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Thermal evaluation of tubular light guides LIGHTWAY

Contractor:

Mrs. Radek Soukup
- technical director
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Assessment completed at:

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Head of the institute:

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Completed by:

Doc. Ing. Jitka Mohelníková, PhD

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In Brno, 25th November 2010

The aim of the assessment

The assessment is focused on the evaluation of the overall heat loss coefficient U-value [$\text{W}\cdot\text{m}^{-2}\text{K}^{-1}$] of the basic composition of tubular light guides LIGHTWAY. A thermal evaluation of a detail of a new tubular light guide Lightway with thermal insulation and glass unit was also completed.

Assessment arrangement

The assessment was carried out on basis of agreement with Mr. Radek Soukup, technical director of LIGHTWAY company, address Ledvinova 1714/12, 149 00 Prague 4, Czech Republic (agreed on 8th June 2010).

Provided technical materials

Technical protocols and catalogues for tubular light guides design by company LIGHTWAY, technical information data about the light guide materials, characteristic details of the light guides applications in building constructions.

Standards requirements

The assessment is based on requirements of the Czech technical standard (ČSN):

- *ČSN 730540-1:2005 Thermal protection of buildings. Part 1 Terminology*
- *ČSN 730540-2:2007 Thermal protection of buildings. Part 2 Requirements*
- *ČSN 730540-3:2005 Thermal protection of buildings Part 3 Design data*
- *ČSN 730540-4:2005 Thermal protection of buildings Part 4 Calculation procedures*
- *Czech Regulation no. 268/2009 Sb., about technical requirements on buildings*

EVALUATION OF OVERALL HEAT LOSS COEFFICIENT U-VALUE OF TUBULAR LIGHT GUIDES LIGHTWAY

The evaluation of the overall heat loss coefficient U-value [$\text{W}/\text{m}^2\text{K}$] of the basic composition of the tubular light guide as follows: glass roof dome, light pipe, and ceiling cover (diffuser).

There are two design variation of the tubular light guides LIGHTWAY compositions::

Variation I:

- glass roof dome (thickness 4 mm),
- light pipe (length 0,6 m),
- transparent ceiling cover – glass (thickness 4 mm).

Variation II:

- glass roof dome (thickness 4 mm),
- light pipe (length 0,6 m),
- transparent double – layer ceiling cover in the following composition:
 - polycarbonate plate PET G, thickness 0,7 mm,
 - air cavity 15 mm,
 - polycarbonate plate PET G, thickness 3 mm.

Typo of the evaluated construction: tubular light guide – thermal flux direction from interior to exterior (upward) in winter season.

The evaluation was completed in the computer program Teplo 2009.

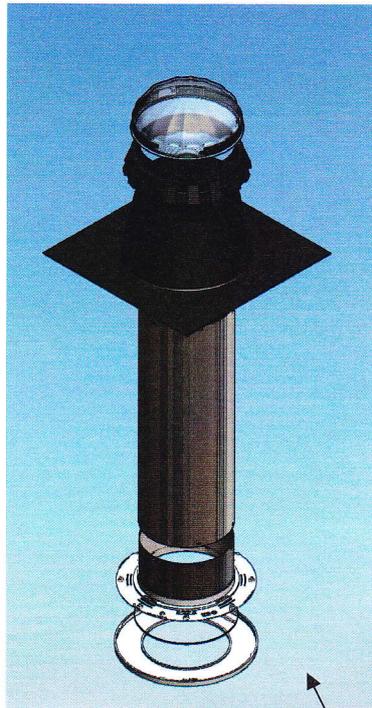
Input data:

- | | | |
|----------------------------------|-----------------|----------------|
| -Design outdoor temperature | θ_{ac} : | -15.0°C |
| -Design indoor temperature | θ_{ai} : | 21.0°C |
| -Design indoor relative humidity | ϕ_i : | 50.0 % (+5.0%) |

Note:

The composition of the individual layers of roof transparent dome without the influence of the neighbouring building constructions and thermal insulation layers. – correction of the U-value was used for the computer simulations : 0.150 $\text{W}/\text{m}^2\text{K}$.

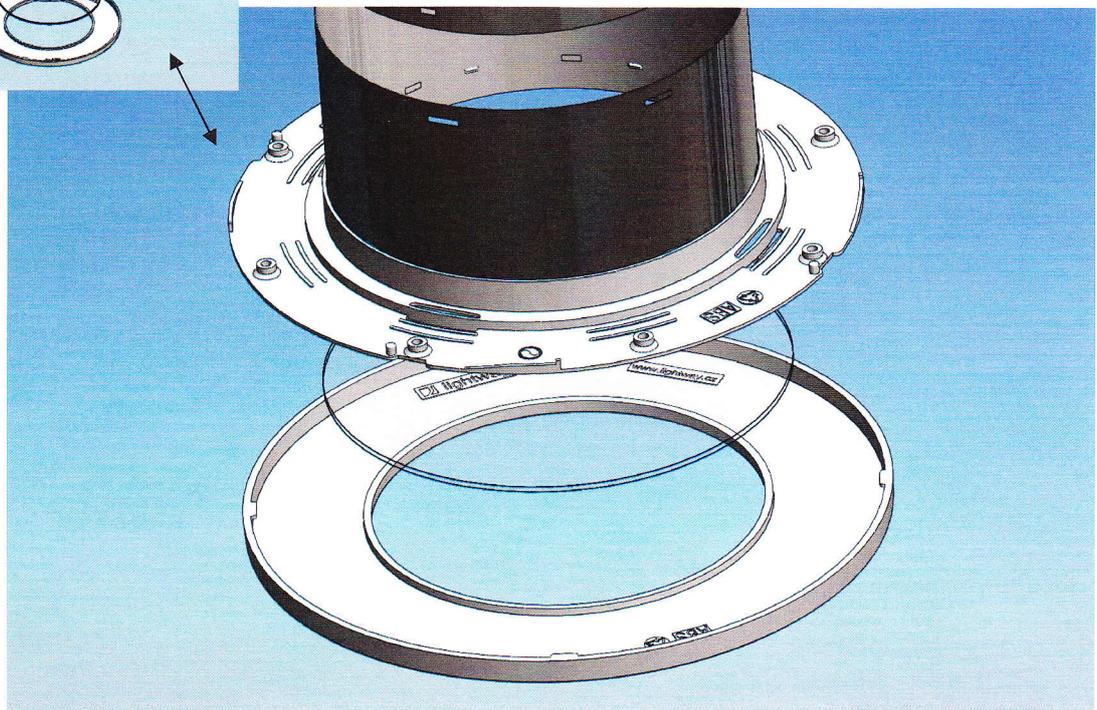
Tubular light guide – variation I



glass roof dome (thickness 4 mm)

light pipe
(non-ventilated air cavity, thickness. 0.6 m)

transparent ceiling cover – glass, thickness 4 mm



Thermal resistance and overall heat loss coefficient determined in accordance with ČSN EN ISO 6946:

Thermal resistance R : 0.32 m²K/W
Overall heat loss coefficient U : **2.189 W/m²K**

Overall heat loss coefficient embedded into building constructions:

U_c : 2.21 / 2.24 / 2.29 / 2.39 W/m²K

The values are orientative and their accuracy depends on different quality of building construction details and elimination of thermal bridges.

Tubular light guide – variation II



glass roof dome (thickness 4 mm)

tubular light guides
(non-ventilated cavity, thickness 0.6 m)

transparent double-layer ceiling cover:
- polycarbonate plate PET G, th. 0.7 mm
- non-ventilated cavity, th.15 mm
- polycarbonate plate PET G, th. 3 mm



Thermal resistance and overall heat loss coefficient determined in accordance with ČSN EN ISO 6946:

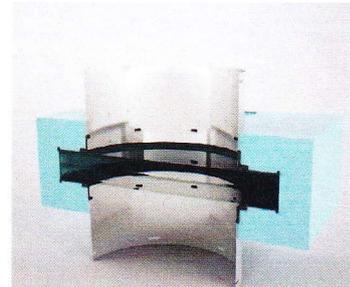
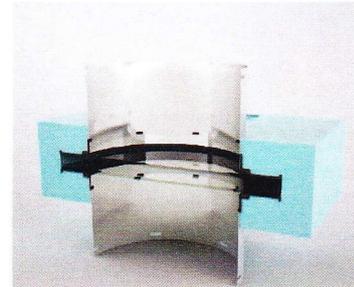
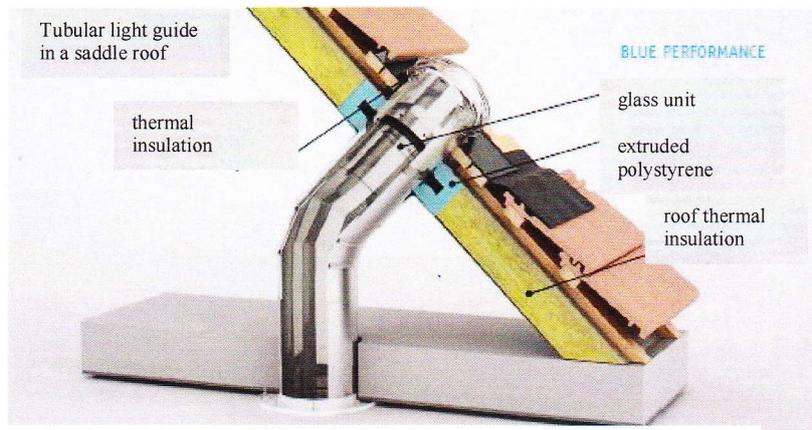
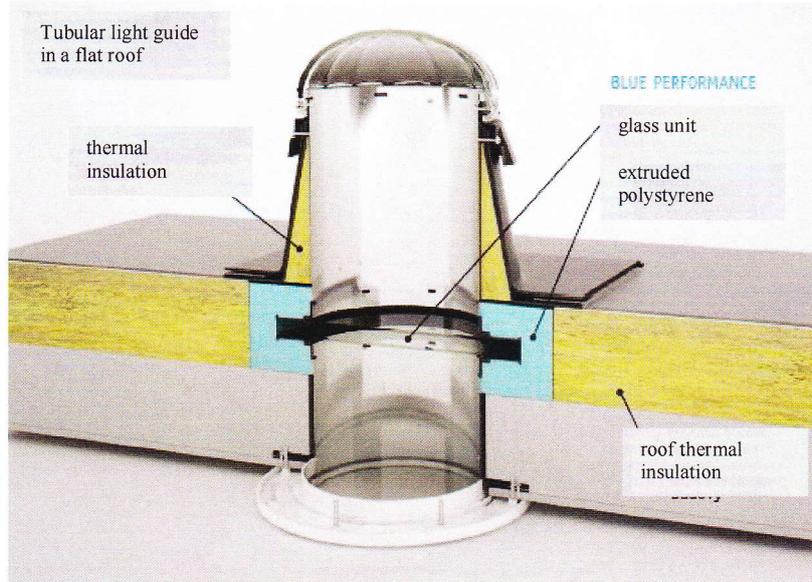
Thermal resistance R : 0.46 m²K/W
Overall heat loss coefficient U : **1.658 W/m²K**

Overall heat loss coefficient embedded into building constructions:

U_c : 1.68 / 1.71 / 1.76 / 1.86 W/m²K

The values are orientative and their accuracy depends on different quality of building construction details and elimination of thermal bridges.

EVAUATION OF DETAIL OF TUBULAR LIGHT GUIDE LIGHTWAY WITH INSULATING BLUE PERFORMANCE COMPONENT



Type LW BP 1.0

Technical data
 $U=1.0 \text{ W/m}^2\text{K}$
 Double glass unit: 4-16-4 (Argon filling)
 Thermal insulation: Extruded polystyrene
 Thickness of the thermal insulation 120 mm
 Dimensions:
 LW 300 – 470x470 mm
 LW 400 – 570x570 mm
 LW 600 – 885x885 mm
 LW 800 – 1120x1120 mm
 Height: 120 mm

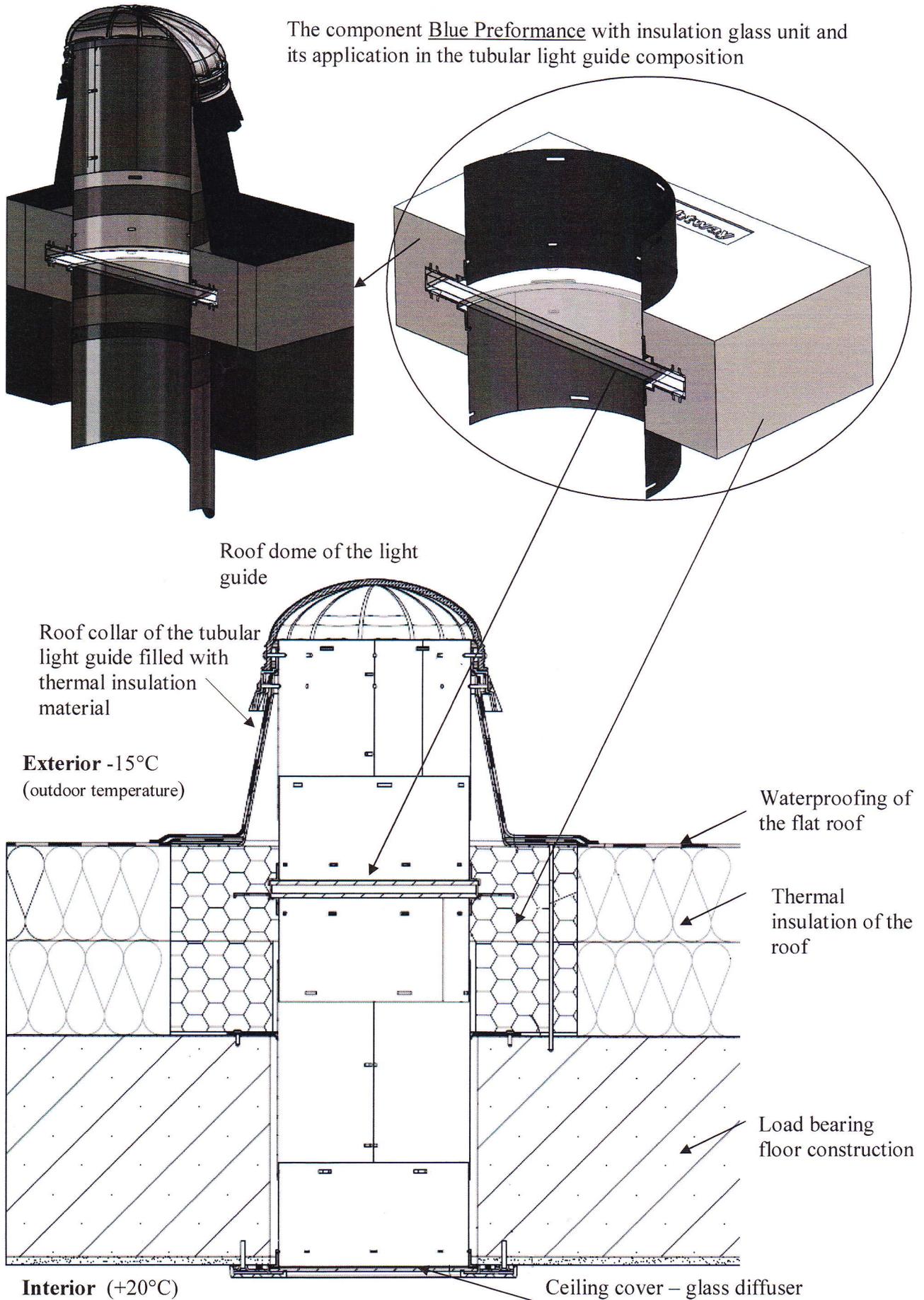
Type LW BP 0.6

Technical data
 $U=0.6 \text{ W/m}^2\text{K}$
 Triple glass unit: 4-16-4-16-4 (Argon filling)
 Thermal insulation: Extruded polystyrene
 Thickness of the thermal insulation 140 mm
 Dimensions:
 LW 300 – 470x470 mm
 LW 400 – 570x570 mm
 LW 600 – 885x885 mm
 LW 800 – 1120x1120 mm
 Height: 140 mm

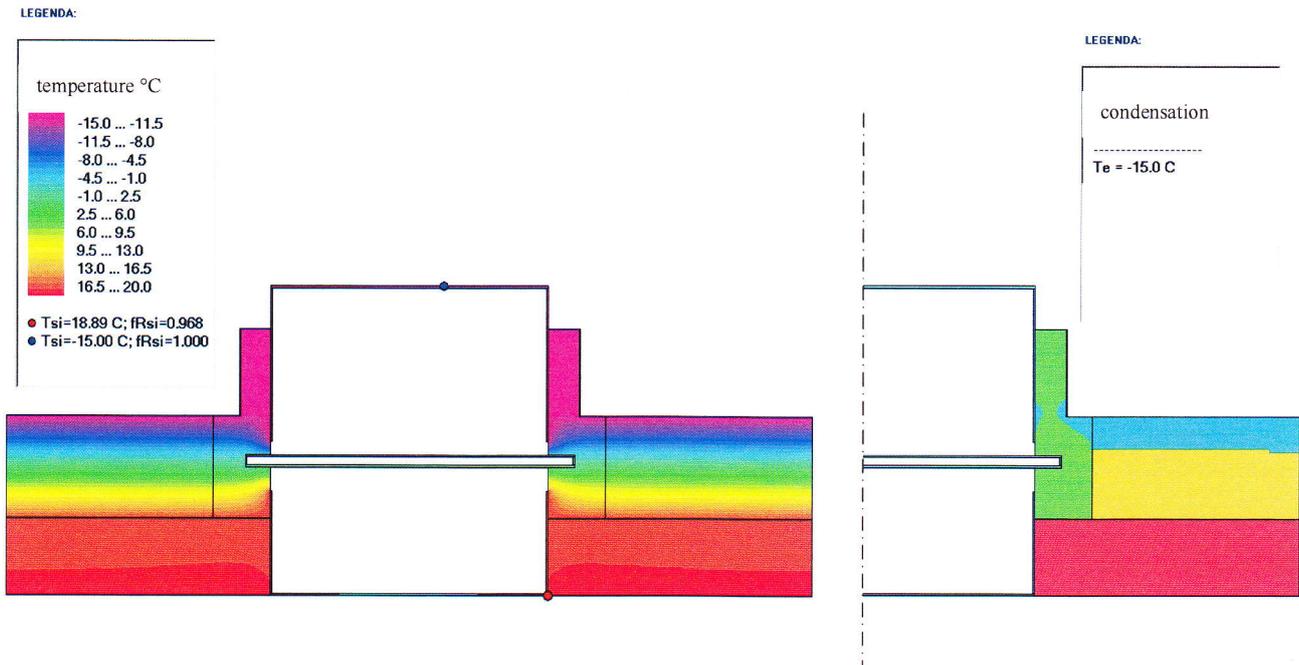
Patent pending no PV 2010-433
 Utility sample PUV 2010-22789

Detail of tubular light guide LIGHTWAY with insulatin component Blue Performance embedded into a flat roof

The component Blue Performance with insulation glass unit and its application in the tubular light guide composition



Evaluation of 2-D temperature profile and condensation region in the detail of the tubular light with the Blue Performance component applied in the flat room, simulated in the computer program Area 2009.



Determination of heat losses through transparent components of the tubular light guides LIGHTWAY with Blue Performance

Heat transmission loss Q_v through transparent components of the tubular light guide

$$Q_v = U \times A \times (\theta_i - \theta_e) \text{ [W]}$$

where

U ... overall heat loss coefficient [$\text{Wm}^{-2}\text{K}^{-1}$]

A ... cross sectional area of the tubular light guide [m^2]

θ_i ... indoor temperature [$^{\circ}\text{C}$]

θ_e ... outdoor temperature [$^{\circ}\text{C}$]

The tubular light guide diameter	Heat transmission loss of glass unit in the tubular light guide (without the roof dome and ceiling diffuser)	
	double glazed unit $U=1.0 \text{ Wm}^{-2}\text{K}^{-1}$	triple glazed unit $U=0.6 \text{ Wm}^{-2}\text{K}^{-1}$
220 mm	1.3 W	0.8 W
320 mm	2.8 W	1.7 W
520 mm	7.4 W	4.5 W
760 mm	15.9 W	9.5 W
The tubular light guide diameter	Heat transmission loss of the tubular light guide transparent components composition: roof dome + glass unit + ceiling diffuser	
	The whole composition $U=0.6 \text{ Wm}^{-2}\text{K}^{-1}$ (with double glazed unit $U=1.0 \text{ Wm}^{-2}\text{K}^{-1}$)	The whole composition $U=0.45 \text{ Wm}^{-2}\text{K}^{-1}$ (with triple glazed unit $U=0.6 \text{ Wm}^{-2}\text{K}^{-1}$)
220 mm	0.8 W	0.6 W
320 mm	1.7 W	1.3 W
520 mm	4.5 W	3.3 W
760 mm	9.5 W	7.2 W

Note: Determined for $\theta_i=20^{\circ}\text{C}$, $\theta_e=-15^{\circ}\text{C}$