# THERMAL SIMULATION REPORT

| | |
|---|---|
| *Report Number:* | **WIN2023-GGL-016** |
| *Prepared For:* | **Granada Glazing Ltd.<br>Campbell Way<br>Dinnington<br>Sheffield<br>S25 3QD** |
| *Primary (External) Window:* | **Timber frame, single 4mm float glass** |
| *Secondary (Internal) Window:* | **Slimline Hinged Unit<br>Single 6mm Pilkington K glass<br>Low Threshold** |
| *Notes:* | **Assumed minimum air gap of 50mm between primary and secondary windows.** |

## *Results*

| | | |
|---|---|---|
| *Thermal Transmittance – Primary Window* | **4.7** | *W/(m$^2$K)* |
| *Thermal Transmittance – Secondary Window* | **4.0** | *W/(m$^2$K)* |
| *Thermal Transmittance – Combined Windows* | **1.4** | *W/(m$^2$K)* |
| *Percentage Reduction compared to Primary* | **70** | *%* |

*(Window Configuration – 1230mm wide x 1480mm high as per the requirements of ADL and EN 14351)*

*Report Prepared By:* ***Dr Gary Morgan<br>Windata Ltd.<br>Maen Llwyd Cottage<br>Rudry<br>Caerphilly<br>CF83 3EB***

*Signed:* G Morgan

*Date:* ***28th April 2023***

*The simulations in this report were performed using Win Iso ® version 2.8.1, strictly in accordance with the requirements of BS EN ISO 10077-2:2017, using the radiosity approach to frame cavity modelling.*
*The overall window U value was determined in accordance with the requirements of BS EN ISO 10077-1:2017.*
*The simulation files and spreadsheet generated are attached to this report as appendices.*
*All material thermal conductivity values are taken from BS EN ISO 10077-2:2017 unless otherwise stated.*

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**Primary Window**

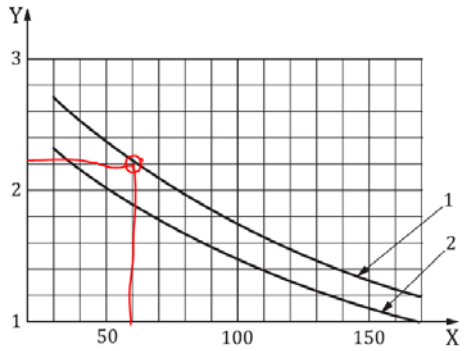
Primary window U-value estimate based on BS EN ISO 10077-1 – Annex F and Annex H.

Single-glazed hardwood window.

## Annex F

Assume 60mm solid hardwood frame: -

ISO 10077-1:2017(E)




Key

X thickness of frame, $d_f$, expressed in millimetres
Y thermal transmittance of frame, $U_f$, in W/(m²·K)
1 hardwood (density 700 kg/m³), λ = 0,18 W/(m·K)
2 softwood (density 500 kg/m³), λ = 0,13 W/(m·K)

**Figure F.2 — Thermal transmittances for wooden frames and metal-wood frames (see Figure F.3) depending on the frame thickness, $d_f$**

Gives $U_f$ = 2.2 W/(m²K)

## Annex H

Table H1 gives: -

**Table H.1 — Thermal transmittances, $U_w$, for vertical windows with fraction of the frame area 30 % of the whole window area, common types of glazing spacer bars**

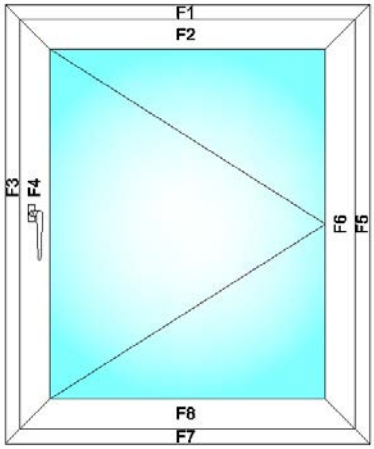
Values in W/(m²·K)

| Type of glazing | $U_g$ | Thermal transmittances, $U_w$, for vertical windows with fraction of the frame area 30 % of the whole window area for common types of glazing spacer bars and following $U_f$ values | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0,80 | 1,0 | 1,2 | 1,4 | 1,6 | 1,8 | 2,0 | 2,2 | 2,6 | 3,0 | 3,4 | 3,8 | 7,0 |
| Single | 5,8 | 4,3 | 4,4 | 4,4 | 4,5 | 4,5 | 4,6 | 4,7 | 4,7 | 4,8 | 5,0 | 5,1 | 5,2 | 6,1 |
| Double or triple | 3,3 | 2,7 | 2,8 | 2,8 | 2,9 | 2,9 | 3,0 | 3,1 | 3,2 | 3,3 | 3,4 | 3,5 | 3,6 | 4,5 |
| | 3,2 | 2,6 | 2,7 | 2,7 | 2,8 | 2,9 | 2,9 | 3,0 | 3,1 | 3,2 | 3,3 | 3,5 | 3,6 | 4,4 |
| | 3,1 | 2,6 | 2,6 | 2,7 | 2,7 | 2,8 | 2,9 | 2,9 | 3,0 | 3,1 | 3,3 | 3,4 | 3,5 | 4,3 |
| | 3,0 | 2,5 | 2,5 | 2,6 | 2,7 | 2,7 | 2,8 | 2,8 | 3,0 | 3,1 | 3,2 | 3,3 | 3,4 | 4,2 |
| | 2,9 | 2,4 | 2,5 | 2,5 | 2,6 | 2,7 | 2,7 | 2,8 | 2,9 | 3,0 | 3,1 | 3,2 | 3,4 | 4,2 |
| | 2,8 | 2,3 | 2,4 | 2,5 | 2,5 | 2,6 | 2,6 | 2,7 | 2,8 | 2,9 | 3,1 | 3,2 | 3,3 | 4,1 |
| | 2,7 | 2,3 | 2,3 | 2,4 | 2,5 | 2,5 | 2,6 | 2,6 | 2,7 | 2,9 | 3,0 | 3,1 | 3,2 | 4,0 |
| | 2,6 | 2,2 | 2,3 | 2,3 | 2,4 | 2,4 | 2,5 | 2,6 | 2,7 | 2,6 | 2,9 | 3,0 | 3,2 | 4,0 |
| | 2,5 | 2,1 | 2,2 | 2,3 | 2,3 | 2,4 | 2,4 | 2,5 | 2,6 | 2,5 | 2,8 | 3,0 | 3,1 | 3,9 |
| | 2,4 | 2,1 | 2,1 | 2,2 | 2,2 | 2,3 | 2,4 | 2,4 | 2,5 | 2,5 | 2,8 | 2,9 | 3,0 | 3,8 |
| | 2,3 | 2,0 | 2,1 | 2,1 | 2,2 | 2,2 | 2,3 | 2,4 | 2,5 | 2,4 | 2,7 | 2,8 | 3,0 | 3,8 |
| | 2,2 | 1,9 | 2,0 | 2,0 | 2,1 | 2,2 | 2,2 | 2,3 | 2,4 | 2,3 | 2,6 | 2,8 | 2,9 | 3,7 |
| | 2,1 | 1,9 | 1,9 | 2,0 | 2,0 | 2,1 | 2,2 | 2,2 | 2,3 | 2,3 | 2,6 | 2,7 | 2,8 | 3,6 |
| | 2,0 | 1,8 | 1,9 | 2,0 | 2,0 | 2,1 | 2,1 | 2,2 | 2,3 | 2,5 | 2,6 | 2,7 | 2,8 | 3,6 |
| | 1,9 | 1,8 | 1,8 | 1,9 | 1,9 | 2,0 | 2,1 | 2,1 | 2,3 | 2,4 | 2,5 | 2,5 | 2,7 | 3,6 |
| | 1,8 | 1,7 | 1,8 | 1,8 | 1,9 | 1,9 | 2,0 | 2,1 | 2,2 | 2,3 | 2,4 | 2,6 | 2,7 | 3,5 |
| | 1,7 | 1,6 | 1,7 | 1,7 | 1,8 | 1,9 | 1,9 | 2,0 | 2,1 | 2,2 | 2,4 | 2,5 | 2,6 | 3,4 |
| | 1,6 | 1,6 | 1,6 | 1,7 | 1,7 | 1,8 | 1,9 | 1,9 | 2,1 | 2,2 | 2,3 | 2,4 | 2,5 | 3,3 |
| | 1,5 | 1,5 | 1,5 | 1,6 | 1,7 | 1,7 | 1,8 | 1,8 | 2,0 | 2,1 | 2,2 | 2,3 | 2,5 | 3,3 |
| | 1,4 | 1,4 | 1,5 | 1,5 | 1,6 | 1,7 | 1,7 | 1,8 | 1,9 | 2,0 | 2,2 | 2,3 | 2,4 | 3,2 |
| | 1,3 | 1,3 | 1,4 | 1,5 | 1,5 | 1,6 | 1,6 | 1,7 | 1,8 | 2,0 | 2,1 | 2,2 | 2,3 | 3,1 |
| | 1,2 | 1,3 | 1,3 | 1,4 | 1,5 | 1,5 | 1,6 | 1,6 | 1,8 | 1,9 | 2,0 | 2,1 | 2,3 | 3,1 |
| | 1,1 | 1,2 | 1,3 | 1,3 | 1,4 | 1,4 | 1,5 | 1,6 | 1,7 | 1,8 | 1,9 | 2,1 | 2,2 | 3,0 |
| | 1,0 | 1,1 | 1,2 | 1,3 | 1,3 | 1,4 | 1,4 | 1,5 | 1,6 | 1,8 | 1,9 | 2,0 | 2,1 | 2,9 |
| | 0,9 | 1,1 | 1,1 | 1,2 | 1,2 | 1,3 | 1,4 | 1,4 | 1,6 | 1,7 | 1,8 | 1,9 | 2,0 | 2,9 |
| | 0,8 | 1,0 | 1,1 | 1,1 | 1,2 | 1,2 | 1,3 | 1,4 | 1,5 | 1,6 | 1,7 | 1,9 | 2,0 | 2,8 |
| | 0,7 | 0,93 | 0,99 | 1,0 | 1,1 | 1,2 | 1,2 | 1,3 | 1,4 | 1,5 | 1,7 | 1,8 | 1,9 | 2,7 |
| | 0,6 | 0,86 | 0,92 | 0,98 | 1,0 | 1,1 | 1,2 | 1,2 | 1,4 | 1,5 | 1,6 | 1,7 | 1,8 | 2,7 |
| | 0,5 | 0,79 | 0,85 | 0,91 | 0,97 | 1,0 | 1,1 | 1,2 | 1,3 | 1,4 | 1,5 | 1,6 | 1,8 | 2,6 |

Thus, $U_w$ of primary window = 4.7 W/(m²K)

## Secondary Window

### U Value / Energy Rating Spreadsheet - Single Opening Light Window / Roof Window




| | | | |
|---|---|---|---|
| Report No: | WIN2023-GG016 | | |
| Report Date: | 28 April 2023 | | |
| System Details | Slimline Hinged Unit - Low Threshold | | |
| Window Height | 1480 | mm | Air leakage /m @50 Pa |
| Window Width | 1230 | mm | |

| Glazing Properties | Glazing |
|---|---|
| U value (W/m$^2$K) | 3.6 |
| g value | |
| Light Transmission | |



| Frame Properties | $b_f$ (mm) | Frame Offset | Gasket Protrusion | Uf (W/m$^2$K) | ψ (W/mK) |
|---|---|---|---|---|---|
| F1 - Fixed Head Rail | 30.3 | | | 5.9859 | 0.0000 |
| F2 - Moving Head Rail | 27.0 | 0.0 | 2.0 | | |
| F3 - Fixed Lock Jamb | 30.3 | | | 5.9859 | 0.0000 |
| F4 - Moving Lock Jamb | 27.0 | 0.0 | 2.0 | | |
| F5 - Fixed Hinge Jamb | 30.3 | | | 5.9859 | 0.0000 |
| F6 - Moving Hinge Jamb | 27.0 | 0.0 | 2.0 | | |
| F7 - Fixed Sill | 7.5 | | | 7.5628 | 0.0000 |
| F8 - Moving Sill | 27.0 | 0.0 | 2.0 | | |

| Frame Element | Area (m$^2$) | Sight Line (m) | Heat Flow (W/K) | |
|---|---|---|---|---|
| F1+F2 - Head Rail | 0.06719571 | 1.12 | 0.4022268 | |
| F3+F4 - Lock Jamb | 0.08217393 | 1.39 | 0.491884928 | |
| F5+F6 - Hinge Jamb | 0.08217393 | 1.39 | 0.491884928 | |
| F12+F13 - Sill | 0.04045815 | 1.12 | 0.305976897 | Area inc. gaskets (m$^2$) |
| Glazing Pane | 1.54839828 | | 5.574233808 | 1.53839988 |
| | | Total | 7.26620736 | |
| Seal Length (m) | 5.22 | $L_{50}$(m$^3$/(m$^2$.h) | 0.00 | |

| | |
|---|---|
| Thermal Transmittance, W/(m$^2$.K) | 4.0 |
| Air Leakage Heat Loss, W/(m$^2$.K) | N/A |
| Solar Gain (g) value | N/A |
| Visible Light Transmittance value | N/A |
| Window Energy Rating, kWh/(m$^2$.yr) | N/A |
| Energy Rating Band | N/A |


**Note –** The linear thermal transmittance ($\Psi_g$) for the secondary glazing has been set at zero in accordance with BS EN ISO 10077-2, Clause 6.3.2.5

**Combined Windows**

## Determination of Thermal Performance of Secondary Glazing

$$U_W = \frac{1}{1/U_{W1} - R_{si} + R_s - R_{se} + 1/U_{W2}} \quad (4)$$

where

$U_{W1}, U_{W2}$ are the thermal transmittances of the external and internal window, respectively, calculated according to Formula (2);

$R_{si}$ is the internal surface resistance of the external window when used alone;

$R_{se}$ is the external surface resistance of the internal window when used alone;

$R_s$ is the thermal resistance of the space between the glazing in the two windows.

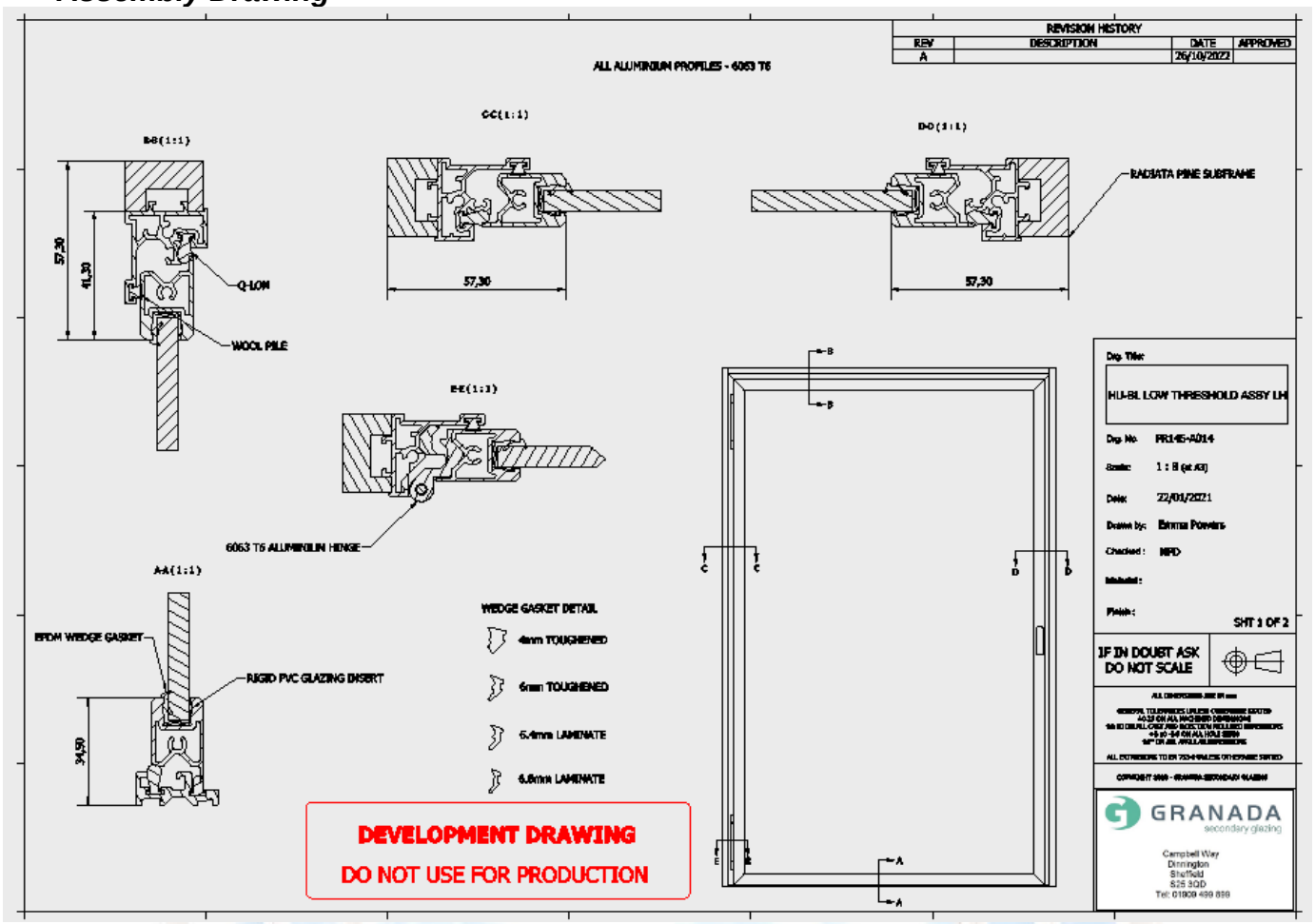
(BS EN ISO 10077-1:2017 Clause 6.4.2.1.2)

| | | | |
|---|---|---|---|
| $U_{W1}$ | **4.7** | W/(m$^2$.K) | Primary (External) Window |
| $U_{W2}$ | **4** | W/(m$^2$.K) | Secondary (Internal) Window |
| $R_{si}$ | **0.13** | m$^2$.K/W | (BS EN ISO 10077-1 - Annex D) |
| $R_{se}$ | **0.04** | m$^2$.K/W | (BS EN ISO 10077-1 - Annex D) |
| $R_s$ | **0.406** | m$^2$.K/W | (BS EN ISO 10077-1 - Annex E) |

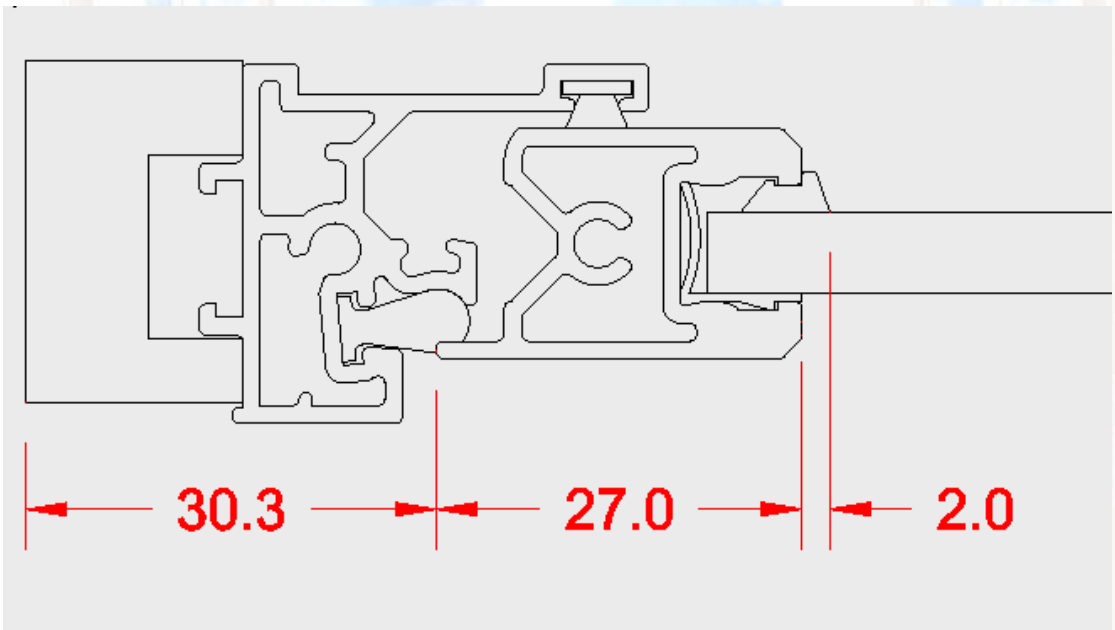
| | | |
|---|---|---|
| Thickness of Air Space | **50** | mm |

| | | |
|---|---|---|
| **$U_w$ - combined** | **1.4** | **W/(m$^2$.K)** |
| **$U_w$ reduction** | **70%** | **%** |

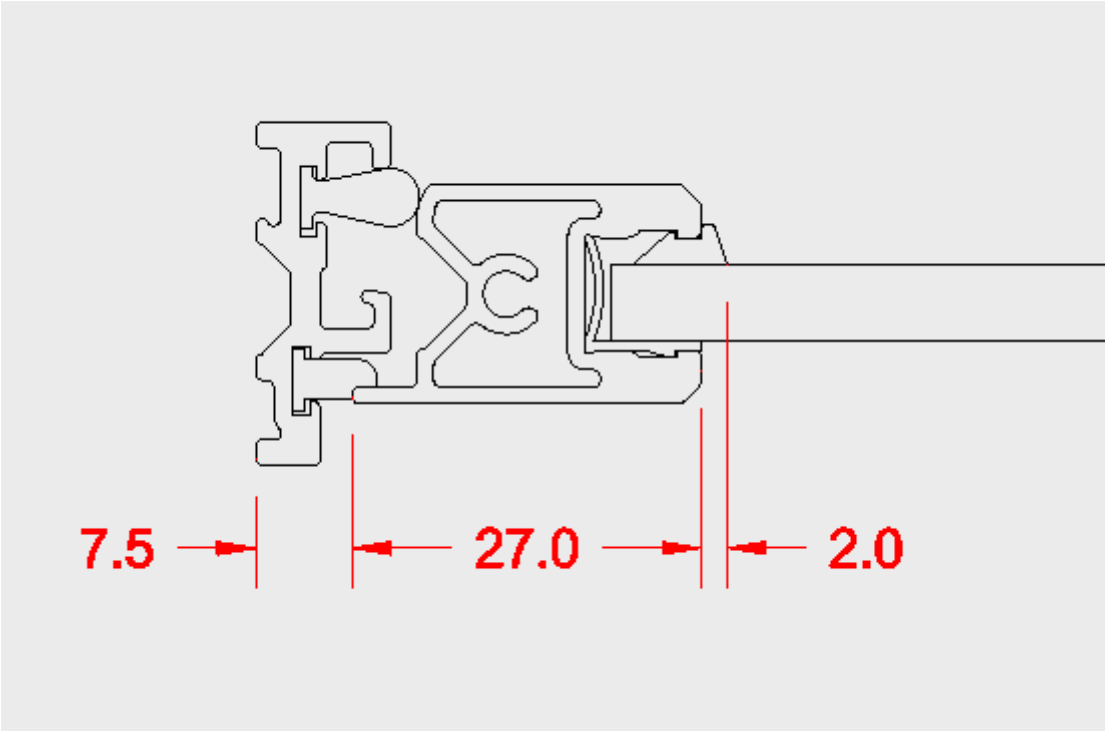
## *Assembly Drawing*




## *Frame Section*



***Low Threshold***

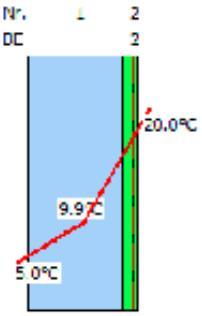


# Calculation SommerGlobal

**Project: 2022_12_19**
**Position: 01**

**Layer composition (outside to inside)**

| Number | BE | Description | mm |
|---|---|---|---|
| 1 | | Optifloat | 6.00 |
| 2 | 2 | K Glass N (en=13%) | |
| | | | 6.00 |




**Transmission, reflexion, absorption**

$\rho_v$ = 0.11 (Light reflection factor outside)
$\rho'_v$ = 0.12 (Light reflection factor inside)
$\rho_e$ = 0.10 (direct radiation reflection factor outside)
$\rho'_e$ = 0.11 (direct radiation reflection factor inside)
$\alpha_e$ 1 = 0.20 (direct radiation absorption factor)

$T_{UV}$ = **0.47** (ultraviolet transmittance)
$T_v$ = **0.82** (Light transmission)
$T_e$ = **0.70** (direct radiation transmission factor)
$R_a$ = 100 (general color rendering index (CRI))

**EN 410**

SC = 0.84 (Shading Coefficient, g/0,87)
b-Faktor = 0.91 (VDI 2078, g/0,80)

$q_i$ = **0.03** (secondary heat inside)
g = **0.73** (Total energy transmission factor)

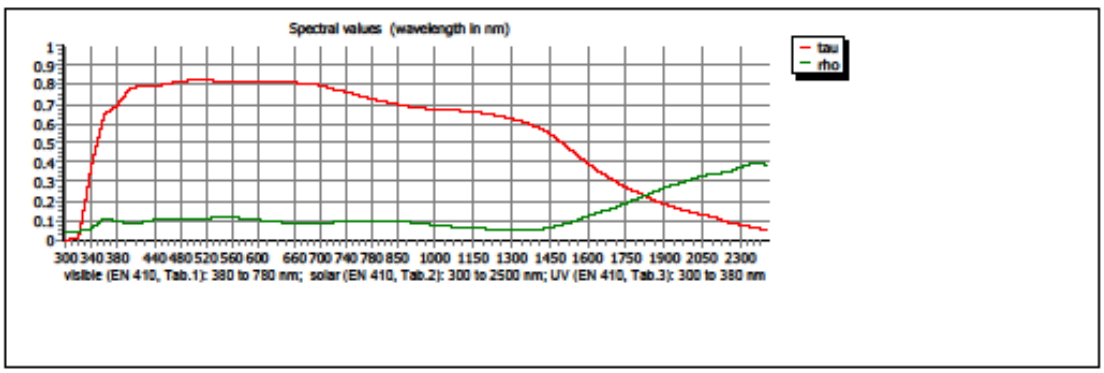
**EN 673** Installation angle = 90° vertical

$U_g$ = **3.6 W/m²K** (Heat transfer coefficient)
Corrected emissivity according to EN 12898:2019

**EN ISO 52022-3** $T_e$ = 5.00 °C $T_i$ = 20.00 °C

$g_{th}$ = 0.006 (Thermal radiation factor)
$g_c$ = 0.025 (Convection factor)
$g_v$ = 0.000 (Ventilation factor)

$E_s$ = 300.00 W/m² System height = 1.50 m
$h_{c,e}$ = 18.00 W/m²K $h_{c,i}$ = 3.60 W/m²K
$q_i$ = **0.031** (secondary heat inside)
$g_{tot}$ = **0.73** (Total energy transmission factor)



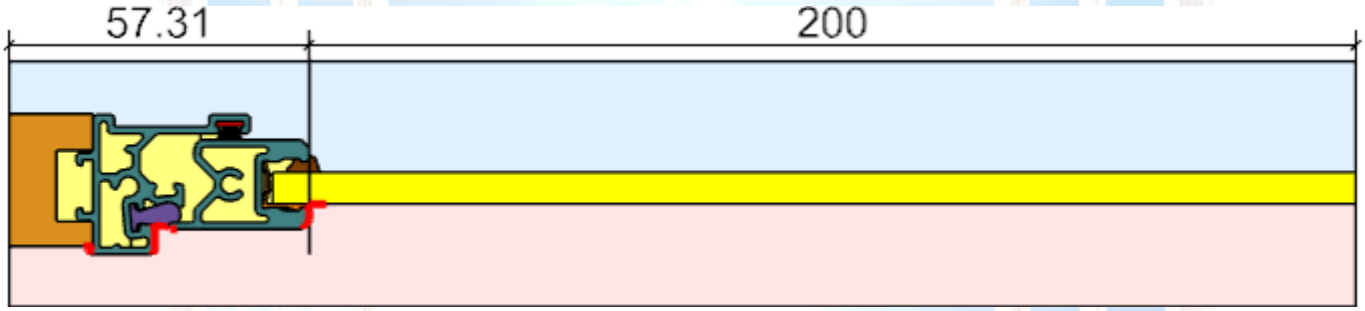



EN 410, EN 673, EN ISO 52022-3, EN 12898:2019

ift-certified lt. validation report no. 410 42167 (status as of 11/2009)
Registered for: Windata Ltd. - Windata Ltd.

## Simulation Models and Results

**Image: Uf**

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**$U_f$-Value**

$Q_{tot} = 18.567 \frac{W}{m}$ $\Delta T = 20$ K $L_{2D} = \frac{Qtot}{\Delta T} = 0.9283 \frac{W}{m \cdot K}$

$U_p = 2.926 \frac{W}{m \cdot K}$ Width of panel = 200 mm ($b_p$) Width of frame = 57 mm ($b_f$)

$$U_f = \frac{L2D - Up \cdot bp}{bf} = \frac{0.9283 - 2.9264 \cdot 0.20000}{0.05731} = 6.0\ (5.9859) \frac{W}{m^2K}$$

| | Boundaries | R [m²K/W] | T [°C] | Qges [W/m] |
|---|---|---|---|---|
| | Boundary condition external 0.04, 0°C, 80% | 0.040 | 0.000 | -18.567 |
| | Boundary condition internal 0.13, 20°C, 50% | 0.130 | 20.000 | 16.818 |
| | Boundary condition internal 20°C 0.20 | 0.200 | 20.000 | 1.749 |

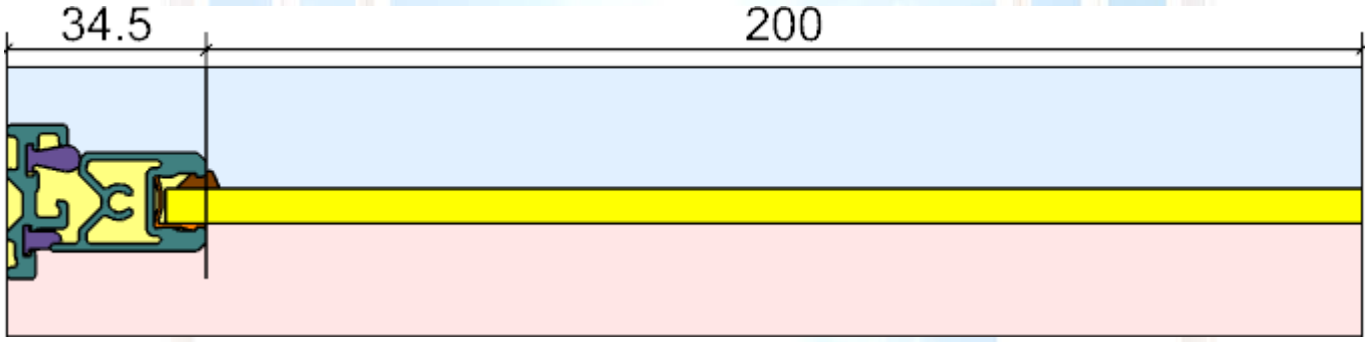
| | Solids | A [mm²] | λ [W/(mK)] | ε [-] |
|---|---|---|---|---|
| | 3 alu (Si-Leg.) 160 | 340.30 | 160.000 | 0.900 |
| | 3 PVC-U Hard | 12.43 | 0.170 | 0.900 |
| | 3 softwood Rd = 500 kg / m³ | 307.87 | 0.130 | 0.900 |
| | 4 ABS (acrylic-butadiene-styrene) | 5.30 | 0.200 | 0.900 |
| | 5 brush seal | 8.87 | 0.140 | 0.900 |
| | 5 EPDM | 12.93 | 0.250 | 0.900 |
| | 5 Qlon Declared Value | 34.75 | 0.041 | 0.900 |
| | Replacement panel EN ISO 10077-2 | 1244.02 | 0.035 | 0.900 |

| | Cavities | A [mm²] |
|---|---|---|
| | Unventilated air cavity - EN ISO 10077-2 | 496.91 |

## Calculation of Uf (EN ISO 10077)

Sommer Informatik

### Image: Uf

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### $U_f$-Value

$Q_{tot} = 16.924 \frac{W}{m}$ $\Delta T = 20$ K $L_{2D} = \frac{Qtot}{\Delta T} = 0.8462 \frac{W}{m \cdot K}$

$U_p = 2.926 \frac{W}{m \cdot K}$ Width of panel = 200 mm ($b_p$) Width of frame = 35 mm ($b_f$)

$$U_f = \frac{L2D - Up \cdot bp}{bf} = \frac{0.8462 - 2.9264 \cdot 0.20000}{0.03450} = 7.6\ (7.5628) \frac{W}{m^2K}$$

| | Boundaries | R [m²K/W] | T [°C] | Qges [W/m] |
|---|---|---|---|---|
| | Boundary condition external 0.04, 0°C, 80% | 0.040 | 0.000 | -16.924 |
| | Boundary condition internal 0.13, 20°C, 50% | 0.130 | 20.000 | 16.924 |

| | Solids | A [mm²] | λ [W/(mK)] | ε [-] |
|---|---|---|---|---|
| | 3 alu (Si-Leg.) 160 | 261.98 | 160.000 | 0.900 |
| | 3 PVC-U Hard | 12.43 | 0.170 | 0.900 |
| | 5 EPDM | 14.17 | 0.250 | 0.900 |
| | 5 Qlon Declared Value | 53.44 | 0.041 | 0.900 |
| | Replacement panel EN ISO 10077-2 | 1243.06 | 0.035 | 0.900 |

| | Cavities | A [mm²] |
|---|---|---|
| | Unventilated air cavity - EN ISO 10077-2 | 278.45 |