THERMAL SIMULATION REPORT

Report Number:	**WIN2022-GGL-003**
Prepared For:	**Granada Glazing Ltd. Campbell Way Dinnington Sheffield S25 3QD**
Primary (External) Window:	**Timber frame, single 4mm float glass**
Secondary (Internal) Window:	**Aluminium Vertical Slider, single 6mm Pilkington K glass**
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	**4.3**	*W/(m^{2}K)*
Thermal Transmittance – Combined Windows	**1.5**	*W/(m^{2}K)*
Percentage Reduction compared to Primary	**68**	*%*

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

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Signed: G Morgan

Date: ***22nd*** **December 2022**

The simulations in this report were performed using Win Iso ® version 2.8.0, 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.

Primary Window

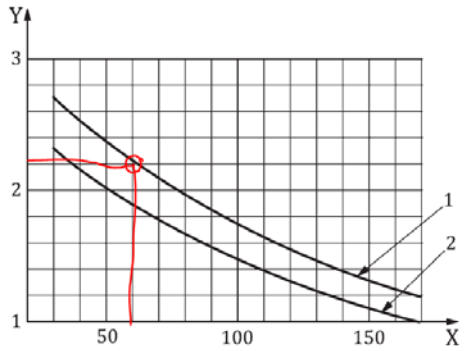
Primary window U-value estimate based on BS EN ISO 10077-1 – Annex F and Annex H.

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

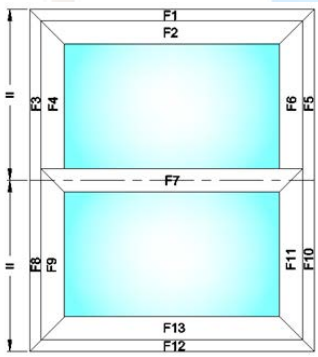
Values in W/(m²·K)

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 - Vertical Sliding Sash Window



Report No:	WIN2022-GGL003	
Report Date:	22 December 2022	
System Details	Balanced Vertical Sliding Secondary Glazing	
Window Height	1480 mm	Air leakage /m @50 Pa
Window Width	1230 mm	

Glazing Properties	Upper Pane	Lower Pane
U value (W/m^{2}K)	3.6	3.6
g value		0
Light Transmission		0

Frame Properties	b_f (mm)	Frame Offset	Gasket Protrusion	Uf (W/m^{2}K)	ψ (W/mK)
F1 - Fixed Head Rail	42.0			9.2823	0.0000
F2 - Moving Head Rail	9.9	0.0	2.0		
F3 - Fixed Upper Left Jamb	42.0			7.9624	0.0000
F4 - Moving Upper Left Jamb	15.2	0.0	2.0		
F5 - Fixed Upper Right Jamb	42.0			7.9624	0.0000
F6 - Moving Upper Right Jamb	15.2	0.0	2.0		
F7 - Meeting Rail	22.0	0.0	2.0	10.6104	0.0000
		0.0	2.0		
F8 - Fixed Lower Left Jamb	42.0			6.4886	0.0000
F9 - Moving Lower Left Jamb	15.2	0.0	2.0		
F10 - Fixed Lower Right Jamb	42.0			6.4886	0.0000
F11 - Moving Lower Right Jamb	15.2	0.0	2.0		
F12 - Fixed Sill	42.0			7.8687	0.0000
F13 - Moving Sill	9.9	0.0	2.0		

Frame Element	Area (m^2)	Sight Line (m)	Heat Flow (W/K)	
F1+F2 - Head Rail	0.06086832	1.12	0.564998007	
F3+F4 - Upper Left Jamb	0.04021446	0.68	0.320203616	
F5+F6 - Upper Right Jamb	0.04021446	0.68	0.320203616	
F7 - Meeting Rail	0.0258016	1.12	0.273765297	
F8+F9 - Lower Left Jamb	0.04021446	0.68	0.260935545	Area inc. gaskets and allowing for rebated head and jamb frames
F10+F11 - Lower Right Jamb	0.04021446	0.68	0.260935545	
F12+F13 - Sill	0.06086832	1.12	0.47895455	
Upper Glazing Pane	0.75537276		2.719341936	0.76777176
Lower Glazing Pane	0.75537276		2.719341936	0.75989256
		Total	7.918680048	
Seal Length (m)	6.2	L_{50}(m^3/(m^2.h)	0.00	

Thermal Transmittance, W/(m^2.K)	4.3
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 (Ψ_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.

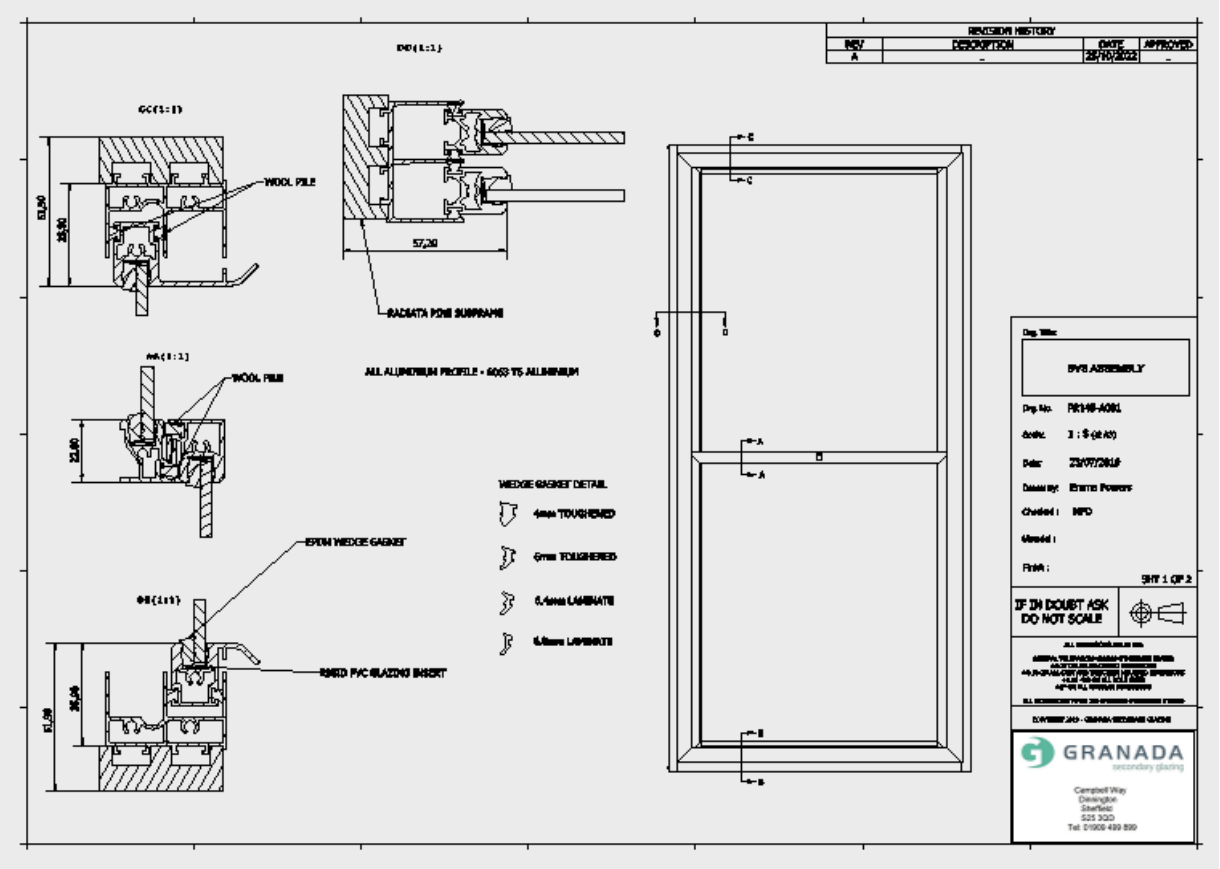
(BS EN ISO 10077-1:2017 Clause 6.4.2.1.2)

U_{W1}	**4.7**	W/(m².K)	Primary (External) Window
U_{W2}	**4.3**	W/(m².K)	Secondary (Internal) Window
R_{si}	**0.13**	m².K/W	(BS EN ISO 10077-1 - Annex D)
R_{se}	**0.04**	m².K/W	(BS EN ISO 10077-1 - Annex D)
R_s	**0.406**	m².K/W	(BS EN ISO 10077-1 - Annex E)

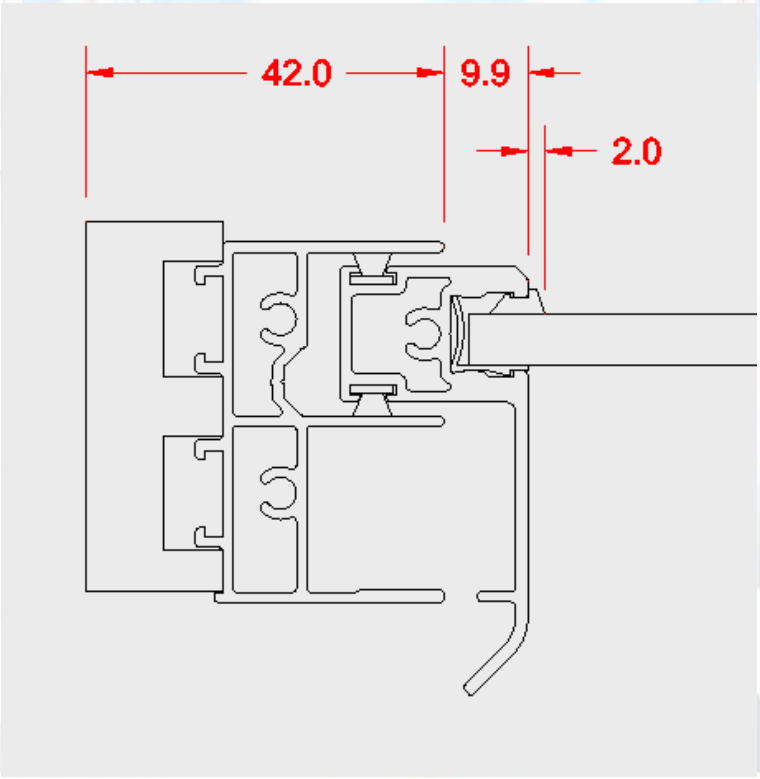
Thickness of Air Space	**50**	mm

U_w - combined	**1.5**	**W/(m².K)**
U_w reduction	**68%**	**%**

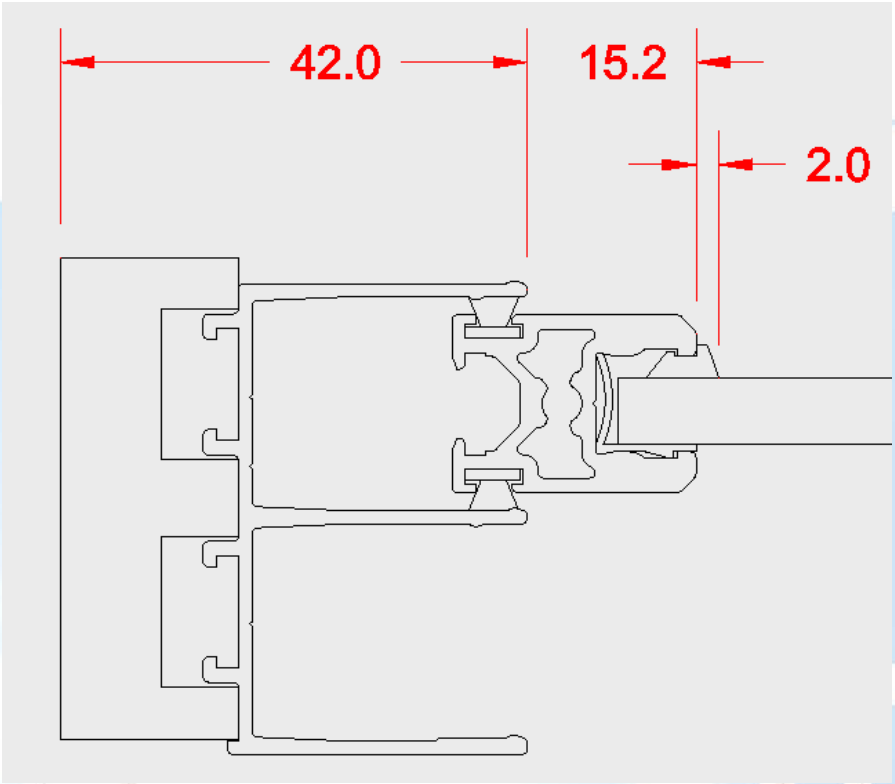
Assembly Drawing



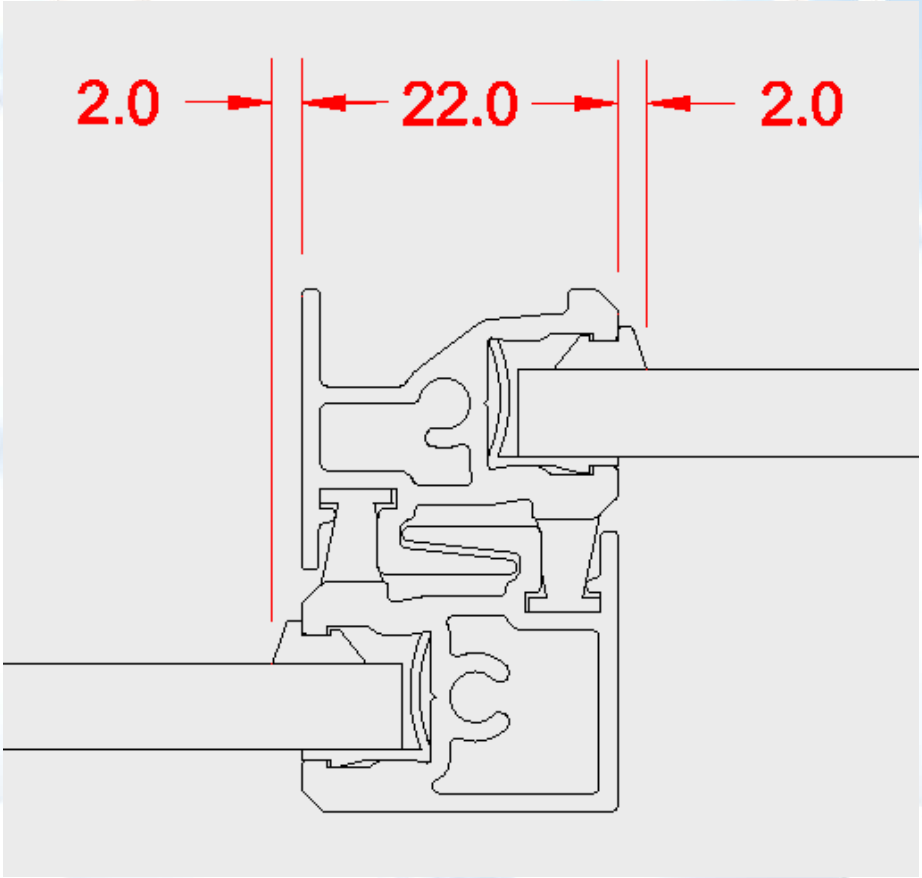
Head Rail Frame Section



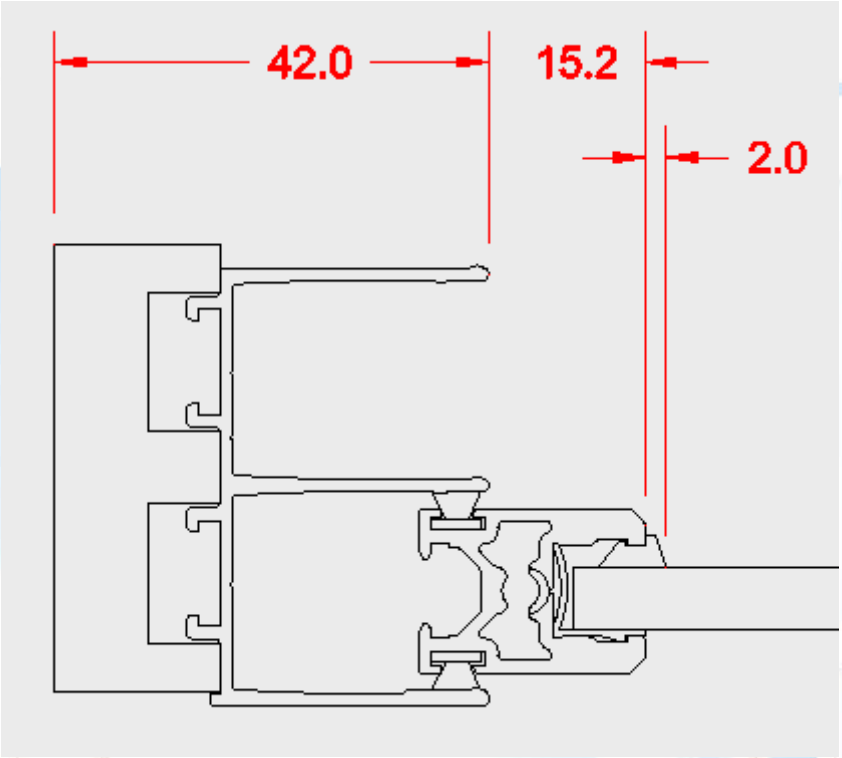
Upper Jamb Frame Section



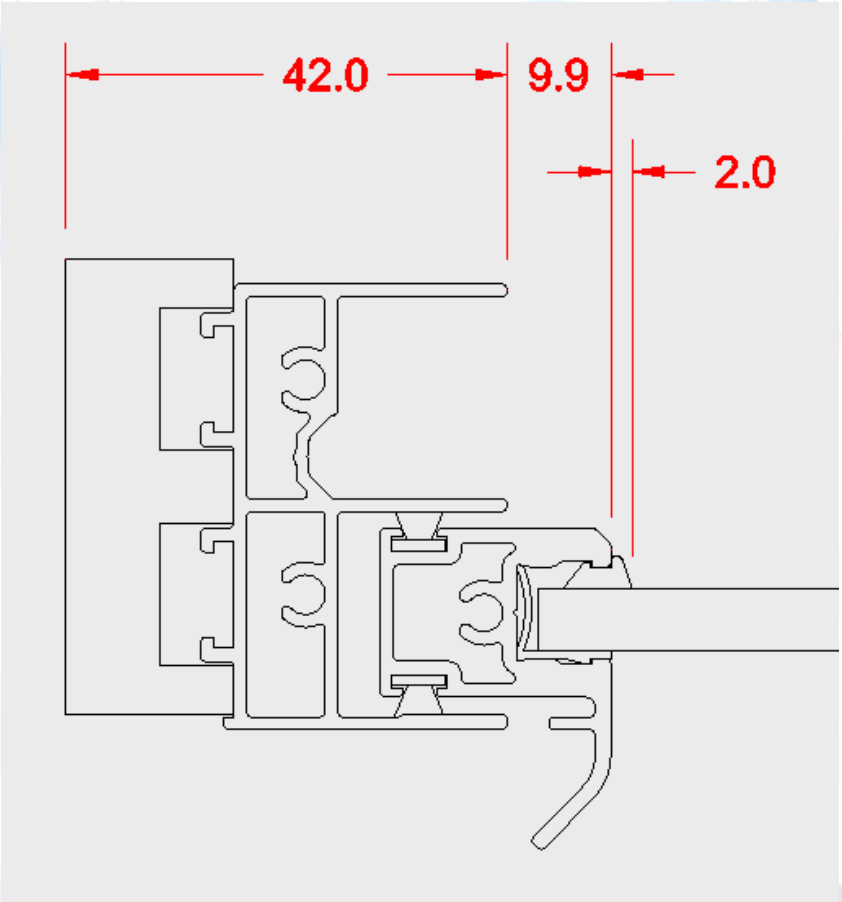
Mid-Rail Frame Section



Lower Jamb Frame Section



Sill Frame Section



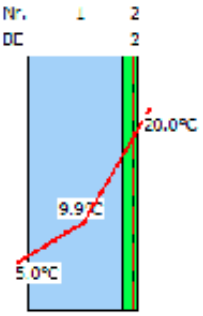
Glazing Performance

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 (εn=13%)	
			6.00



Transmission, reflexion, absorption

ρ_v = 0.11 (Light reflection factor outside)
ρ'_v = 0.12 (Light reflection factor inside)
ρ_e = 0.10 (direct radiation reflection factor outside)
ρ'_e = 0.11 (direct radiation reflection factor inside)
α_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)

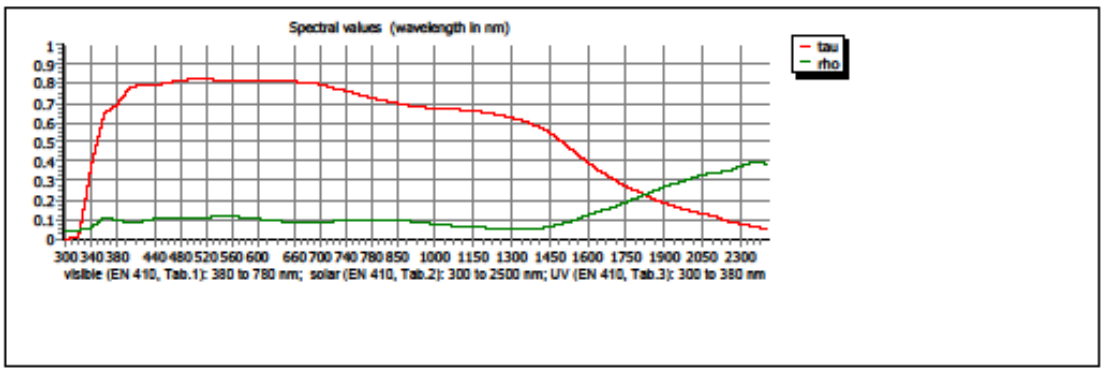
EN 673 Installation angle = 90° vertical

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)

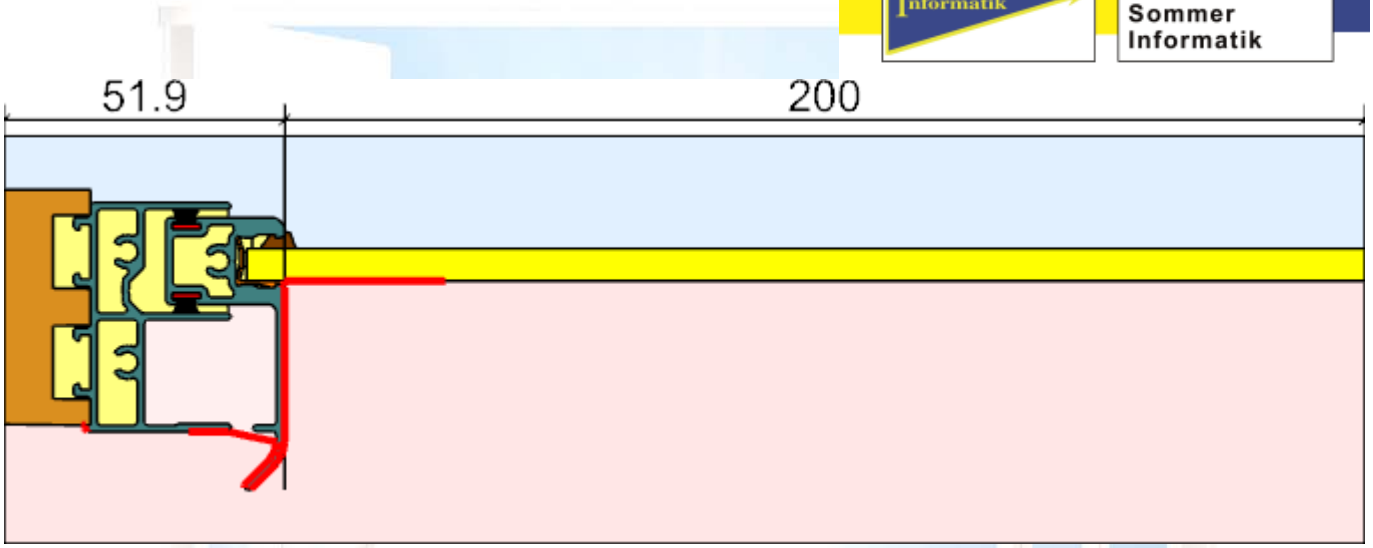


EN 410, EN 673, EN ISO 52022-3, EN 12898:2019

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

Simulation Models and Results

Image: Uf



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U_f-Value

$Q_{tot} = 21.351 \frac{W}{m}$ $\Delta T = 20$ K $L_{2D} = \frac{Qtot}{\Delta T} = 1.0675 \frac{W}{m \cdot K}$

$U_p = 2.929 \frac{W}{m \cdot K}$ Width of panel = 200 mm (b_p) Width of frame = 52 mm (b_f)

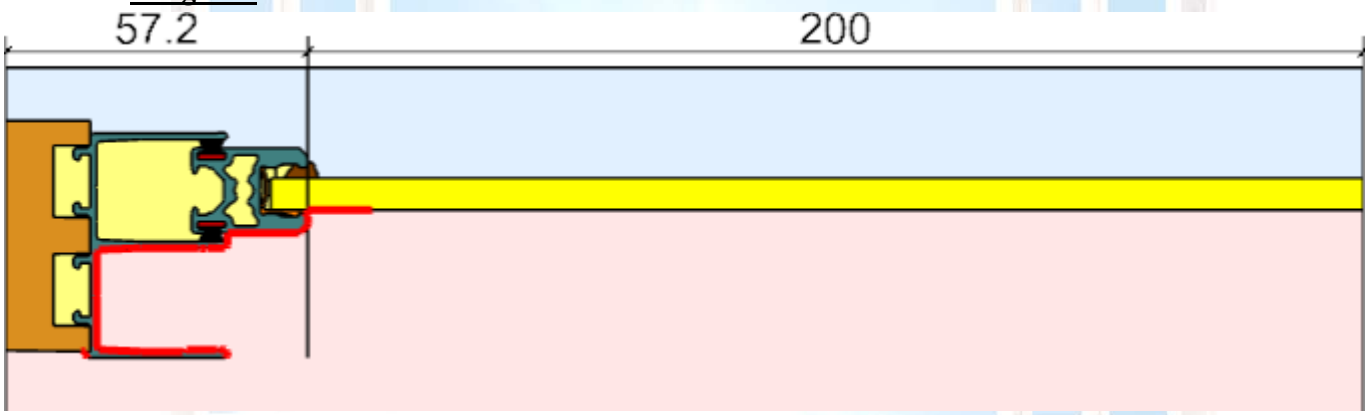
$$U_f = \frac{L2D - Up \cdot bp}{bf} = \frac{1.0675 - 2.9289 \cdot 0.20000}{0.05190} = 9.3\ (9.2823) \frac{W}{m^2K}$$

	Boundaries	R [m²K/W]	T [°C]	Qges [W/m]
	Boundary condition external 0.04, 0°C, 80%	0.040	0.000	-21.351
	Boundary condition internal (SVC) 0.30; 20°C	0.300	20.000	3.775
	Boundary condition internal 0.13, 20°C, 50%	0.130	20.000	12.716
	Boundary condition internal 20°C 0.20	0.200	20.000	4.860

	Solids	A [mm²]	λ [W/(mK)]	ε [-]
	3 alu (Si-Leg.) 160	443.65	160.000	0.900
	3 PVC-U Hard	12.50	0.170	0.900
	3 softwood Rd = 500 kg / m³	505.18	0.130	0.900
	4 ABS (acrylic-butadiene-styrene)	10.60	0.200	0.900
	5 brush seal	19.01	0.140	0.900
	5 EPDM	12.91	0.250	0.900
	Replacement panel EN ISO 10077-2	1242.00	0.035	0.900

	Cavities	A [mm²]
	Unventilated air cavity - EN ISO 10077-2	660.71

Image: Uf



U_f-Value

$Q_{tot} = 20.824 \frac{W}{m}$ $\Delta T = 20$ K $L_{2D} = \frac{Qtot}{\Delta T} = 1.0412 \frac{W}{m \cdot K}$

$U_p = 2.929 \frac{W}{m \cdot K}$ Width of panel = 200 mm (b_p) Width of frame = 57 mm (b_f)

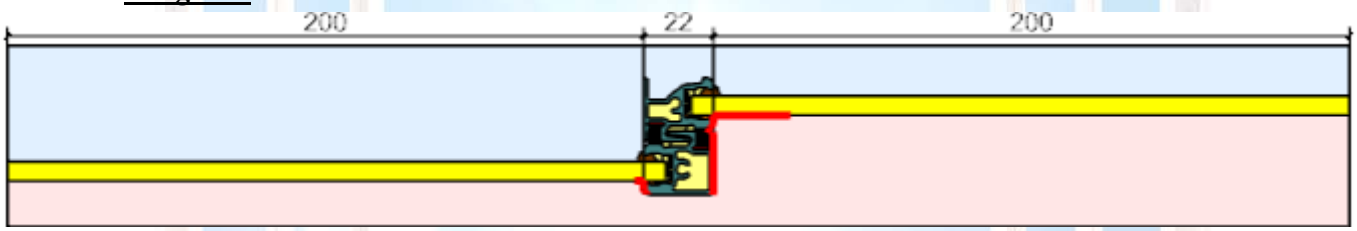
$$\mathbf{U_f = \frac{L2D - Up \cdot bp}{bf} = \frac{1.0412 - 2.9289 \cdot 0.20000}{0.05720} = 8.0\ (7.9624) \frac{W}{m^2K}}$$

	Boundaries	R [m²K/W]	T [°C]	Qges [W/m]
	Boundary condition external 0.04, 0°C, 80%	0.040	0.000	-20.824
	Boundary condition internal (SVC) 0.30; 20°C	0.300	20.000	0.300
	Boundary condition internal 0.13, 20°C, 50%	0.130	20.000	14.203
	Boundary condition internal 20°C 0.20	0.200	20.000	6.321

	Solids	A [mm²]	λ [W/(mK)]	ε [-]
	3 alu (Si-Leg.) 160	316.93	160.000	0.900
	3 PVC-U Hard	12.50	0.170	0.900
	3 softwood Rd = 500 kg / m³	505.17	0.130	0.900
	4 ABS (acrylic-butadiene-styrene)	10.60	0.200	0.900
	5 brush seal	18.29	0.140	0.900
	5 EPDM	12.91	0.250	0.900
	Replacement panel EN ISO 10077-2	1242.00	0.035	0.900

	Cavities	A [mm²]
	Unventilated air cavity - EN ISO 10077-2	641.86

Image: Uf



U_f-Value

$Q_{tot} = 28.100 \frac{W}{m}$ $\Delta T = 20$ K $L_{2D} = \frac{Qtot}{\Delta T} = 1.4050 \frac{W}{m \cdot K}$

$U_p = 2.929 \frac{W}{m \cdot K}$ Width of panel = 200 mm (b_p) Width of frame = 22 mm (b_f)

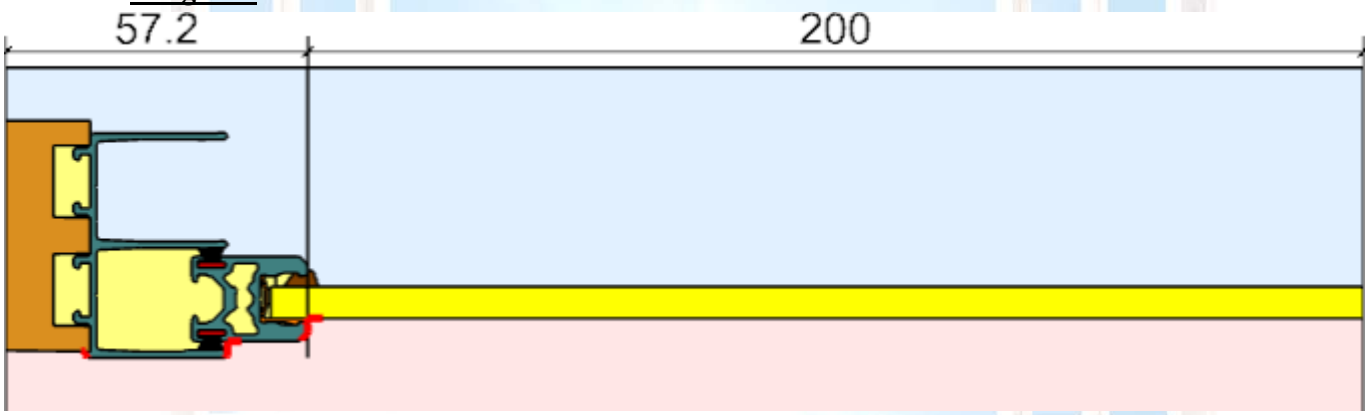
$$U_f = \frac{L2D - Up \cdot bp}{bf} = \frac{1.4050 - 2.9289 \cdot 0.20000 - 2.9289 \cdot 0.20000}{0.02200} = 11\ (10.6104) \frac{W}{m^2K}$$

	Boundaries	R [m²K/W]	T [°C]	Qges [W/m]
	Boundary condition external 0.04, 0°C, 80%	0.040	0.000	-28.100
	Boundary condition internal 0.13, 20°C, 50%	0.130	20.000	24.181
	Boundary condition internal 20°C 0.20	0.200	20.000	3.918

	Solids	A [mm²]	λ [W/(mK)]	ε [-]
	3 alu (Si-Leg.) 160	300.92	160.000	0.900
	3 PVC-U Hard	25.02	0.170	0.900
	4 ABS (acrylic-butadiene-styrene)	10.60	0.200	0.900
	5 brush seal	37.62	0.140	0.900
	5 EPDM	25.81	0.250	0.900
	Replacement panel EN ISO 10077-2	2484.00	0.035	0.900

	Cavities	A [mm²]
	Unventilated air cavity - EN ISO 10077-2	244.41

Image: Uf



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U_f-Value

$Q_{tot} = 19.138 \frac{W}{m}$ $\Delta T = 20$ K $L_{2D} = \frac{Qtot}{\Delta T} = 0.9569 \frac{W}{m \cdot K}$

$U_p = 2.929 \frac{W}{m \cdot K}$ Width of panel = 200 mm (b_p) Width of frame = 57 mm (b_f)

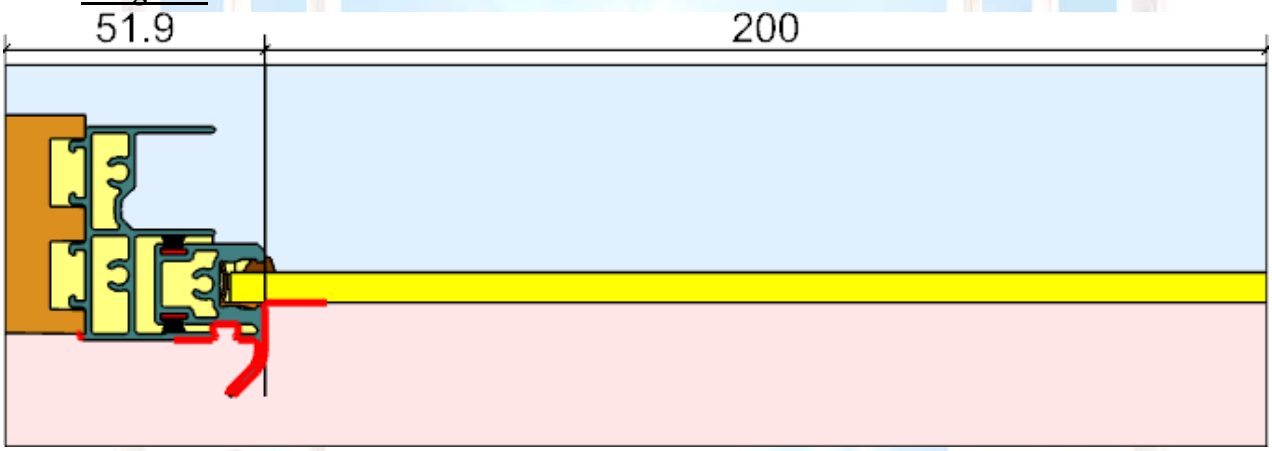
$$U_f = \frac{L2D - Up \cdot bp}{bf} = \frac{0.9569 - 2.9289 \cdot 0.20000}{0.05720} = 6.5\ (6.4886) \frac{W}{m^2K}$$

	Boundaries	R [m²K/W]	T [°C]	Qges [W/m]
	Boundary condition external 0.04, 0°C, 80%	0.040	0.000	-19.138
	Boundary condition internal (SVC) 0.30; 20°C	0.300	20.000	0.370
	Boundary condition internal 0.13, 20°C, 50%	0.130	20.000	17.659
	Boundary condition internal 20°C 0.20	0.200	20.000	1.109

	Solids	A [mm²]	λ [W/(mK)]	ε [-]
	3 alu (Si-Leg.) 160	317.45	160.000	0.900
	3 PVC-U Hard	12.50	0.170	0.900
	3 softwood Rd = 500 kg / m³	505.17	0.130	0.900
	4 ABS (acrylic-butadiene-styrene)	10.62	0.200	0.900
	5 brush seal	18.74	0.140	0.900
	5 EPDM	12.91	0.250	0.900
	Replacement panel EN ISO 10077-2	1242.00	0.035	0.900

	Cavities	A [mm²]
	Unventilated air cavity - EN ISO 10077-2	645.82

Image: Uf



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U_f-Value

$Q_{tot} = 19.883 \frac{W}{m}$ $\Delta T = 20$ K $L_{2D} = \frac{Qtot}{\Delta T} = 0.9942 \frac{W}{m \cdot K}$

$U_p = 2.929 \frac{W}{m \cdot K}$ Width of panel = 200 mm (b_p) Width of frame = 52 mm (b_f)

$$U_f = \frac{L2D - Up \cdot bp}{bf} = \frac{0.9942 - 2.9289 \cdot 0.20000}{0.05190} = 7.9\ (7.8687) \frac{W}{m^2K}$$

	Boundaries	R [m²K/W]	T [°C]	Qges [W/m]
	Boundary condition external 0.04, 0°C, 80%	0.040	0.000	-19.883
	Boundary condition internal 0.13, 20°C, 50%	0.130	20.000	14.691
	Boundary condition internal 20°C 0.20	0.200	20.000	5.192

	Solids	A [mm²]	λ [W/(mK)]	ε [-]
	3 alu (Si-Leg.) 160	413.75	160.000	0.900
	3 PVC-U Hard	12.50	0.170	0.900
	3 softwood Rd = 500 kg / m³	505.18	0.130	0.900
	4 ABS (acrylic-butadiene-styrene)	10.60	0.200	0.900
	5 brush seal	18.90	0.140	0.900
	5 EPDM	12.91	0.250	0.900
	Replacement panel EN ISO 10077-2	1242.00	0.035	0.900

	Cavities	A [mm²]
	Unventilated air cavity - EN ISO 10077-2	652.35