TNO Built Environment and Geosciences

Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek / Netherlands Organisation for Applied Scientific Research

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Date
27 januari 2010

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Project number
034.20924/01.03.01

Subject
U-value measurement glass sealed VIP unit

Dear Sir,

Please find attached our reports on the U-value measurements on your panel.

Yours faithfully,

H.P. Oversloot
autor

ir. L.J.W.M. Krosse
Energy, Comfort and Indoor Environment

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1 Introduction

In request of our AGC Heerlen we carried out the determination of the U-value on a Thermobel VIP glass sealed unit. The total thickness of the unit is 55 mm and the unit is constructed with 6 mm clear float and 40 mm VIP panel. Sealant is based on silicone.

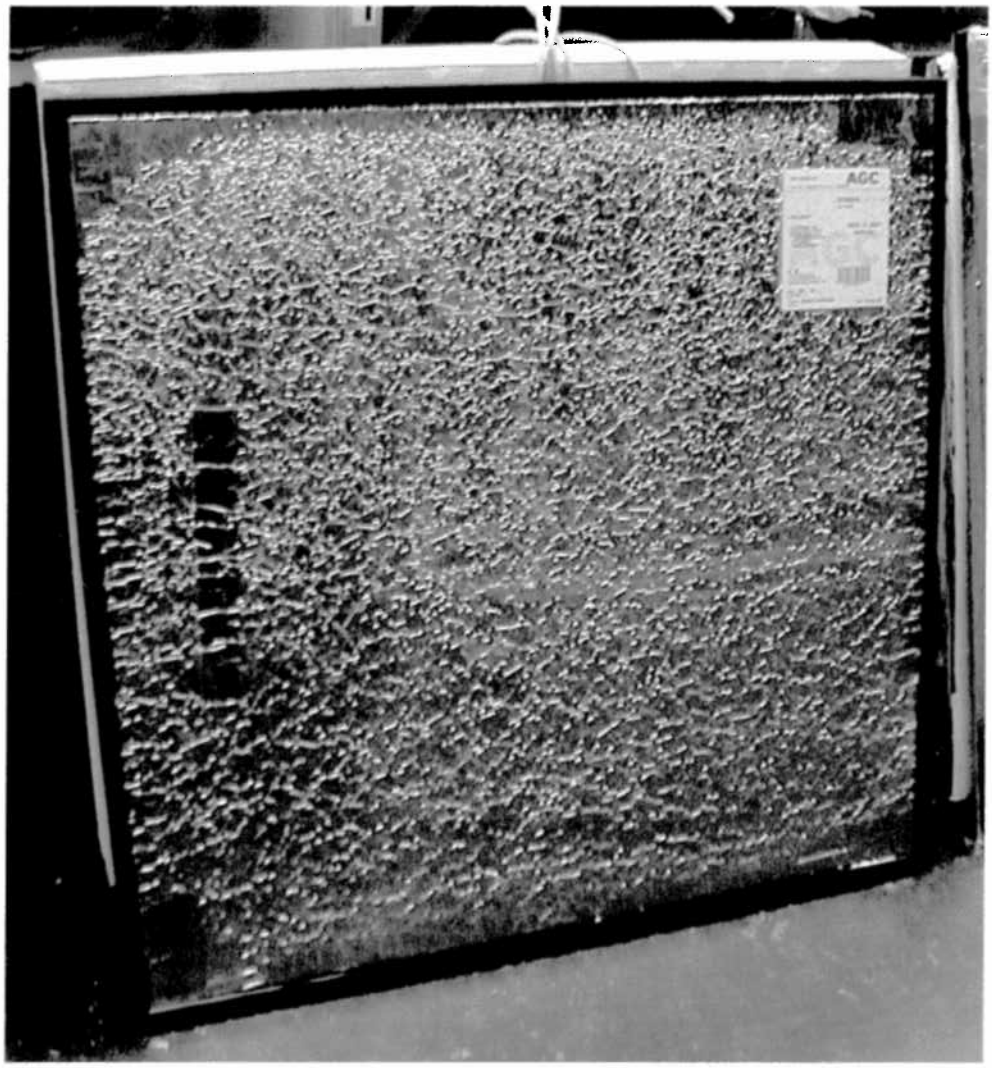

figure 1: photo of VIP panel.

The measurements were carried out using a guarded hot plate instrument. The design of the instrument is based upon ISO 8302. This instrument is developed for glazing components according to EN 674. The European standards EN 674 [2] and EN 675 describe the methods to determine the U-value of the center of glazing, without any edge effect.

The U-value characterizes the heat transfer through the central part of the glazing per degree temperature difference between environmental temperatures on each side. The U-

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value is given in $W/(m^2.K)$. The U-value depends on the thermal resistance of the glazing and the external and internal heat transfer coefficients. The thermal resistance is measured using a guarded hot plate instrument (EN 674) or using a heat flux apparatus (EN 675). The TNO instrument is equipped with both.

The U-value is derived with the following formula:

$$1/U = R + 1/h_e + 1/h_i$$

Where:
R is thermal resistance of the glazing in $(m^2.K)/W$
h_e is the external heat transfer coefficient $W/(m^2.K)$
h_i is the internal heat transfer coefficient $W/(m^2.K)$

The heat transfer coefficients are chosen in accordance with the standard with $h_e = 23$ $W/(m^2.K)$ and $h_i = 8$ $W/(m^2.K)$. The emissivity of clear float glass is well known and fixed in standards to the value of .837.

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2 Description of the measurement procedure

2.1 Thermal measurements

The instrument used is based on the requirements as published in ISO standards. This concerns the ISO 8302 [5] for guarded hot plate instruments and ISO 8301 for heat flux apparatus. The instrument concerns a single specimen instrument with a guarded section on the hot side and heat flux sensors on the cold side of the instrument. The measurements are carried out with the samples mounted in vertical position. Other angles are available on request. A cross section of the instrument is given in figure 1.

The basic units are heavy water flow carrying aluminium sections connected to thermostatic baths. The hot plate carries a square guard section in the centre with sides of 255 mm. Here we find an electrically heated section controlled by PID controller. This insulated section is controlled by a dedicated imbalance sensor measuring the lateral heat flux over the gap. The PID controller regulates the electric power to zero heat flux of the imbalance sensor. When there is no lateral heat flux the full power electrically injected into the guard section is passing through the sample.
At the cold side of the sample there is a layer with 13 heat flux sensors. These sensors are arranged in 3 rings with each 4 sensors with the 13th sensor in the centre. The rings are equidistanced with 10 cm each. These heat flux sensors give information on local heat flux compared to the overall average value. This enables to see effects on the local heat flux due to structural elements that might be hidden in opaque samples.

Guarded Hot Plate Instrument

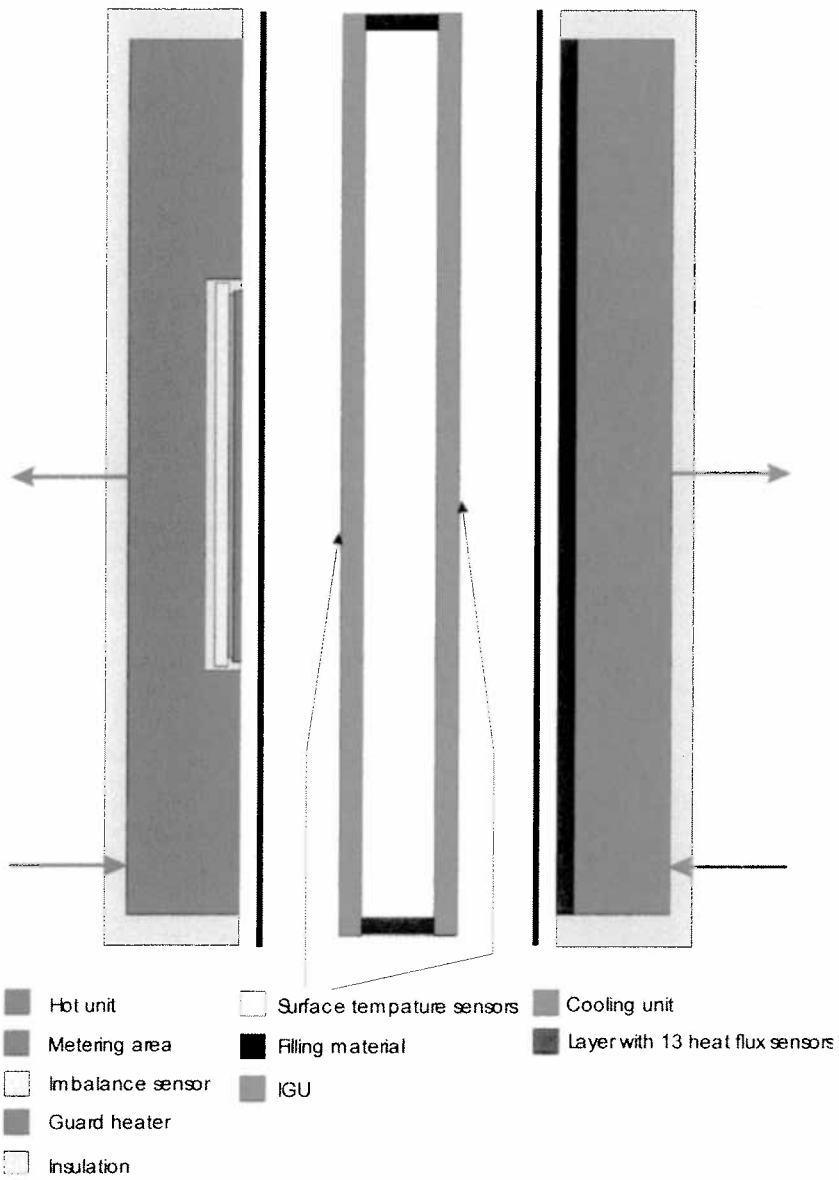

Figure 1: Schema with cross section of instrument

The calibration of the instrument is by direct electrical measurements traceable to international standards by certified institutions. The heat flux calibration is carried out by the guarded hot plate measurements and checked by using reference samples.

The temperature measurements are carried out by 2 sets of 5 thermocouples each of 0.1 mm thickness. The available layers with filling material take care of unevenness caused by thermocouples and small unevenness of the sample by augmenting heat transfer between plate and sample.

3 Results of the measurements

The results of the determination based on guarded hotplate measurements:

Table 3.1: Result of the U-value measurements

measurement	Tavg [°C]	Delta T [°C]	R-value [m^2.K/W]	U-value [W/m^2.K]
1	10.25	16.24	6.52	0.15
2	10.06	15.84	6.52	0.15

The accuracy of the combined measurements ± 3.5% The U-value determined is 0.15 ± 0.005 W/m^2.K Following EN 674 practice the values should be rounded to the first decimal for the U-value upon publication. The mean temperature condition to CEN standards is 10 degrees Centigrade.

References

[1] EN-410 Glass in Building – Determination of the luminous and solar characteristics of glazing

[2] EN-674 Glass in Building – Determination of the thermal transmittance (U-value)-guarded hotplate method

[3] Angular-dependent Light and Total Solar Energy Transmittance for complex glazings. SMT4 –CT9696-2099 Coordinator Fraunhofer Institute for Solar Energy Systems Members: CSTB, DTU, ENEA, ISE, TNO, UWC

[4] On the calculation of the Total Solar Energy Transmittance of Complex Glazings J.L.J. Rosenfeld, University of Wales, Cardiff

[5] ISO 8302 Thermal Insulation – Determination of steady state thermal resistance and relater properties – Guarded hot plat apparatus

[6] The WIS tool has been developed in the 'Advanced Windows Information System (WIS)' project of the European Commission Directorate General XII for Science, Research and Development. WIS–can be free downloaded from http://www.windat.org.
WIS is a uniform, multi-purpose, PC based European software tool to assist in determining the thermal and solar characteristics of window systems (glazing, frames, solar shading devices, etc.) and window components. The tool contains databases with component properties and routines for calculation of the thermal/optical interactions of components in a window. Enquiries for database extension are welcomed

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Results U-value measurement

	VIP		
sample description	paneel 1		
internal frame			
sample code	10-660-ECB/OTH		
day	17/ 2010		
measurement period	00.02 : 00.00		
Measurements			
temperature sample hot side	Ti	oC	18.37
temperature sample cold side	Te	oC	2.12
temperature difference	Ti-Te	oC	16.24
mean temperature sample		oC	10.25
thermal resistance		M²K/W	6.521
intermediate values and constants			
temperature guard	Thp	oC	18.42
Voltage guard	Vhp	V	2.12
resistance guard	Rthp	Ohm	26.10
Power, calculated with Vhp	P	W	0.17
heat flux from Vhp	Q	W/m2	2.49
Measured R-value			
thermal resistance	R	M²K/W	6.5207
conductance	Hnuls	W/m2K	0.15
U-value EN674			
U-value	Unuls	W/m2K	**0.149**
instrument constants			
R		Ohm	26.09
T		oC	21.619
f		m2	0.06887
tcoeff		Ohm/K	0.00329

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Results U-value measurement

sample description	AGC Thermobel 'VIP 50mm		
internal frame			
sample code	10-660-ECB/OTH		
day	19/ 2010		
measurement period	00.02 : 00.00		
Measurements			
temperature sample hot side	Ti	oC	17.98
temperature sample cold side	Te	oC	2.14
temperature difference	Ti-Te	oC	15.84
mean temperature sample		oC	10.06
thermal resistance		M²K/W	6.522
intermediate values and constants			
temperature guard	Thp	oC	18.02
Voltage guard	Vhp	V	2.09
resistance guard	Rthp	Ohm	26.11
Power, calculated with Vhp	P	W	0.17
heat flux from Vhp	Q	W/m2	2.43
Measured R-value			
thermal resistance	R	M²K/W	6.5216
conductance	Hnuls	W/m2K	0.15
U-value EN674			
U-value	Unuls	W/m2K	**0.149**
instrument constants			
R		Ohm	26.09
T		oC	21.619
f		m2	0.06887
tcoeff		Ohm/K	0.00329