, EN 15377-1,..-3, EN 15232, EN 15432, EN 15193,
calculation of energy use for heating and cooling	EN ISO 13790, EN 15255, EN 15265
calculation of heat transfer	EN ISO 13789, EN ISO 6946, EN ISO 13786, EN ISO 13370, EN ISO 10211, EN ISO 14683, EN 10456, EN ISO 12631, EN ISO 10077-1, EN ISO 10077-2, EN 15242, EN ISO 13792, EN 13363-1, -2, EN ISO 15921-1, -2, .. -6, EN 12831

Hygrothermal performance of a building

Standard	Application
EN ISO 6946	Building components and building elements - Thermal resistance and thermal transmittance - Calculation method
EN ISO 10211	Thermal bridges in building construction - Heat flows and surface temperatures - Detailed calculations
EN ISO 13370	Thermal performance of buildings - Heat transfer via the ground - Calculation methods.
EN 1745	Masonry and masonry products. Methods for determining design thermal values
EN ISO 12631	Thermal performance of curtain walling. Calculation of thermal transmittance
EN ISO 10077-1	Thermal performance of windows, doors and shutters - Calculation of thermal transmittance . Part 1: General
EN ISO 10077-2	Thermal performance of windows, doors and shutters. Calculation of thermal transmittance. Numerical method for frames

Hygrothermal performance of a building

Standard	Range of application
EN 1873	Prefabricated accessories for roofing. Individual rooflights of plastics. Product specification and test methods
EN 14963	Roof coverings. Continuous rooflights of plastics with or without upstands. Classification, requirements and test methods
EN 12428	Industrial, commercial and garage doors. Thermal transmittance. Requirements for the calculation
EN 14509	Self-supporting double skin metal faced insulating panels. Factory made products. Specifications
EN ISO 13788	Hygrothermal performance of building components and building elements - Internal surface temperature to avoid critical surface humidity and interstitial condensation - Calculation methods.
EN 15026	Hygrothermal performance of building components and building elements - Assessment of moisture transfer by numerical simulation.

Hygrothermal performance of a building

Standard	Thermal insolation products for buildings
	Factory made products. Specification
EN 13162	MW
EN 13163	EPS
EN 13164	XPS
EN 13165	PUR
EN 13166	PF
EN 13167	CG
EN 13168	WW
EN 13169	EPB
EN 13170	ICB
	In-situ formed product. Specification for the products before installation
EN 14315-1	sprayed rigid polyurethane (PUR) and polyisocyanurate (PIR) foam
EN 15101-1	loose fill cellulose (LFCI)
EN 14316-1	thermal insulation formed from expanded perlite (EP)

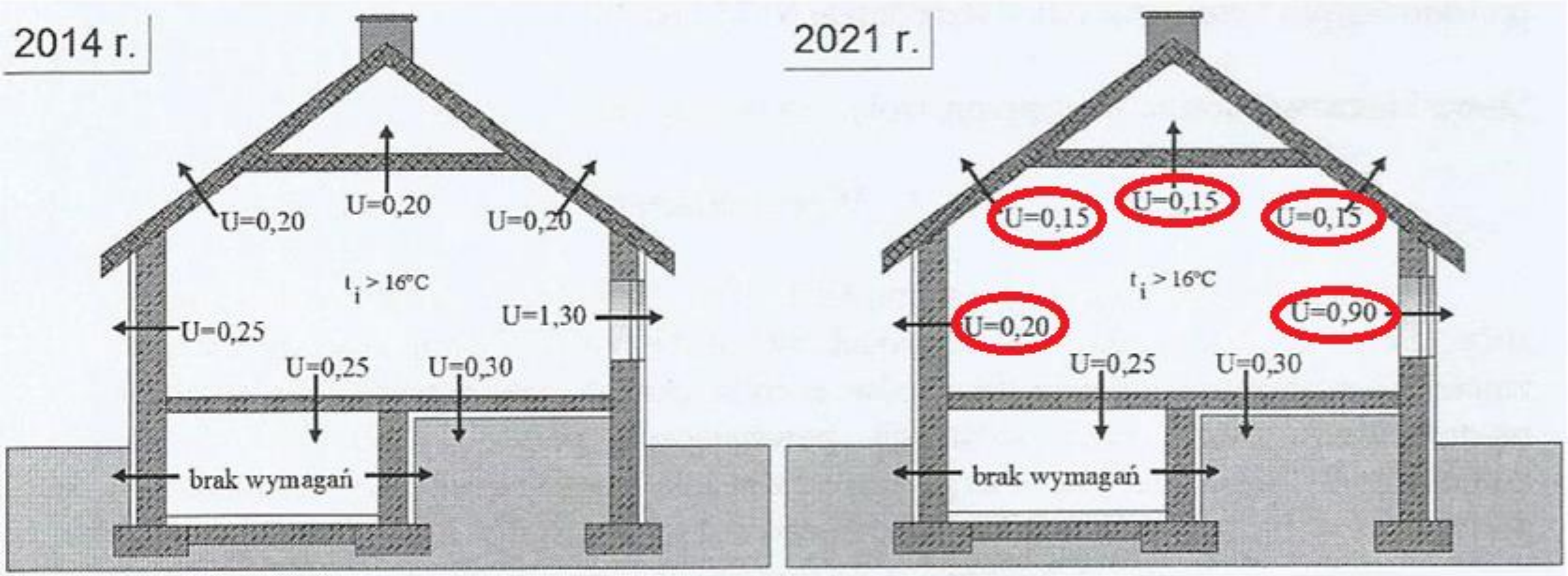
Hygrothermal performance of a building

parameter	modelling
Steady-state heat transfer (2D and 3D)	- thermal transmittances of building components and elements acc. to EN ISO 6946 - thermal performance of windows, doors and shutters acc. to EN ISO 10077-2 - thermal bridges: heat loss calculation, surface condensation acc. to EN ISO 10211 and ISO 13788; - heat transfer via the ground acc. to EN ISO 13370
Transient heat transfer (2D and 3D)	- transient analysis of thermal bridges/ construction elements - dynamic thermal analysis of heating/ cooling - ground heat losses acc. to EN ISO 13370
Heat and moisture transfer	realistic calculation of the coupled one- and two-dimensional heat and moisture transfer in multi-layer building components exposed to natural climate conditions- WUFI software acc. to EN 15026

Hygrothermal performance of a building

Parameter	Input data for numerical modelling: **material properties, boundary conditions, the enclosure geometry**
Thermal transmittance	thermal conductivity values of all materials used in a construction
Heat and moisture transfer	- heat thermal conductivity - heat transport by moisture-dependent thermal conduction (λ(w) plot) - moisture storage by vapour sorption and capillary forces - moisture transport by vapour diffusion (μ) - specific heat capacity - porosity - density

Hygrothermal performance of a building – requirements in Poland



Wymagania termoizolacyjne przegród w budynku jednorodzinnym

Uw calculation

$$U = \frac{\sum U_g \cdot A_g + \sum U_f \cdot A_f + \sum \Psi_g \cdot L}{\sum A_g + \sum A_f}$$

U_g – U of glazing unit, W/(m^2·K),
A_g – area of glazing unit, m^2,
U_f – U of frame section, W/(m^2·K),
Af – area of frame, m^2,
Ψ_g – linear thermal bridge, W/(m·K),
L – length of thermal bridge, m.

Windows

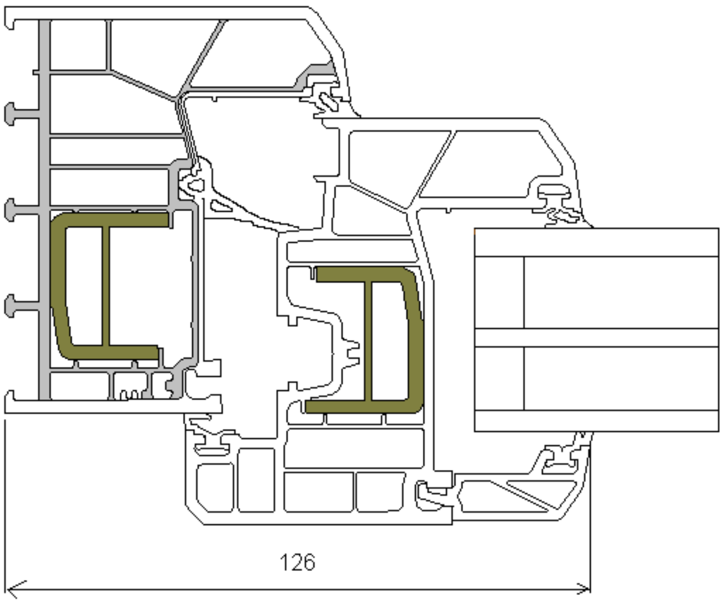
2015

Uw=1,3 W/(m2·K)

2021

Uw=0,9 W/(m2·K)

Windows – Uw calculation



U_f = 1,0 W/(m²·K)

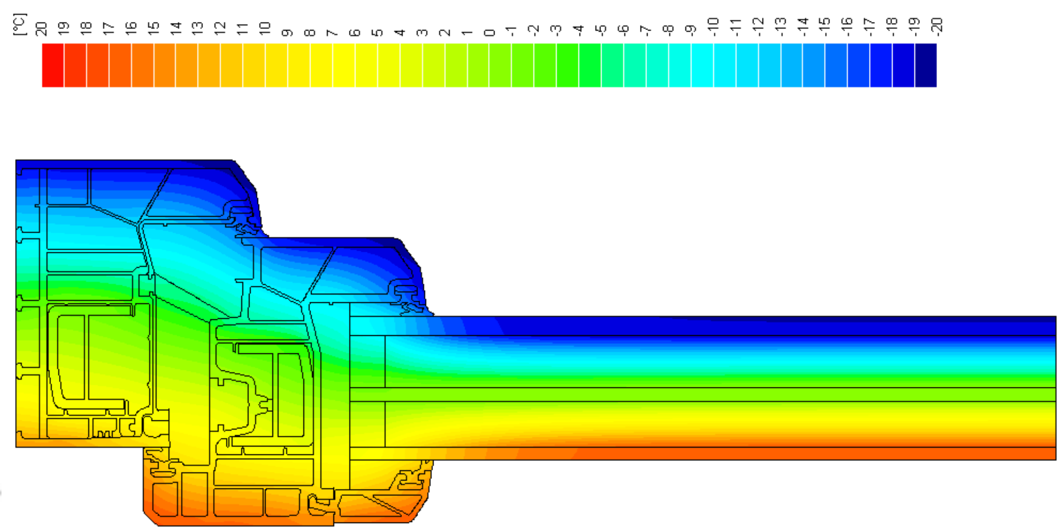
b_f = 0,126 m

Ug = 0,6 W/(m²·K) (4/14/4/16/4)

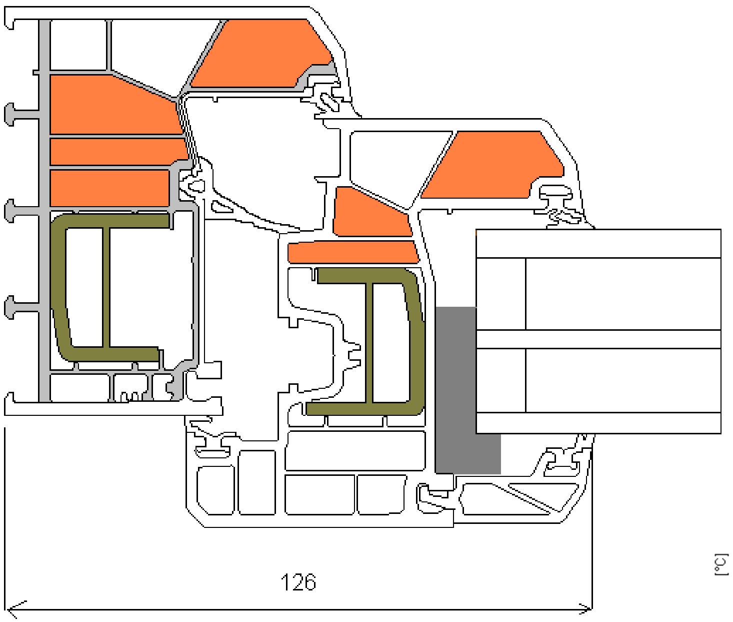
Ψg = 0,035 W/(m·K)

U_W = 0,82 W/(m²·K)

U_W – window size 1,23x1,48 m



Windows



U_f = 0,84 W/(m²·K)

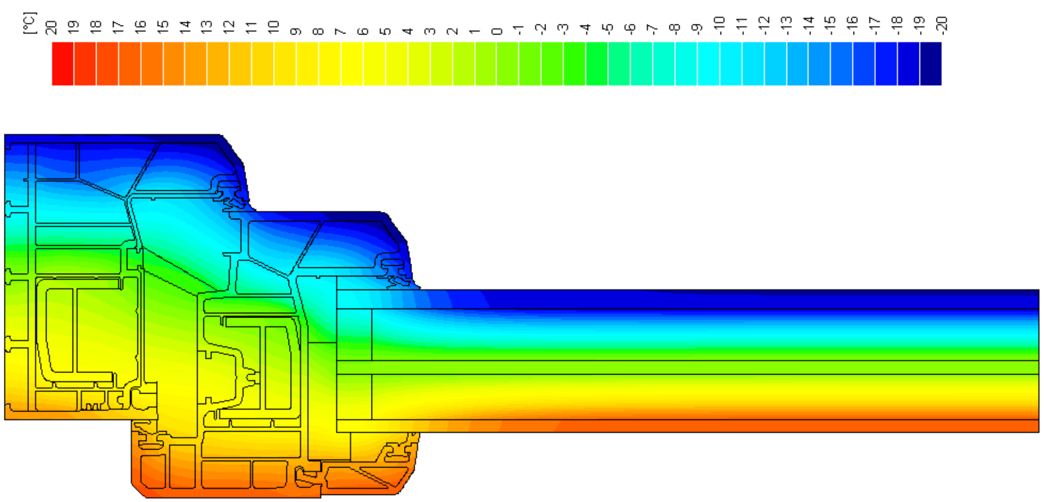
b_f = 0,126 m

Ug = 0,6 W/(m²·K)
(4/14/4/16/4)

Ψg = 0,036 W/(m·K)

U_W = 0,77 W/(m²·K)

U_W – window size 1,23x1,48 m



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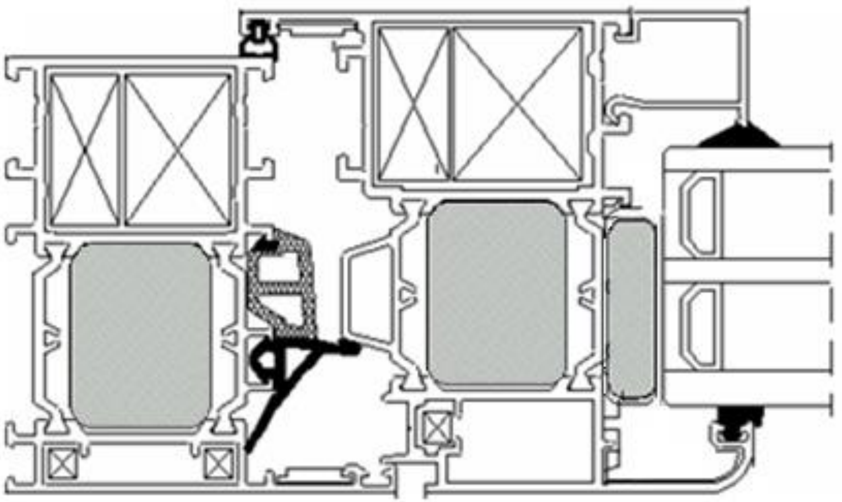
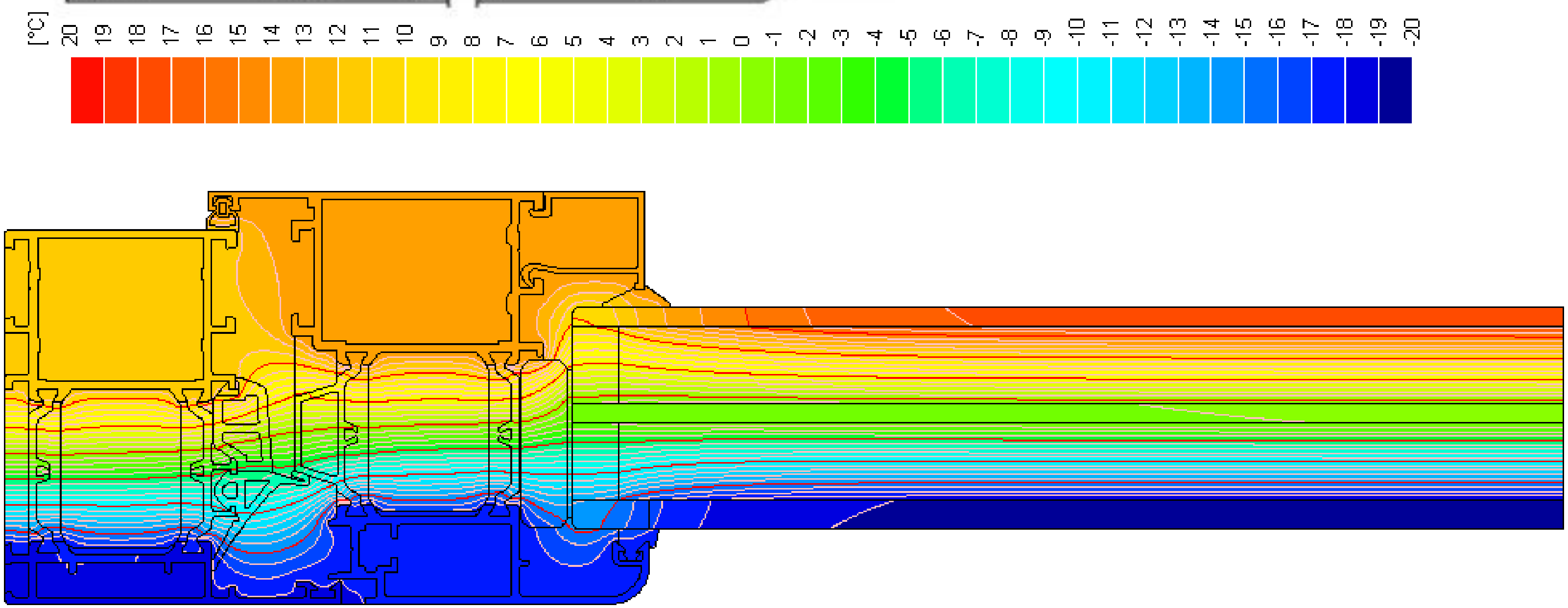
Windows - Uw calculation

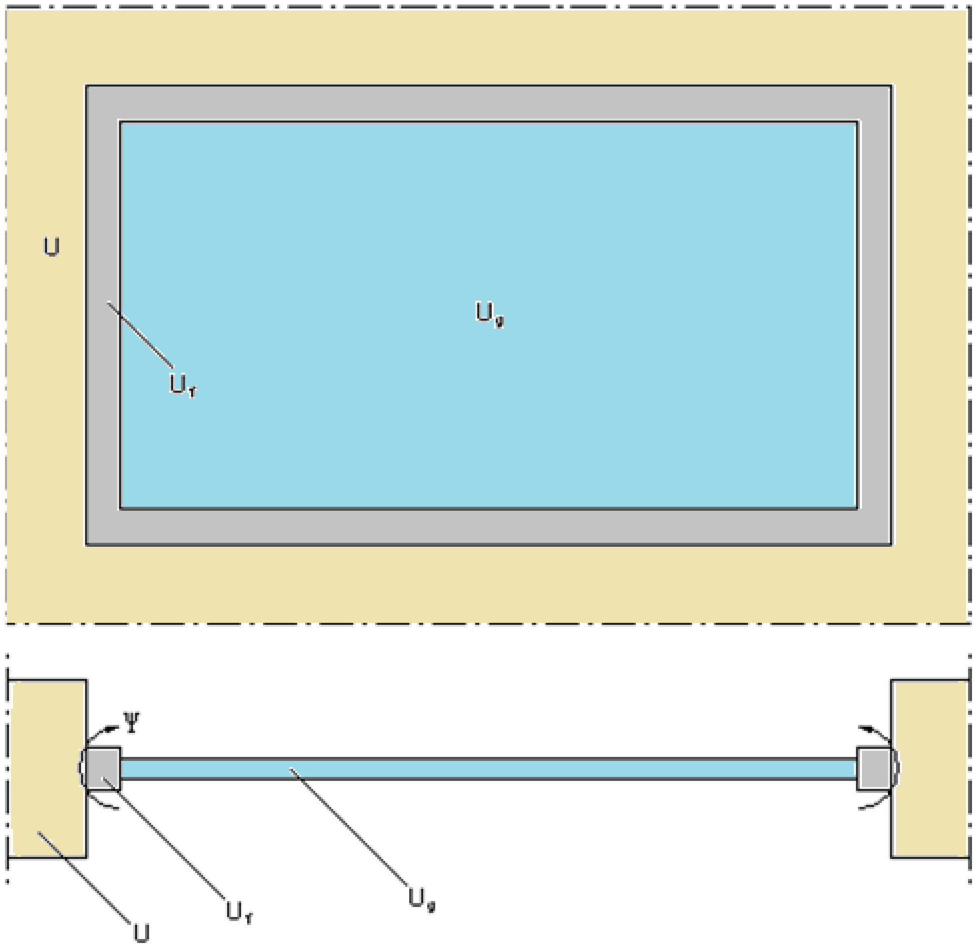


U_f = 1,3 W/(m²·K)
U_w = 0,88 W/(m²·K)

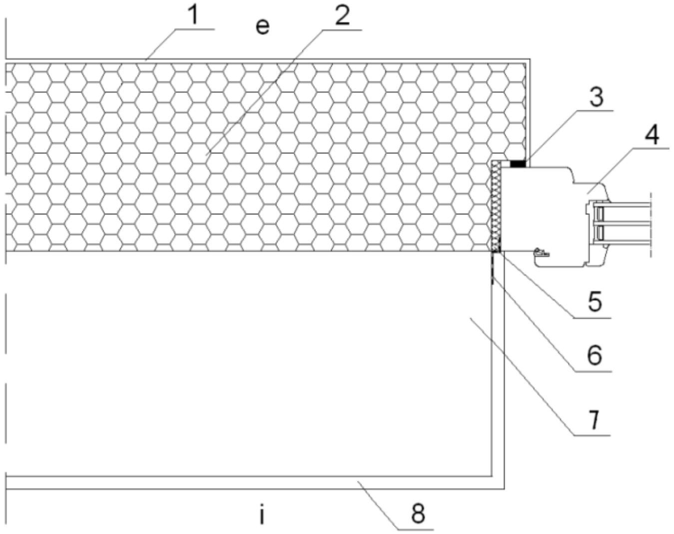
b_f= 0,134 m, Ug=0,5 W/(m²·K), Ψ = 0,039 W/(m·K), window size 1,23 x 1,48 m

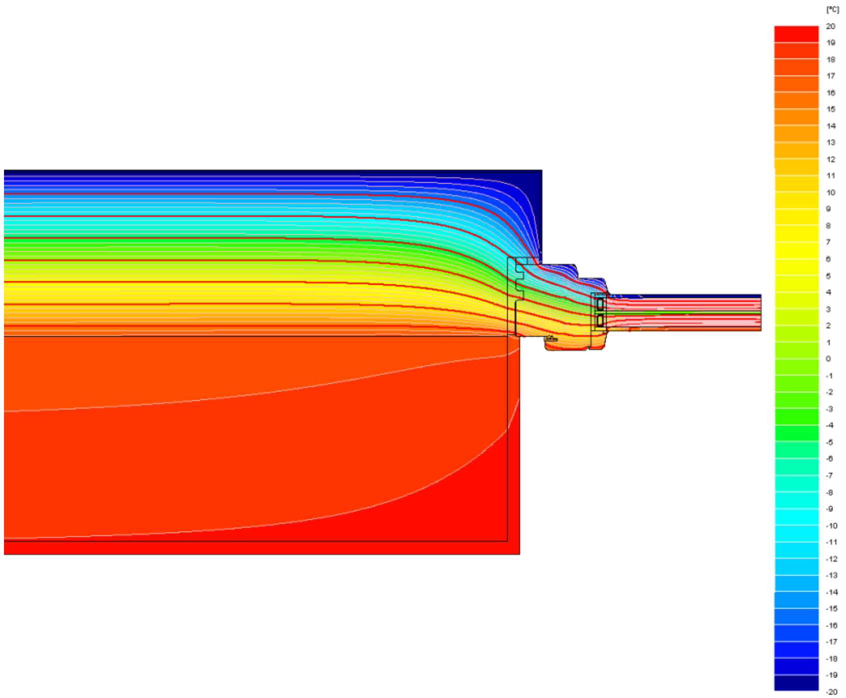


Windows – thermal bridges



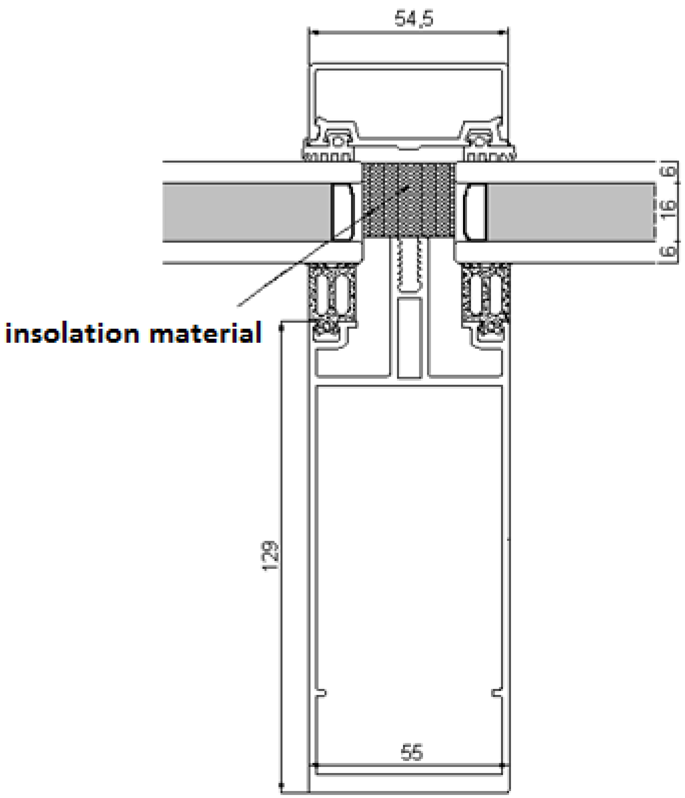
Windows – thermal bridges

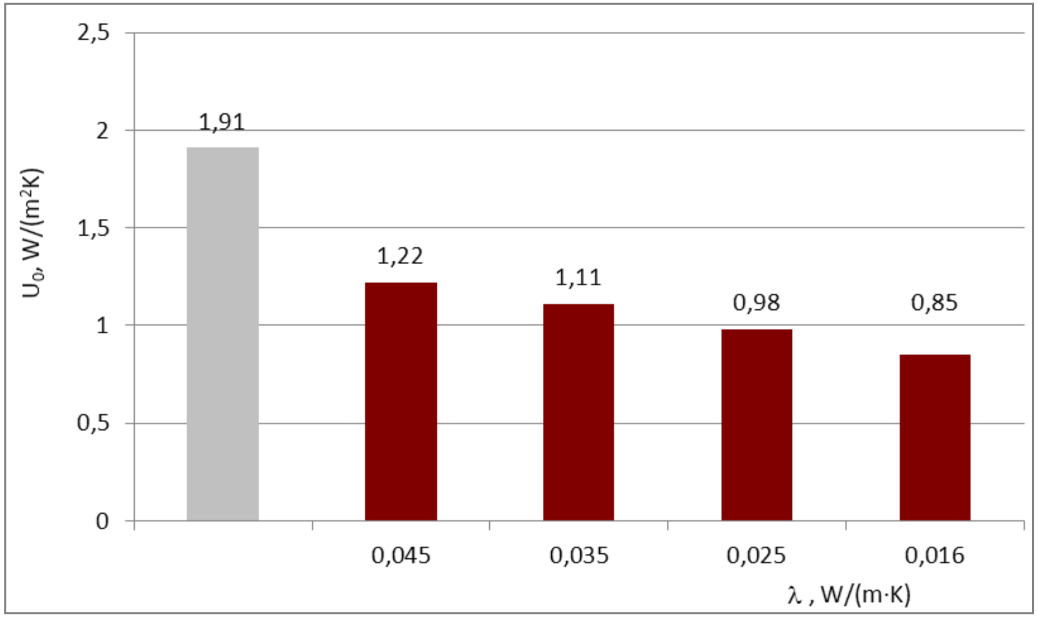




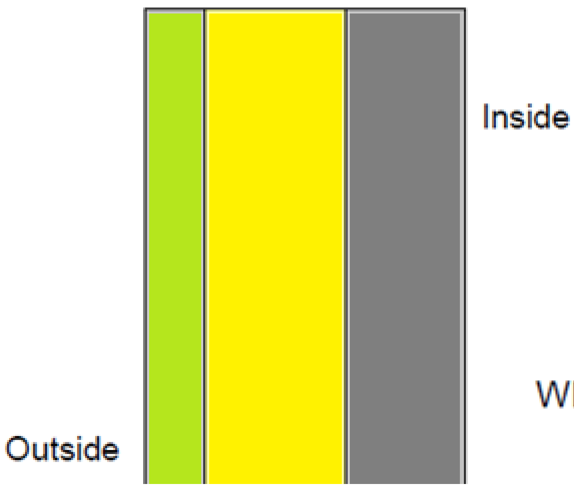
Glazing unit 44 mm, U_g = 0,5 W/(m2·K), Ψ_e < 0,01 W/(m·K), $\Theta_{si,min}$ = 15,3 ºC

Curtain walls





Hygrothermal performance of a building



$$U = \frac{1}{R_{si} + R_{se} + \sum_i \frac{d_i}{\lambda_i}}$$

Where

U = U-value of the wall (W/m^{2}K)

d_i = Thickness (m)

R_{si}, R_{se} = Surface resistance on the inside and outside surfaces (m^{2}K/W)

λ_i= Thermal conductivity (W/m°C)

Mean U-value including thermal bridges

$$U_m = \frac{\left(\sum_{i=1}^{n} U_i \cdot A_i + \sum_{k=1}^{m} l_k \cdot \psi_k + \sum_{j=1}^{p} \chi_j \right)}{A_m}$$

Where

U_i= U-value (W/m²K)

A= Area (m^2)

Ψ_k=Linear thermal bridge, 2d simulation (W/mK)

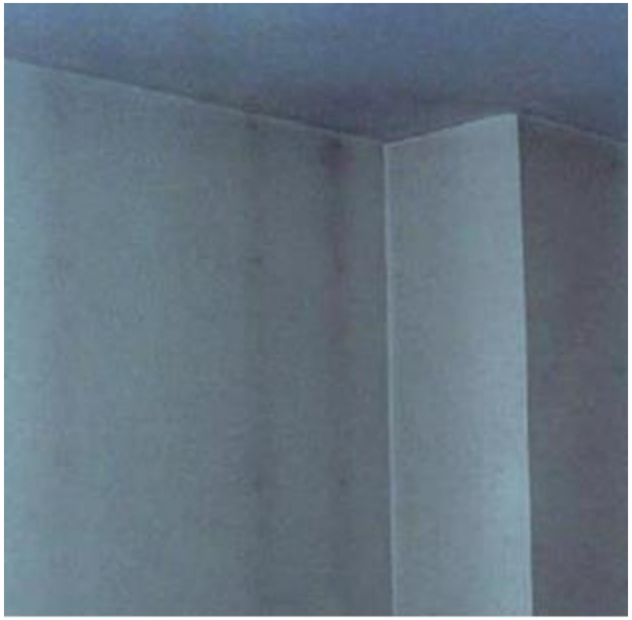
l_k= Length of the linear thermal bridge (m)

χ_j= Point thermal bridge, 3d simulation (W/K)

Am = surface (m^2)

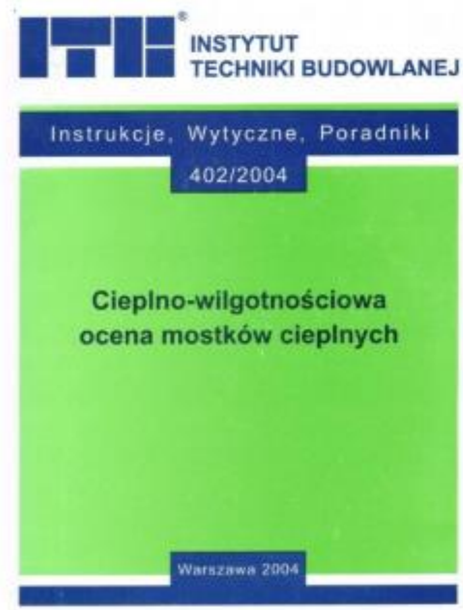
Hygrothermal performance of a building

Hygrothermal performance of a building – requirements in Poland

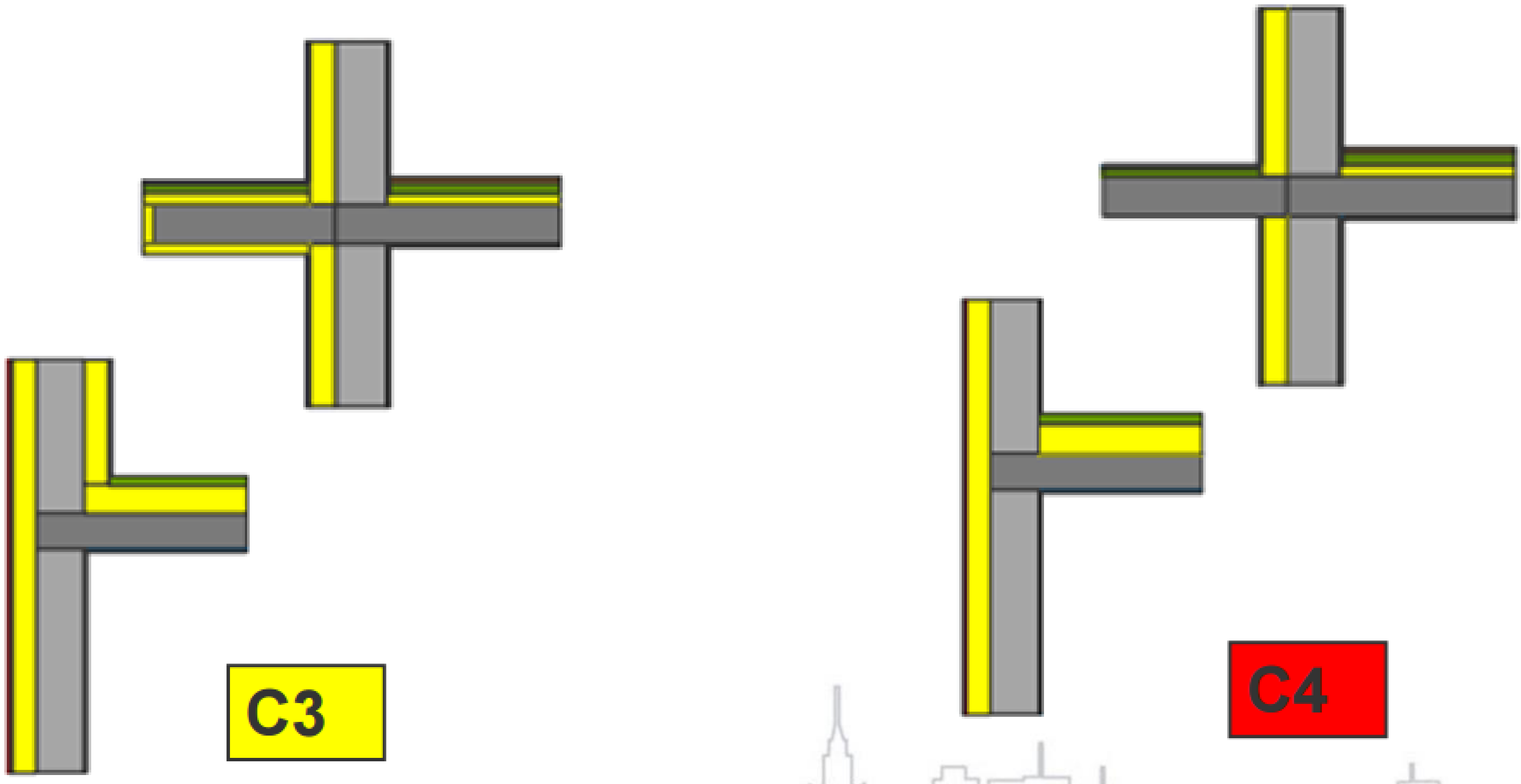


Liniar thermal bridges:
- Calculations acc. to EN ISO 10211
- Catalogue i.e. ITB, 402/2004
- Values acc. To ISO 14683

Klasa C1	$\psi < 0{,}10$ - wpływ pomijalny	C1
Klasa C2	$0{,}10 \leq \psi < 0{,}25$ - mały wpływ	C2
Klasa C3	$0{,}25 \leq \psi < 0{,}5$ - duży wpływ	C3
Klasa C4	$\psi \geq 0{,}5$ - bardzo duży wpływ	C4



Hygrothermal performance of a building – requirements in Poland



Hygrothermal performance of a building – requirements in Poland

Temperature factor f_{Rsi} - acc. to EN ISO 13788

Def.: the difference between the interior surface temperature θsi of a component and exterior air temperature θe, related to (defided by) the difference of temperatures between interior air θi and exterior air θe. The surface temperature is to be determined with some well defined surface resistance Rsi :

$$f_{Rsi} = (\theta_{si} - \theta_e) / (\theta_i - \theta_e)$$

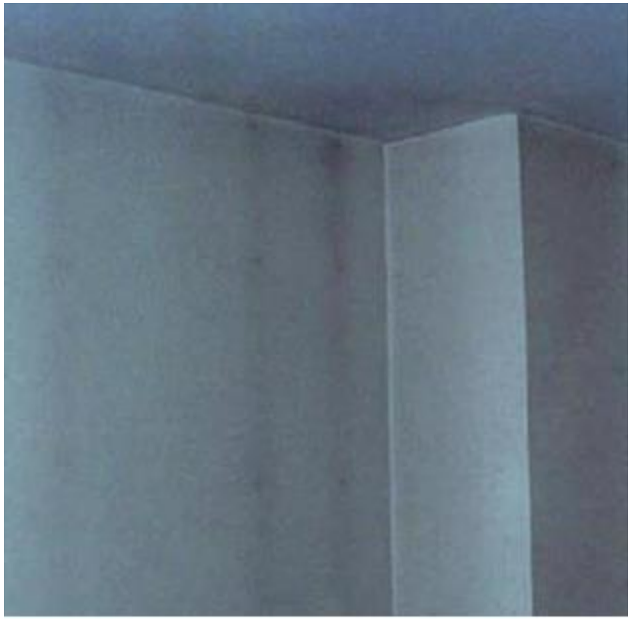
Where : θsi [°C] interior surface temperature
θe [°C] exterior air temperature
θi [°C] interior air temperature

Hygrothermal performance of a building – requirements in Poland

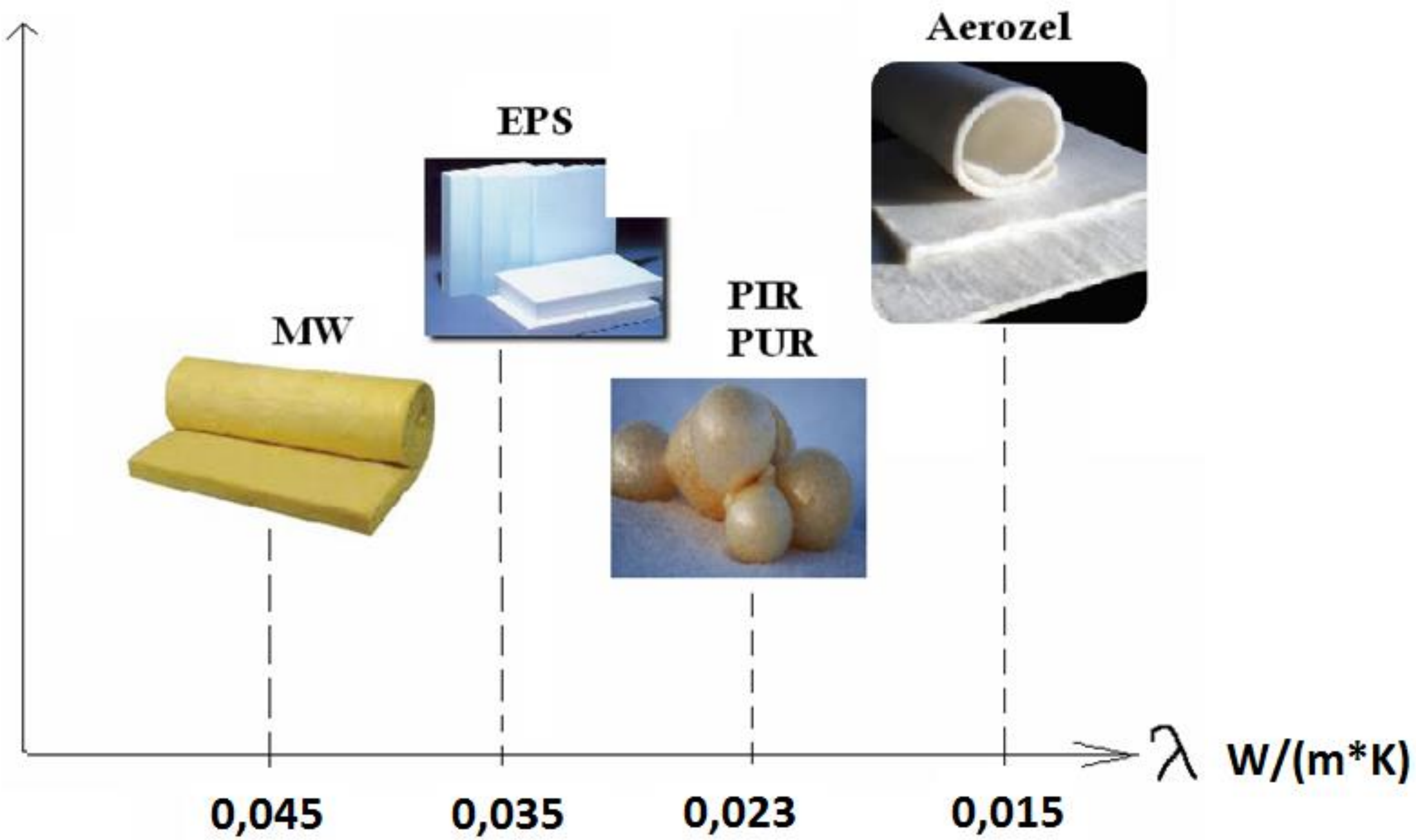
To reduce the mould growth risk by applying design measures the requirements shall be fulfilled:

for all structural, geometrical and material thermal bridges calculated from ISO 10211, the temperature factor f_{Rsi} at the worst location must suffice the requirement of $f_{Rsi} \geq 0,72$

Hygrothermal performance of a building – requirements in Poland



Insolation materials



Insolation materials