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THE IMPACT OF DETAIL SOLUTIONS IN THE WOODEN BUILDING STRUCTURES ON THE THERMAL PARAMETERS OF THE ENCLOSURE

WPŁYW ROZWIĄZAŃ DETALI W BUDYNKACH O KONSTRUKCJI DREWNIANEJ NA WARTOŚCI PARAMETRÓW CIEPLNYCH OBUDOWY

Abstract

As far as modern building technological and material solutions, wood-based constructions are more often applied. New technologies in wood constructions allow to design and construct buildings in low-energy and passive building standards. Producers of system solutions provide the catalogues of different system construction details. The aim of this article is the analysis of thermal bridges of different solution details of both, framework and massive board wood construction. The analysis were conducted in THERM 6.3 program, prepared by Lawrence Berkley National Laboratory. THERM enables to model the effects of two-dimensional heat flow effect and is based on finite elements method, which allows modeling of both simple and geometrically complicated building components. All the results of software calculation facilitates the analysis of the heat exchange and finally allows for the estimation of energy effctiveness. Analyzis of local temperature values allows for assessment of condensation and mould growth problems.

Keywords: thermal bridges, modern wood-based constructions

Streszczenie

We współczesnych budynkach coraz częściej pojawiają się nowe rozwiązania technologiczno-materiałowe na bazie drewna. Nowe technologie o konstrukcji drewnianej pozwalają na konstruowanie obiektów spełniających standard budynków niskoenergetycznych, a nawet standardy budynku pasywnego. W celu zminimalizowania błędów producenci takich rozwiązań systemowych przygotowują w formie katalogowej rozwiązania detali. Celem niniejszego artykułu jest analiza mostków cieplnych dla różnych rozwiązań systemów konstrukcji drewnianych zarówno szkieletowych, jak i masywnych płytowych. Analizę przeprowadzono w programie THERM 6.3 opracowanym przez Lawrence Berkeley National Laboratory. Program umożliwia modelowanie dwuwymiarowych efektów przenoszenia ciepła w elementach budowlanych. Wyniki uzyskane z obliczeń programu umożliwiają analizę przenikania ciepła, a w konsekwencji pozwalają na ocenę efektywności energetycznej produktu, a możliwość obliczenia lokalnych wartości temperatury pozwalają na analizowanie problemów związanych bezpośrednio z kondensacją pary wodnej oraz działaniem wilgoci.

Słowa kluczowe: mostki cieplne, nowoczesne konstrukcje drewniane

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1. Introduction

The contemporary technological and material applications in wood-based constructions (1) discussed in the present article, show the solutions that may occur on the building market. Thanks to some of these technologies, there is possibility of fast and efficient assembly, which can lower costs and the time of construction process. However, the constructor must face restrictive demands of present thermal standard.

The Directive on the Energy Performance of Buildings, published in May 2010, obliges all union countries to make a commitment, that after 2021, all designed and constructed buildings should be almost zero-energy buildings.

In order to timely fulfil the obligations, the National Fund for Environmental Protection (NFOŚ) has introduced supporting programs, which should give the impetus for investors to meet the required low-energy NF40 and passive NF15 standards by all designed buildings. The conducted analysis has allowed to create a set of necessary requirements for keeping the usage of energy for heating and ventilation at levels of respectively 40 kWh/m^{2}year or 15 kWh/m^{2}year.

Table 1 presents examples of minimal requirements of the NFOS for single and multi-family houses.

Table 1

Chosen demands for single and multi-family houses built by the Voivodship Fund for Environmental Protection and Water Management

No.	Demands		NF15	NF40
			Single family house/ multi-family house	
1	Building construction			
1.1	Boundary values of thermal transmittance U_{max} (W/m^{2}K)			
a)	Exterior walls	I, II, III climatic zone IV,V climatic zone	0.10/0,15 0.08/0,12	0.15/0.20 0.12/0.15
b)	Roofs, flat roofs, structural ceiling under no-heating attics	I, II, III climatic zone IV, V climatic zone	0.10/0,12 0.08/0,12	0.12/0.15 0.10/0.15
1.2	Value of linear thermal transmittance limits of thermal bridges' waste			
a)	Balcony panels		0.01/0.01	0.20/ 0.20
b)	Other thermal bridges		0.01/0.01	0.20/ 0.20
1.3	Building air tightness n50 (1/h)		0.60/0.60	1.00/1.00

One of the acts implementing the provisions of the Directive 2010/31 / EU are changes proposed by the Ministry of Infrastructure and Development introduced in the WT Regulations, *Warunki techniczne jakim powinny odpowiadać budynki i ich usytuowanie*. Those changes relate, inter alia, to the strengthening of requirements concerning the insulation of building envelopes. The tightening of those requirements will be carried out gradually between 2014 and 2021 (suggestions are presented in the Table 2).

Table 2

Time schedule and chosen minimal demands for thermal transmittance factor *U* (W/m² K)

Type of boundaries and temperature inside		Thermal transmittance		
		Since 01.01.2014	Since 01.01.2017	Since 01.01.2021
1	Exterior walls with the temp. >16°C	0.25	0.23	0.20
2	Roofs, flat roofs, structural ceiling and no-heated attics: with the temp. >16°C	0.20	0.18	0.15
3	Ground floors	0.30	0.30	0.30

As a result of above changes new technological solutions appear but in the same time the precision of details becomes more and more important. Producers of different systems provide catalogues with construction and material solutions of the details appearing in specific systems.

2. The aim of the research

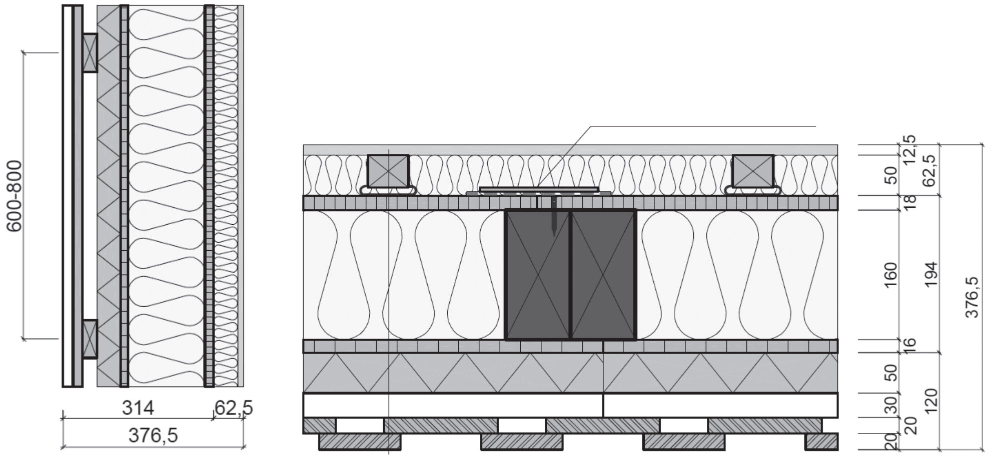
The aim of this paper is analysis of thermal parameters of different connection details of framework and massive wood systems. The analysis was conducted within the Therm 6.3 software.

THERM's two-dimensional conduction heat-transfer analysis is based on the finite-element method, which can model the complicated geometries of building product 3. Thermal analysis of chosen structural nodes for framework walls See Components for more details.

As far as the present framework structures are concerned, their thermal insulation is installed in a few layers to minimize failures of structural elements. Different framework system nodes (connections) were analyzed as an example.

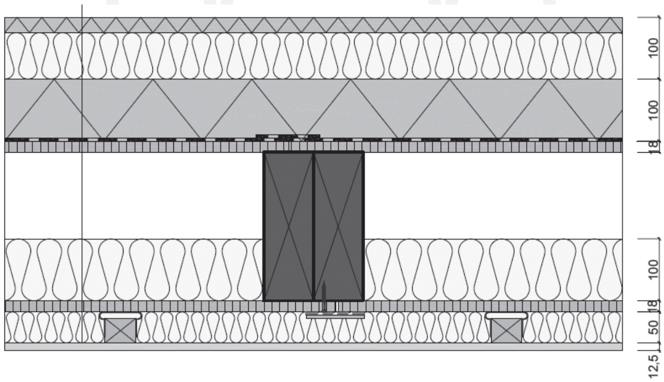
3. Thermal analysis of selected nodes of stud wall construction.

For the section presented in the Ill. 1, the total thickness of thermal insulation of about 26 cm, allows to achieve the thermal transmittance U = 0.149 (W/m^{2}K). Such a level of insulation meets the requirements created by the NFOS for low-energy buildings NF40 (Table 1) located in I, II and III climatic zones of Poland.



Ill. 1. Exemplary sections of framework exterior wall. Layers from inside: plasterboard 12,5 mm, mineral wool 50 mm, wood-based material 18 mm, mineral wool 160 mm, wood-based material 16 mm, wood lightweight board 50 mm

The requirements for roofs and flat roofs are much more demanding. The solution presented in Ill. 2 meets those requirements as $U = 0.109$ (W/m^{2}K).

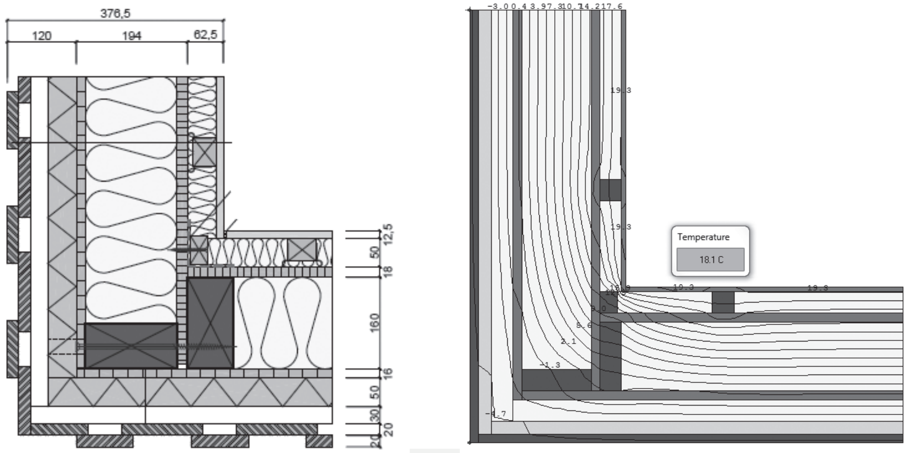


Ill. 2. Flat roof cross section $U = 0{,}109$ (W/m^{2}K) [2]

The solutions of the corner detail in framework technology, presented in the Ill. 3a, allow to keep high temperature on the inside surface of the wall. According to the results of the computer simulation presented in the Ill. 3b, for the interior air temp. –5°C, the internal surface temperature in the corner is 18,3°C, which prevents water vapour condensation and the risk of mould growth.

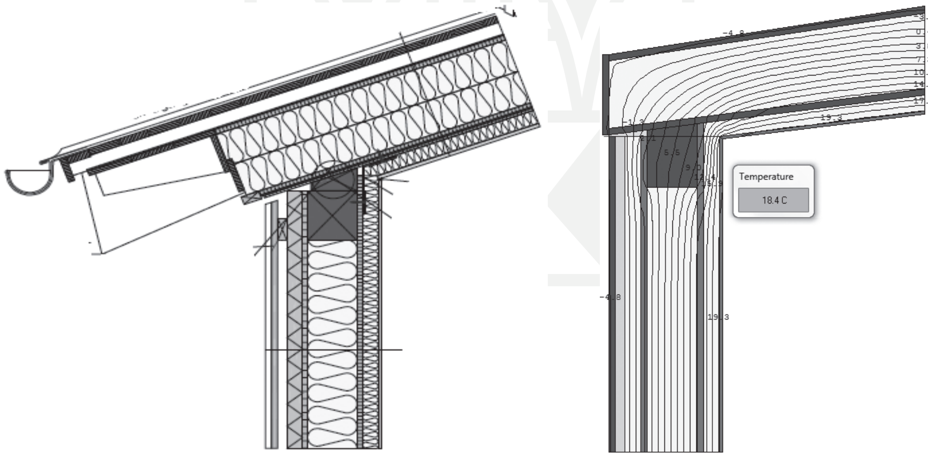
Examples of different solutions, also correct as far as thermal issues, confirmed by the results of the calculations conducted in the THERM software, are presented in Ill. 4b, 5b and 5c.

a) b)



Ill. 3. a) Corner detail in the framework system (2), b) Isotherm layout in the analyzed node generated in the Therm

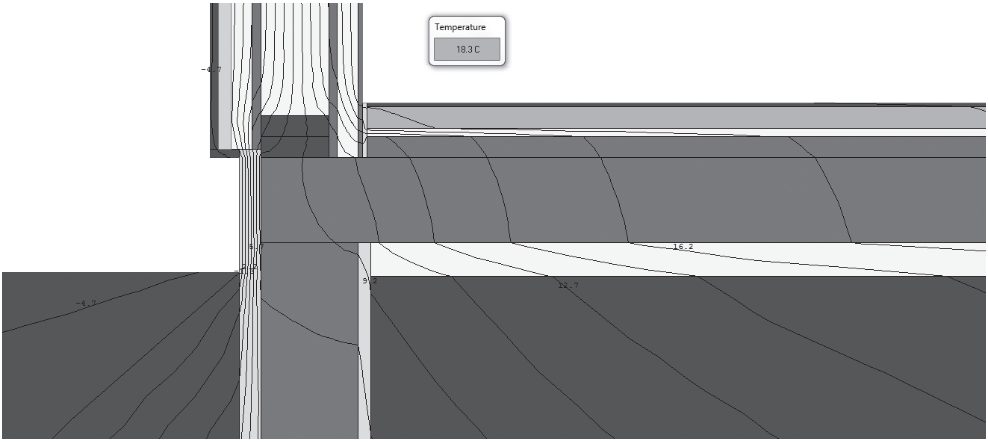
a) b)



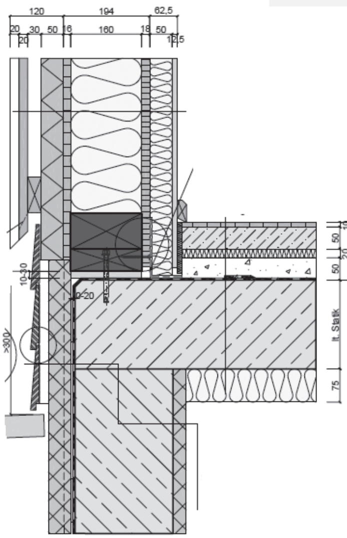
Ill. 4. a) Connection between external wall and roof, b) Layout of isotherm in the analyzed node generated in the THERM software

In the designing process of low-energy buildings, it is essential to carefully plan all architectural and construction details to minimize thermal bridge effects. Inevitable are the connections between the window and door frames and supporting walls. Some solutions of those bridges are presented in Ill. 6a and 7a. On the basis of computer analysis, the linear thermal transmittance values were determined. For connections of window sill, jamb and lintels, the linear thermal transmittance is 0.071(W/mK).

a)



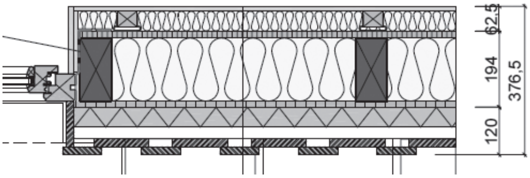
b)



c)

Ill. 5. a) Connection detail between ground floor and external wall, b) Layout of isotherms in the analyzed node – the THERM software, c) Temperature distribution in the node – the THERM software

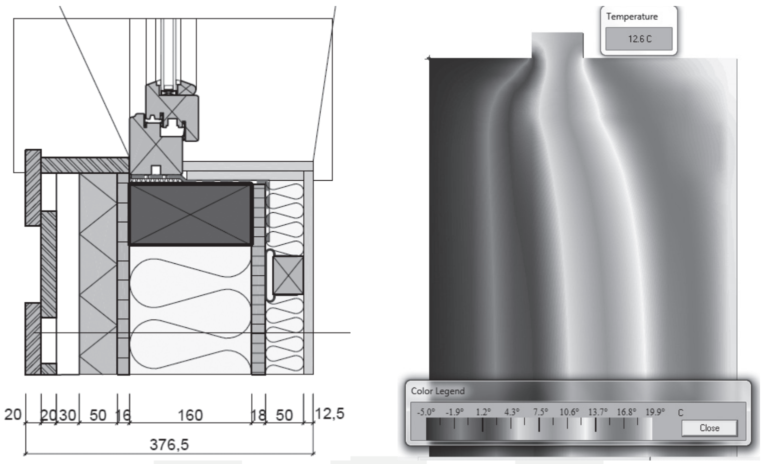
a)



b)

Ill. 6. a) Connection detail of window sill and external wall, b) Temperature distribution in the analyzed node – Therm

a) b)



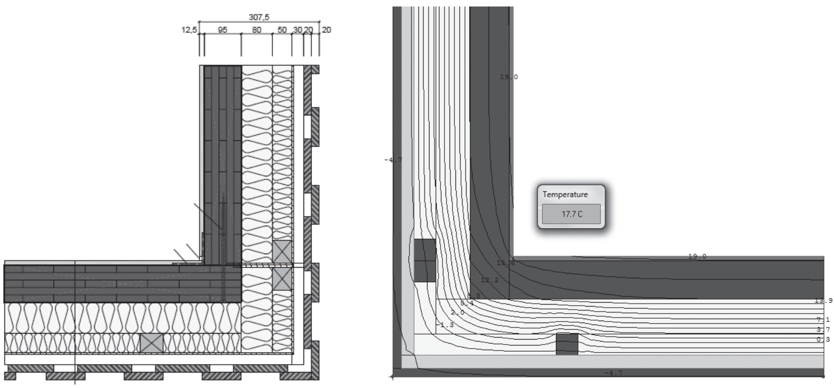
Ill. 7. a) Connection detail of window sill and external wall b)Temperature distribution in the node – the Therm software

Presented solutions allow for the meeting of the requirements for low-energy buildings NF40. To meet the requirements of passive buildings, details of window and door carpentry must be characterized by higher insulation level.

4. Thermal analysis of chosen construction details for massive walls

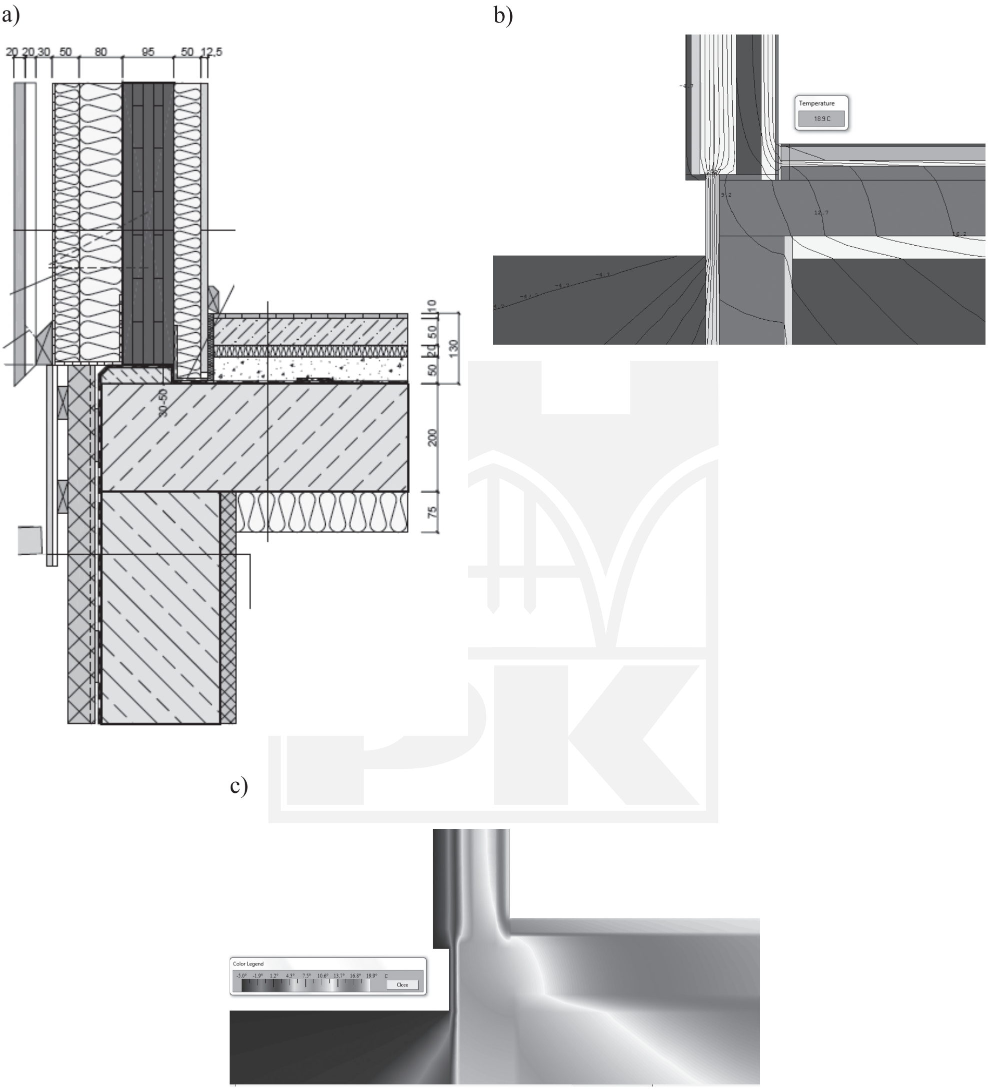
The authors have conducted an analysis, similar to that presented in chapter 3, for wooden walls in massive technology.

a) b)



Ill. 8. a) Corner node solution e.g., in the CLT system (2), b) Layout of isotherms in the corner node – the THERM software

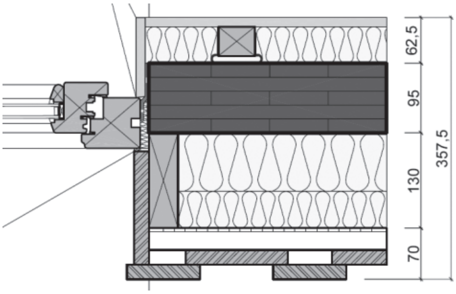
The solutions presented in the Ill. 8 and 9 allow, similarly to the framework system, to avoid surface condensation and the risk of mould growth.



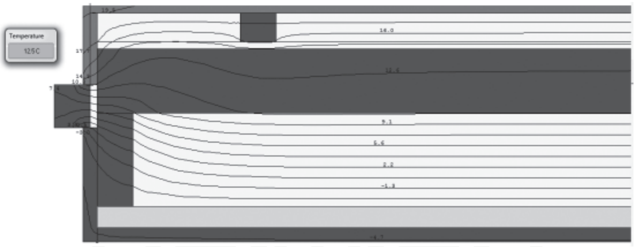
Ill. 9. a) Connection detail between ground floor and external wall, b) Isotherm layout in the node – the Therm software, c) Temperature distribution in the analyzed node – the THERM software

The linear thermal transmittance, for the detail shown in Ill. 10, is 0.084 (W/mK) and for the window sill equals 0.058 (W/mK).

a)

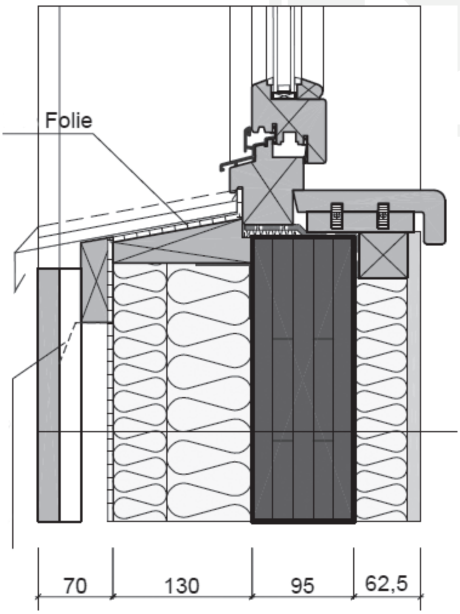


b)



Ill. 10. a) Connection detail of window sill and external wall, b) Isotherm layout in the node – the Therm software

a)



b)

Ill. 11. a) Connection detail of window jamb and external wall, b) Temperature fields in the node

5. Conclusions

The analyzed examples allow to formulate a thesis about wooden architecture, which follows the latest trends and allows to reach low-energy building standards: “To comply with the standards of passive architecture, it is necessary to improve detail solutions, especially the connections between the window and door framings as well as supporting components”.

Table 3

Chosen bridges complication

Technology	Solution type	Linear thermal transmittance
MBD	Window joinery in the windowsill	0.058 (W/mK)
SBD	Window joinery in the frame (windowsill, lintel)	0.071 (W/mK)
SBD	Window position in the frame	0.084 (W/mK)
MBD	Window position	0.084 (W/mK)

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