Façade Manual

InDeWaG represents a novel type of smart façade elements, fully capable of autonomous regulation of heat uptake.

European Commission
Horizon 2020
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for Research & Innovation

Fluid Flow Glazing Façades are capable of collecting or rejecting solar energy with the help of a liquid passing through the panels. This limits the heat from the sun being absorbed into the internal environment of a building and therefore minimizing the energy consumption of HVAC.

Inhalt

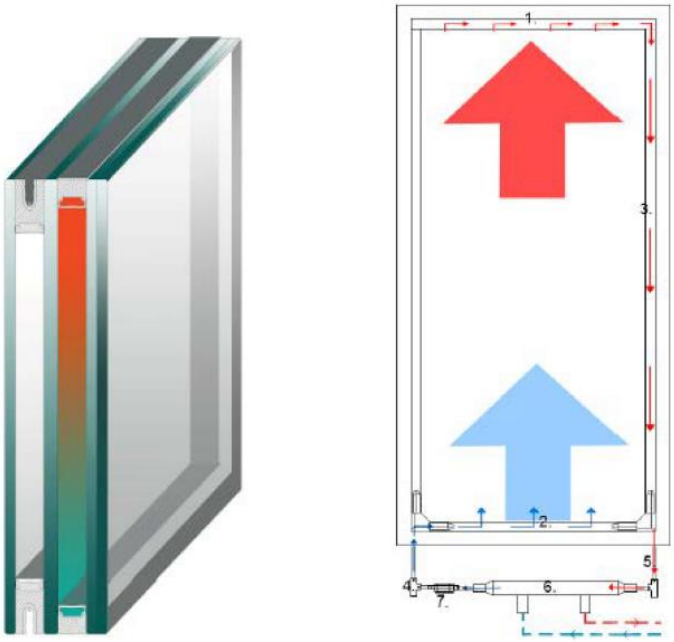
I. Product features

Fluid Flow Glazing (FFG) façades are considered active building envelopes able to react and/or to adapt to the external and internal thermal conditions of the building.

The aim of the InDeWaG concept is to combine FFG with other technologies in HVAC systems, such as photovoltaic and high-efficiency heat exchangers leading to minimized total energy consumptions of buildings without restrictions of daylight autonomy.

1. General description

In Fluid Flow Glazing façade elements solar heat is absorbed by a fluid constantly circulating through the glass panels, limiting the heat from the solar radiation being transmitted into the internal environment. This leads to moderate room temperature and an ambient room climate without the need of additional cooling. Furthermore, FFG has the potential to store and reuse absorbed energy. This enables the use of the inner glass pane as panel heating, limiting the cooling of the building in winter.



The InDeWaG concept frees architects of using sun-shading devices, allowing full transparency, as all the daylight enters the indoor spaces, with little heating by solar radiation.

- Increased use of natural light reducing artificial lighting and energy demand of the building

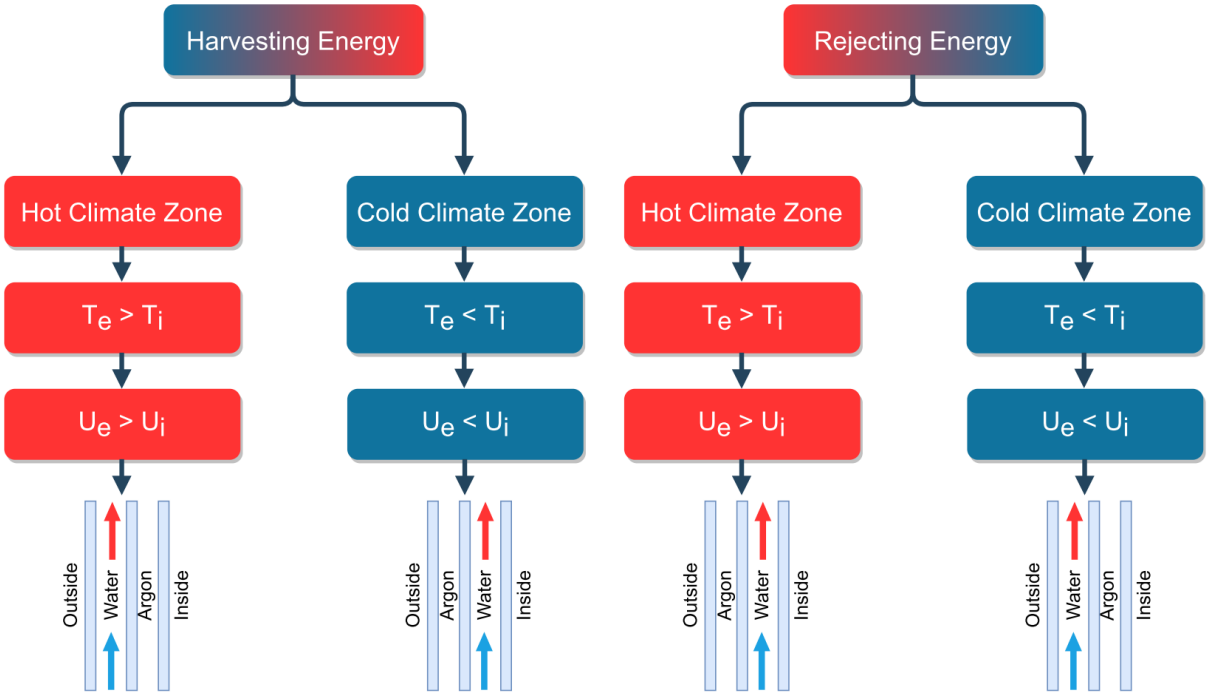
- Reducing the demand of cooling and ventilation by repelling solar energy
- Moderate room temperature and an ambient room climate without the need of additional cooling
- No accumulation of heat inside the building
- Adjustable amount of absorbed heat energy by variation of the circulation flow

Reliable building simulation is key for evaluating the overall energy balance of buildings in an early stage of planning. Therefore, InDeWaG provides a free module for IDA-ICE, allowing architects and façade planners to implement fluid flow glazing systems into their projects for thermal simulation of novel buildings.

2. Energy strategies

The InDeWaG modular façade unit utilises two different strategies of energy management: Harvesting and rejection.

In case energy harvesting is required, a high absorbing glazing (*HeatGlass*) is chosen. This absorbed energy can be transferred indoors or can be transported to a buffer tank for future use. The energy uptake can be adjusted by switching the flow rate of the glazing *on* and *off*. This can be achieved by one or more thermostats, which take information from outdoors, water chamber temperature, indoor temperature and buffer tank temperature.



When the flow rate is stopped the absorbed energy is transferred indoors. On the contrary, if a high flow rate is considered, the absorbed energy is transported by the flow.

Later, this energy is transferred by a heat exchanger connected to a primary circuit with a buffer tank. This surplus energy can be used to preheat domestic hot water or to store energy in a buffer tank, which can be used by a heat pump. A water-water heat pump takes heat from the buffer tank and raises its temperature by introducing some mechanical or electrical work. This higher temperature can be used in terminal units such as a radiant surface or a water flow glazing to heat indoors. The lower the difference of temperature between the buffer tank and the radiant surfaces, the higher the coefficient of performance of the heat pump and, consequently, the energy efficiency of the system.

In case energy rejection is required, a high reflective glazing (*CoolGlass*) is chosen with the intention to reject sun energy. Furthermore, with the water chamber of the glazing facing towards the room, interior heat loads can be eliminated when it is required. A water-water heat pump connected to a buffer tank is considered to produce cool water for the glazing. Once again, to minimize the electrical consumption of the heat pump, the temperature of buffer tank should be close to the cool water for the glazing. Free cooling techniques based on evaporative cooling and cooling by night are considered. Besides, the outermost glass layer could be combined with a photovoltaic semi-transparent layer to produce enough electrical power for the heat pump.

II. Technical Specifications

1. System overview – Technical data sheets

1.1. System test results / CE product pass in accordance with DIN EN 13830

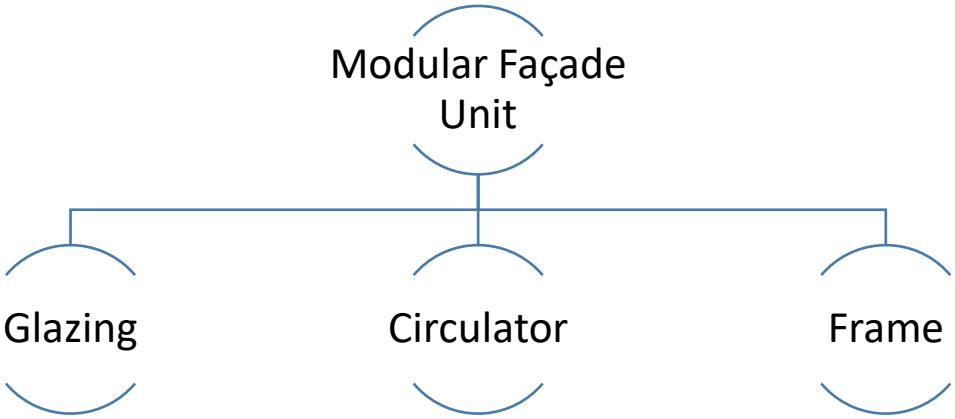
Air permeability:	Class A2 (300 Pa) according to EN 12152
Water tightness:	R4 (200 Pa) according to EN12154 3A (100Pa) according to EN12208
Resistance to wind load:	1000 / –1000 Pa according to EN 13116
Impact resistance:	Class E4 / I4 ← Recommend E5 / I5
Quality assurance:	Certified according to ISO 9001:2008

1.2. Technical performance

System width:	60 mm
Profile technic:	depth: 352 mm expansion joint 28 mm← vertical/horizontal outside window bar as frame expansion joint gasket for connection between elements
Frame connection technic:	element frame with aluminium casting angles, injection glued and mechanically fixed T-joints directly fixed by screwing T-joints with connectors Intersection with connectors
Surface:	Anodized, powder or wet coating
Glazing:	inside laminated glass 2x8 mm heat strengthened glass with 1.52 mm PVB – 24 mm water filled cavity – laminated glass 2x8 mm heat strengthened glass with 1.52 mm PVB – 16mm air filled cavity – 10 mm monolithic, fully toughened glass, heat soaked
Infill thickness:	Up to 83.2 mm as standard system, above on request
Unit sizes:	(w x h) up to 1350 mm x 3.500 mm, up to 775 mm width without mid posts

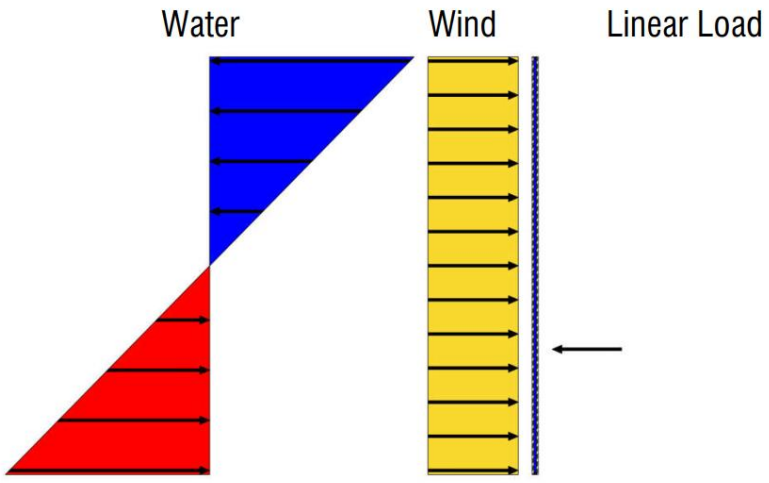
1.3. System technology

The InDeWaG modular façade unit consists of three major elements:



1.4. Static diagram

Major load case is water pressure deriving from the water-filled cavity. To reduce the hydrostatic pressure a vacuum is applied and balanced to half the pressure and receive a zero-pressure line at mid-height of the glass unit. This is a permanent load case.

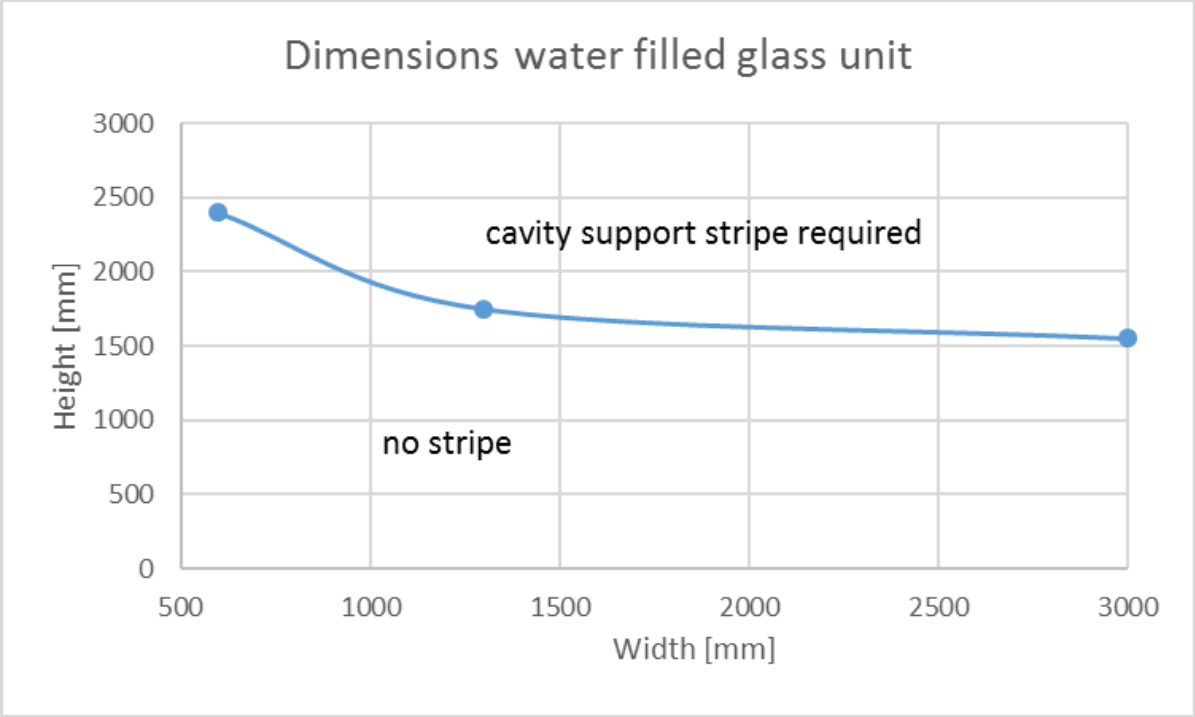


For exterior glass units wind loads need to be applied additionally.

For glazing acting as barriers a horizontal line load needs to be applied additionally and pendulum tests might be required.

Depending on the dimensions of the glass unit and the balancing of the hydrostatic pressure additional support stripes can be introduced to control and limit the deflection of the glass adjacent to the water filled cavity. A maximum deflection of approximately 5mm from either pane is allowed.

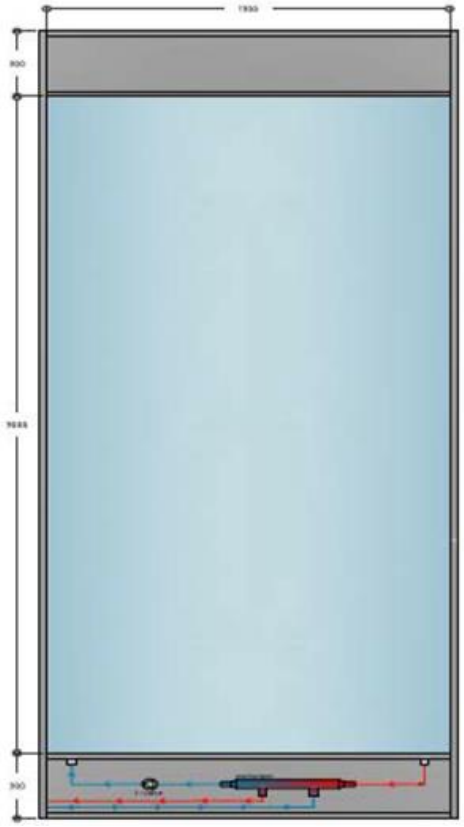
Every glass unit needs to be structurally analysed considering the boundary conditions for the specific application. The following graphic provides an estimation whether additional cavity support is required:



- Static diagram of wind load for different deflection cases (1/100 – 1/500 max. 8mm) and load cases
- Static diagram glass load
- Structural values of mullions and transoms

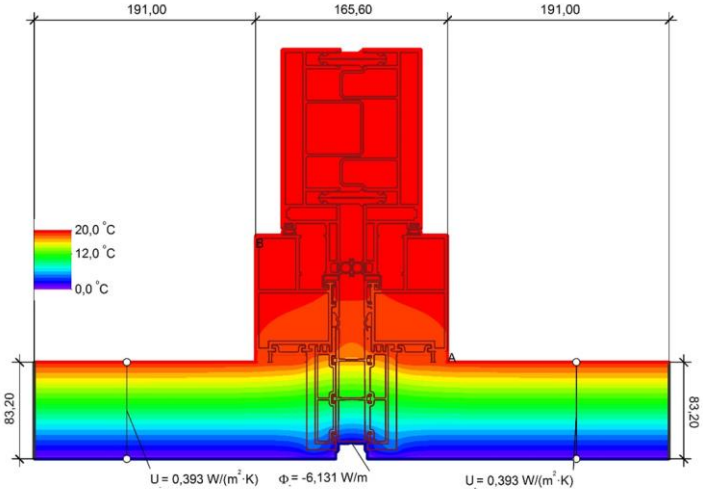
2. Thermal insulation of the frame

U_f Mullion		
	Profile depth [mm]	269.2
	Infill thickness [mm]	83.2
	22-36	0.945



U_f Transom		
	Profile depth [mm]	269.2
	Infill thickness [mm]	83.2
	22-36	0.954

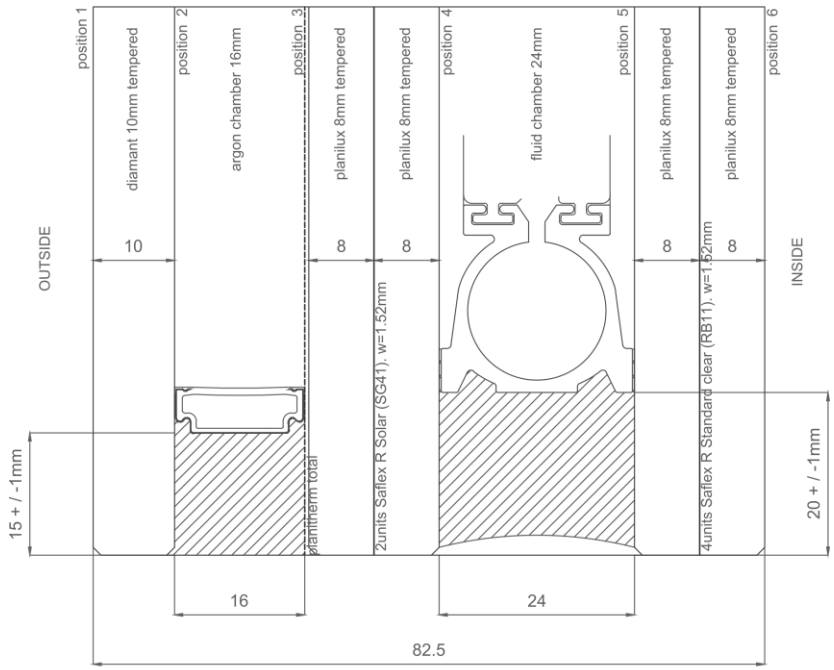
U_f Mullion / Transom		
	Profile depth [mm]	269.2
	Infill thickness [mm]	83.2
	22-36	0.945



3. Glazing Configuration

3.1. HeatGlass

HeatGlass is a triple glazing configuration intended to harvest energy. Since the energy absorption should be maximized, a highly absorptive PVB interlayer is positioned close to the water chamber. Furthermore, in order to reduce the U-value a low emissivity coating is set at position 3.



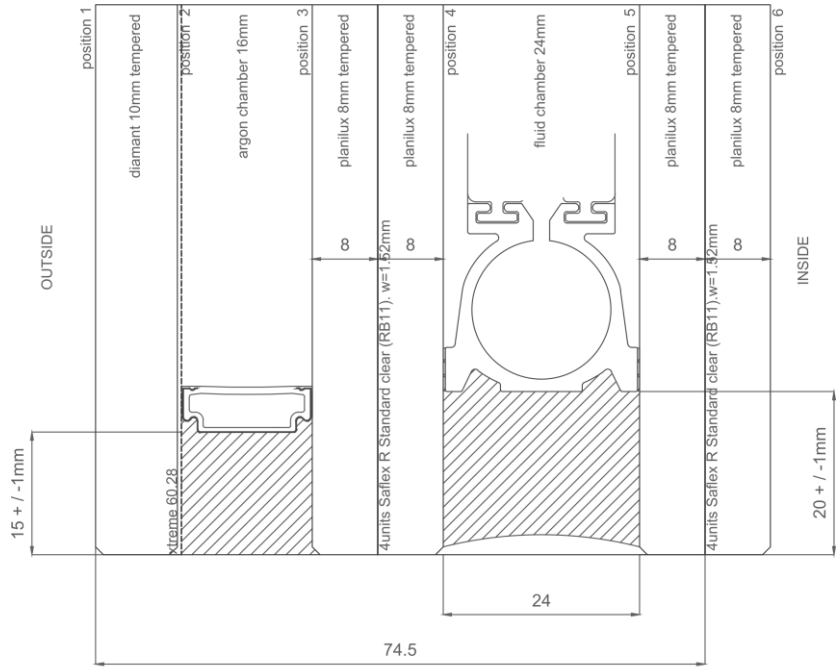
HEATGLASS THICKNESSES TRIPLE GLAZING GLASS FORMATS Lv x Hv

The maximum g value g_{off} of this configuration is around 0.7 and the minimum value g_{on} is around 0.2. This allows by switching on the hydraulic pump (g_{on}) to transport the absorbed energy to a buffer tank and by switching off to heat indoors by means of high g_{off} value.

Spectral Properties		Thermal Properties			
T_V	**T**	**Flow**	**U**	**U_w**	**g**
0.529	0.214	on	0.066	6.459	0.240
		off	1.041	0.000	0.592

3.2. CoolGlass

A triple glazing to reject energy is considered. Since the energy absorption should be minimized, a highly reflective coating (e.g. Xtreme 60.28) is positioned close to outermost glass pane (position 2). This coating allows to reduce the U-value because it can be considered a low emissivity coating at the same time (e.g. Planitherm XN).



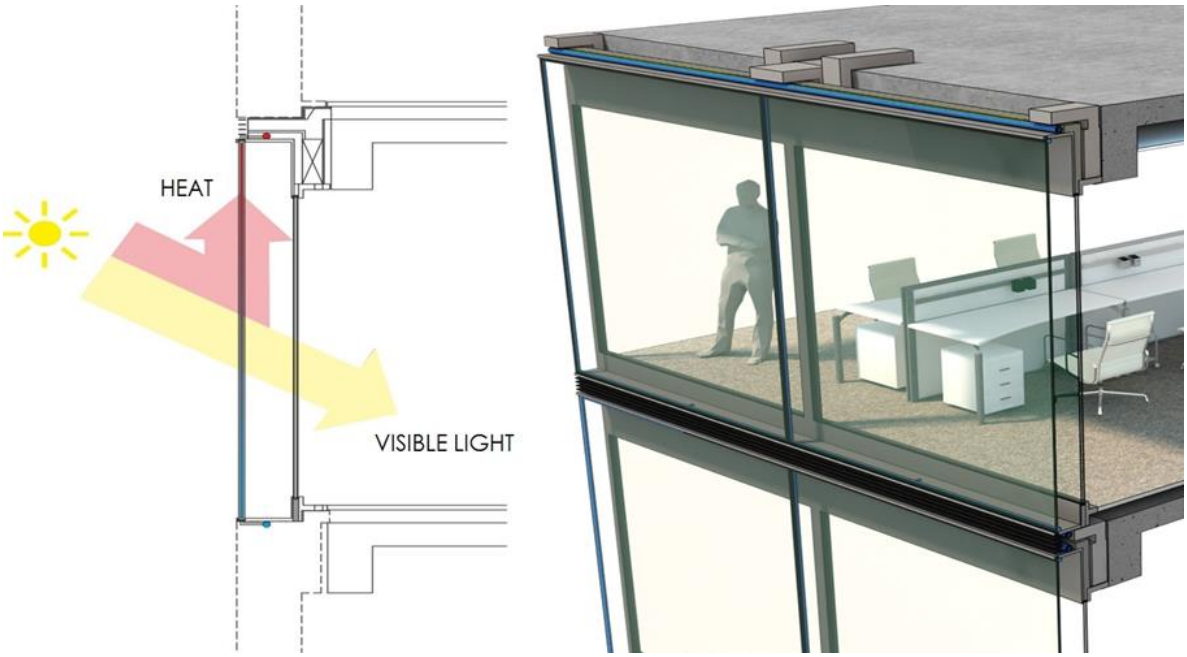
COOLGLASS THICKNESSES TRIPLE GLAZING GLASS FORMATS Lv x Hv

The maximum g-value (g_{off}) and the minimum g value (g_{on}) are almost the similar and around 0.2. Since the difference between g_{on} and g_{off} is very low, the glazing is not used to harvest energy. The strategy behind this glazing is to eliminate internal heat loads by circulating cool water through the water chamber facing indoors. This cool isothermal envelope allows insulating the building from outer boundary conditions.

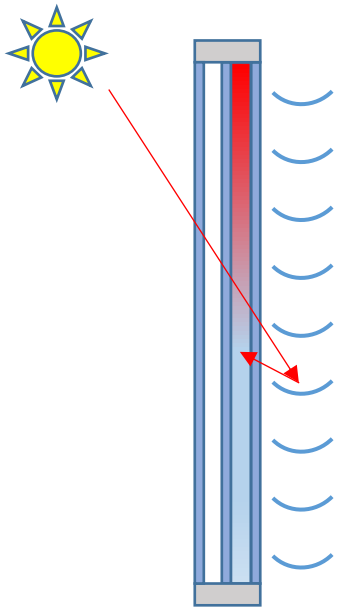
Spectral Properties		Thermal Properties			
T_V	**T**	**Flow**	**U**	**U_w**	**g**
0.550	0.215	on	0.063	6.462	0.221
		off	0.995	0.000	0.269

4. Sun shading

In general, sun shading devices are crucial for adjusting the amount of sun light penetrating a façade. In hot climate zones, shading devices can help to reduce extreme solar gains that could lead to a high demand of cooling energy. Today, the control of heat uptake is the major reason for the application of shading devices. Modern façades use motorized shading blinds to control the solar penetration in a dynamic way. The more transparent the glazing is, the bigger the dynamics of the daylight is. Smart and dynamic use of daylight may reduce significantly the usage of artificial light. These shading devices are also applicable for the InDeWaG concept. However, as Fluid Flow Glazing is absorbing a high amount of energy, the intake of heat is already reduced.



Thus, the focus of sun shading is shifted from heat to daylight management. Although the intake of daylight is generally considered to have positive effects on the working environment, it can lead to differences in light density within a work space (e.g. an office room). The results are glare effects, either directly or via reflection, exposing employees to unnecessary stresses. In order to avoid this, the intake of daylight to the working space can be adjusted with internal glare control devices such as venetian blinds. The InDeWaG concept supports the use of interior shading elements, as they are suitable to improve its performance under certain conditions.



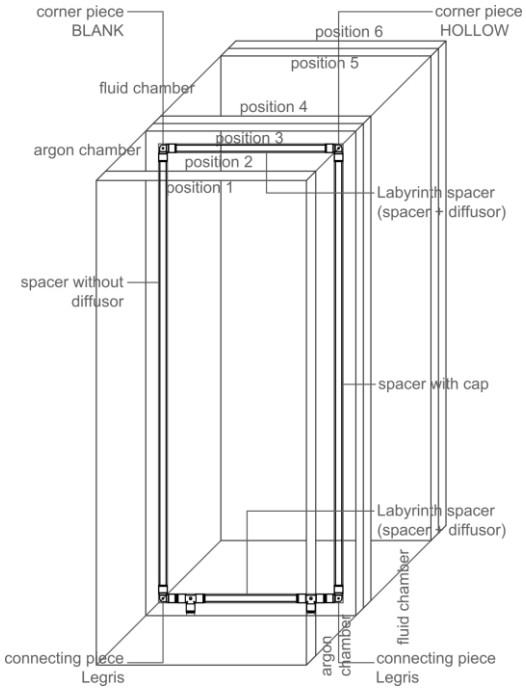
The Fluid Flow Glazing element works as double-sided collector and it absorbs heat from the inside as well as it does from the outside.

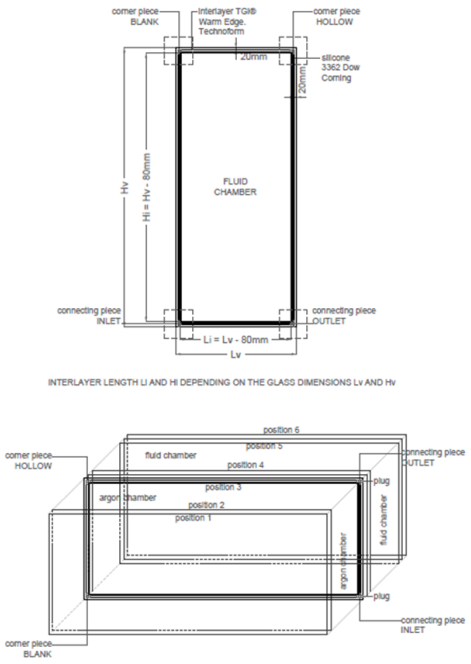
Sun light reflected from the shading element will penetrate the water chamber. Additional heat energy is absorbed or transported out of the façade. Thus, internal shading will work effectively as daylight management system without having negative impact on interior comfort.

Using of such system will affect better distribution of daylight during summer. The system will minimize direct glaring to interior and at the same time will transfer maximum diffuse daylight inside, reducing significantly artificial light during daytime.

5. Assembly

5.1. Assembly of glazing





1) Choose one glazing configuration depending on the climate, the usage of the building and the energy strategy.
2) Assembly the triple glazing with all the layers and interfaces defined by the glazing catalogue.
   a) Argon chamber will be assembled with TGI Warm Edge 16 mm spacer including desiccant gel.
   b) Water chamber will be assembled with InDeWaG 24 mm spacer made of pipe + diffusor mounted with the special parts (inlet, outlet, hollow corner and structural corner).
3) Butyl will be used as the first impermeable barrier 3-4 mm.
4) Structural Glazing Sealant Dow Corning 993 (15 mm) will be used as the second barrier and final enclosure of the perimeter.
5) Fill up the glass with the Water-Glycol solution and check there is no water leak in the glass unit.
6) If there is a leak, repair the unit.

5.2. Assemble of Element

Each of the frames (main frames and sub frames) is prepared separately, as the connection between them is done by hanging and locking devices, thus following the frame-in-frame concept.

First thing is placing the selected joint adhesive in the joint holes, after which the corner joints are put in place and the frame is put together. The assembly of the frame is done, after the joints are crimped on a crimping machine.

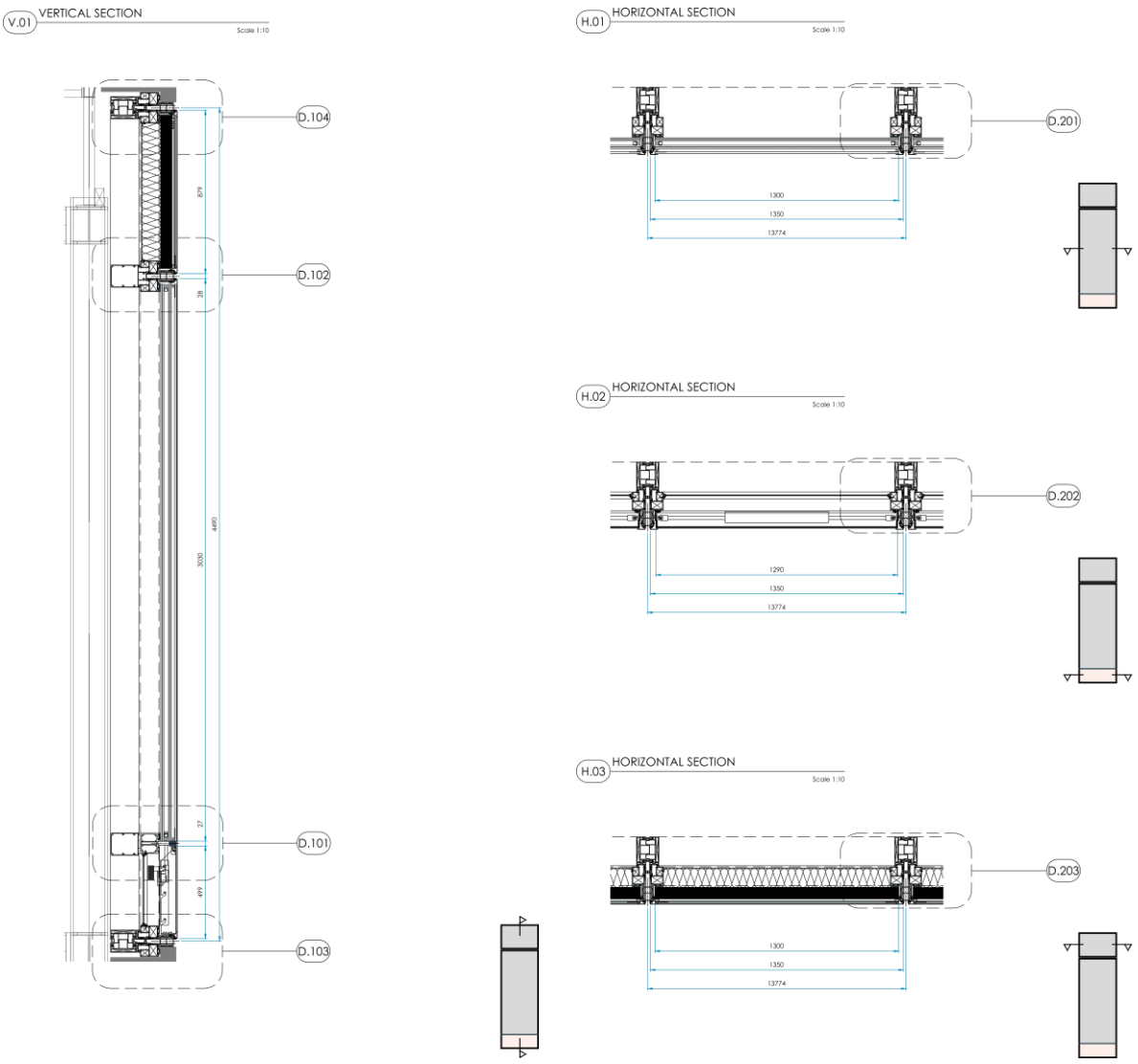
After the perimeter of the frame is finished, the T-profiles are placed.

The additional accessories (hangers and lockers) are then placed, in accordance with the drawings, allowing the design connection between the main frame and sub frame to be accomplished.

The final system component to be placed in the assembly are the gaskets. These are to assure a certain level of water and air permeability (sub-frame to main frame, main frame to main frame, etc.), as well as to assure the proper connection gap and contact between the different elements and components.

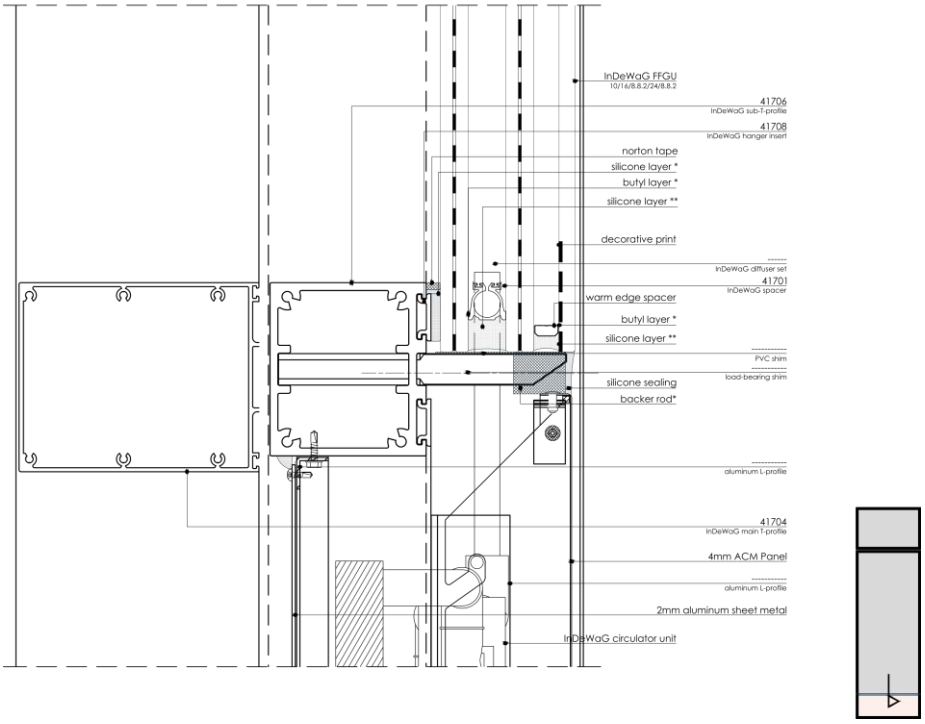
Once the aluminium frames are assembled and finished, they are ready for the circulator and glazing attachment. Each façade module contains one circulator and three glazing units – two DGUs (top and bottom) and one TGU (performing the fluid circulation, as a middle panel). The glazing units are attached to the sub-frame by means of adhesives, and then additionally concealed with aluminium caps, assuring its design position.

6. Example of application



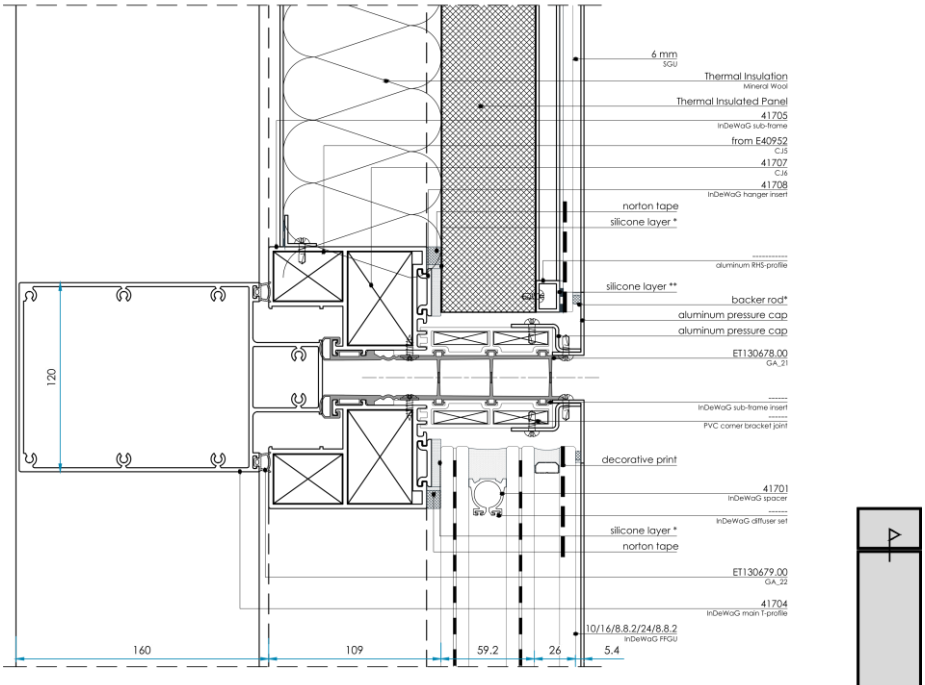
D.101 VERTICAL SECTION - SUB-T-PROFILE

Scale 1:2



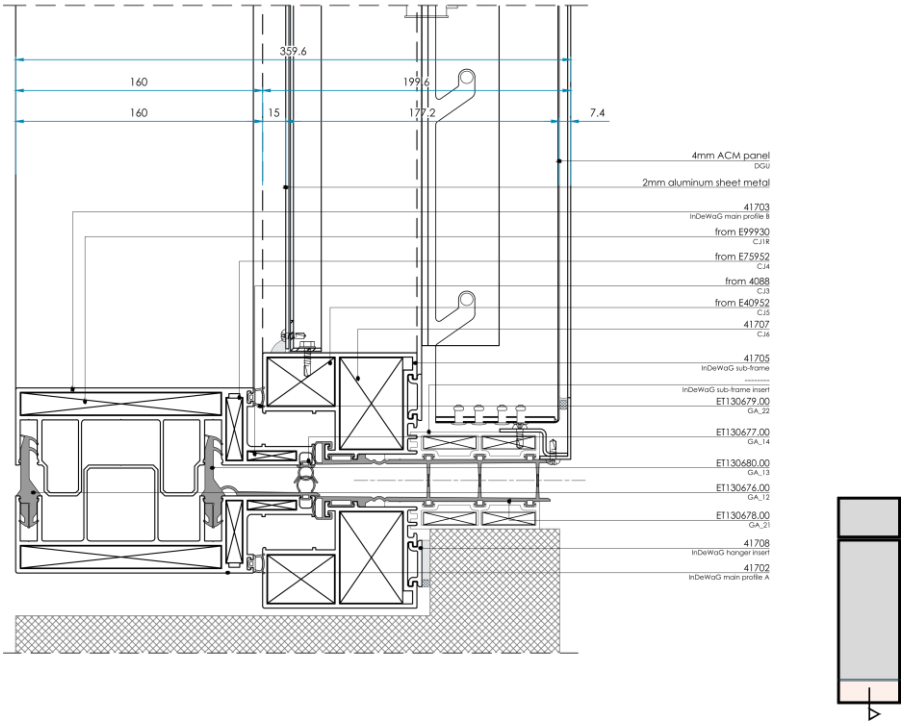
D.102 VERTICAL SECTION - MAIN-T-PROFILE

Scale 1:2



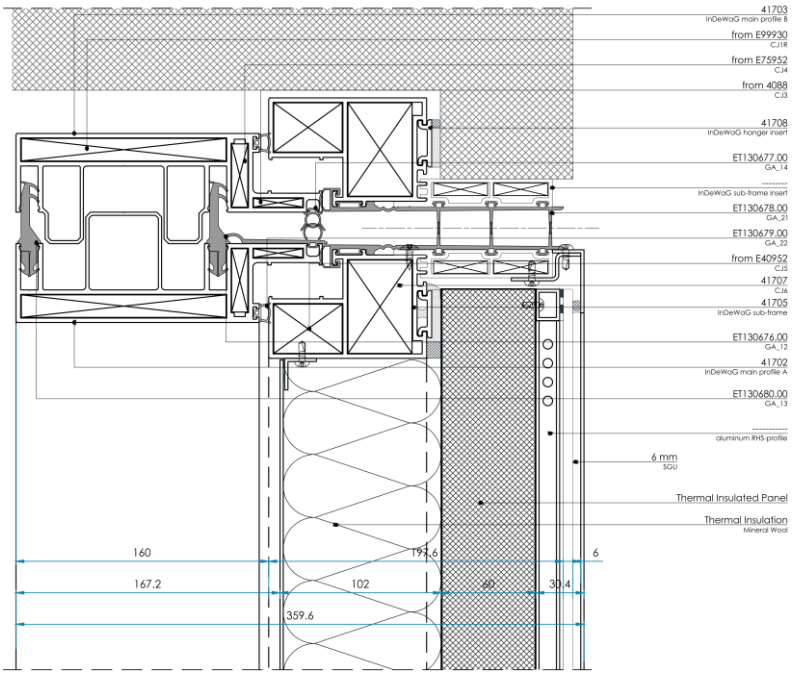
D.103 VERTICAL SECTION - BOTTOM DETAIL

Scale 1:2



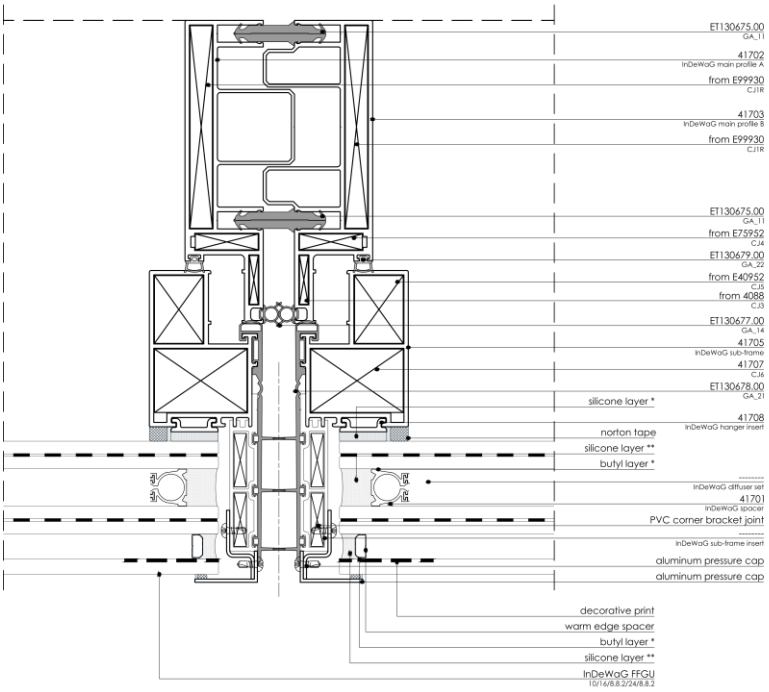
D.104 VERTICAL SECTION - TOP DETAIL

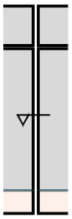
Scale 1:2



D.201 HORIZONTAL SECTION - VERTICAL JOINT 1

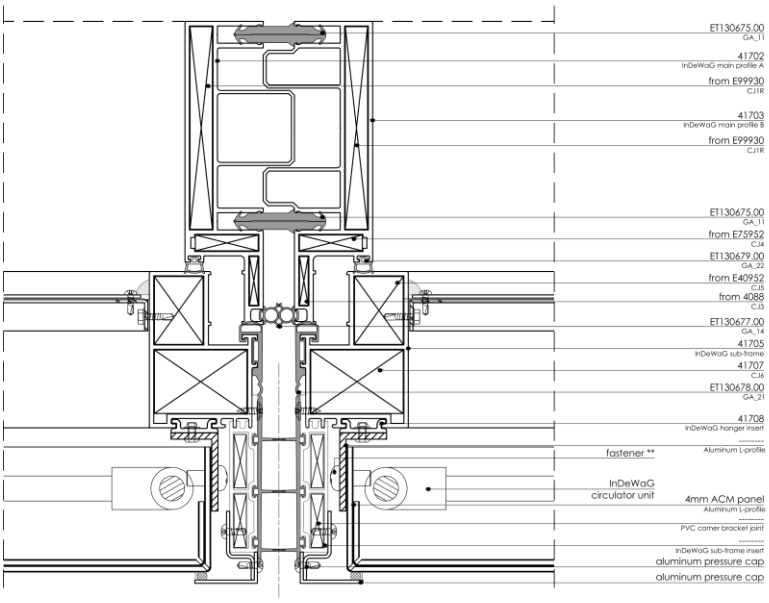
Scale 1:2

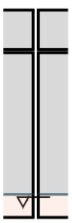




D.202 HORIZONTAL SECTION - VERTICAL JOINT 2

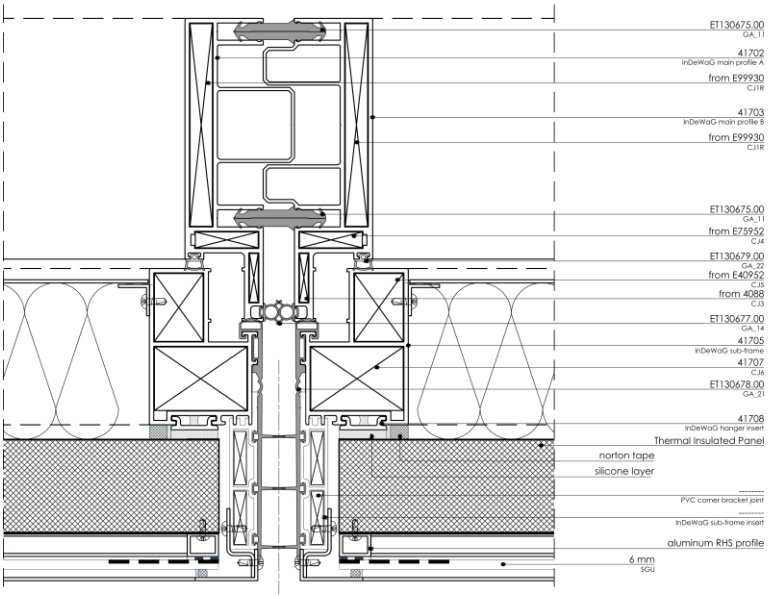
Scale 1:2

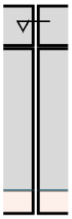




D.203 HORIZONTAL SECTION - VERTICAL JOINT 3

Scale 1:2





7. Selection table parts

A detailed list of the main components – profiles, accessories and other components (fasteners, interface elements etc.), for one module of the FFG InDeWaG facade system is presented below:

#	purpose / position	type	Size (mm)	material	QTY per module	total QTY	QTY in 1 pack	total packs
1	Hanging Devices - for IDW-HG3, IDW-HG4	DIN 923 - M8 x 20	20	A4-70	10	300	1	300
2	Hanging Devices - for IDW-HG1, IDW-HG1M	DIN 923 - M6 x 16	16	A4-70	24	720	1	720
3	Hanging Devices for IDW-HG2	DIN 7991 - M8 x 59 (drawing)	70	A4-70	24	720	1	720
4	Hanging Devices for IDW-HG5, IDW-HG6	DIN 7991 - M8 x 70	70	A4-70	10	300	1	300
5	Hanging Devices for IDW-HG5, IDW-HG6	DIN 970 - M8	-	A4-70 / A4-50	10	300	1	300

6	Hanging Devices for IDW-HG5, IDW-HG6	DIN 9021 - M8	-	A4 / A2	10	300	1	300
7	Hanging Devices for IDW-HG2	BN 4879 - M8	d_i=8,4mm h=5mm d_e=25mm	A4 / A2	24	720	1	720
8	Locking devices for IDW-Lk1, IDW-Lk2, IDW-Lk3	DIN 912 - M6 x 25	25	A2-70	7	210	1	210
9	Locking devices for IDW-Lk4	DIN 912 - M6 x 30	30	A2-70	2	60	1	60
10	Locking devices for IDW-Lk1	DIN 9021 - M6	-	A2	2	60	1	60
11	Locking devices	DIN 127 - M6	-	A2	11	330	1	330
12	Locking devices	Blind Rivet M6 x 15,5 - countersunk head (Masterfix)	15.5	A2	7	210	1	210
13	Locking devices for IDW-Lk1, IDW-Lk2	Blind Rivet M6 x 18 - countersunk head (Masterfix)	18	A2	5	150	1	150
14	Locking devices for IDW-Lk5	DIN 7504 K ST 5,5 x 25 - (Ejot, Hilti, Wuerth)	25	A2-St	4	120	1	120
15	Coimbra Fixing Brackets	DIN 4017 - M20x150/8.8	150	Zinc Plated	6	18	1	18
16	Coimbra Fixing Brackets	Pin - M10 x 350	350	Zinc Plated	4	12	1	12
17	Coimbra Fixing Brackets	DIN 970 - M10	-	Zinc Plated	20	60	1	60
18	Coimbra Fixing Brackets	DIN 125A - M10	-	Zinc Plated	20	60	1	60
19	for Corner T-Bracket Joints for IDW-TJ10	DIN 7337 - Ø5 x 20 Type A	20	A2 / A2	4	12	1	12
20	for Corner Bracket Joints for IDW-CJ3	DIN 7337 - Ø5 x 8 Type A	8	A2 / A2	16	48	1	48
21	for Corner Bracket Joints for IDW-CJ1, IDW-CJ1-1, IDW-CJ2-1, IDW-CJ2, IDW-CJ6	DIN 7337 - Ø5 x 12 Type A	12	A2 / A2	16	48	1	48
22	Hanging Devices for HK1	DIN 6912 - M12 x 80	80	A2-70	16	48	1	48

23	Hanging Devices for HK1	DIN 127 - M12	-	A2	16	48	1	48
24	Hanging Devices for HK1	DIN 125A - M12	-	A2	16	48	1	48
25	Hanging Devices for HK1	DIN 970 - M12	-	A4-70 / A4-50	16	48	1	48
26	for PVC	DIN 968 - ST4,2 x 16 - C - H	16	A2	60	180	1	180
27	For all fasteners	Wuerth High Strength Threadlocker	-	-	50ml	150ml	1	150ml
28	for EPDM	DIN 7504 ST 4,2 x 13 - M - Z	13	A2	30	90	1	90
29	-	DIN 7049 ST 5,5 x 38 - TX	38	A2-70	30	900	1	900
30	Sub-Frame	DIN 931 - M8 x 65	65	A2-70	4	120	1	120
31	Sub-Frame	DIN 931 - M8 x 95	95	A2-70	4	120	1	120
32	Sub-Frame	DIN 127A - M8	-	A2	8	240	1	240
33	Sub-Frames	DIN 7337 - 4,8 x 10	10	A2/A2	10		1	
34	Sub-Frames	DIN 7337 - 4,8 x 12	12	A2/A2	14		1	
35	Sub-Frames	DIN 7337 - 4,8 x 16	16	A2/A2	8		1	
36	Sub-Frames	DIN 7504 - ST4,8 x 19 - K	19	A2	10		1	
37	Sub-Frames	DIN 7504 - ST4,2 x 13 - M - Z	13	A2	30		1	
38	Sub-Frames	DIN 125A - M5	M5	A2	14		1	
39	Sub-Frames	DIN 7985 M8 x 20 - Full Thread	20	A2	6		1	
40	Sub-Frames	Резбова втулка (Threaded Screw Insert) - M8 - As per drawing	-	AISI 304	6		1	
41	Sub-Frames	DIN 7504 - T - 4,8 x 16 (в краен случай DIN 968 - 4,8 x 16 - C - H)	16	A2	30		1	

42	Coimbra Interface Brackets	DIN 7504 - K - ST5,5 x 19 - Hexagonal Head and EPDM Washer	19	A4	190	190	1	190
43	Outer Glazing Frame	DIN 7504 - 4,8 x 13 - M -Z	13	A4 (A2)	80	2400	1	2400
44	Corner Brackets	DIN 976 -1 M10 x 200 Stud Bolt, Class - min. 4.6	200	Zinc Plated	1	4	1	4
45	Corner Brackets	DIN 970 - M10, Class - min. 4.6		Zinc Plated	2	8	1	8
46	Corner Brackets	DIN 4017 - M20 x 150, Class - min. 6.8		Zinc Plated	2	8	1	8
47	Corner Brackets	DIN 6334 - M20, Class - min. 6.8	60	Untreated	2	8	1	8
48	Corner Brackets	DIN 970 - M10, Class - min. 4.6		Untreated	1	4	1	4

8. Glazing Configuration – Technical Overview

Model	CoolGlass	HeatGlass
Dimensions	3000 x 1300 *mm*	3000 x 1300 *mm*
Thickness	82 *mm*	82 *mm*
Total Area	3.9 m^2	3.9 m^2
Useful Area	3.73 m^2	3.73 m^2
Weight	409.50 *kg*	409.50 *kg*
Acrylic glass stripe	15 x 24 x 2888 *mm**	15 x 24 x 2888 *mm**
Composition	10/16A/8+8/24F**	10/16A/8+8/24F/8+8**
Zero-line pressure	500 *mm****	500 *mm****
Glass Types	Diamant Tempered/ Planiclear Heat Stregthened	Diamant Tempered/ Planiclear Heat Stregthened
PVB	Saflex R Standard Clear (RB11) 1.52*mm*	Saflex R Solar (SG41) 1.52*mm*
Coatings	Xtreme 60.28 (face2)	Planitherm XN (face3)
Fluid capacity	93.6 liters	93.6 liters
Visual Transmittance (T_v)	0.550	0.529
Transmittance (*T*)	0.215	0.214
***g* Factor**	0.221 – 0.269****	0.240 – 0.592****
Thermal Transmittance (*U*)	0.063–0.995 $W/(m^2K)$	0.066–1.041 $W/(m^2K)$
Thermal Transmittance (U_w)	6.462–0.00 $W/(m^2K)$	6.459–0.00 $W/(m^2K)$
Design Flow Rate	8 *l/min*	8 *l/min*
Design Inlet Temperature	17 *ºC/ 21 ºC*	17 *ºC/ 21 ºC*
Outlet Temperature	18.3 *ºC/* 21.9 *ºC*	21.3 *ºC/ 24.9 ºC*
Indoor Cooling capacity	154.05 *W/ 67.86 W*	-

Indoor Heating capacity	-	81.51 *W* / 4.29 *W*
Heat transport capacity	317.9 *W*/ 215.7 *W*	1018 *W* / 915 *W*
Electric pump consumption	10 *W*	10 *W*