THERMAL PERFORMANCE CALCULATION

Façade Engineering and Analysis Services Limited.

Analysis undertaken and report prepared on behalf of XXXXXXX for….

XXXXXXX

DOCUMENT REF :- XXX/TP/XXXX Rev 01
Document title :- 3D U value and interstitial condensation risk analysis typical rainscreen backing wall.
Date of original issue :- XXXXX
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FEA

Revisions

Rev 00	Original document issue	XX XXX XXXX

This document provides an assessment of the thermal performance only and does not indicate or contain assessments of the façade suitability regarding any other aspects, including but not limited to, structural and fire resistance. These must be assessed by the client and their specialist engineers.

Summary

This calculation document has been complied to demonstrate the thermal performance of the rainscreen backing wall for XXXXX.

The calculation has been undertaken on behalf of XXXXX.

This document contains 3 dimensional analysis of the rainscreen backing with a view to achieve a target U value of 0.17 W/m^2K.

The wall construction is an aluminum rainscreen supported on helping brackets and horizontal rails fixed back to a SFS wall construction.

By convention, from BR443, the external rainscreen element is ignored in U value calculations but an amendment to the external surface resistance of the insulating material is made to allow for the sheltering effect of the rainscreen cladding and penetrating brackets through the insulation must be allowed for. See analysis notes for further details.

The examined construction consists of mineral wool insulation in the cavity behind the rainscreen mounted onto a 12 mm thick calcium silicate sheathing board supported by 150 mm SFS construction assumed at 600 mm centres. The SFS zone is fully insulated by mineral wool and 2 layers of 12.5 mm plasterboard have been included as internal finishes.

It is assumed a VCL will be fitted behind these finishes.

Helping hand brackets have been examined at 600 x 600 mm centres and taken to be aluminium with thermal break elements.
The bracket is a typical aluminium façade bracket and assessed as 75 mm long.

A 5mm thick isolating pad has been included between the channel bracket and top hat.

The horizontal top hats have been examined as fabricated from 2 mm thick steel (galvanised), aluminium or stainless steel options to assess the depth of cavity insulation required to achieve the target U value.

The U value of the construction analysed is 0.17 W/m^2K with brackets at 600 x 600 mm centres when the following thickness of cavity insulation is utilised.

- **With steel top hats 170 mm of mineral is required in the rainscreen cavity**
- **With aluminium top hats 190 mm of mineral is required in the rainscreen cavity**
- **With stainless steel top hats 150 mm of mineral is required in the rainscreen cavity**

The overall wall U value achieved will need to be verified by a weighted area U value calculation as variations in bracket centre may affect the results.

Intestinal condensation risk analysis shows no issue with this construction.

Condensation may occur within the ventilated cavity on the rear of the aluminium, this is normal and will dissipate.

3D analysis method.

The following thermal analysis was undertaken using “TRISCO ver 13.w” 3 dimensional finite elemental analysis software.
This software has been developed by Physibel for 3 dimensional steady state thermal simulation and this produces constant and reliable analysis of constructions measuring heat transfer in rectangular objects.

TRISCO is a thermal analysis program for steady state heat transfer in three-dimensional rectangular objects consisting of different materials and submitted to different boundary conditions. The geometry is described with a list of rectangular blocks, which vertices lie on grid points of a rectangular grid. Materials and surface boundary conditions with different thermal properties are identified using separate colours. Each geometry block is part of either a material or a surface boundary condition region, and has a reference to one of these colours. Node boundary conditions with fixed temperature or power are possible, and can be placed in grid point locations. Also border face boundary conditions in the interface between two colour regions with fixed temperature or heat flux, or (material boundary conditions with fixed temperature or heat power density are possible.

After input of geometry and thermal properties a system of linear equations is calculated based on the energy balance technique, and solved using a fast iterative method. Possible non-linear problems are solved using of different cycles of adjusted linear systems.

These simulations benefit from incorporation of Physibel's RADCON module for additional accuracy in analysis by calculating infrared radiation and convection in a more realistic manner than TRISCO alone.

RADCON is a program add-on module to calculate infrared radiation and convection in a physically more realistic way. The radiation is based on view factors, surface emissivities and surface temperatures. The convection is based on empirical laws.

Material properties such as thermal conductivity (λ values) used in these calculations have been taken from BS EN 12524:2000, BS EN ISO 10077-2:2003 or directly from the Physibel material database.

In addition specific product thermal conductivity values may be taken from suppliers’ own literature in the case of the material not being specifically included in the British Standards.

Equivalent thermal conductivities of ventilated and unventilated air cavities are calculated by the software.

The analyses assume steady state heat flow and therefore any thermal mass effect of any adjacent construction or building component has not been considered.

Analysis output.

Information taken from the resulting software studies and included within the individual analysis includes…..

- Diagrams indicating assigned thermal conductivity values according to appropriate materials and software generated equivalent cavity values if applicable.
- Thermal gradient diagrams indicating temperature across the examined construction.
- Text files showing build-up of material blocks and coordinates used to construct the analysis.
- Text output showing resulting material temperature ranges, U value through the inspected construction and temperature factor indicting internal RH level at which surface condensation could occur.

From BR443

4.9.5 Rainscreen cladding

Make no allowance in U-value calculations for the effect of the rainscreen cladding itself, because the space behind is fully ventilated. The effect of brackets or rails fixing the cladding to the wall behind needs to be allowed for, if the brackets or rails penetrate an insulation layer or part of an insulation layer.
As the effect of fixing brackets or rails on the U-value of the wall can be large, even when a thermal break pad is included, their contribution to the overall U-value needs to be assessed by a detailed calculation.
The calculation model should omit the cladding but include the fixing rails or brackets to their full length. The external surface resistance should be taken as 0.13 m^2K/W (rather than 0.04 m^2K/W) to allow for the sheltering effect of the cladding (see 4.8.6).
For further information see CAB/CWCT Guide

NOTE ONLY VERSION INCLUDED IN THIS EXAMPLE DOCUMENT

Detail

170mm mineral wool onto 150mm SFS wall with brackets at 600 mm centres attached to steel top hat rails

U value analysis.

- Material thermal conductivity diagram.
- Temperature gradient diagrams.
- FEA input data sheet.
- FEA output data sheet.

Finite element analysis undertaken using TRISCO version 13.0w software.

Summary.

A sample area of 600 mm x 600 mm was examined and the effective U value of this area was found to be **0.17 W/m^{2}K.**

Material Thermal Conductivity Diagram.

Wall section = 600mm x 600mm
U value = 0.171 W/m^{2}K

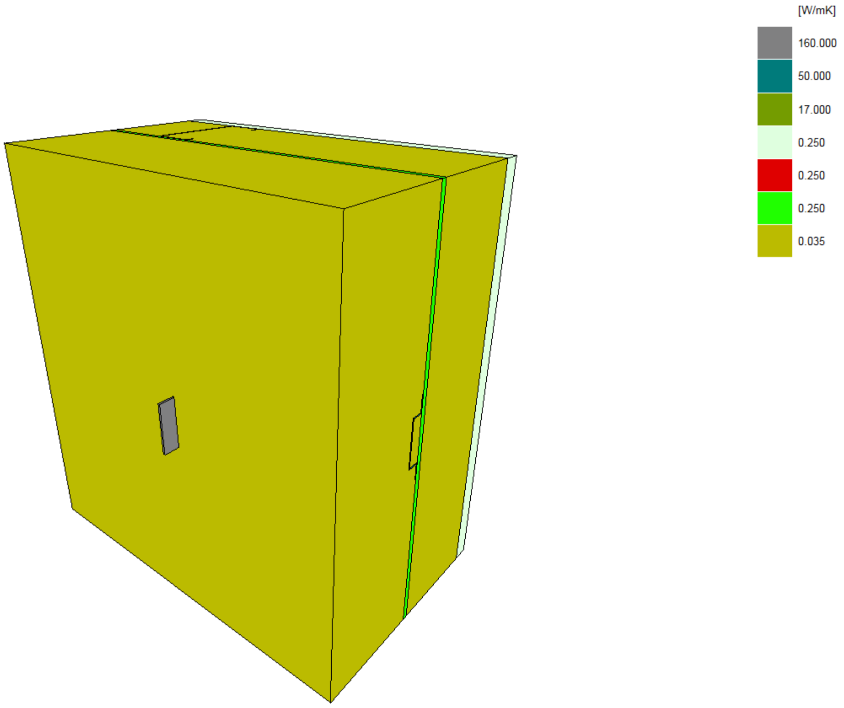


Figure 1 External material thermal conductivity diagram

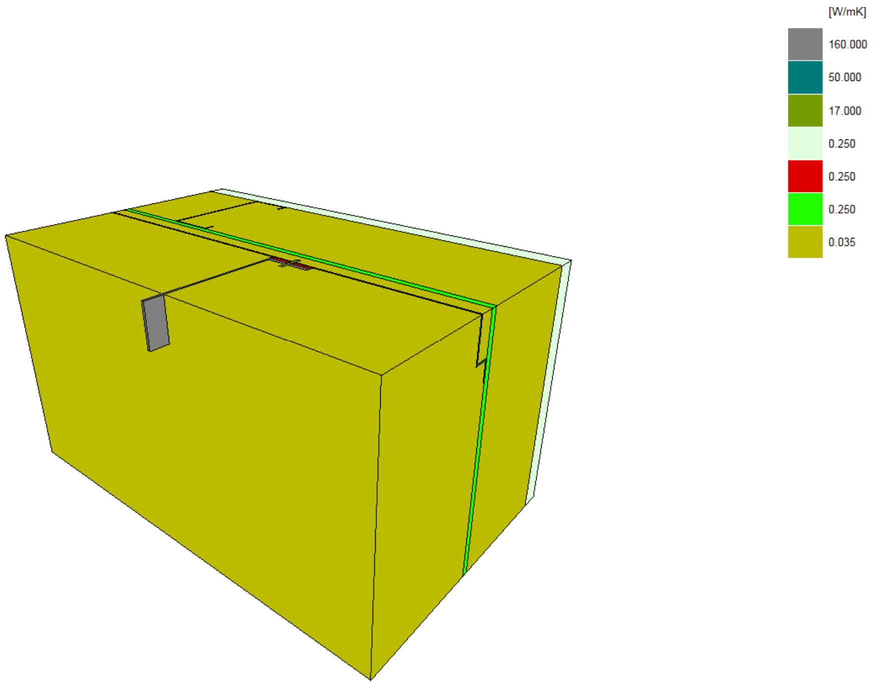


Figure 2 Cut through material thermal conductivity diagram

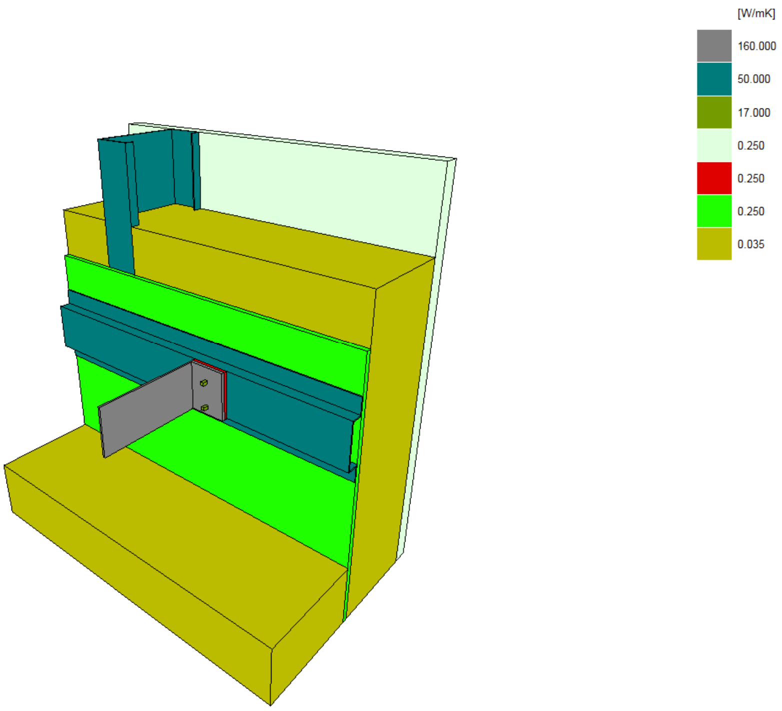


Figure 3 Material thermal conductivity dia. – insulation cut back to show brackets etc.

Temperature Gradient Diagrams

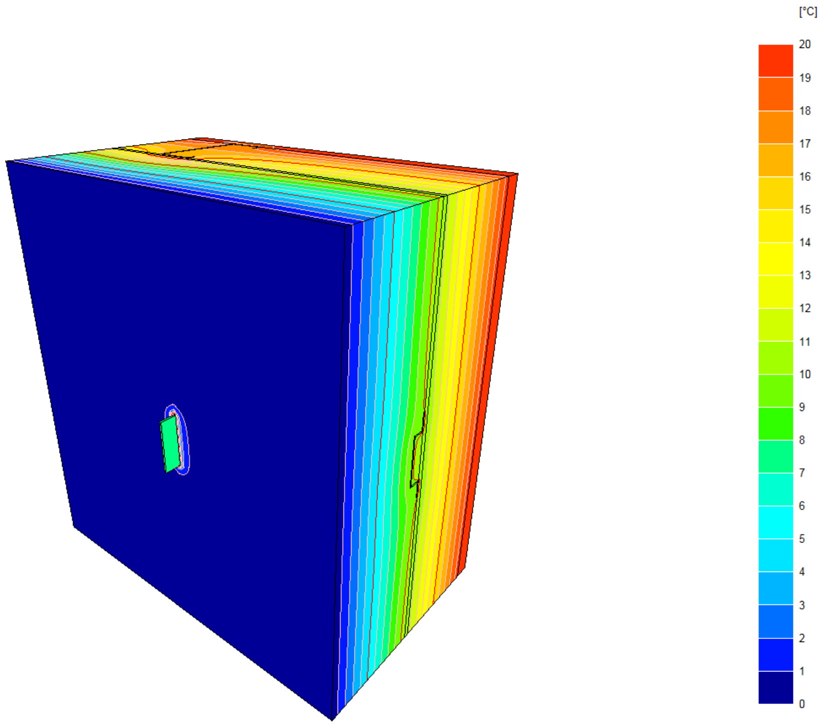


Figure 4 External temperature gradient diagram

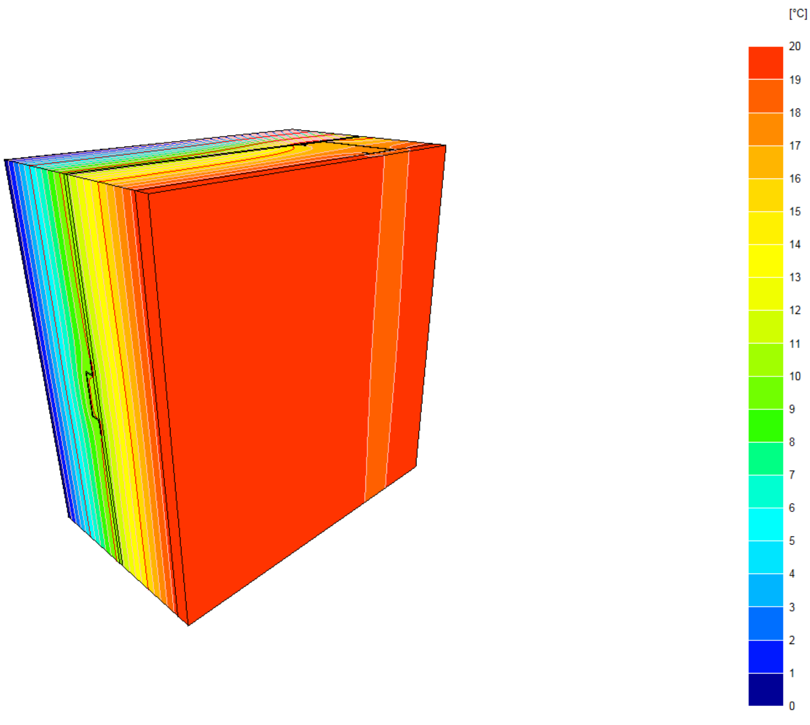


Figure 5 Internal temperature gradient diagram

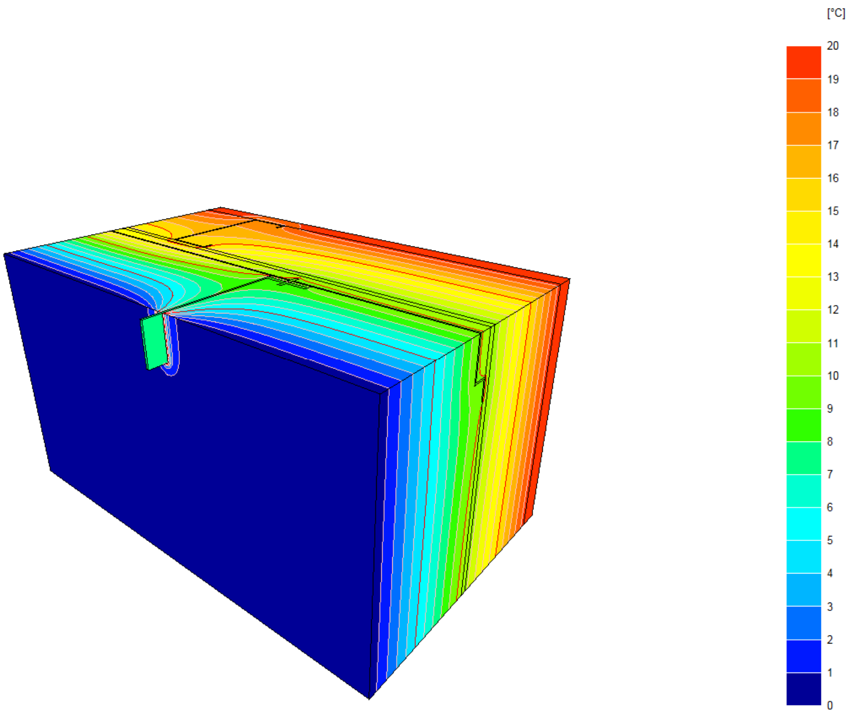


Figure 6 Cut through temperature gradient diagram

TRISCO - Input Data

TRISCO data file: typ nvelope bracket steel top hat.trc

COLOURS

Col.	Type	CEN-rule	Name	lambda [W/mK]	eps [-]	t [°C]	h [W/m²K]	q [W/m²]
8	MATERIAL		aluminium	160.000				
11	MATERIAL		stainless_steel	17.000				
13	MATERIAL		steel	50.000				
35	MATERIAL		sheathing_board	0.250				
36	MATERIAL		polyamid_nylon	0.250				
151	MATERIAL		insulation	0.035				
161	MATERIAL		gypsum_plasterb	0.250				
174	BC_SIMPL	HI_NORML				20.0	7.70	0
185	BC_SIMPL	NIHIL	highly_ventilat			0.0	7.70	0

CALCULATION PARAMETERS

Maximum number of iterations = 10000
Maximum temperature difference = 0.0001°C
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %

TRISCO - Calculation Results

TRISCO data file: typ nvelope bracket steel top hat.trc

Number of nodes = 1006240
Heat flow divergence for total object = 0.000658509 %
Heat flow divergence for worst node = 0.780524 %

Col.	Type	Name	tmin [°C]	X	Y	Z	tmax [°C]	X	Y	Z
8	MATERIAL	aluminium	7.41	47	1	56	8.93	66	40	56
11	MATERIAL	stainless_steel	8.88	55	39	71	9.72	55	42	61
13	MATERIAL	steel	9.60	59	41	71	17.94	32	81	134
35	MATERIAL	sheathing_board	9.92	68	47	57	16.38	21	49	134
36	MATERIAL	polyamid_nylon	8.78	47	40	73	10.34	47	41	77
151	MATERIAL	insulation	0.28	91	6	28	19.57	46	81	134
161	MATERIAL	gypsum_plasterb	17.50	21	81	66	19.76	48	86	134
174	BC_SIMPL		18.74	25	86	66	19.76	48	86	134
185	BC_SIMPL	highly_ventilat	0.28	91	6	28	7.49	48	6	67

Col.	Type	Name	ta [°C]	Flow in [W]	Flow out [W]
174	BC_SIMPL			1.23	0.00
185	BC_SIMPL	highly_ventilat		0.00	1.23

Temperature factor (EN ISO 10211) = 0.937
  hi = 7.70 W/(m².K)
  Rsi = 0.13 m².K/W
Surface condensation if RH > 92 % (at 20.00°C)
Equivalent thermal transmittance
Ueq = Q/((ti-te)*A1) = 0.171 W/(m².K)
  Q = 1.227 W
  ti = 20.00°C
  te = 0.00°C
  A1 = 0.359063 m²
    Xmin=0 Xmax=91 Ymin=28 Ymax=28 Zmin=0 Zmax=134

Uwall = (Q/(ti-te))/A1 = 0.171 W/(m².K)

Notes:

Text highlighted blue is U value of examined element.

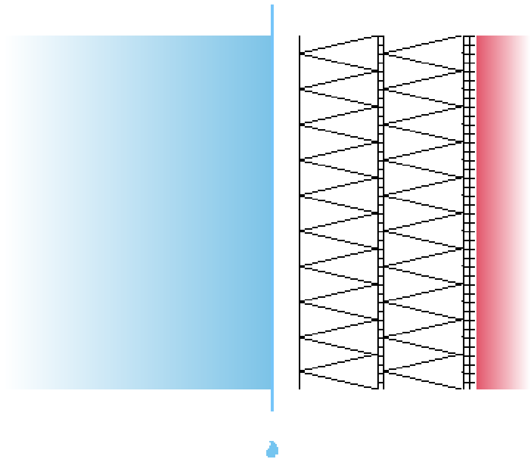
Intestinal condensation risk analysis

Façade Engineering and Analysis Services Limited.

Documentation of the component
Calculation according BS EN ISO 13788
Source: **own catalogue**
Component: **Steel cold frame. Brick facing. 150 mm MW**

22. October 2016

OUTSIDE INSIDE



The list of material layers shown below may differ from those in the U-value calculation printout. Only material layers which are used in the Condensation Risk Analysis are listed.

This calculation of the Condensation risk analysis according to BS EN ISO 13788:2002 has been performed on a construction containing inhomogeneous layers. This calculation is only valid through the selected section. It is advisable that you should also select the alternative position and recalculate the Condensation Risk Analysis for a more complete assessment of the construction.

Assignment: External wall

Name	Thickn. [m]	lambda [W/(mK)]	Q	μ [-]	Q	sd [m]	R [m²K/W]
Aluminium alloys	0.0030	160.000	D	999999.00	D	3000.00	0.0000
Slightly vent. air layer: 50 mm, horiz. heat flow	0.0500	0.556	D	1.00	D	0.05	0.0899
Rainscreen Duo-Slab (100-150mm)	0.1500	0.035	B	1.00	C	0.15	4.2857
CP Board	0.0120	0.220	E	1778.00	E	21.34	0.0545
Mineral wool batt - Variable thickness	0.1500	0.038	D	1.00	D	0.15	3.9474
Polyethylene 0.15 mm	0.0002	0.170	D	300000.00	D	45.00	0.0009
Gypsum plasterboard	0.0125	0.250	D	4.00	D	0.05	0.0500
Gypsum plasterboard	0.0125	0.250	D	4.00	D	0.05	0.0500

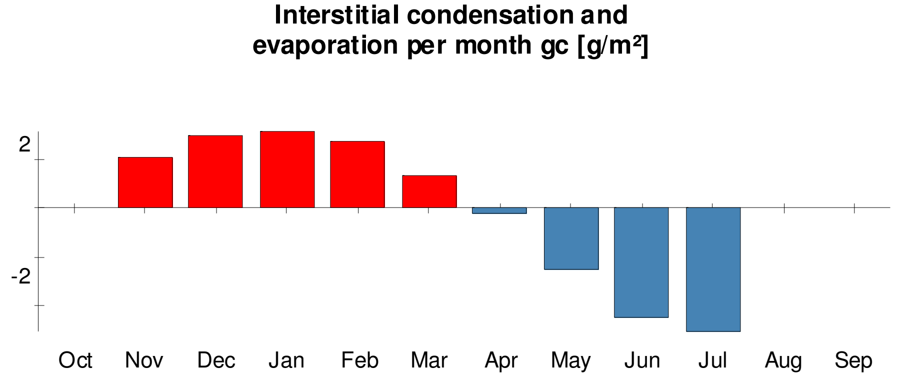
Q .. The physical values of the building materials has been graded by their level of quality. These 5 levels are the following
A .. A: Data is entered and validated by the manufacturer or supplier. Data is continuously tested by 3rd party.
B .. B: Data is entered and validated by the manufacturer or supplier. Data is certified by 3rd party
C .. C: Data is entered and validated by the manufacturer or supplier.
D .. D: Information is entered by BuildDesk without special agreement with the manufacturer, supplier or others.
E .. E: Information is entered by the user of the BuildDesk software without special agreement with the manufacturer, supplier or others.

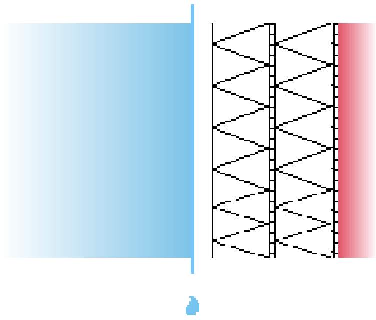
Condensation risk analysis - summary of main results
Calculation according BS EN ISO 13788

**Surface temperature to avoid critical surface moisture:
No danger of mould growth is expected.**

Interstitial condensation occurs, but all the condensate is predicted to evaporate during the summer months.

The risk of degradation of building materials and deterioration of thermal performance as a consequence of the calculated maximum amount of moisture shall be considered according to regulatory requirements and other guidance in product standards.





Component, condensation range

CRA calculations according to BS EN ISO 13788:2002 are used as a guide in predicting interstitial condensation. This methodology uses some simplifications of the dynamic processes involved and subsequently does have some limitations. Further information can be found in Information Paper IP 2/05 'Modelling and controlling interstitial condensation in buildings" Feb 2005.

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Surface temperature to avoid critical surface humidity
Calculation according BS EN ISO 13788

Location: Northolt; Humidity class according BS EN ISO 13788 annex A: Offices, shops

		1	2	3	4	5	6	7	8	9	10	11	12
	Month	Te	phi_e	Ti	phi_i	pe	delta p	pi	ps(Tsi)	Tsi,min	fRsi	Tsi	Tse
		[°C]	---	[°C]	---	[Pa]	[Pa]	[Pa]	[Pa]	[°C]	---	[°C]	[°C]
	January	5.0	0.830	20.0	0.500	724	445	1169	1461	12.6	0.509	19.6	5.1
	February	4.7	0.800	20.0	0.487	683	454	1137	1422	12.2	0.491	19.6	4.8
	March	7.0	0.750	20.0	0.487	751	386	1137	1421	12.2	0.401	19.6	7.1
	April	8.9	0.700	20.0	0.482	798	330	1127	1409	12.1	0.287	19.7	9.0
	May	12.4	0.690	20.0	0.522	993	226	1219	1523	13.3	0.114	19.8	12.4
	June	15.6	0.690	20.0	0.579	1222	131	1353	1691	14.9	-0.164	19.9	15.6
	July	17.8	0.690	20.0	0.629	1406	65	1471	1839	16.2	-0.735	19.9	17.8
	August	17.5	0.700	20.0	0.631	1399	74	1473	1842	16.2	-0.516	19.9	17.5
	September	14.6	0.750	20.0	0.602	1246	160	1406	1758	15.5	0.163	19.8	14.6
	October	11.1	0.810	20.0	0.571	1070	264	1334	1668	14.7	0.400	19.7	11.1
	November	7.5	0.840	20.0	0.531	870	371	1242	1552	13.6	0.484	19.6	7.6
●	December	5.9	0.850	20.0	0.517	789	419	1208	1510	13.1	0.513	19.6	6.0

- The critical month is December with $f_{Rsi,max}$ = 0.513
  f_{Rsi} = 0.971

$f_{Rsi} > f_{Rsi,max}$, the component complies.

Nr	Explanation
1	External temperature
2	External rel. humidity
3	Internal temperature
4	Internal relative humidity
5	External partial pressure $p_e = \phi_e * p_{sat}(T_e)$; $p_{sat}(T_e)$ according formula E.7 and E.8 of BS EN ISO 13788
6	Partial pressure difference. The security factor of 1.10 according to BS EN ISO 13788, ch.4.2.4 is already included.
7	Internal partial pressure $p_i = \phi_i * p_{sat}(T_i)$; $p_{sat}(T_i)$ according formula E.7 and E.8 of BS EN ISO 13788
8	Minimum saturation pressure on the surface obtained by $p_{sat}(T_{si}) = p_i / \phi_{si}$, where ϕ_{si} = 0.8 (critical surface humidity)
9	Minimum surface temperature as function of $p_{sat}(T_{si})$, formula E.9 and E.10 of BS EN ISO 13788
10	Design temperature factor according 3.1.2 of BS EN ISO 13788
11	Internal surface temperature, obtained from $T_{si} = T_i - R_{si} * U * (T_i - T_e)$
12	External surface temperature, obtained from $T_{se} = T_e + R_{se} * U * (T_i - T_e)$

Documentation of the component
Calculation according BS EN ISO 13788
Source: **own catalogue**
Component: **Steel cold frame. Brick facing. 150 mm MW**

22. October 2016

Interstitial condensation - main results
Calculation according BS EN ISO 13788

Interstitial condensation occurs but all the condensate is predicted to evaporate during the summer months.

The risk of degradation of building materials and deterioration of thermal performance as a consequence of the calculated maximum amount of moisture shall be considered according requirements and other guidance in product standards.

Climcatic conditions
Location: Northolt; Humidity class according BS EN ISO 13788 annex A: Offices, shops

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Internal temperature [℃]	Ti	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Internal rel. humidity [%]	phi_i	50.0	48.7	48.7	48.2	52.2	57.9	62.9	63.1	60.2	57.1	53.1	51.7
External temperature [℃]	Te	5.0	4.7	7.0	8.9	12.4	15.6	17.8	17.5	14.6	11.1	7.5	5.9
External rel. humidity [%]	phi_e	83.0	80.0	75.0	70.0	69.0	69.0	69.0	70.0	75.0	81.0	84.0	85.0

Monthly moisture content per area gc [g/m²]
Accumulated moisture content per area Ma [g/m²]

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Aluminium alloys / Slightly vent.	gc	0	2	2	2	2	1	0	-2	-3	-4	---	---
air layer: 50 mm, horiz. heat flow	Ma	0	2	4	6	8	9	9	7	4	---	---	---