Curtain Curtain Wall & Architectural Cladding

Swiss Middle East

Design - Engineering - Planning - Consulting

UCS SYSTEM

ITEM

U – VALUE ANALYSIS FOR TYPICAL FACADE

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CHAPTER 1

INTRODUCTION

Thermal analysis presented in this document to verify the typical curtain wall thermal performance by calculating the thermal transmittance of frame & panel using approved simulation program, Flixo. Analysis carried out in accordance with EN ISO standards.

CHAPTER 2

DESIGN CRITERIA & SPECIFICATIONS

2.1 Properties of Glass:

Density of Glass	=	25 kN/m^3
Modulus of elasticity, E	=	71700 N/mm^2
Co-efficient of thermal Expansion	=	8.8 x 10^{-06} / ^{0}C
U – Value (Glass Type: E-Lite Blue Green 30) (6mm Emicool Solite Mistral 47/29 + 16AG (90% Argon gas) + 6mm Clear Glass)	=	1.07 W/m^{2}K (Glass performance Data - Attached)

2.2 Reference Standards

EN ISO 10077-1:2006 – Thermal Performance of Windows, doors & Shutters – Calculation of Thermal Transmittance – Part 1: Simplified Method

EN ISO 10077-2 – Thermal Performance of Windows, doors & Shutters – Calculation of Thermal Transmittance – Part 2: Numerical Method

2.3 Computer Programs used in Calculation Set

Flixo Pro 8.0.920.1

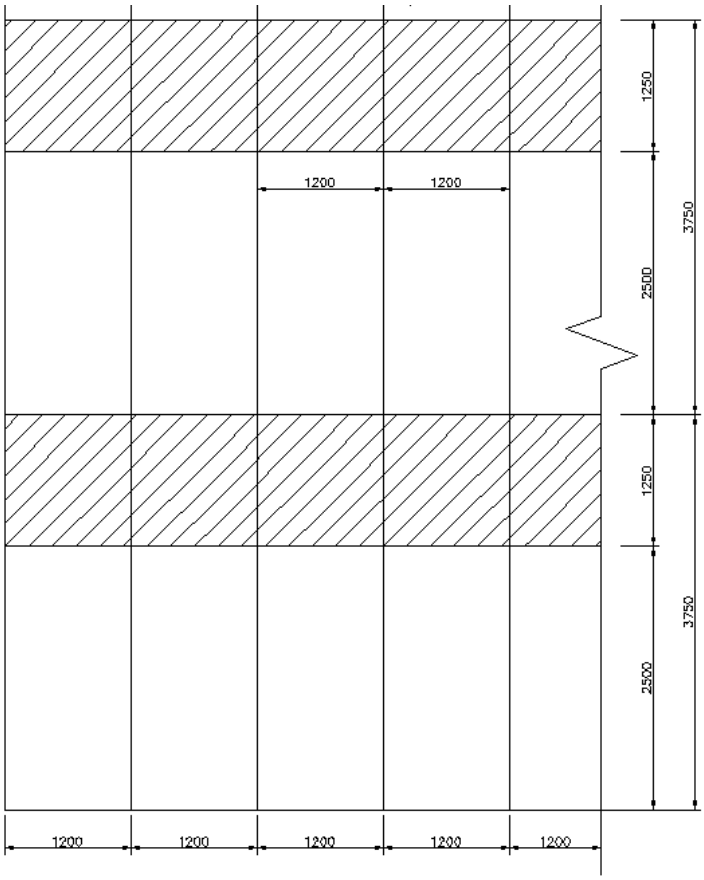
2.4 Environmental Condition: (As per EN ISO 10077-2 & EN ISO 6946)

Outdoor Condition of the Building	-10^{o}C
Indoor Condition of the Building	20^{o}C

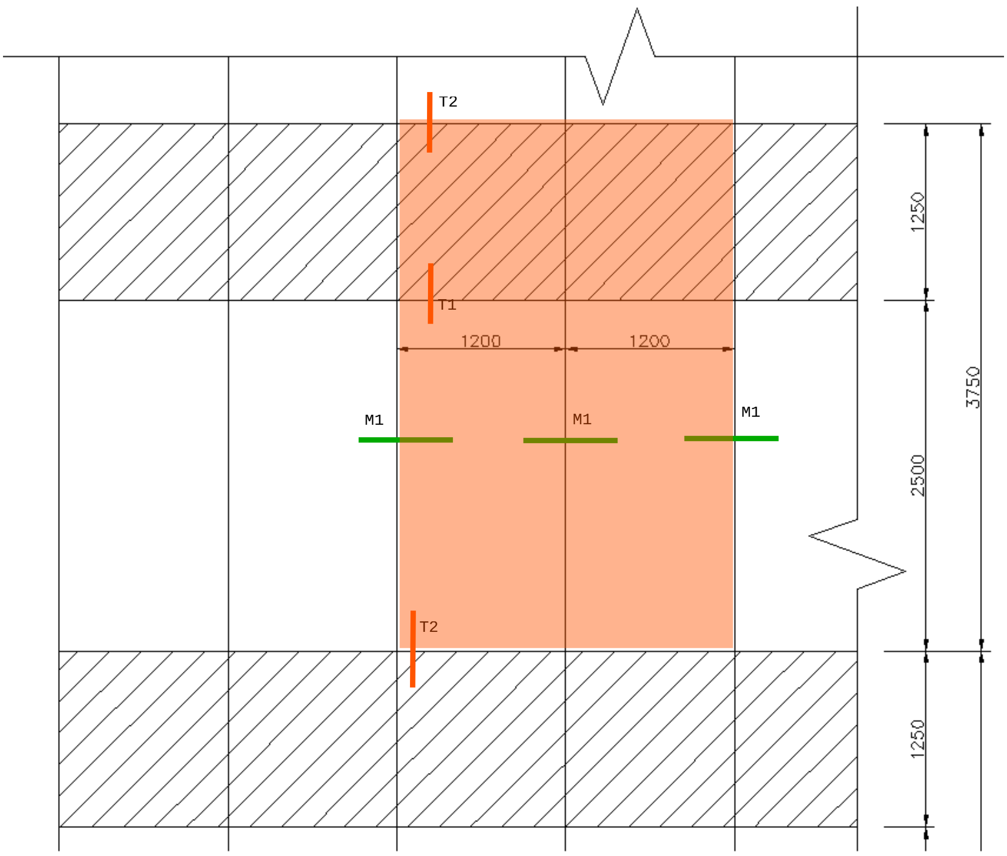
CHAPTER - 3

RELATED DRAWINGS

Reference Part Elevation:



Panel Considered for Analysis:



CHAPTER - 4

DETERMINATION OF U - VALUE

Determination Curtain Wall - U Factor:

Thermal transmittance of curtain wall U_w is calculated as per BS EN ISO 10077-1 2000.

$$U_W = \frac{A_g U_g + A_f U_f + l_g \Psi_g}{A_g + A_f}$$

Where,

A_g – Area of glass

U_g – Thermal transmittance of glass

A_f – Area of frame

U_f – Thermal transmittance of frame

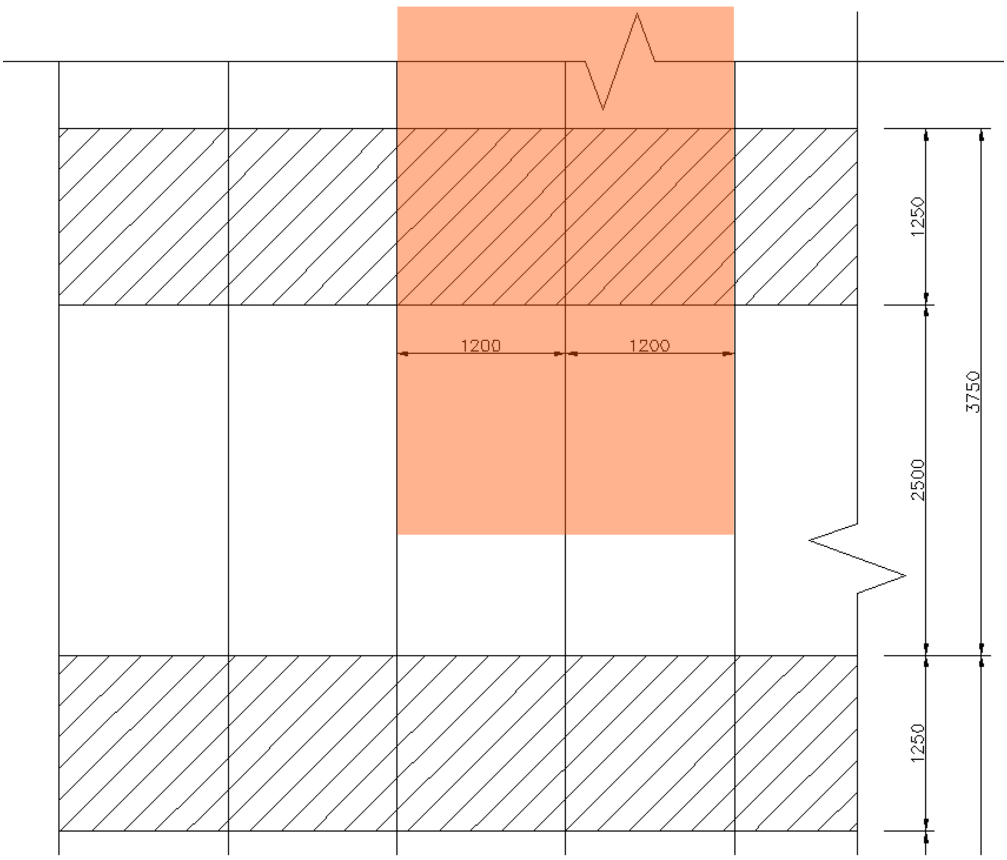
L_g – Length of Edge seal

Ψ_g – Linear thermal transmittance of due to effects of glazing, spacer & frame.

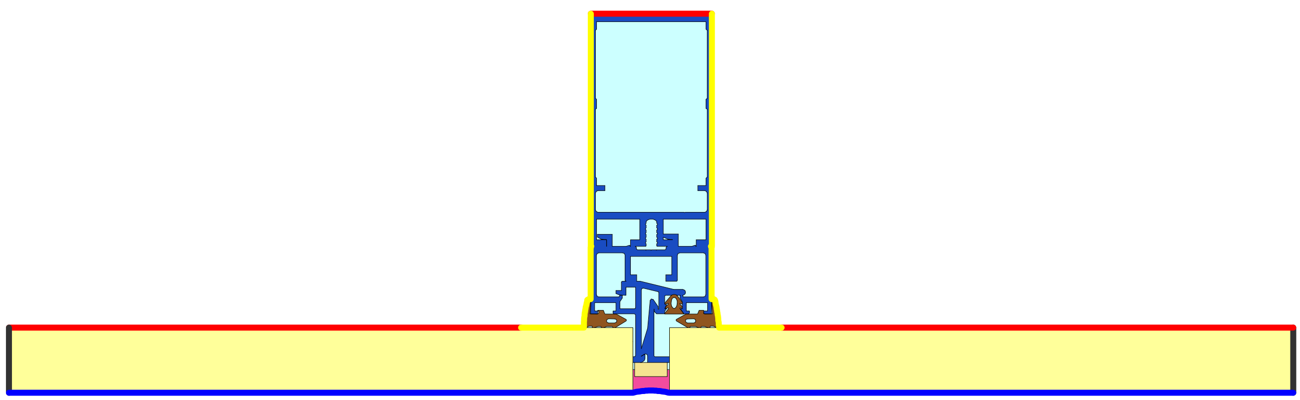
Note:

Thermal transmittance of the frame and linear thermal transmittance is calculated using Flixo software. And thermal transmittance of glass is used as per glass performance data. (Data sheet attached for reference)

To determine the thermal transmittance of frame, 2 No's of horizontal section and 2 No's vertical section considered as shown below.



TYPICAL MULLION (M1) INPUT:



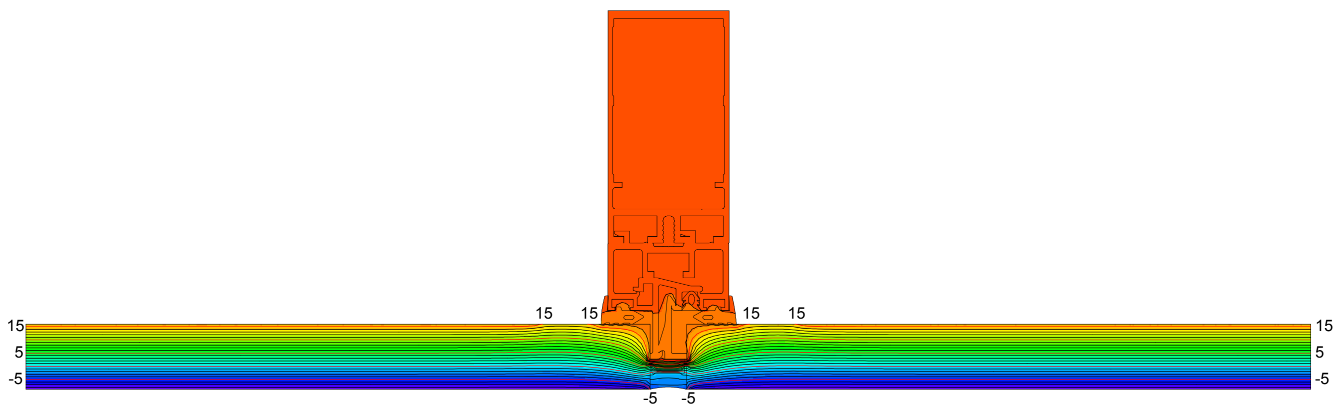
Material	λ[W/(m·K)]
Aluminium (Si Alloys)	160.000
EPDM (ethylene propylene diene monomer)	0.250
Elastomeric foam, flexible	0.050
Panel	0.035
Silicone, filled	0.500
Unventilated air cavity **	

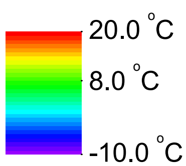
** Simplified approach

Boundary Condition	q[W/m^2]	θ[°C]	R[(m^2·K)/W]
Exterior, normal		-10.000	0.040
Interior, frame, normal		20.000	0.130
Interior, frame, reduced		20.000	0.200
Symmetry/Model section	0.000		

TYPICAL MULLION (M1):

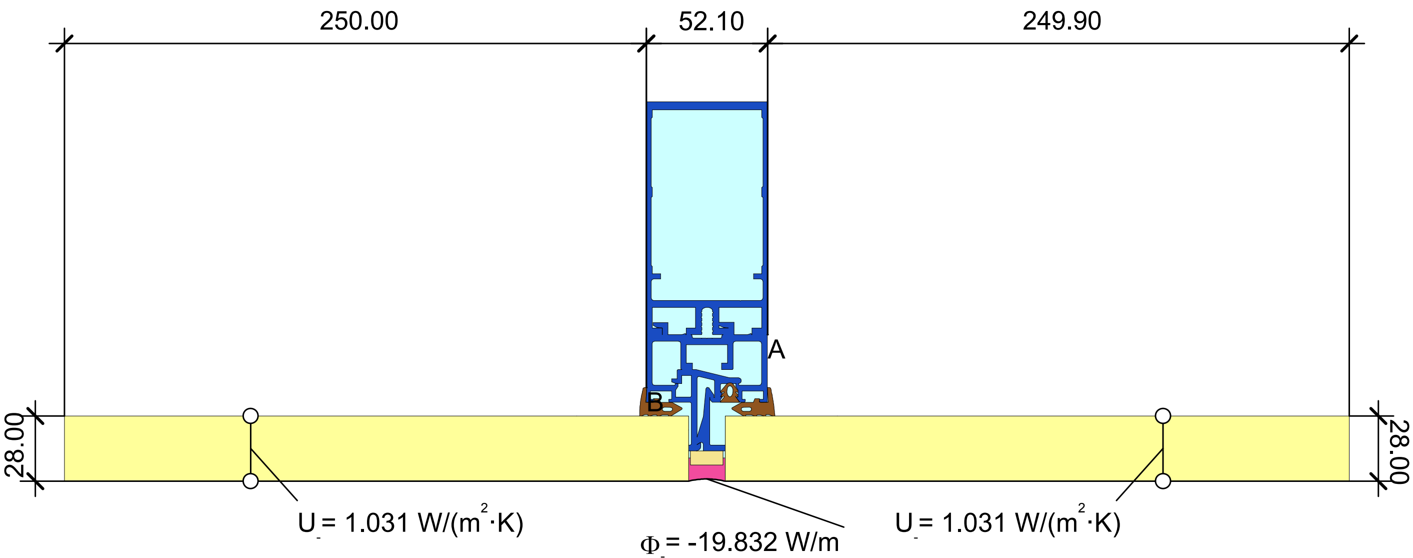
TEMPERATURE FIELD & ISOTHERM:





TYPICAL MULLION (M1):

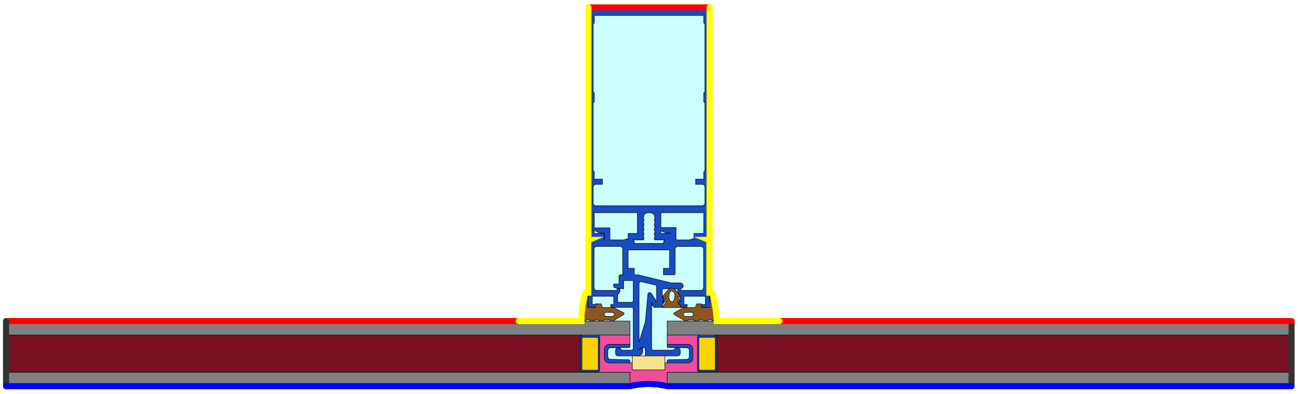
FRAME U-VALUE:



$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1}\cdot b_{p1} - U_{p2}\cdot b_{p2}}{b_f} = \frac{\frac{19.832}{30.000} - 1.031\cdot 0.250 - 1.031\cdot 0.250}{0.052} = 2.80\ W/(m^2\cdot K)$$

TYPICAL MULLION (M1):

EDGE SEAL INPUT (Psi):



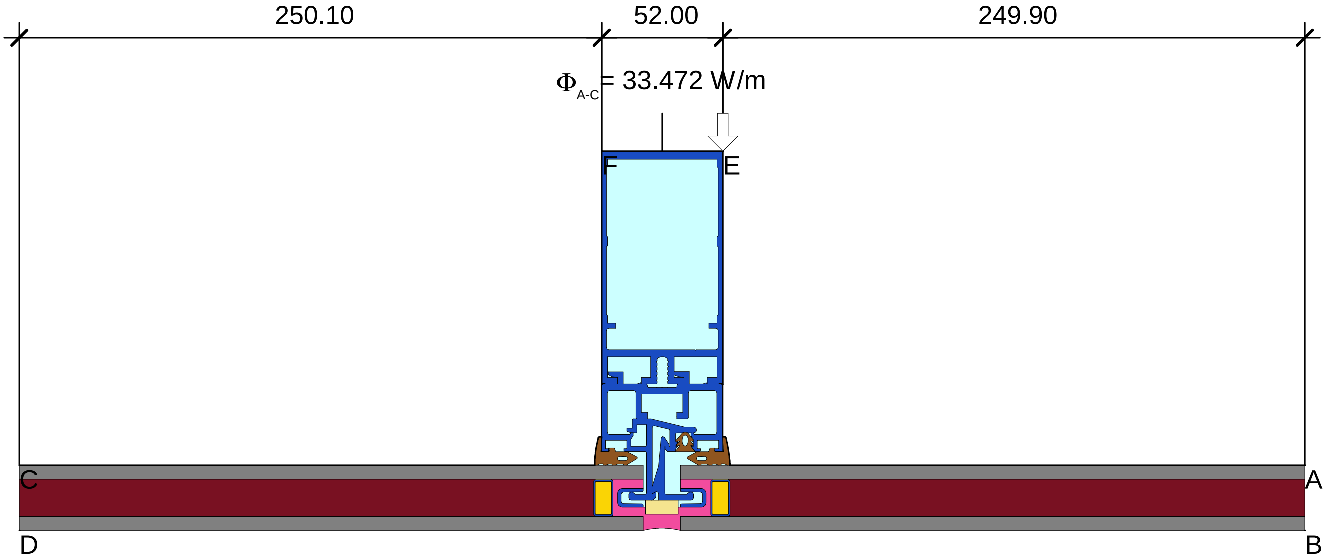
Material	λ[W/(m·K)]
Aluminium (Si Alloys)	160.000
Argon	0.017
EPDM (ethylene propylene diene monomer)	0.250
Elastomeric foam, flexible	0.050
Silica gel (desiccant)	0.130
Silicone, filled	0.500
Soda lime glass	1.000
Unventilated air cavity **	

** Simplified approach

Boundary Condition	$q[W/m^2]$	$\theta[^{\circ}C]$	$R[(m^2\cdot K)/W]$
Exterior, normal		-10.000	0.040
Interior, frame, normal		20.000	0.130
Interior, frame, reduced		20.000	0.200
Symmetry/Model section	0.000		

TYPICAL MULLION (M1):

EDGE SEAL VALUE (Psi):



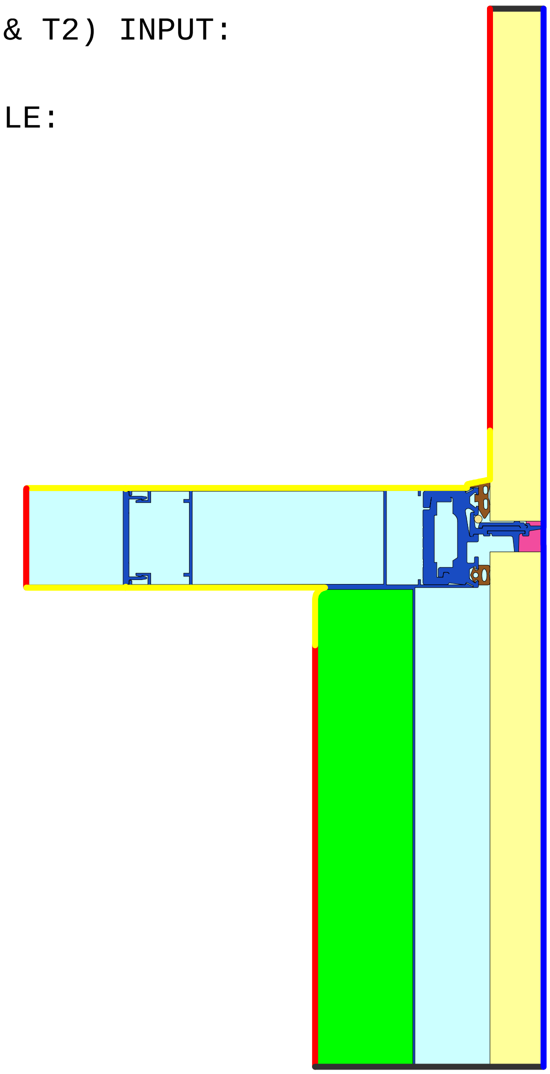
$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 - U_3 \cdot b_3 = \frac{33.472}{30.000} - 1.070 \cdot 0.250 - 2.800 \cdot 0.052 - 1.070 \cdot 0.250 = 0.435 \text{ W/(m·K)}$$

U1, U3 = Glass U Value

U2 = Frame U value

TRANSOM WITH SPANDREL (T1 & T2) INPUT:

WITH ALUMINIUM CLEAT PROFILE:



Material	λ[W/(m·K)]
Aluminium (Si Alloys)	160.000
EPDM (ethylene propylene diene monomer)	0.250
Elastomeric foam, flexible	0.050
Panel	0.035
Rockwool	0.035
Silicone, filled	0.500
Unventilated air cavity **	
** Simplified approach	

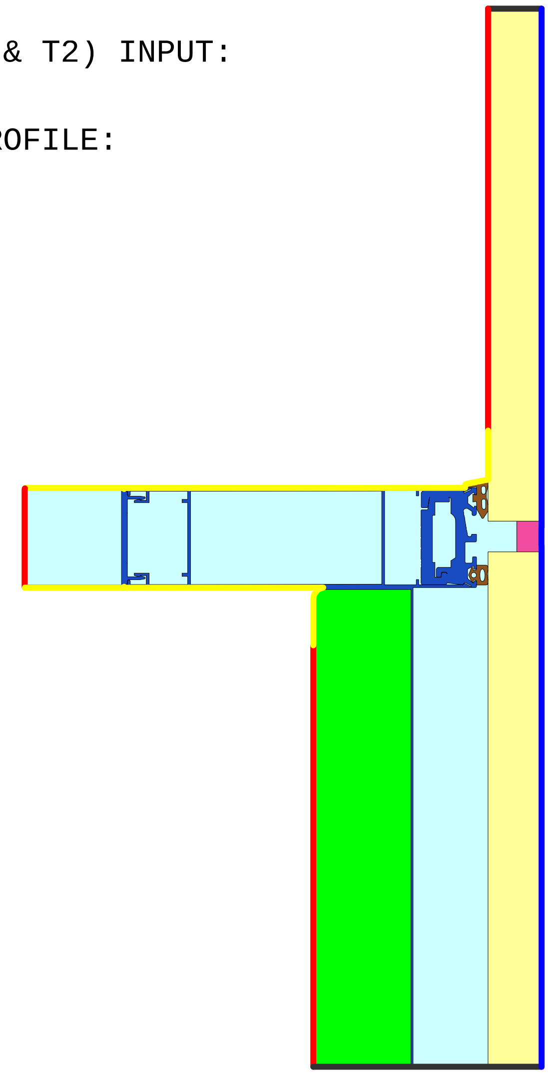
Boundary Condition	q[W/m^2]	θ[°C]	R[(m^2·K)/W]
Exterior, normal		-10.000	0.040
Interior, frame, normal		20.000	0.130
Interior, frame, reduced		20.000	0.200
Symmetry/Model section	0.000		

NOTE:

Transom vertical detail analyzed with glass toggle and without toggle. Hence the glass toggle used as piece by piece. (40% of total width of glass)

TRANSOM WITH SPANDREL (T1 & T2) INPUT:

WITHOUT ALUMINIUM CLEAT PROFILE:



Material	λ[W/(m·K)]
Aluminium (Si Alloys)	160.000
EPDM (ethylene propylene diene monomer)	0.250
Panel	0.035
RockWool	0.035
Silicone, filled	0.500
Unventilated air cavity **	

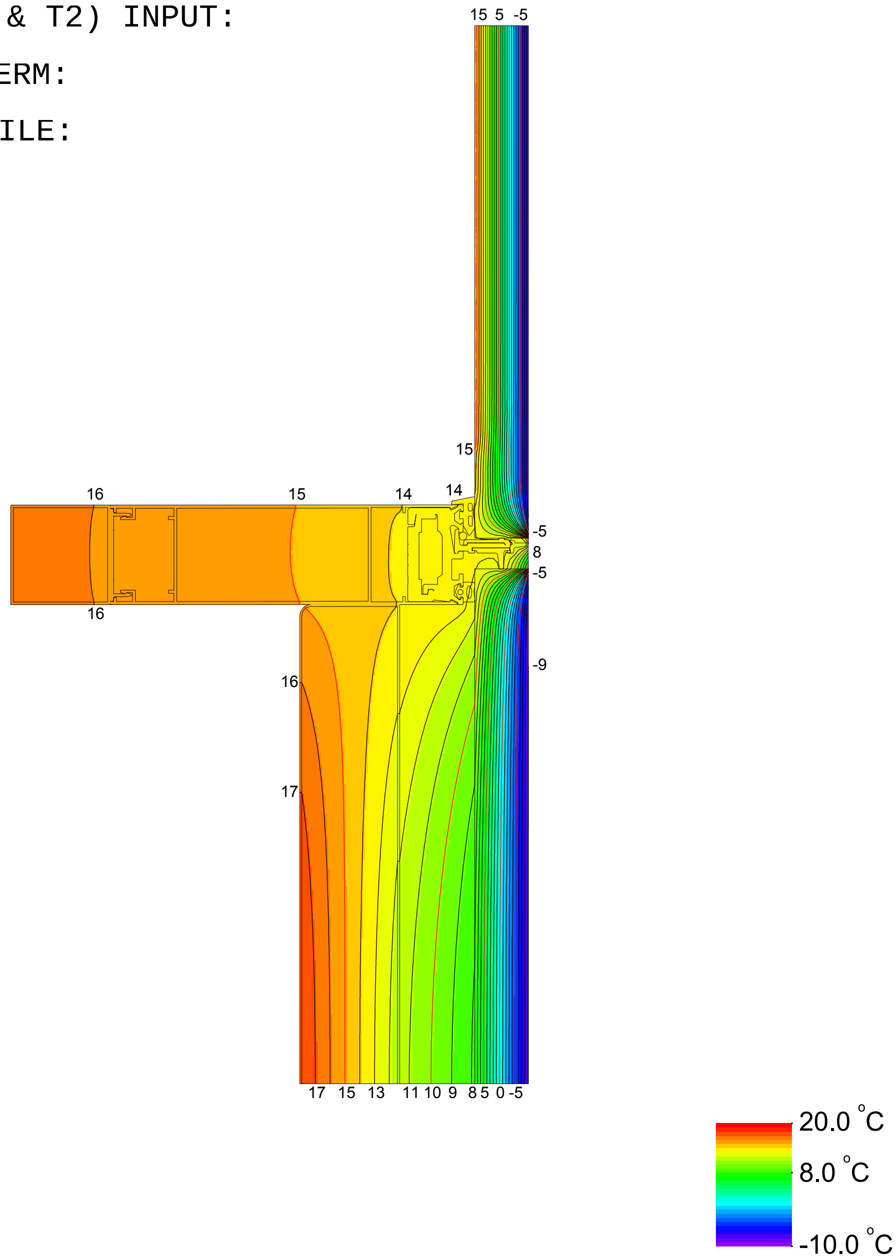
** Simplified approach

Boundary Condition	q[W/m²]	θ[°C]	R[(m²·K)/W]
Exterior, normal		-10.000	0.040
Interior, frame, normal		20.000	0.130
Interior, frame, reduced		20.000	0.200
Symmetry/Model section	0.000		

TRANSOM WITH SPANDREL (T1 & T2) INPUT:

TEMPERATURE FIELD & ISOTHERM:

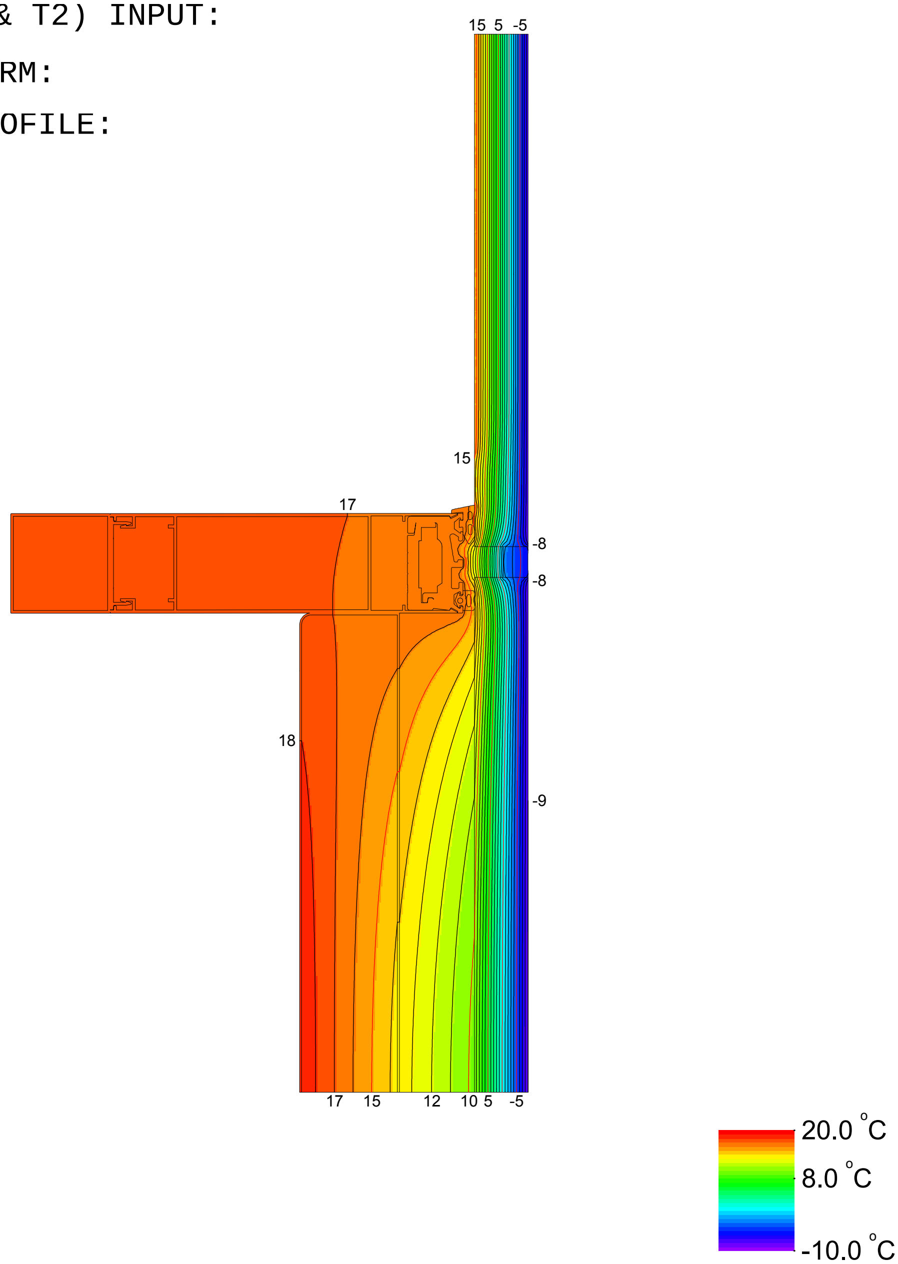
WITH ALUMINIUM CLEAT PROFILE:



TRANSOM WITH SPANDREL (T1 & T2) INPUT:

TEMPERATURE FIELD & ISOTHERM:

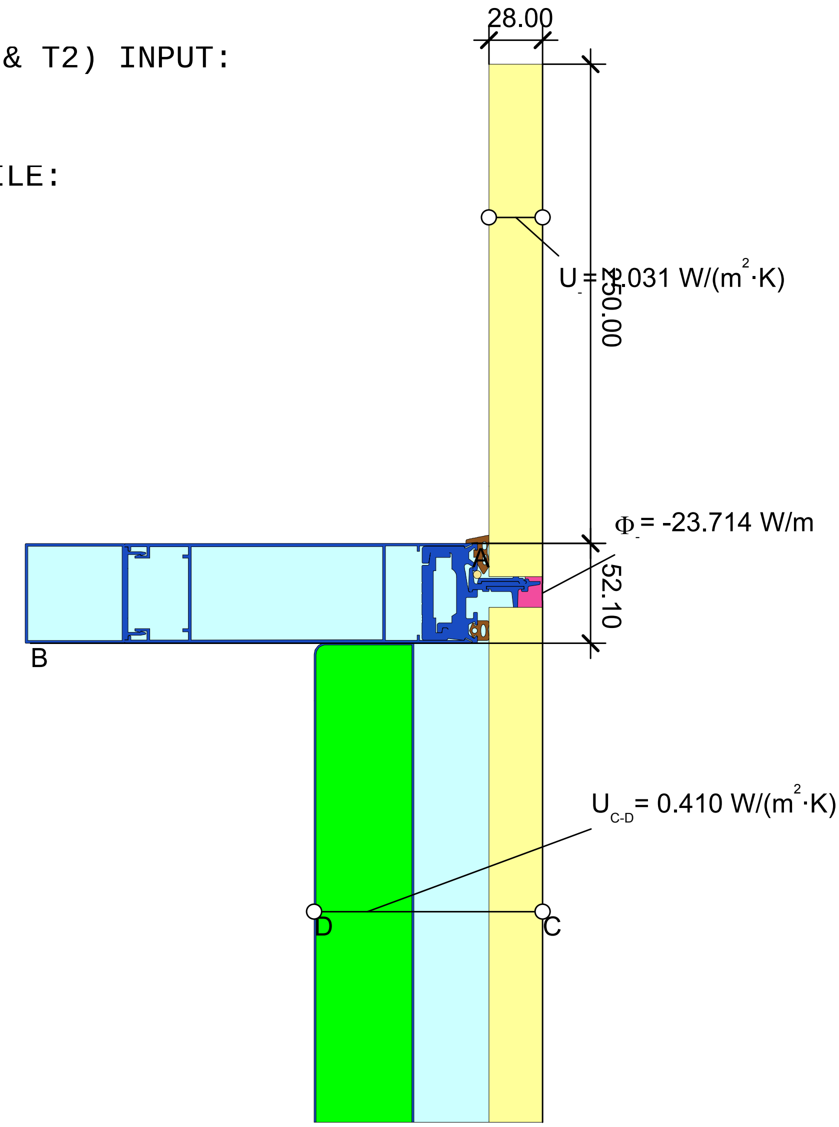
WITHOUT ALUMINIUM CLEAT PROFILE:



TRANSOM WITH SPANDREL (T1 & T2) INPUT:

FRAME U-VALUE:

WITH ALUMINIUM CLEAT PROFILE:

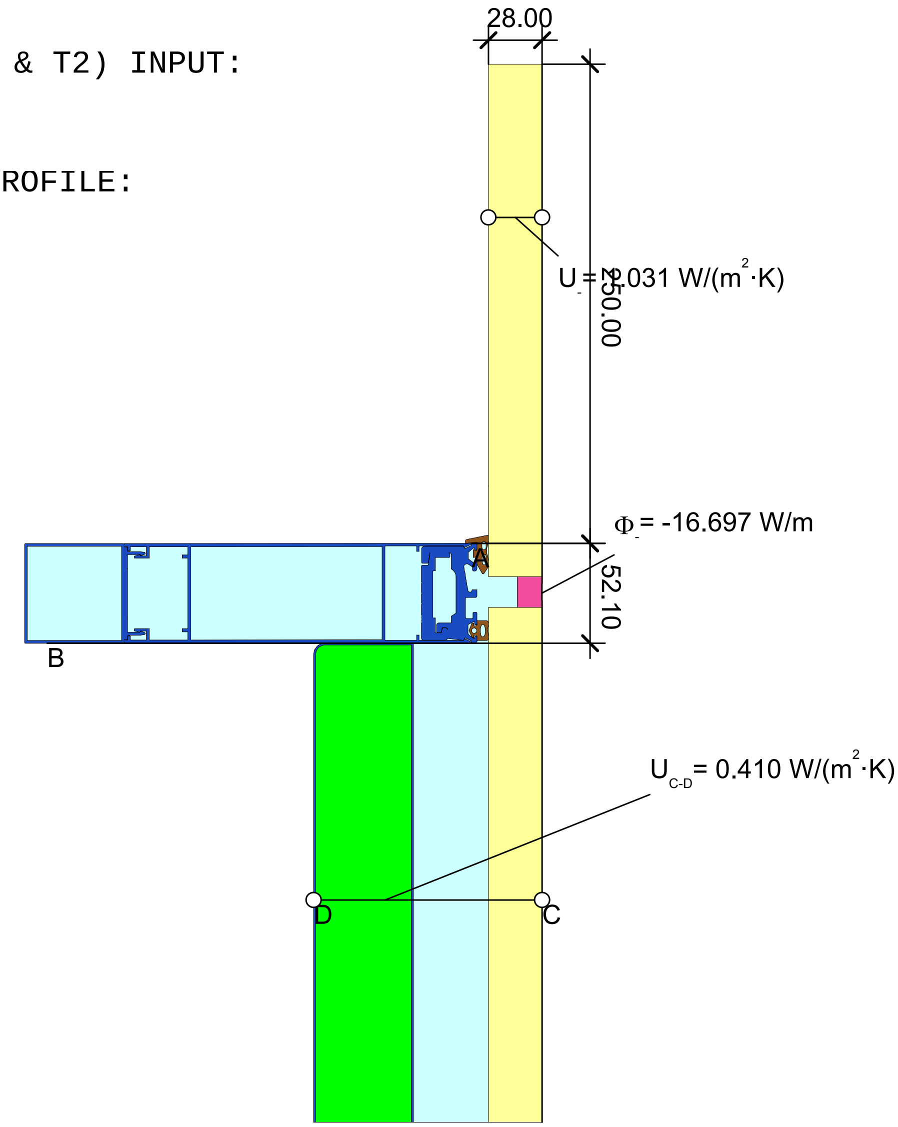


$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{23.714}{30.000} - 1.031 \cdot 0.250}{0.052} = 10.2\ \mathrm{W/(m^2 \cdot K)}$$

TRANSOM WITH SPANDREL (T1 & T2) INPUT:

FRAME U-VALUE:

WITHOUT ALUMINIUM CLEAT PROFILE:

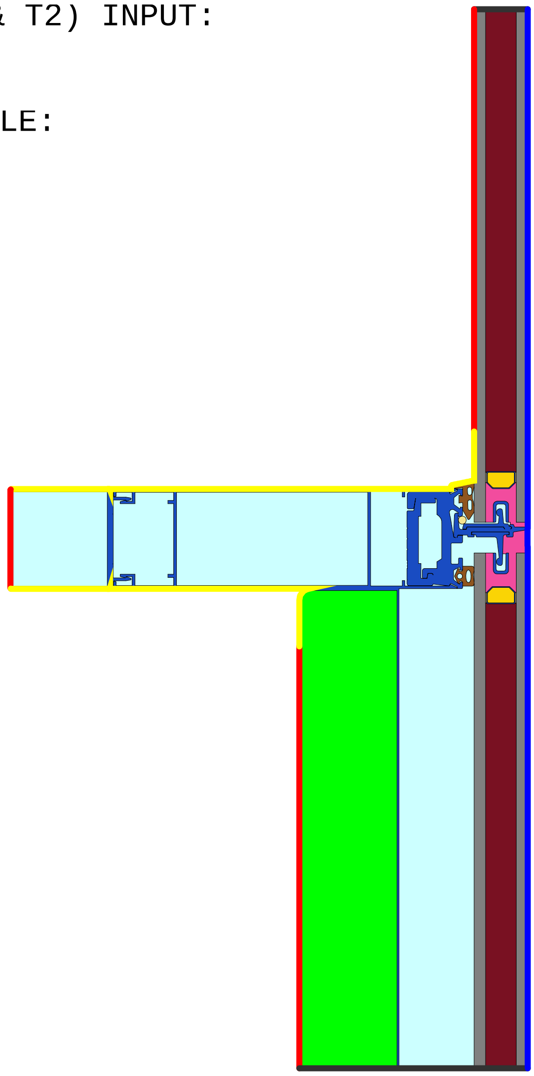


$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{16.697}{30.000} - 1.031 \cdot 0.250}{0.052} = 5.74\ \mathrm{W/(m^2 \cdot K)}$$

TRANSOM WITH SPANDREL (T1 & T2) INPUT:

EDGE SEAL INPUT (Psi):

WITH ALUMINIUM CLEAT PROFILE:



Material	λ[W/(m·K)]
Aluminium (Si Alloys)	160.000
Argon	0.017
EPDM (ethylene propylene diene monomer)	0.250
Elastomeric foam, flexible	0.050
Rockwool	0.035
Silica gel (desiccant)	0.130
Silicone, filled	0.500
Soda lime glass	1.000
Unventilated air cavity **	

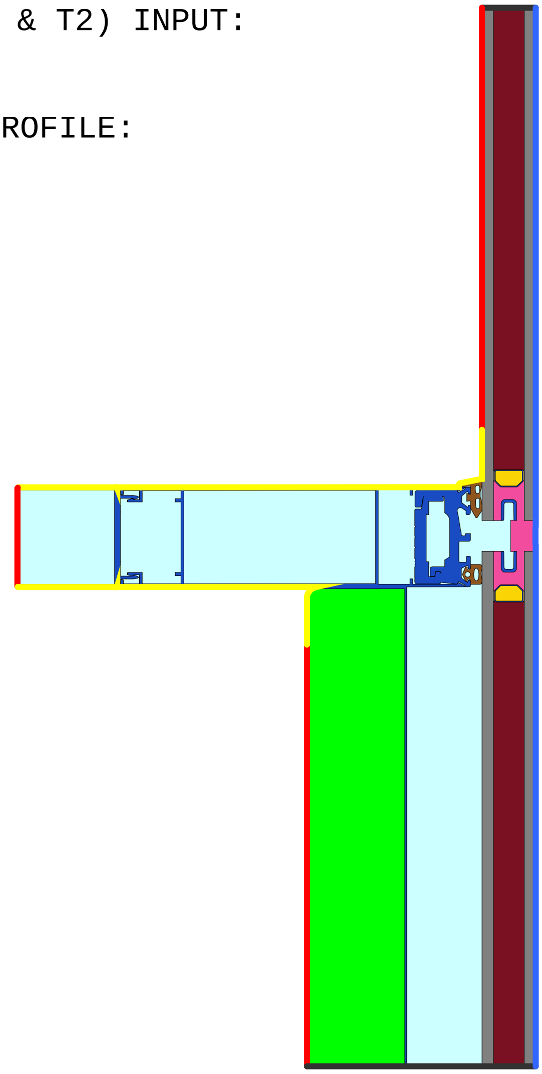
** Simplified approach

Boundary Condition	q[W/m²]	θ[°C]	R[(m²·K)/W]
Exterior, normal		-10.000	0.040
Interior, frame, normal		20.000	0.130
Interior, frame, reduced		20.000	0.200
Symmetry/Model section	0.000		

TRANSOM WITH SPANDREL (T1 & T2) INPUT:

EDGE SEAL INPUT (Psi):

WITHOUT ALUMINIUM CLEAT PROFILE:

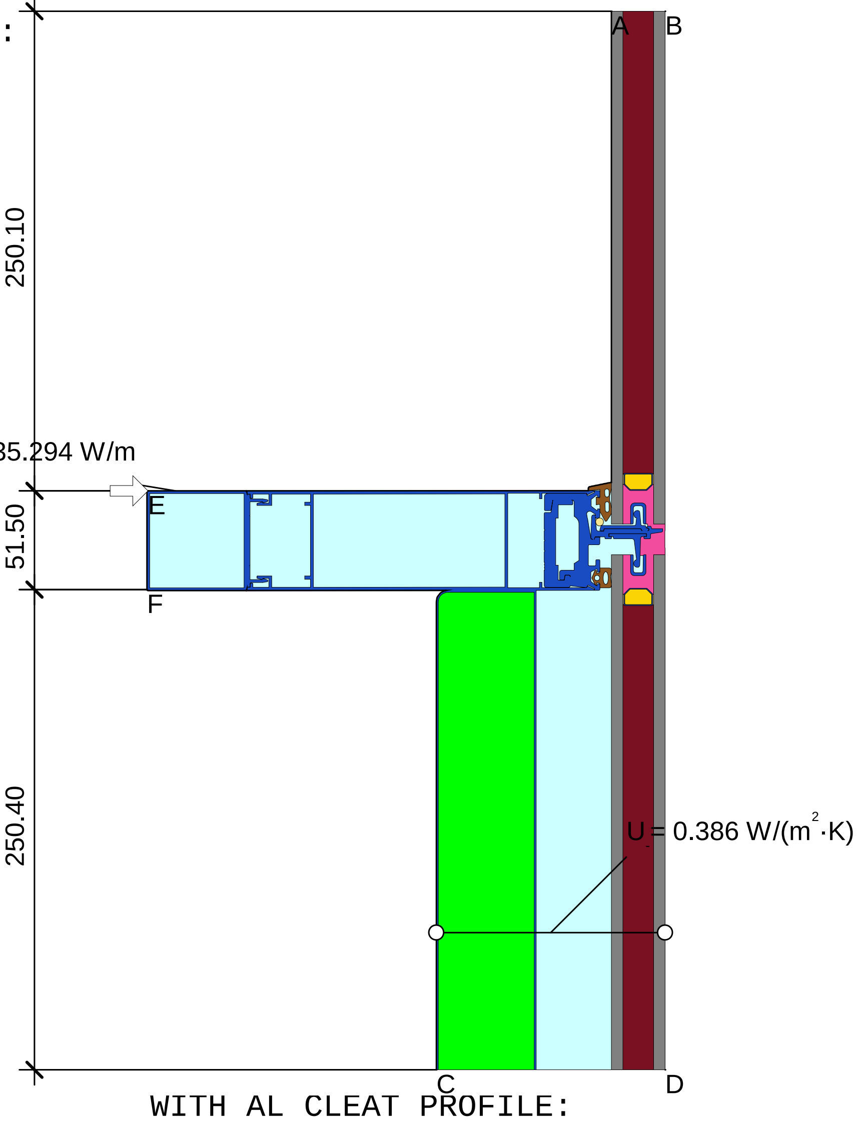


Material	λ[W/(m·K)]
Aluminium (Si Alloys)	160.000
Argon	0.017
EPDM (ethylene propylene diene monomer)	0.250
Elastomeric foam, flexible	0.050
RockWool	0.035
Silica gel (desiccant)	0.130
Silicone, filled	0.500
Soda lime glass	1.000
Unventilated air cavity **	
** Simplified approach	

Boundary Condition	q[W/m²]	θ[°C]	R[(m²·K)/W]
Exterior, ventilated		-10.000	0.130
Interior, frame, normal		20.000	0.130
Interior, frame, reduced		20.000	0.200
Symmetry/Model section	0.000		

TRANSOM WITH SPANDREL (T1 & T2) :

EDGE SEAL VALUE (Psi):



WITH AL CLEAT PROFILE:

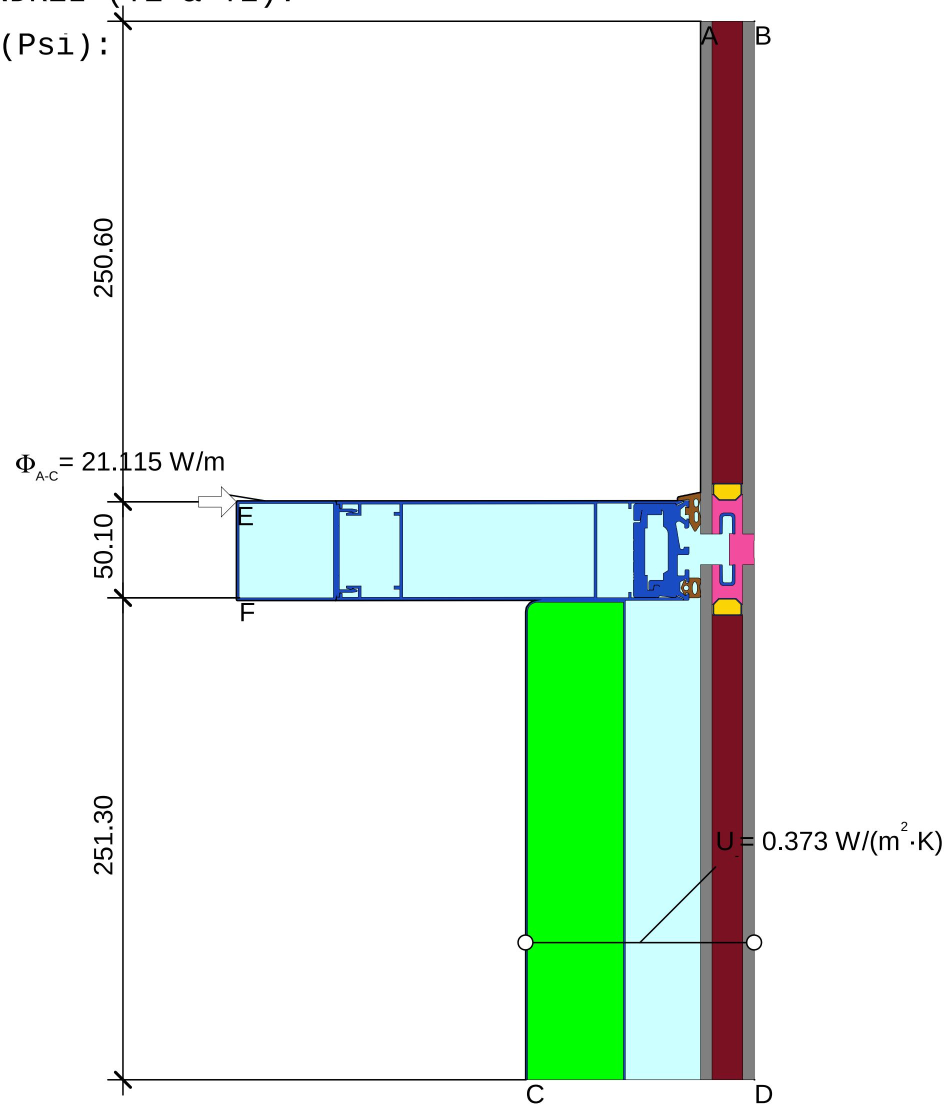
$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 - U_3 \cdot b_3 = \frac{35.294}{30.000} - 1.070 \cdot 0.250 - 10.200 \cdot 0.052 - 0.386 \cdot 0.250 = 0.287 \text{ W/(m·K)}$$

U1, U3 = Glass U Value

U2 = Frame U value

TRANSOM WITH SPANDREL (T1 & T2):

EDGE SEAL VALUE (Psi):



WITHOUT AL CLEAT PROFILE:

$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 - U_3 \cdot b_3 = \frac{21.115}{30.000} - 1.070 \cdot 0.251 - 5.740 \cdot 0.050 - 0.373 \cdot 0.251 = 0.054 \text{ W/(m·K)}$$

U1, U3 = Glass U Value

U2 = Frame U value

Frame U - Value (U_f) @ Different Section:

Frame value summarized as table format below from the Flixo output;

Frame U - Value (U_f) From Flixo Output							
S.No	Location (Refer Dwg)	Quantity No's	Width (W) m	Length (L) m	Area (A_f) - W.L m^2	U_f W/m^2K	$A_f.U_f$ W/K
1	M1	2	0.052	3.8	0.395	2.8	1.1066
2	T1 (40% with profile)	2	0.052	0.4	0.042	10.2	0.4243
3	T1(without profile)	2	0.052	0.75	0.078	5.74	0.4477
4	T2 (40% with profile)	2	0.052	0.4	0.042	10.2	0.4243
5	T2(without profile)	2	0.052	0.75	0.078	5.74	0.4477
			Total Area (m^2)		**=**	**0.634**	
			Total Heat Loss in Frame(W/K)			**=**	**2.85**

Glass U - Value (U_g):

Infill U - Value (U_g) - U Value from Glass Technical Sheet							
S.No	Location	Quantity No's	Width (W) m	Height (H) m	Area (A_g) - W.H m^2	U_g W/m^2K	$A_g.U_g$ W/K
1	G1	2	1.184	2.484	5.88	1.07	6.29
2	G2	2	1.184	1.234	2.92	1.07	3.13
			Total Area (m^2)	**=**	**8.804**		
			Total Heat Loss in Panel(W/K)			**=**	**9.421**

Edge seal Values (Ψ_g):

Edge Seal Values, Linear thermal Transmittance - Flixo Output							
S.No	Location	Quantity No's	Width (W) m	Height (H) m	Total Length (L) m	Ψ (Psi) W/m.K	L.Ψ W/K
1	M1	2	-	3.8	7.6	0.435	3.306
2	T1 (40% with profile)	2	0.4	-	0.8	0.287	0.230
3	T1(without profile)	2	0.75	-	1.5	0.054	0.081
4	T2 (40% with profile)	2	0.4	-	0.8	0.287	0.230
5	T2(without profile)	2	0.75	-	1.5	0.054	0.081
			Total Length (m)	**=**	**12.20**		
			Total Heat Loss in Edge(W/K)			**=**	**3.927**

Result					
Total Area of Frame, A_f (m^2)	=	0.634	Heat Loss in Frame, **$A_f.U_f$ (W/K)**	=	2.85
Total Area of Glass, A_g (m^2)	=	8.804	Heat Loss in Panel, **$A_g.U_g$ (W/K)**	=	9.421
Total Area (m^2)	=	9.4	Heat Loss in Edge, **L.Ψ (W/K)**	=	3.927
Frame Ratio (%)	=	6.72	Heat Loss in Window **(W/K)**	=	16.198

Determination Curtain Wall - U Factor:

Thermal transmittance of curtain wall U_w is calculated as per BS EN ISO 10077-1 2000.

$$U_W = \frac{A_g U_g + A_f U_f + l_g \Psi_g}{A_g + A_f}$$

Thermal Transmittance, U- Factor for Curtain wall (U_w) (Heat loss/Area)	**=**	**1.72**	**W/m^{2}K**

REFERENCES

3 Definitions, symbols and units

3.1 Definitions

For the purposes of this standard, the definitions given in EN 673 and EN ISO 7345 apply.

In clause 4 of this standard, descriptions are given of a number of geometrical characteristics of glazing and frame.

3.2 Symbols

Symbol	Quantity	Unit
A	area	m^2
R	thermal resistance	$m^2 \cdot K/W$
T	temperature	K
U	thermal transmittance	$W/(m^2 \cdot K)$
b	width	m
d	distance / thickness	m
l	length	m
q	density of heat flow rate	W/m^2
Ψ	linear thermal transmittance	$W/(m \cdot K)$
λ	thermal conductivity	$W/(m \cdot K)$

3.3 Subscripts

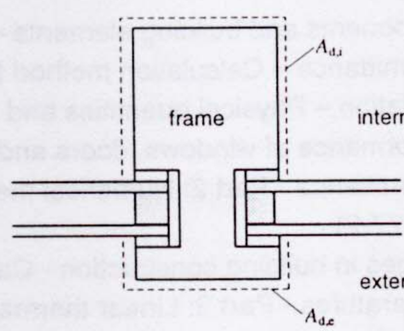


Figure 1 - Internal and external developed area

D	door		
W	window		
WS	window with closed shutter	j	summation index
d	developed	p	panel (opaque)
e	external	s	space (air or gas space)
f	frame	se	external surface
g	glazing	sh	shutter
i	internal	si	internal surface
sa	sash		

5 Calculation of thermal transmittance

5.1 Windows

5.1.1 Single windows

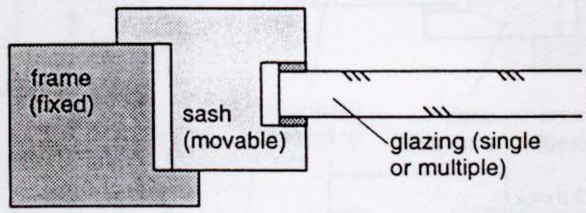


Figure 4 - Illustration of single window

The thermal transmittance of a single window U_w shall be calculated using equation (1):

$$U_w = \frac{A_g U_g + A_f U_f + l_g \Psi_g}{A_g + A_f} \qquad (1)$$

where

U_g is the thermal transmittance of the glazing;

U_f is the thermal transmittance of the frame;

Ψ_g is the linear thermal transmittance due to the combined thermal effects of glazing, spacer and frame;

and the other symbols are defined in clause 4.

In the case of single glazing the last term of the numerator in equation (1) shall be taken as zero (no spacer effect) because any correction is negligible.

When opaque panels are used instead of some of the glazing, U_w is calculated as follows:

$$U_w = \frac{A_g U_g + A_p U_p + A_f U_f + l_g \Psi_g + l_p \Psi_p}{A_g + A_p + A_f} \qquad (2)$$

where

U_p is the thermal transmittance of the opaque panel(s);

Ψ_p is the linear thermal transmittance for the opaque panel(s).

If the opaque panel is thermally bridged at the edge by a less insulating spacer, the effect of the bridging shall be taken into account in the same way as for glazing; otherwise $\Psi_p = 0$.

NOTE Typical values of the linear thermal transmittance are given in annex E.
prEN ISO 10077-2 gives a method for calculating linear thermal transmittance.
prEN 12412-2 gives a method for measuring the linear thermal transmittance.

EMIRATES GLASS LABORATORY

GLASS PERFORMANCE ANALYSIS

Print date : 17-Jul-2017

Glazing	Thickness		Coating	Glass colour
Outer Pane	6	mm	EmiCool Solite Mistral 47/29	Clear
Air Space	16	mm	With 90% argon gas	
Inner Pane	6	mm		Clear

Table of Results:		6mm EmiCool Solite Mistral 47/29 Clear + 16mmAS + 6mm Clear
Optical and Thermal Radiation Properties :		
U-Value (Summer)	U	1.07
Light Transmittance	τv	44
Light Reflectance (out)	ρv	17
Light Reflectance (in)	ρv'	16
Secondary Ht. Transfer inside glazing	qi	4
Direct Energy Transmittance	τe	22
Direct Energy Reflectance (out)	ρe	28
Direct Energy Reflectance (in)	ρe'	34
Total Energy Trans. (Solar Heat Gain Coefficient)	SHGC	0.26
Shading Coefficient	S.C.	0.31

Glass Performance Analysis:
Measurements are done at Emirates Glass Laboratory using Perkin Elmer Spectrophotometers and the calculations are based on the calculation files developed OMT Solutions, Netherlands. Input data for the calculation of optical and thermal radiation properties are according to NFRC 300,301 & 302.

Tolerances:
The above data represent NOMINAL VALUES based on center-of-glass measurements and take no account of IG Spacers or framing.
Slight Variations might occur due to manufacturing as well as the type of instrumentation used to measure the spectrophotometric and thermal insulation values.

AJU PAPPACHAN
QC Lab

Doc.No.:QC-QR-11
Rev:1
Date:1.10.2008