D5.5 – Development of installation, commissioning and maintenance guidelines

WP5

Lead Partner: BGTec

Partner Contributors: Focchi, RINA-C, UNSTUDIO, GMD

Dissemination Level: Public

Deliverable due date: M48 Actual submission date: M49

Deliverable Version: V0.1

Project Acronym	EENSULATE
Project Title	Development of innovative lightweight and highly insulating energy efficient components and associated enabling materials for cost-effective retrofitting and new construction of curtain wall facades
Grant Agreement n°	723868
Funding Scheme	Innovation Action
Call	H2020- EEB-2016
Topic	EEB-01-2016 Highly efficient insulation materials with improved properties
Starting Date	1st August 2016
Duration	55 Months

Executive Summary

The present document constitutes Deliverable 5.5 “Development of installation, commissioning and maintenance guidelines”, part of WP5 “Validation of performance, sustainability and replicability”, in the framework of EENSULATE project.
This deliverable is strictly related to the preparatory works concerning particular demo buildings, installation of developed solution and it is based on the results of the previous WPs, in particular WP4 “Detailed design, prototyping and lab characterisation of EENSULATE façade modules”.
The objective of this deliverable is to describe particular components and steps for the installation of EENSULATE solutions and to provide recommendations for the manufacturing and installation process, starting with description of system components.
In order to facilitate explanation of steps, photos from the installation of EESULATE solutions will be included after demonstration activities.

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Abbreviations and Acronyms

D - Deliverable

VIG – Vacuum Insulated Glass

WP – Work Package

DGU –Double Glazed Unit

TGU - Triple Glazed Unit

OCF - One component foam

BCF - Bicomponent foam

PVB - polyvinyl butyral

1 Introduction

The aim of this deliverable is to produce guidelines for design, installation, commissioning and maintenance of the EENSULATE components.

This deliverable also describes particular steps to be performed during installation and necessary equipment for proper installation process taking into consideration maintenance and transport issues.

The scope of the provided recommendations is ensuring that the whole retrofitting process is completed on time and budget by identifying any relevant risks and issues escalated in timely manner so they can be efficiently resolved.

2 Overview of the EENSULATE retroffiting process

EENSULATE project is focused on development and installation of Vacuum Insulated Glass (VIG) modules. It is a novel high insulating glazing type, nevertheless the installation process does not differ significantly from state-of–the-art façade and windows installation. Description of particular components of the overall system and installation steps are presented in following sections.

Three new products to be integrated into façade and window systems developed within the project will be implemented on real demo buildings in different configuration demonstrating their applicability in various retrofitting scenarios, as summarised below.

- ✓ **EENSULATE foam** (developed and described in WP2) - with thermal conductivity of 0.024 W/m2K, and reaction to fire of B1 suitable for two kind for different applications:
  - One component foam (OCF) for facilitating installation and insulating space around the window;
  - Bicomponent foam (BCF) to fill the spandrel volume in façade modules.
- ✓ **EENSULATE VIG** (developed and described in WP3) - transmittance of 0.37W/m2K for thickness of 18.5 mm. Light and thin Vacuum glazing suitable for new, existing and historical windows.
- ✓ **EENSULATE façade module** (developed in WP4) - part of the curtain wall system which integrates VIG and BCF in façade solution and its combination with a customized profile (transmittance of 0.64 W/m2K).

In order to validate the products integrated into façade and window system and monitor real installation process four different demo buildings have been originally selected. The last one have been eliminated with the first amendment approved on January 2020.

- **Polish Primary School** – Tertiary Building in Dzierżoniów, Poland where Eensulate façade modules will be installed.
- **Museum City of Dzierżoniow** – Historical building in Dzierżoniów, Poland to install the EENSULATE VIG and foam to renovate the original old windows.
- **San Giovanni Public Library** – Historical building renovated in 2002, Pesaro, Italy to install the EENSULATE VIG in the selected window door.
- **Focchi Headquarters** – Tertiary Building, Poggio Torriana (Rimini), Italy to install the EENSULATE VIG – cancelled from the list of demonstrators

On that basis, four retrofitting scenarios are defined in order to demonstrate the wide applicability of EENSULATE components in different building retrofitting case. Application guideline was defined supporting the retrofitting market with EENSULATE components, with approach as below:

- **Curtain Wall Façade**:

  - Façade replacement – EENSULATE module for the replacement of existing Curtain Wall Façade (Polish Primary School case) - lightweight solution to improve the weight on the load bearing structure of the building and to increase its energy performance.
  - Existing glass replacement – EENSULATE VIG for the replacement of standard triple or double glazing units in Curtain Wall Façade (Focchi Headquarters). In this case the adoption of the EENSULATE VIG is possible with minor changes in Curtain Wall system.

-**Windows**:

  - Historical window – EENSULATE VIG for the replacement of old glass with improvement of energy transmittance without affecting the overall view of the window.

- Contemporary window – EENSULATE VIG for the replacement of standard DGU/TGU in existing window with improvement of performance without affecting the overall configuration of the window.

In the next chapter the document will focuse on installation steps for retrofitting of curtain wall (on the basis of School case) and historical window retroffiting (for the Museum case).

3 EENSULATE retrofitting installation process

Despite developed solutions are suitable both for new and retrofit constructions, selected demonstration buildings reflect retroffiting cases.
Installation process does not differ much from state-of the art façade and windows retroffiting and its particular steps are summarized below.

Curtain Wall Façade retroffiting:

Figure 1 Work flow - Façade

Demo 1 case - Polish Primary School – Tertiary Building in Dzierżoniów, Poland.

Window retroffiting:

Figure 2 Work flow – Windows

Demo 2 case - Museum City of Dzierzoniow – Historical building, Dzierżoniów, Poland

Demo 3 case – San Giovanni Public Library – Historical building, Pesaro, Italy

Installation activities are followed by preparatory works the procedures includes activities as preliminary design, computer calculations of the systems, assessment of connections methods between particular elements and building.

Façade systems has big influence on the general building shape, not only because of its thermal, hygrothermal, assuring structural stability, static and aesthetic aspect but also safety issues during and after its installation. For that reason planning and proper preparation are important.

School retroffiting case - preparatory works before installation:

Figure 3 School building

Site visit

In order properly plan all activities related with selecting proper solution, site visit is necessary. Some photos of the building before the intervention taken during the first survey are reported below.

Figure 4 Exisiting façade – School external view

Figure 5 Exisiting façade – School internal view

Visualization

To facility visualization of solution to be implemented on the building, 3D drawings are prepared both of the external as well as the internal part reflecting scope of the future intervention (exterior and interior view), as shown below.

Figure 6 Exterior view - Visualization

Figure 7 Interior view - Visualization

Stocktaking of exisiting façade

It was crucial that façade appearace is the same like exisiting one. Exact measurements were taken during the on site survey to keep the same divisions and mullion and transom position in the retrofitted façade to preserve the aesthetical result. Some details are reported in the figure below.

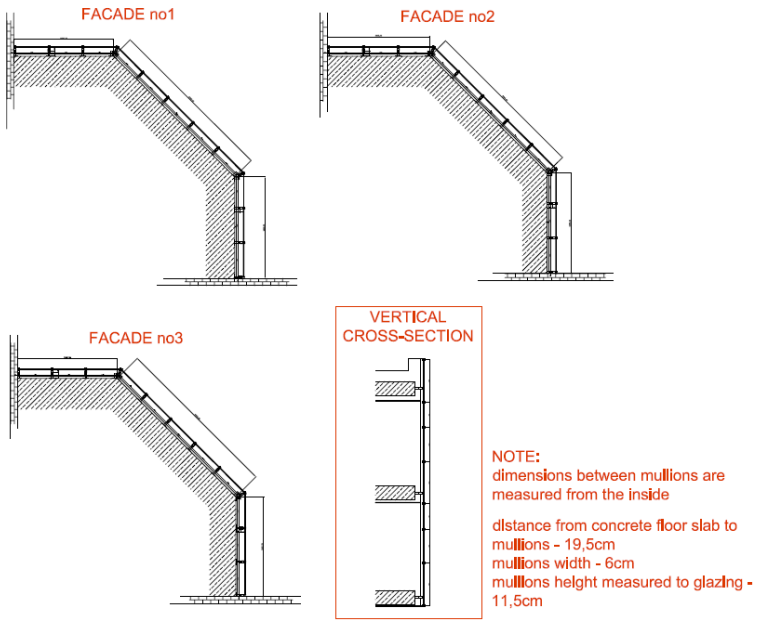


Figure 8 Building inventory – School facade

Conceptual design and preliminary drawings

On the basis of inventory taken on site, preliminary design is prepared for eventual discussion and approval. The main drawings of the architectural design are reported in the following.

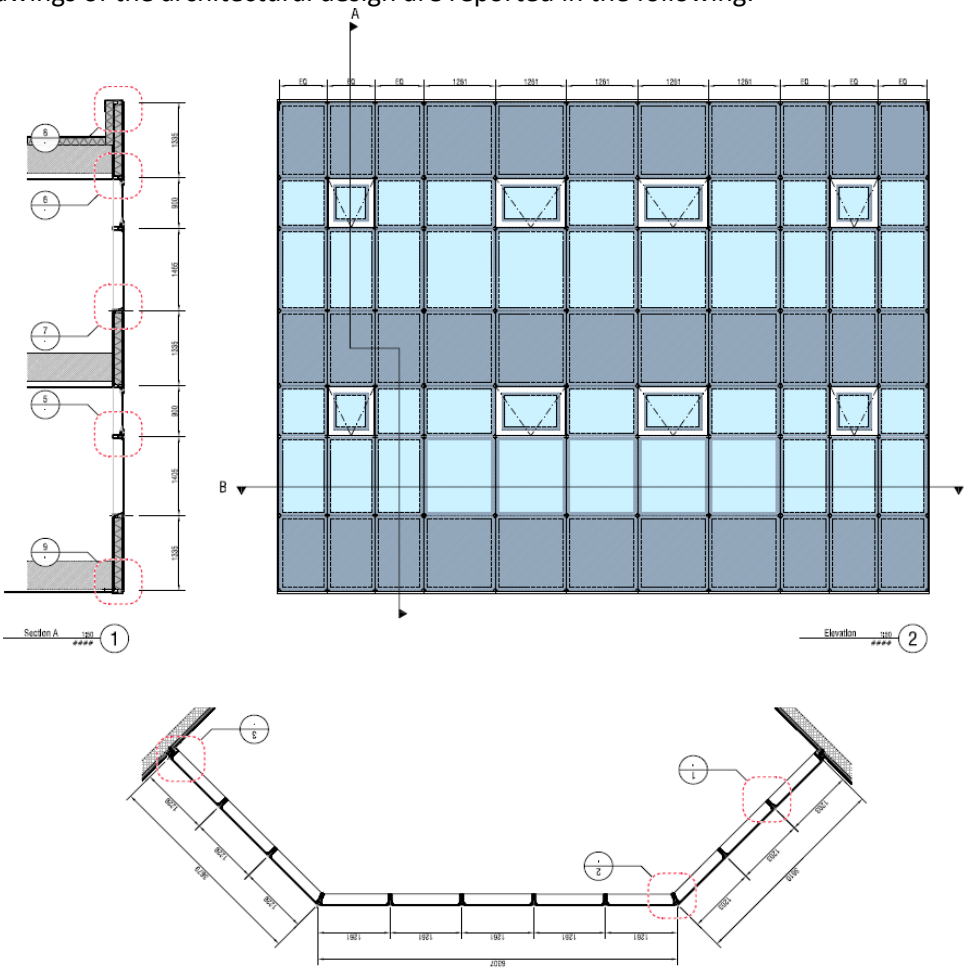


Figure 9 First drawings

Detailed drawings (section, plan, details, connections)

For proper connection of the aluminium facade with the building structure, detail drawings including joints and finishing details are prepared. An example is reported below.

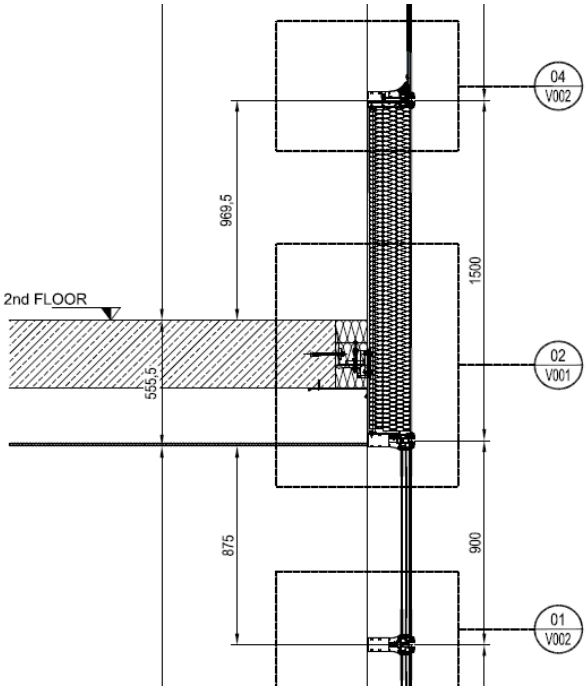
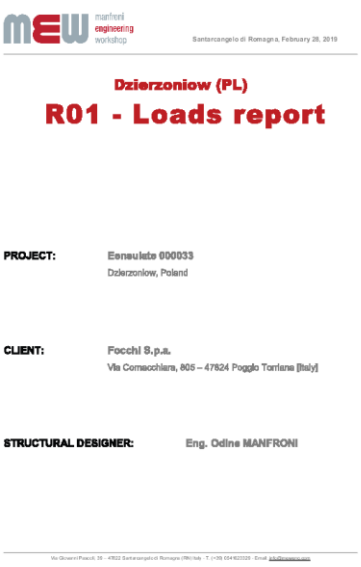


Figure 10 Section of the façade with details

Structural calculations

In order to resist forces subjecting the new costruction, it is crucial to perform structural calculations. Developed solution has to be well design in accordance with regulations and assuring structural stability.



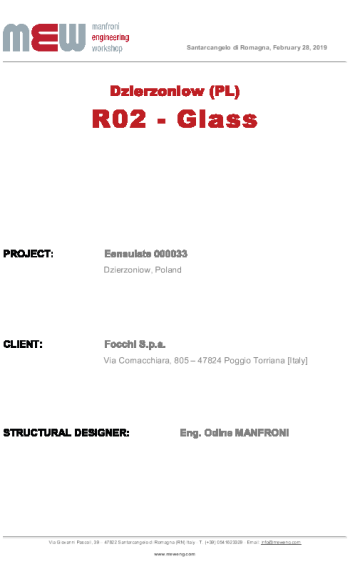


Figure 11 Structural calculations

Preparation of material

After approval of divisions, connections and structure it is possible to make a material orders based on the bill of quantities and manufacturing of façade components.

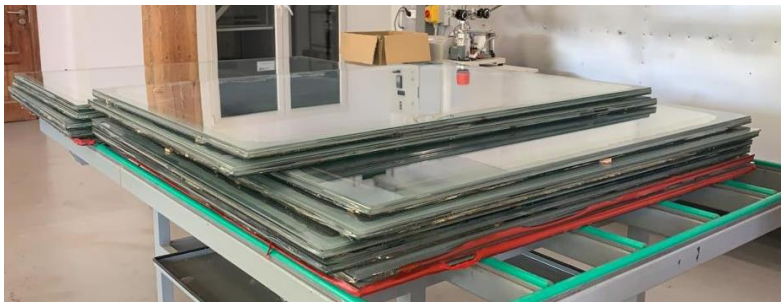


Figure 12 Preparation of the glazing units

Permission phase

To enable installation process it is necessary to obtain necessary permissions from demo owner and depending on the case, from the municipality.

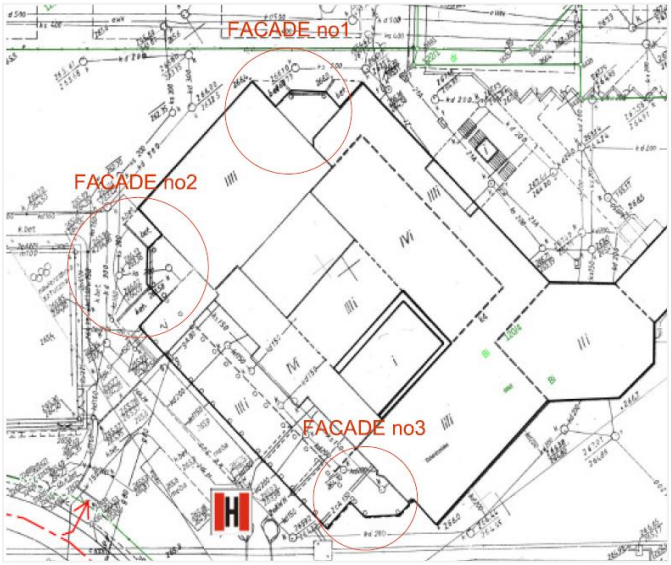


Figure 13 Plan

Installation

After performing of these preparatory activities, installation process can start to the selected sites.

3.1 Curtain wall solution - Primary School in Dzierzoniow case

3.1.1 Overview

Primary School in Dzierżoniów represents the retroffiting process of public building case.

One of the three existing curtain wall facades of surface 115m2 will be substituted with new unitized façade system including EENSULATE foam and VIGs. Part of the selected façade will be renovated with VIGs and part

with standard TGU to enable assessments and comparison of the solutions developed in EENSULATE project with respect to commercial ones.

Figure 14 Primary school building in Dzierzoniow

Figure 15 View of the exisiting façade in Dzierzoniow demo building

3.1.2 Façade components

EENSULATE module integrating EENSULATE components (BCF foam and VIG).

Unitized curtain walls are composed of structural units that are fully pre-fabricated in factory then transported and fitted to the buildings. Modules are hanging from brackets fixed along the edge of the upper floor slab.
Spandrels covering slabs (opac parts) will be filled with ENSULATE BCF foam and the parts between floors are transparent thanks to VIG or TGU units.
In order to provide weather tightness, open grooves and overlapping gaskets are planned along the perimeter of the units so as to form drainage channels along the edge of such units.
The glass system is mechanically captured in gaskets by means of an exterior frame that is thermally isolated from the internal one.

3.1.2.1 Mullion

Supporting construction is composed with aluminium profiles (Material: aluminium alloy 6063-T6).

Bellow is reported a drawing of the type of mullions to be applied.

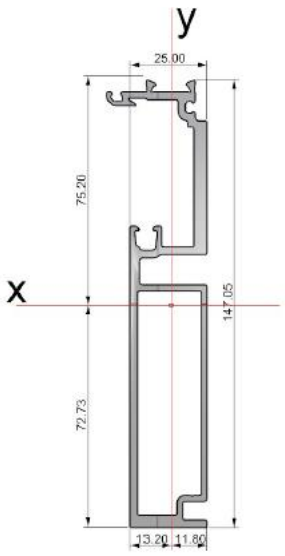


Figure 16 Façade mullion

3.1.2.2 Transoms

In the following, horizontal elements of the façade construction are detailed, including technical drawings.

Female transom

Material: aluminium alloy 6063-T6

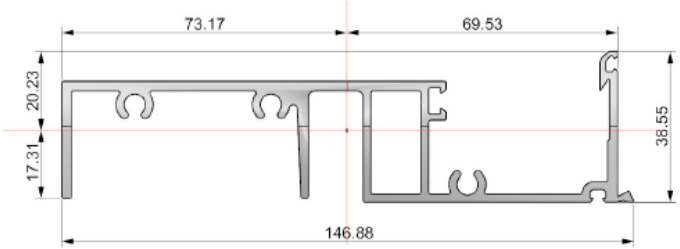


Figure 17 Female transom

Male transom

Material: aluminium alloy 6063-T6

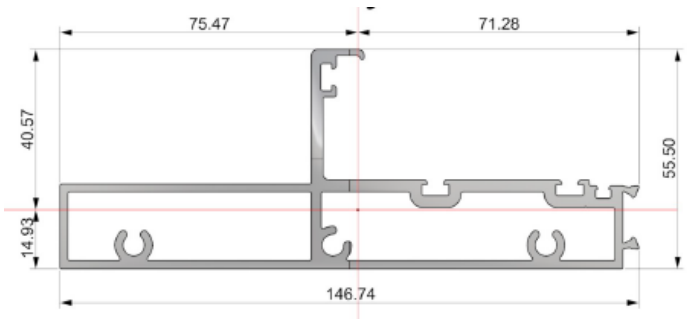


Figure 18 Male transom

Central transom

Material: aluminium alloy 6063-T6

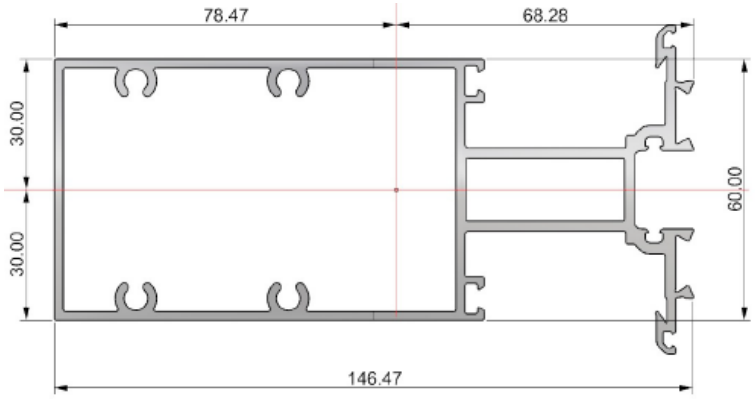


Figure 19 Central transom

Lower and upper transoms

Female transom

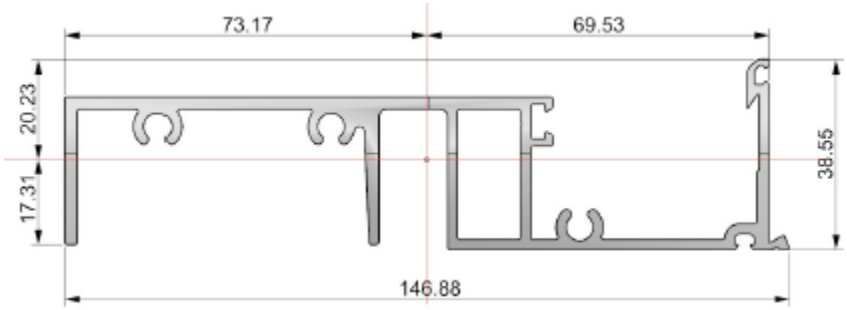


Figure 20 Female transom

Male transom

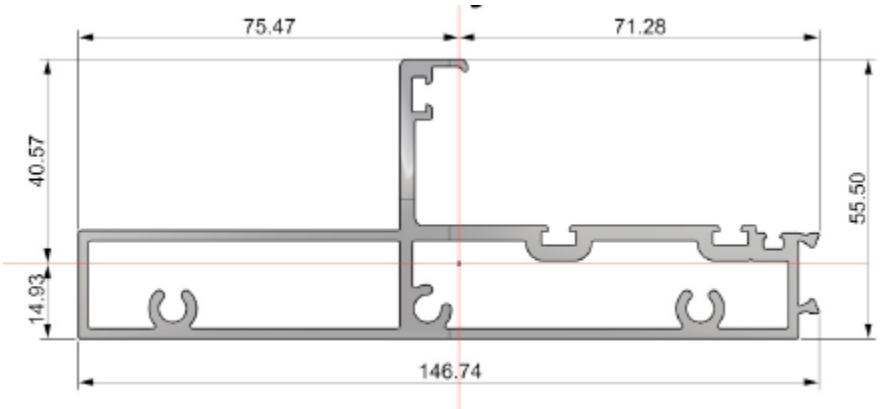


Figure 21 Male transom

3.1.2.3 Connectors

The connectors constituting the façade system are listed below, including drawings.

Female transom

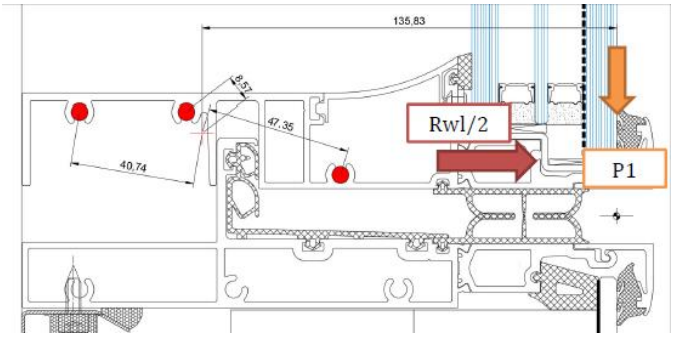


Figure 22 Lower transom detail – Lateral view

Stack Joint Connection

Three screws guarantee the connection between the lower transom to the vertical mullions, another three between the male transom to the vertical mullions.

Central transom connection

The central transom is connected to the mullion with four screws on the end.

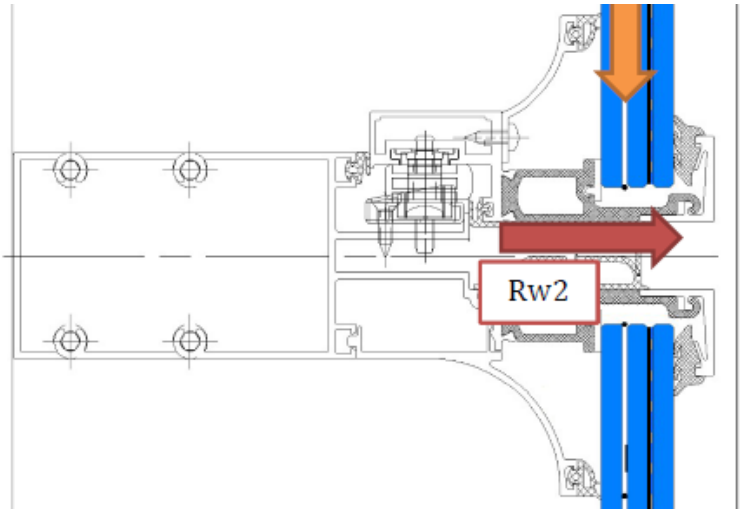


Figure 23 Central transom connection

Lower transom detail- lateral view

Glasses shelves

Glasses are supported on their lower edge by two glass shelves each.

Shelf A

Type A supports a DGU glass 1200mm high.

Vertical load is applied on a single shelf

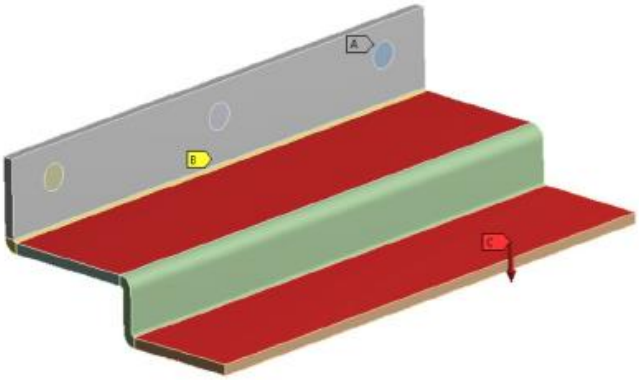


Figure 24 Glass shelve type A

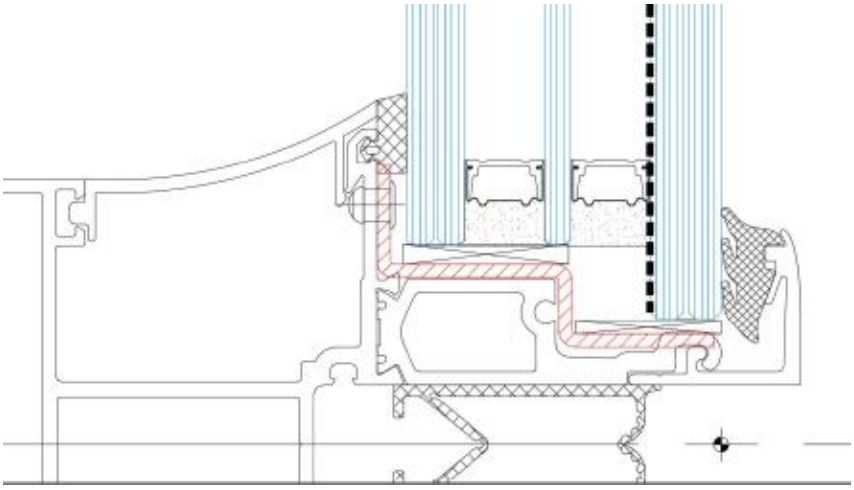


Figure 25 Glass shelve type A position- Section

Type B supports a DGU glass 900mm high.

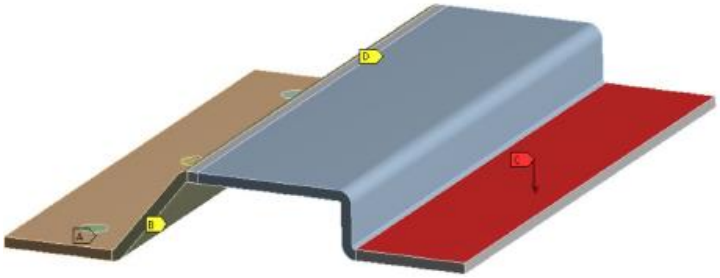


Figure 26 Glass shelve type B

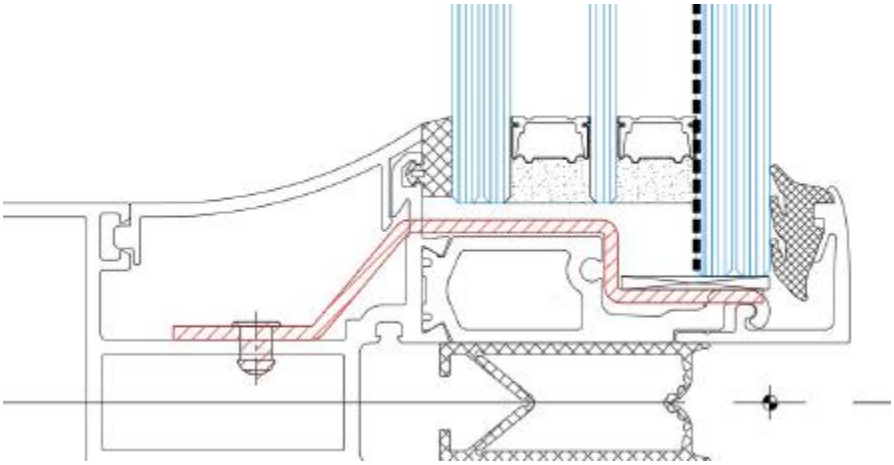


Figure 27 Glass shelve type B position -Section

Connections to the exisiting buildings

Each unit is connected to the rear concrete slab with an aluminium bracket.

The bracket is fixed to the concrete slab with two mechanical anchors HST3 M12. The unit is hooked to the main racket with another aluminium bracket which is bolted to the first one.

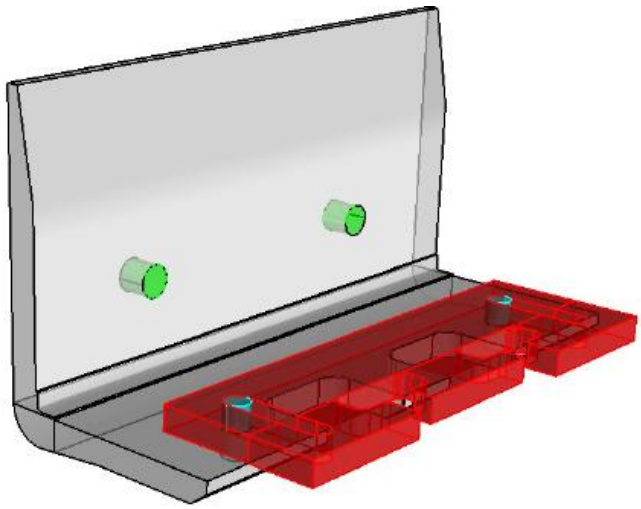


Figure 28 Hool- on bracket

Hook-on racket is connected by two M10 bolts.

Connection to the concrete slab

There are two brackets: the one for the first support of the unit and the one connected to the slab.

The bracket is connected to the rear concrete slab with two mechanical anchors HST3 M12.

Anchor type and size is HILTI HST3 M12 hef2

Figure 29 HILTI HST3 M12

Connection to the existing building – corner connection

Connection to the exisisting building on its corners is similar. It is composed of aluminium angular and aluminium plate, connected to the main building. Façade is connected to the angular with a steel curved plate and an hook-on bracket.

Façade is supported by the steel angular made of steel S275, as shown in the figure below.

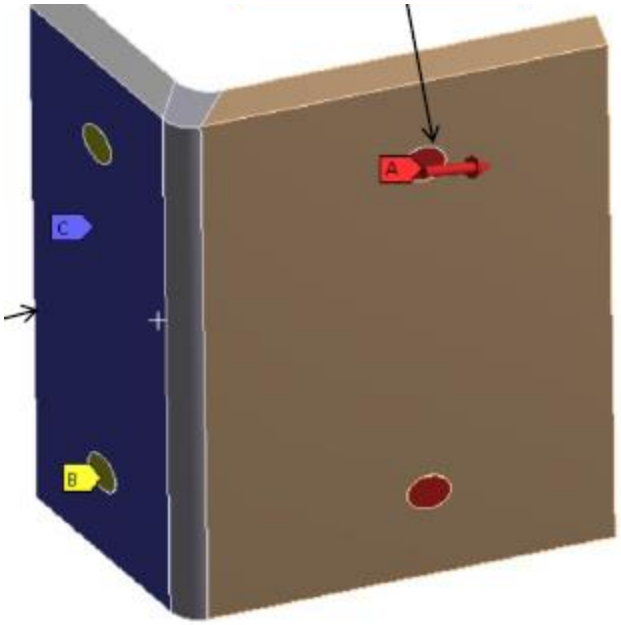


Figure 30 Angular element

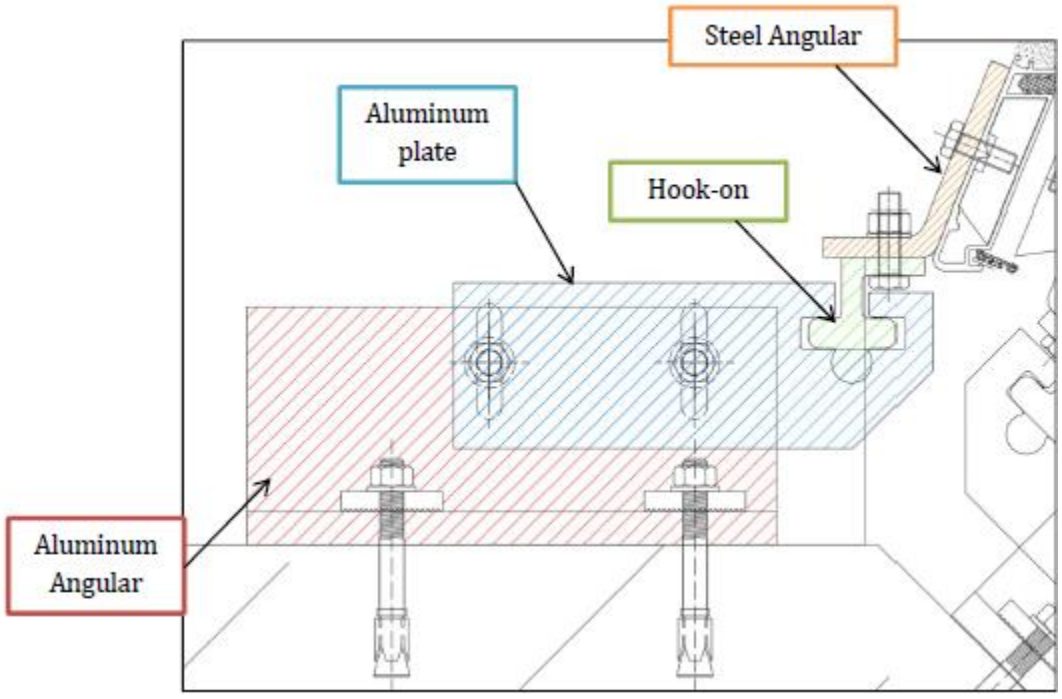


Figure 31 Top view of the corner connection -Section

3.1.2.4 Glazing

Glass is transparent component of the curtain wall. Different type and configuration can be applied depending on the requirements of the building.

Vacuum Insulated Glass (VIG) is an alternative for already available on the market double or triple glazing providing good performance properties not increasing weight and reducing thickness of the unit.

Three types of glass to be installed in the Polish school in Dzierżoniów for the EENSULATE project have been selected.

Double glass unit with vacuum

Glass 1 = 66.4 (full tempered with Pvb interlayer) + 0.25 (Vacuum) + 6 (full tempered), as shown in the section reported below.

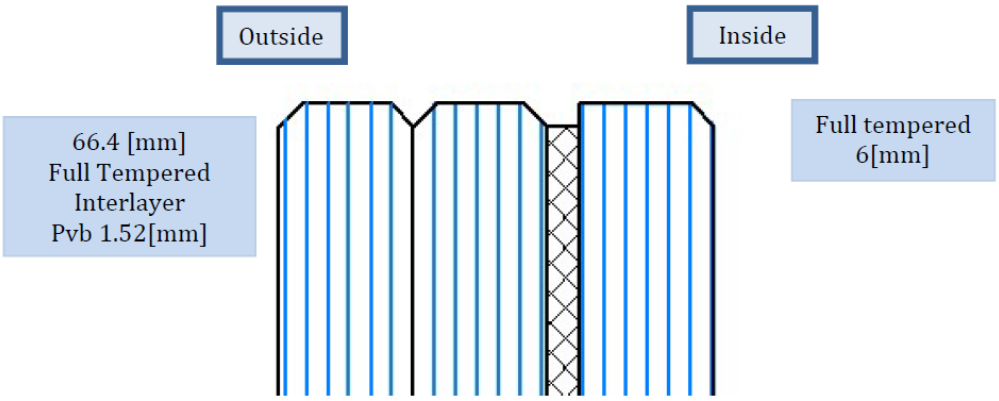


Figure 32 Double glass unit – vertical section

VIG Assembly

VIG is composed of tempered glass 6mm thick with 0,25 mm of vacuum chamber in between. Two panes of glass attached with PVB for protection. In order to preserve vacuum in the chamber, panes are sealed on the perimetral with EENSULATE sealant together with getter absorbing gas applied to guaranty vacuum. Vacuum is extracted by hole located 85mm from the external layers of the pane. The overall configuration of the VIG is illustrated in the figure below.

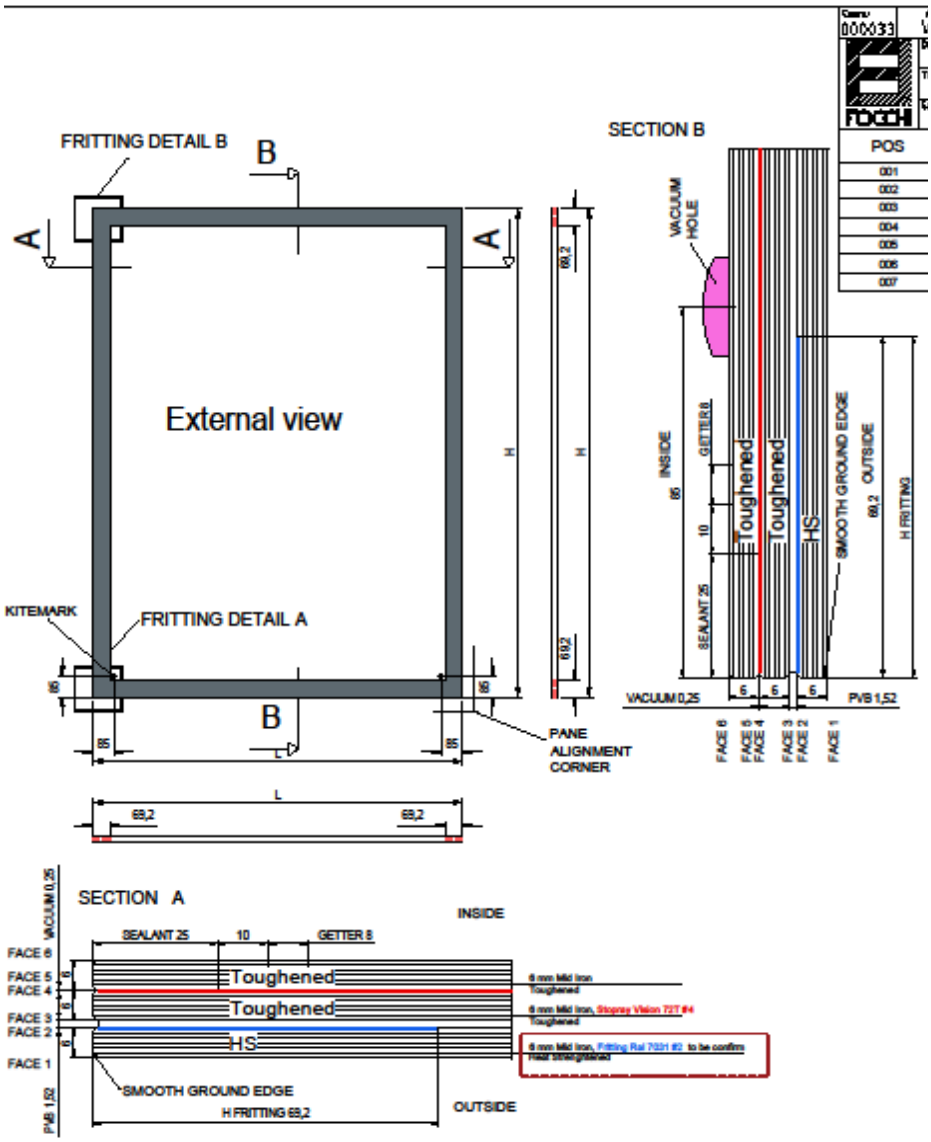


Figure 33 Glazing configuration- VIG construction

For astetics reasons, fritting of the glass is applied on its perimetral. Some details of the fritting finishing are reported in the figure below.

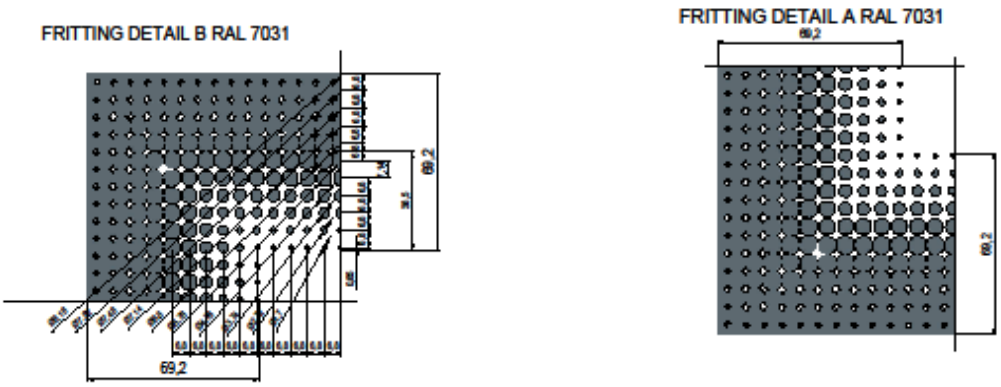


Figure 34 Fritting details

Manufacturing procedures of the EENSULATE vacuum glass is described in document D3.2. Below general steps to be taken during assembly are described.

VIG production process steps are summarised below:

1. Glass Processing
2. Glass Cleaning
3. Pillars deposition
4. Sealant and getter application
5. Unit assembly - glass paring
6. Peripheral edge clamping
7. Sealant curing
8. Cooling down and inspection
9. Indium soldering, disc cover positioning
10. Vacuum pumping
11. Indium Pump out hole sealing
12. Activation of the getter
13. Inspection

Single pane

Glass 2 = 6 (full tempered)

Glass for spandrel

In order to cover slabs opac glass is applied. A representation of the single pane for spandrel application is reported in the figures below.

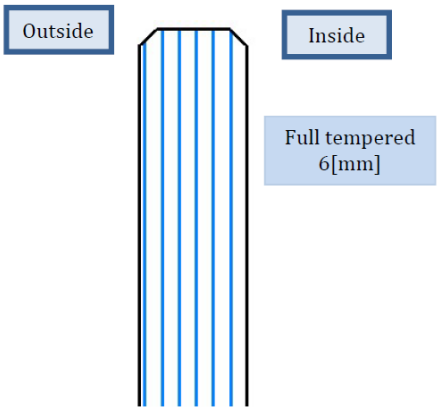


Figure 35 Single pane

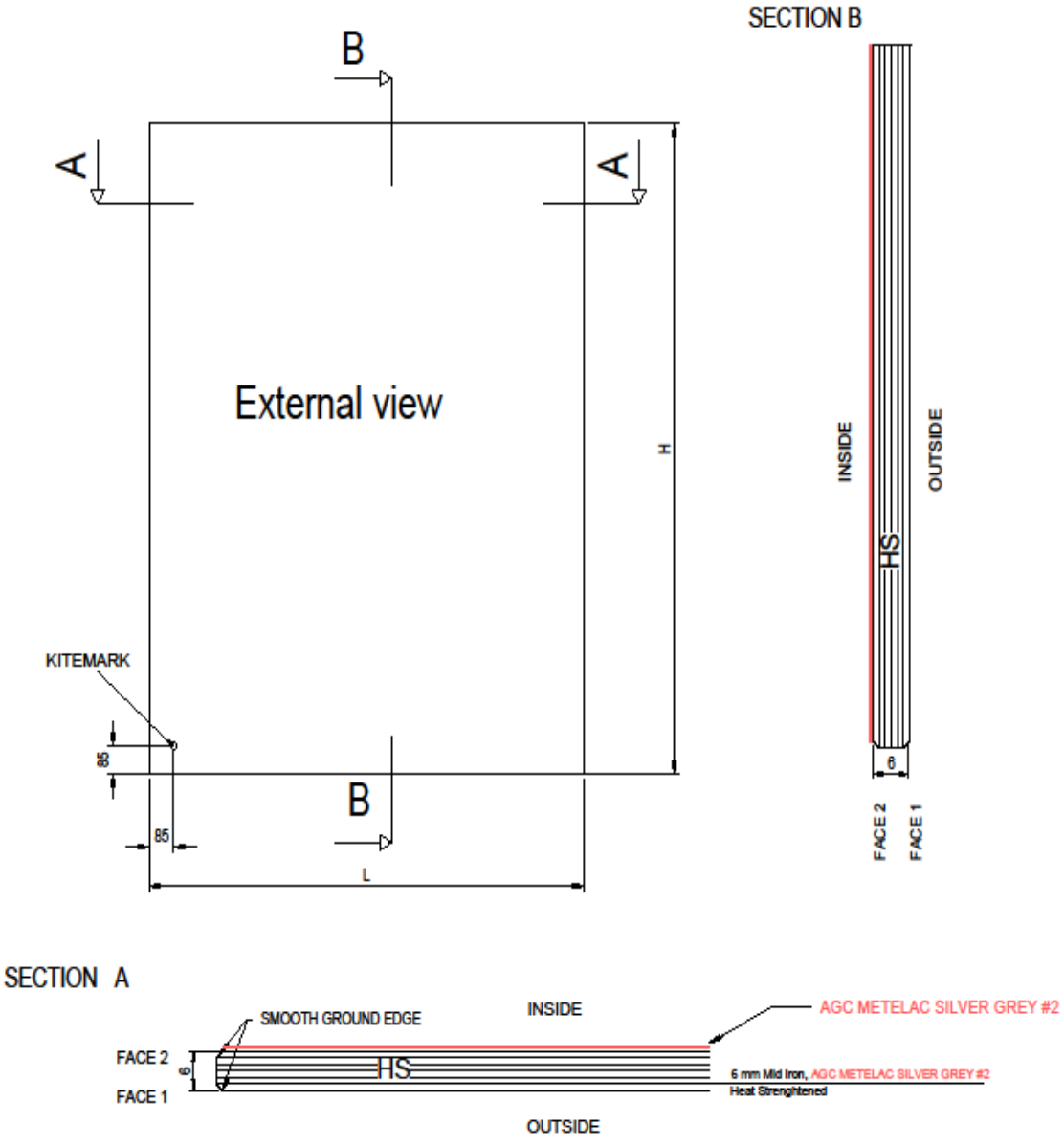


Figure 36 Glass for spandrel – View and sections

TGU Triple Glazing Unit

Glass 3 = 55.2 (annealed with Pvb interlayer) + 12 (air) + 5 (full tempered) + 12(air) +44.2 (annealed with Pvb interlayer)

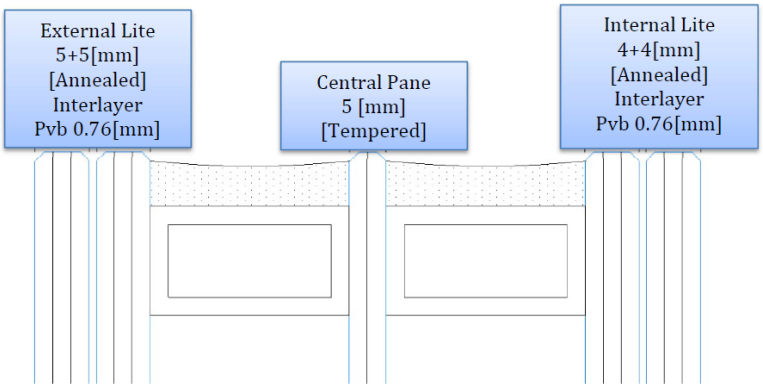


Figure 37 Triple glazing unit - section

All the details related to the Triple Glazing Unit (TGU) construction are indicated in the figure below.

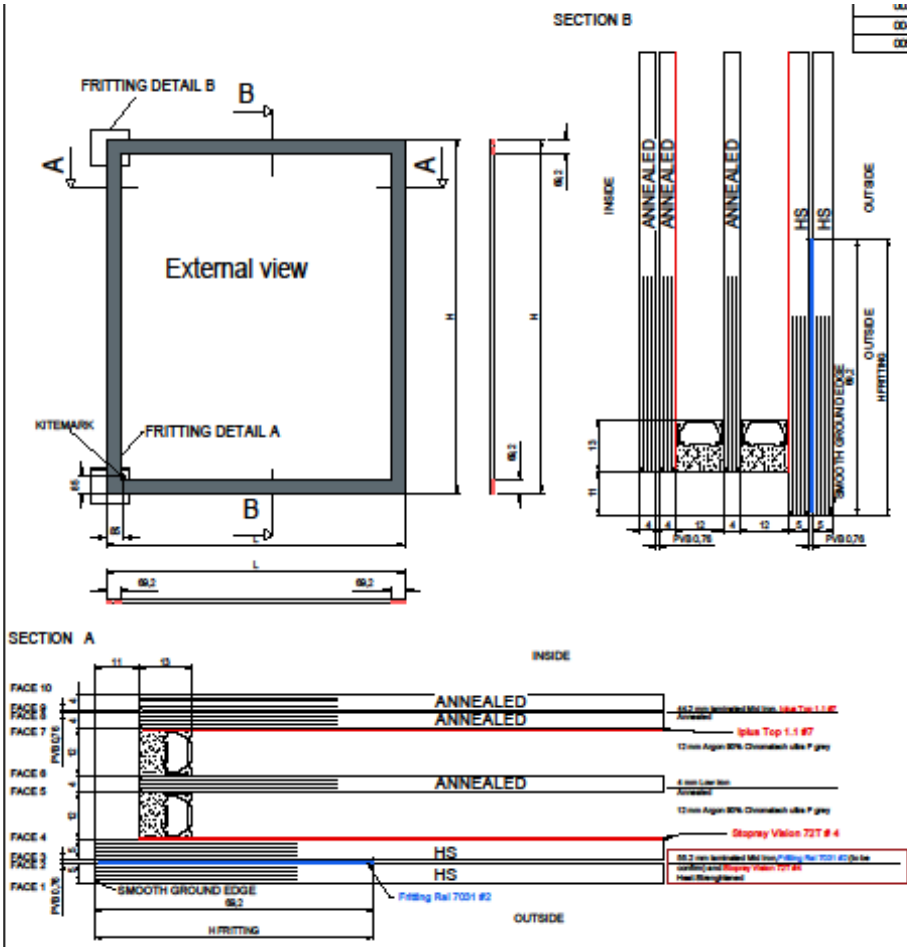


Figure 38 TGU construction – View and sections

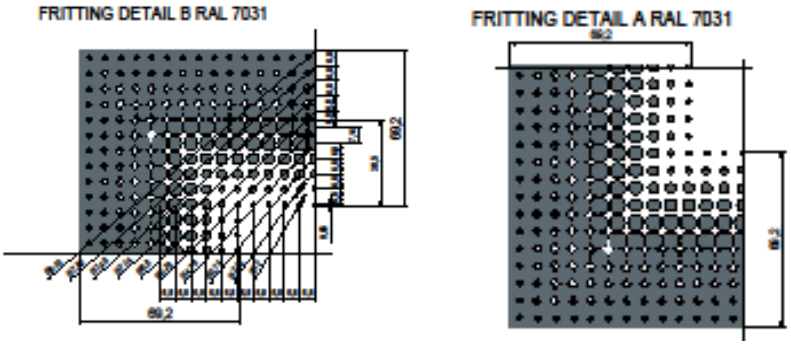
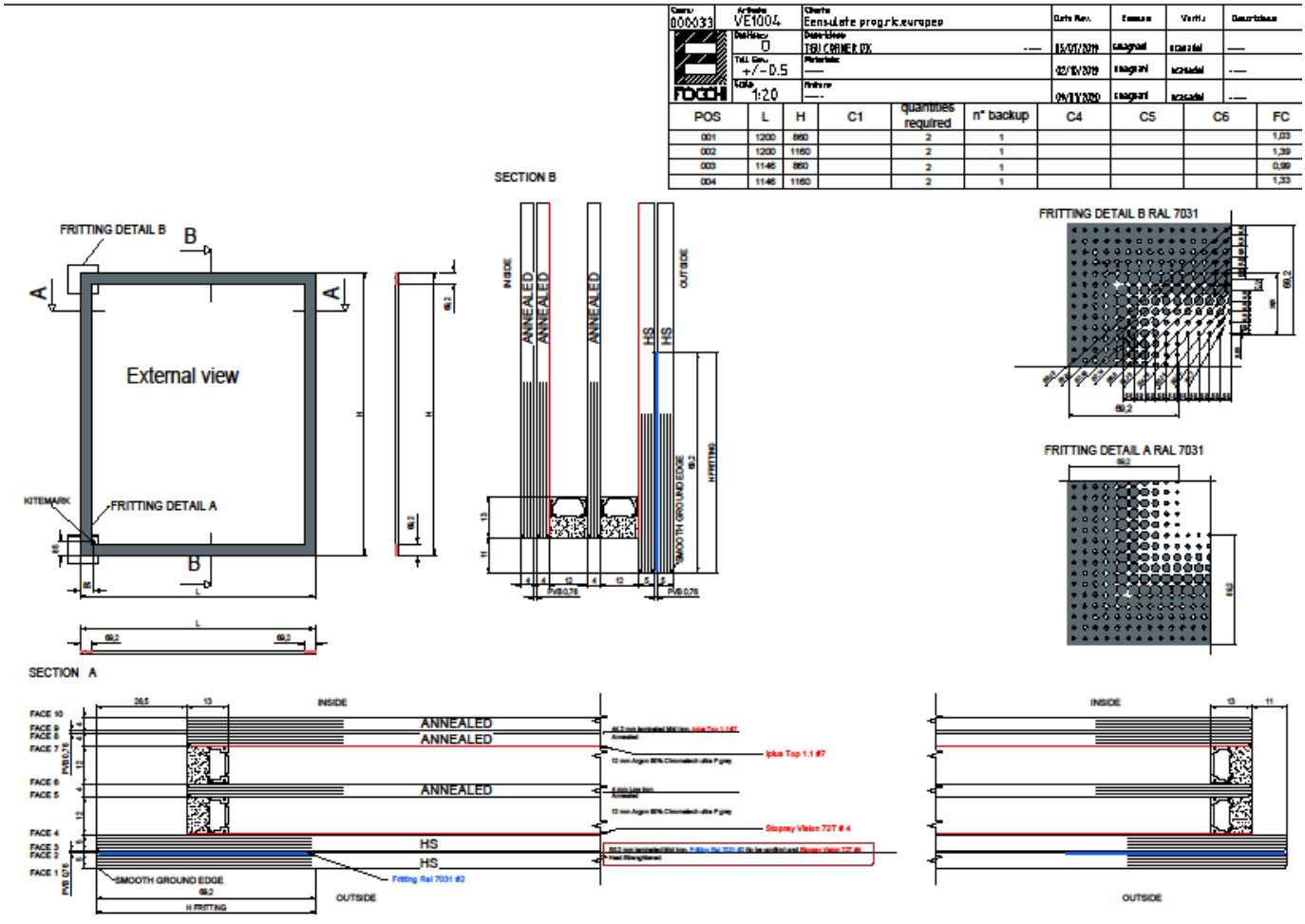


Figure 39 Fritting detail

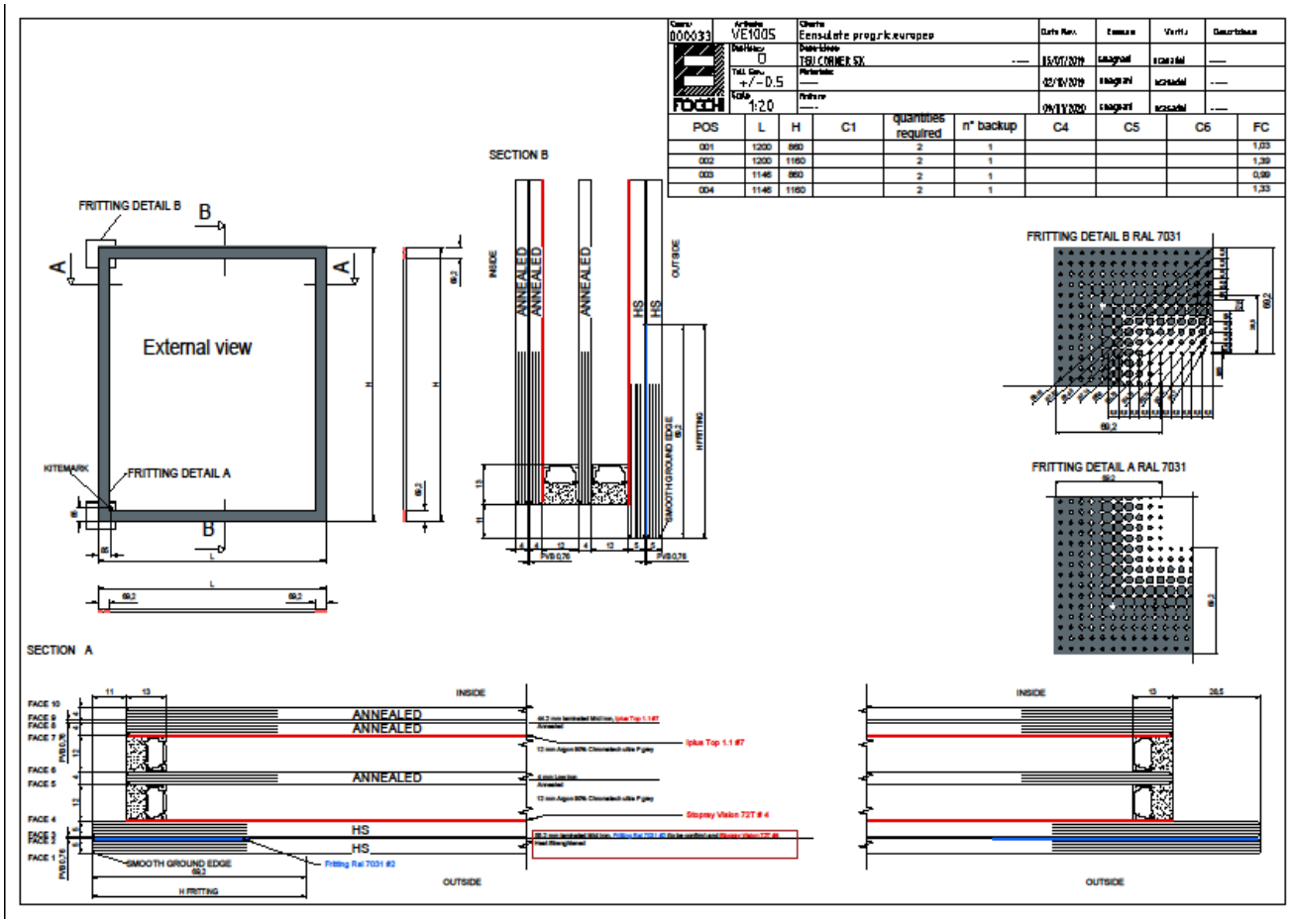
TGU special constructions

On the corners special types of the glass is foreseen.



POS	L	H	C1	quantities required	n° backup	C4	C5	C6	FC
001	1200	860		2	1				1,03
002	1200	1160		2	1				1,39
003	1146	860		2	1				0,99
004	1146	1160		2	1				1,33

Figure 40 TGU right corner



POS	L	H	C1	quantities required	n° backup	C4	C5	C6	FC
001	1200	860		2	1				1,03
002	1200	1160		2	1				1,39
003	1146	860		2	1				0,99
004	1146	1160		2	1				1,33

Figure 41 TGU left corner

In case of Dzierżoniów school, façade dimensions of the glasses 1 and 3 are approximately 1261x1465mm. Spandrel glass (glass 2) is approximately 1261x1335mm.

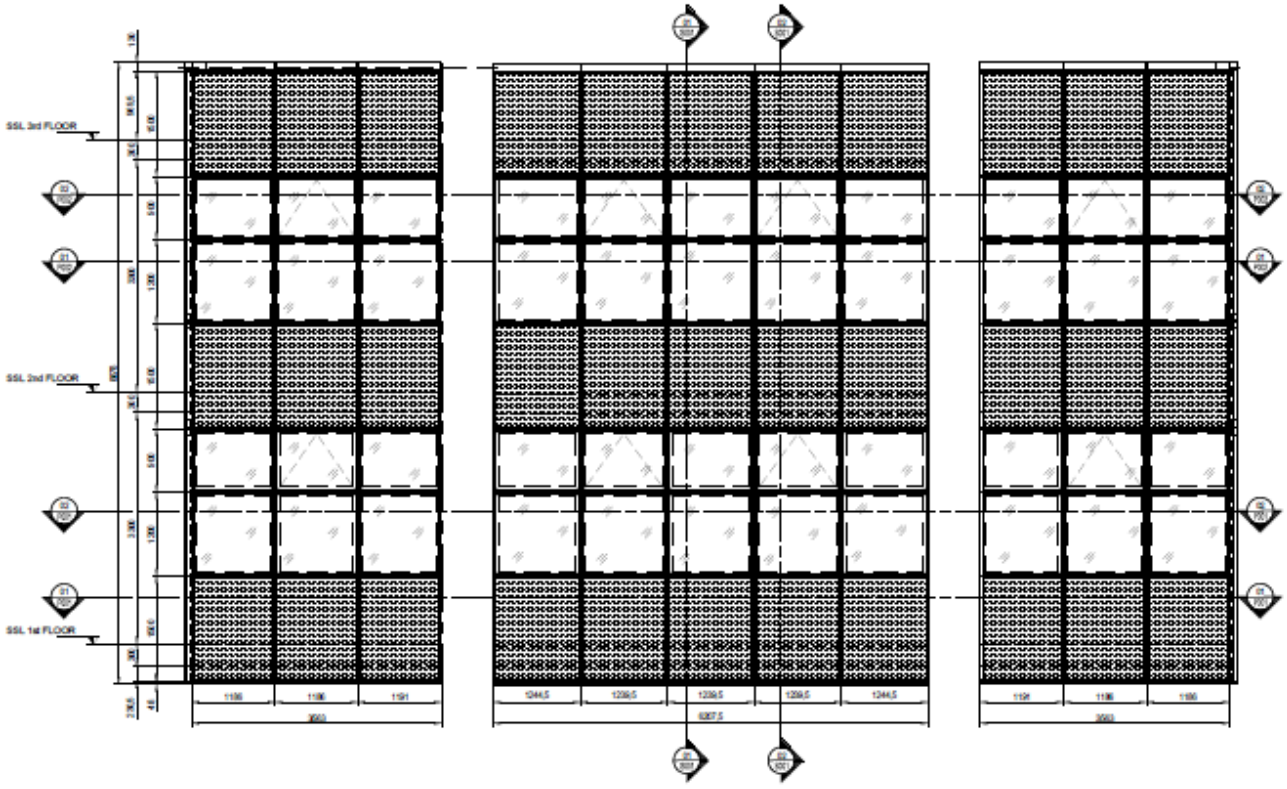


Figure 42 Elevation – view of façade glazing units

Foam

To fill the spandrel volume in the façade module, EENSULATE bicomponent foam (BCF) is used which achieve thermal conductivity value of 0.024 W/m$_2$K and a reaction to fire of B1.

3.1.3 Installation steps

The installation process of the EENSULATE façade system are similar to the instalaltion procedure used for traditional façade retrofitting. The main installation steps are:

- Site preparation and brackets installation
- Units Setting

Details are reported in the following.

Site Preparation and Brackets Installation

Initial on-site activities involve preparing the site for the installation of the facade systems.

This work includes such a procedures as securing the construction site and prevision of material storage area.

Installation process begins with proper positioning of the brackets located on the front of the floor slabs. A precise survey is to be conducted to mark the anchor locations at the building interface, according to the position signed on the drawing.

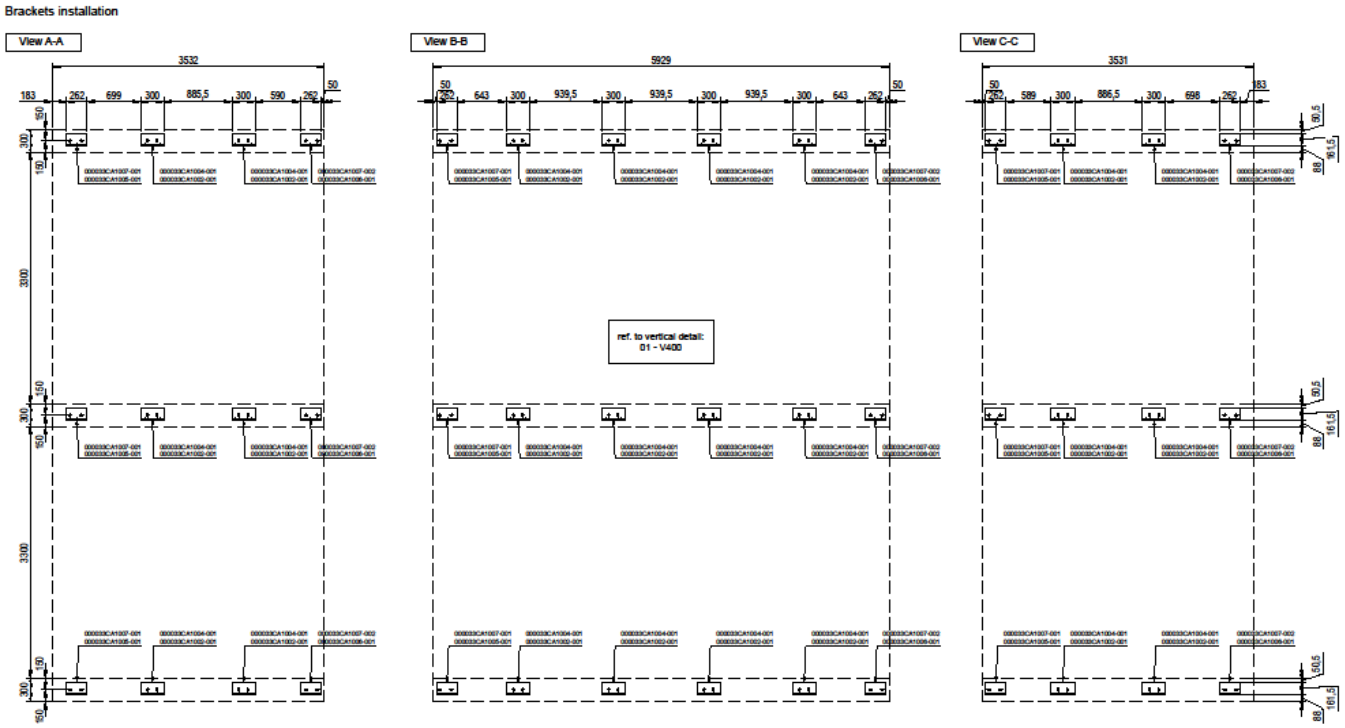


Figure 43 Elevation for brackets installation

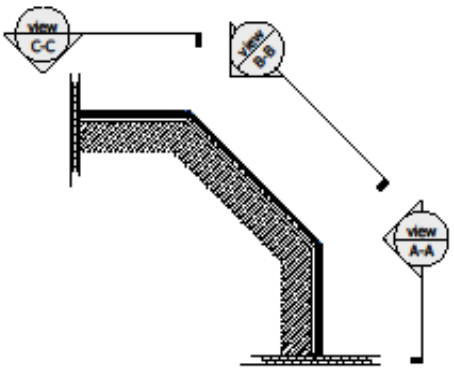


Figure 44 Horizontal section

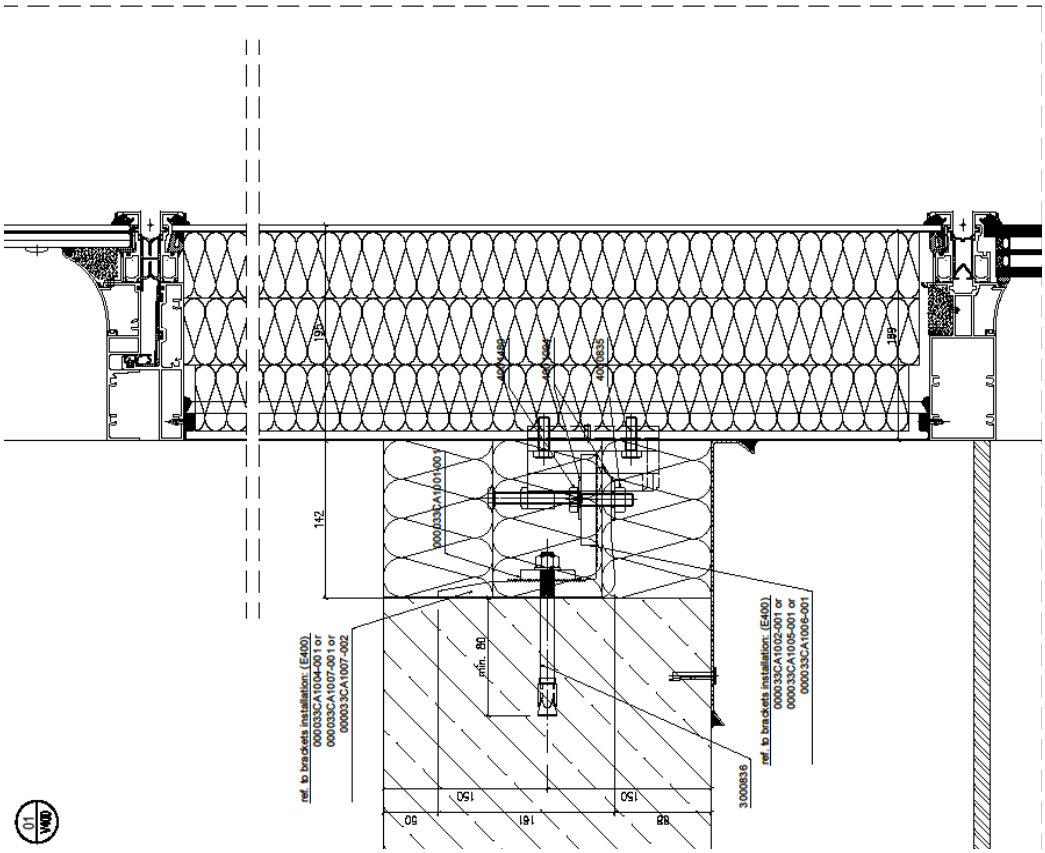


Figure 45 Vertical detail for bracket installation

Units Setting

Next step is to settle the modular curtain wall units into position and secure to the building. Generaly the units can be located to setting: from inside or outside of the building. Installation from the inside required units to be previously delivered to the settling area. It is more recommended for bigger buildings with smaller modules.

The units settle from the outside are lifted from a placement area on the ground adjoining to the building. Particular units are lifted and directed to the appropriate location by means of crane then guided and hosted into position by the crew in order to be secured to the preinstalled anchors.

The tower crane is used to pick units from the ground and place them at required position on the building façade. The horizontal joint between upper and lower transon is paired and vertical mullios are connected.

Modules are attached sequentially following instruction marked on the prepared drawing.

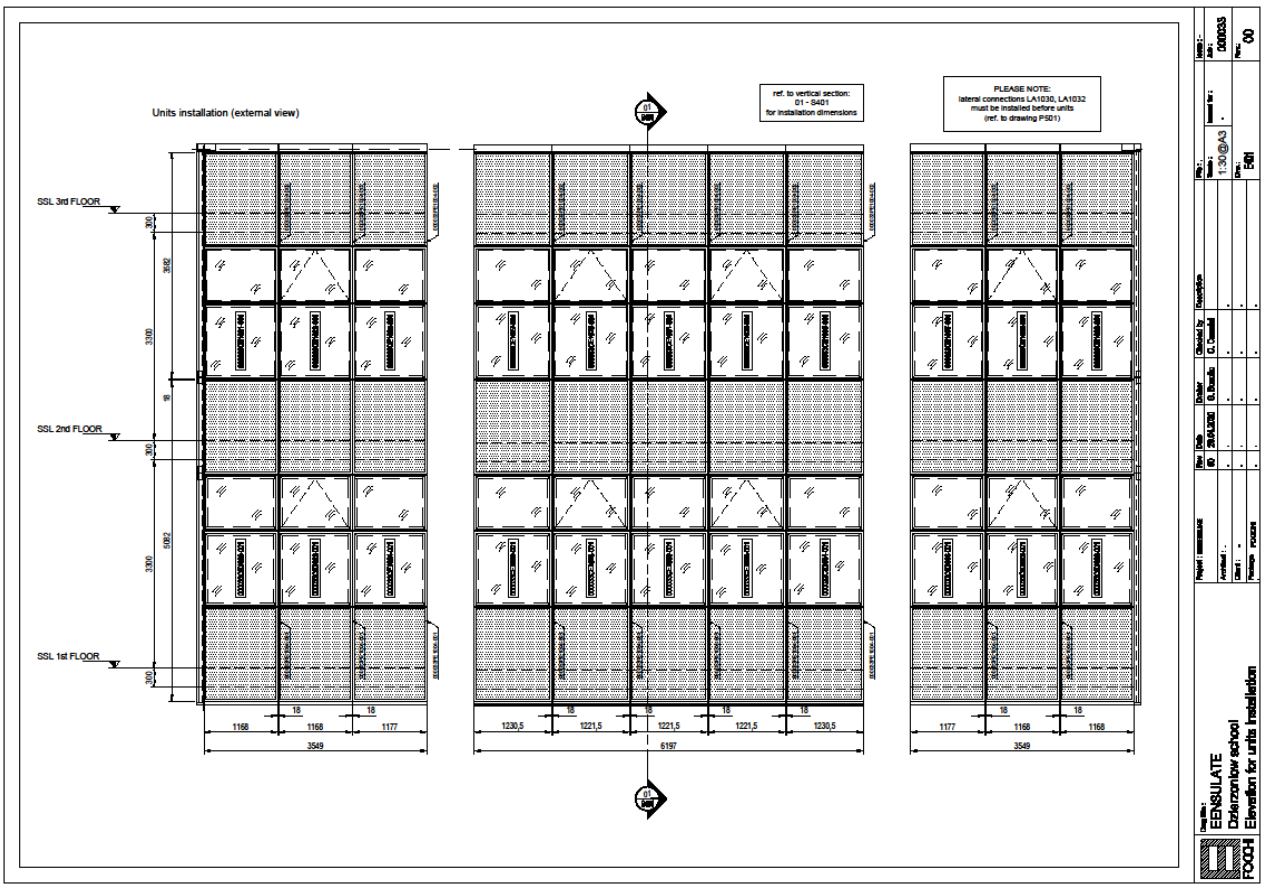


Figure 46 Elevation for unit installation

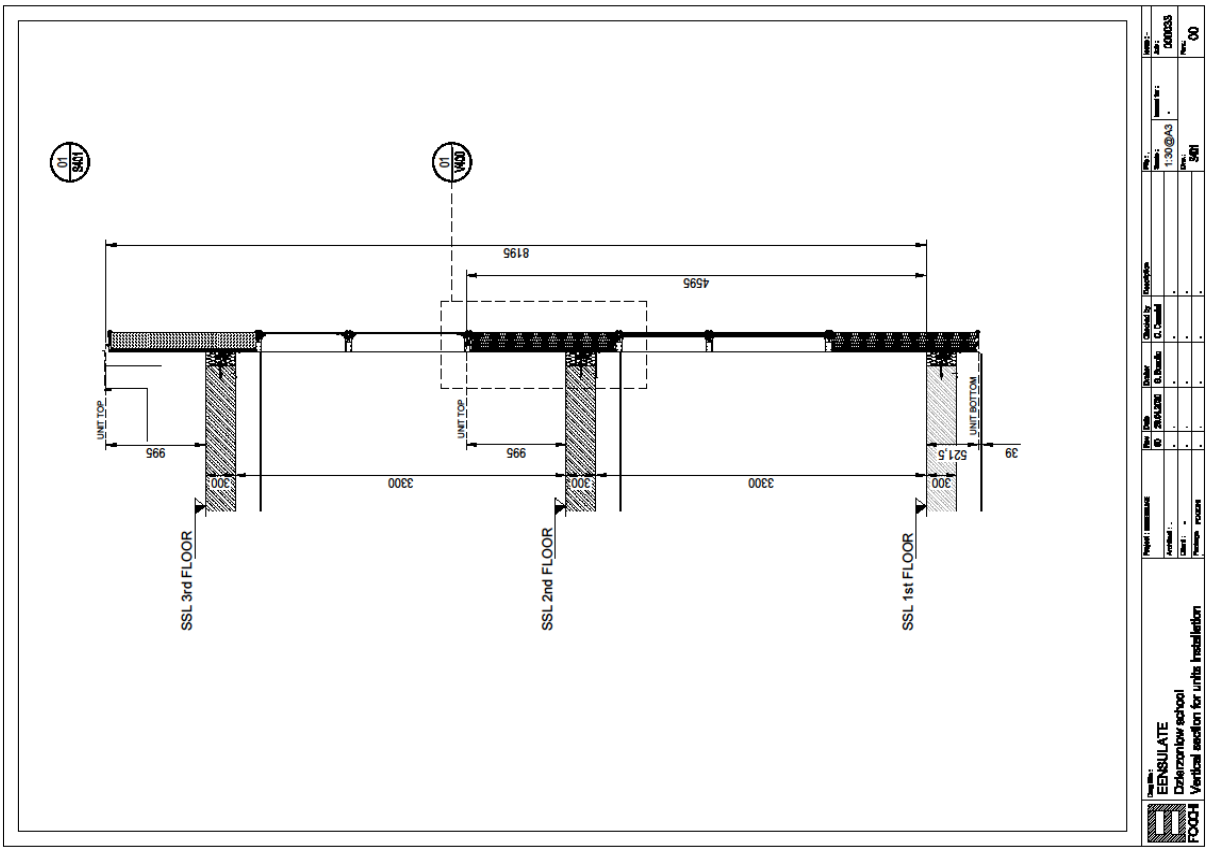


Figure 47 Vertical section for units installation

Particular attention is given to assure full engagement and the correct sealing of gaskets. Gaskets are necessary in order to avoid air leakage and water penetration, distribute and absorb loads and allow relative movements.

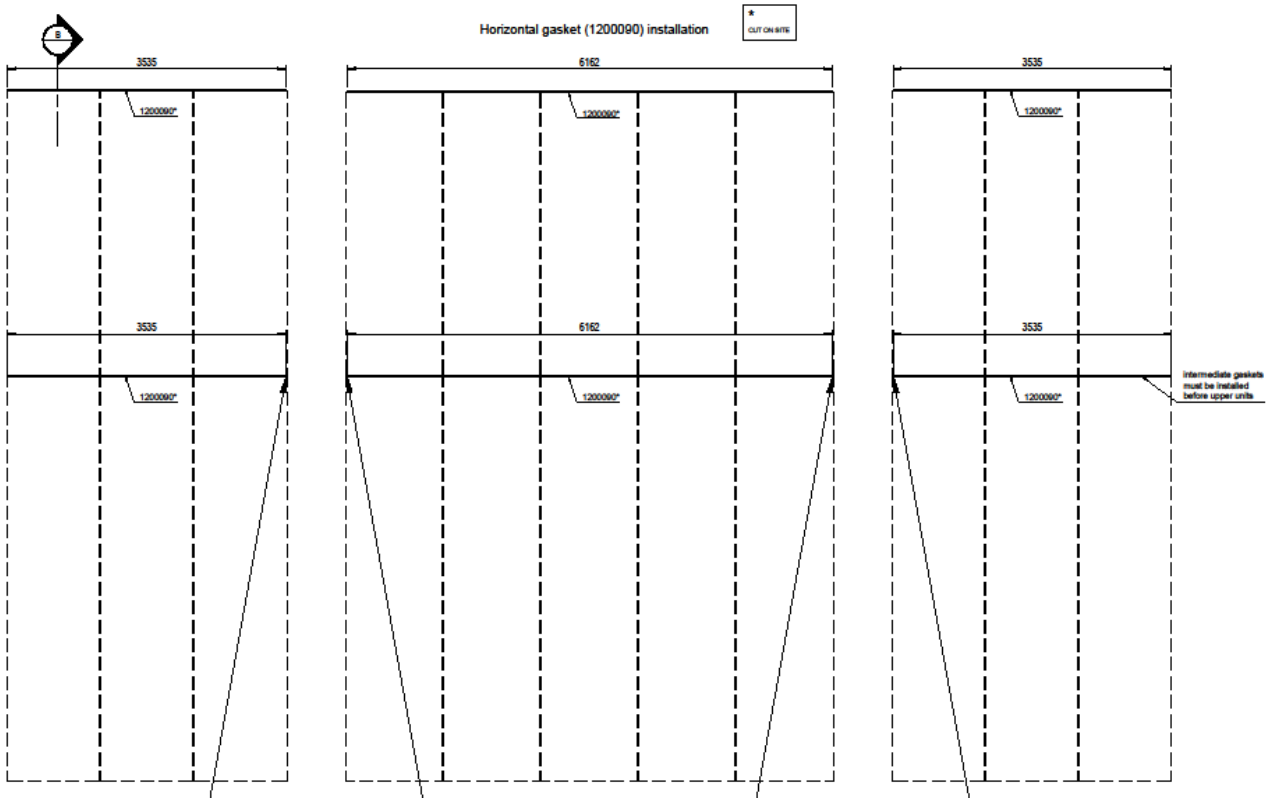


Figure 48 Elevation for gasket installation

Gasket will be cut with proper angles to adjust to the construction.

Figure 49 Gasket cutting angles

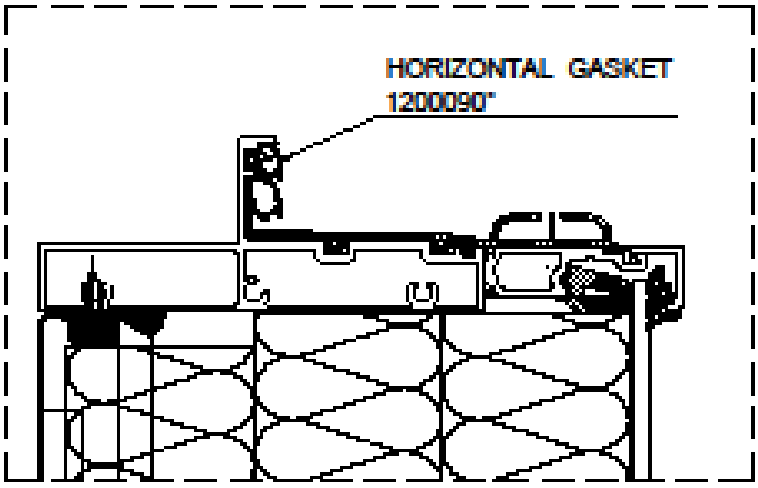


Figure 50 Detail and positioning of the gasket in alluminium profile

Then installation of the finishing elements is to be done according to the previously prepared details and its position.

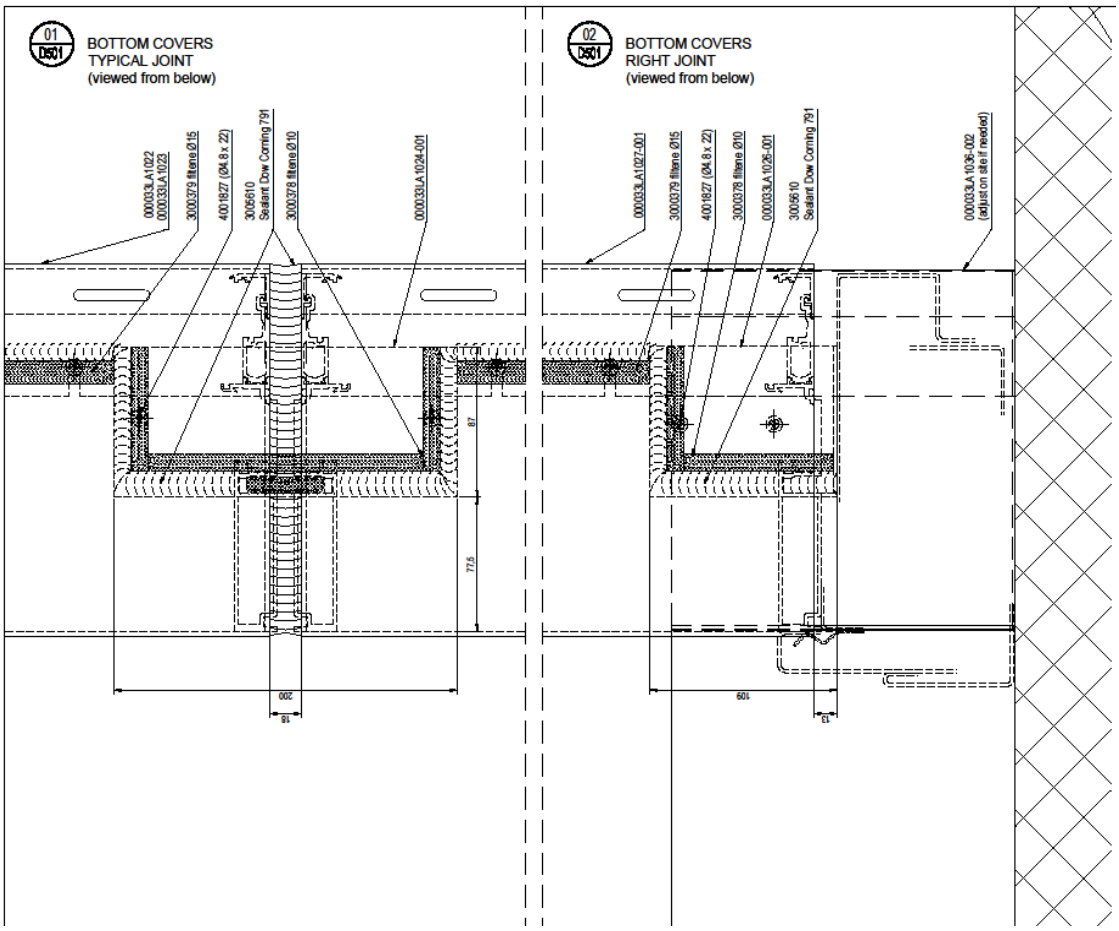


Figure 51 Bottom covers installation – typical joint and right joint

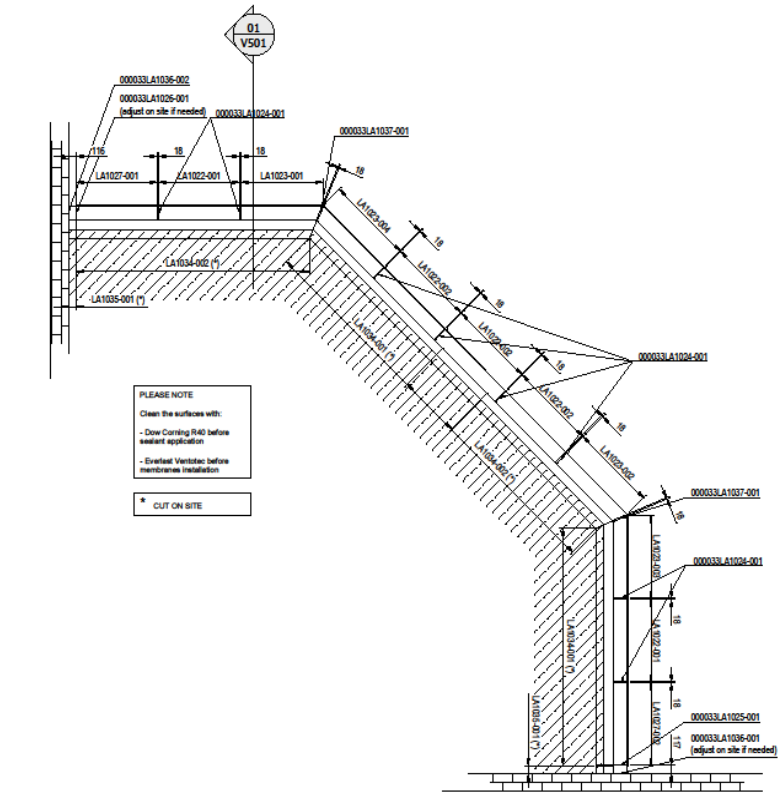


Figure 52 Bottom covers installation

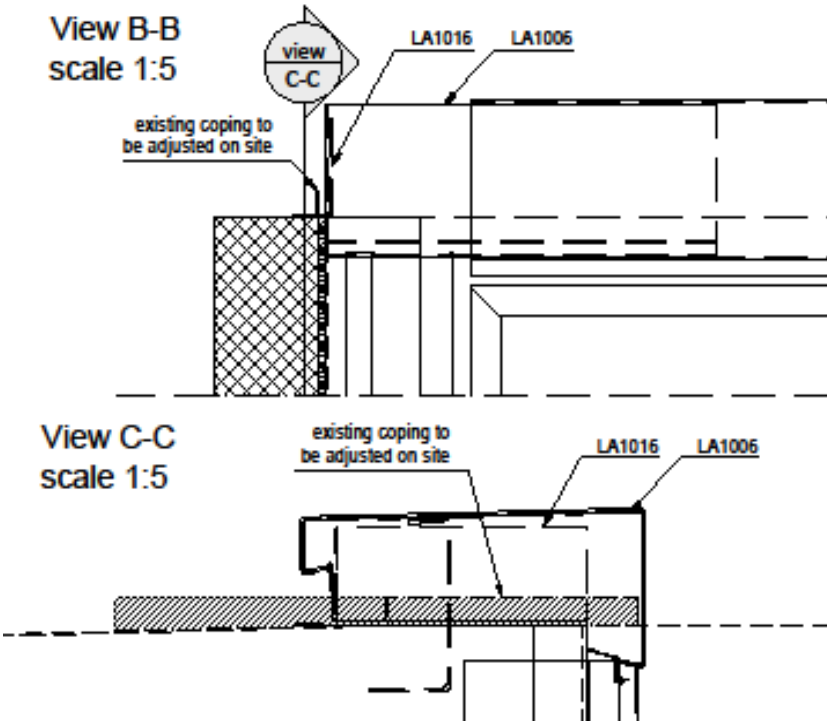


Figure 53 Coping installation details

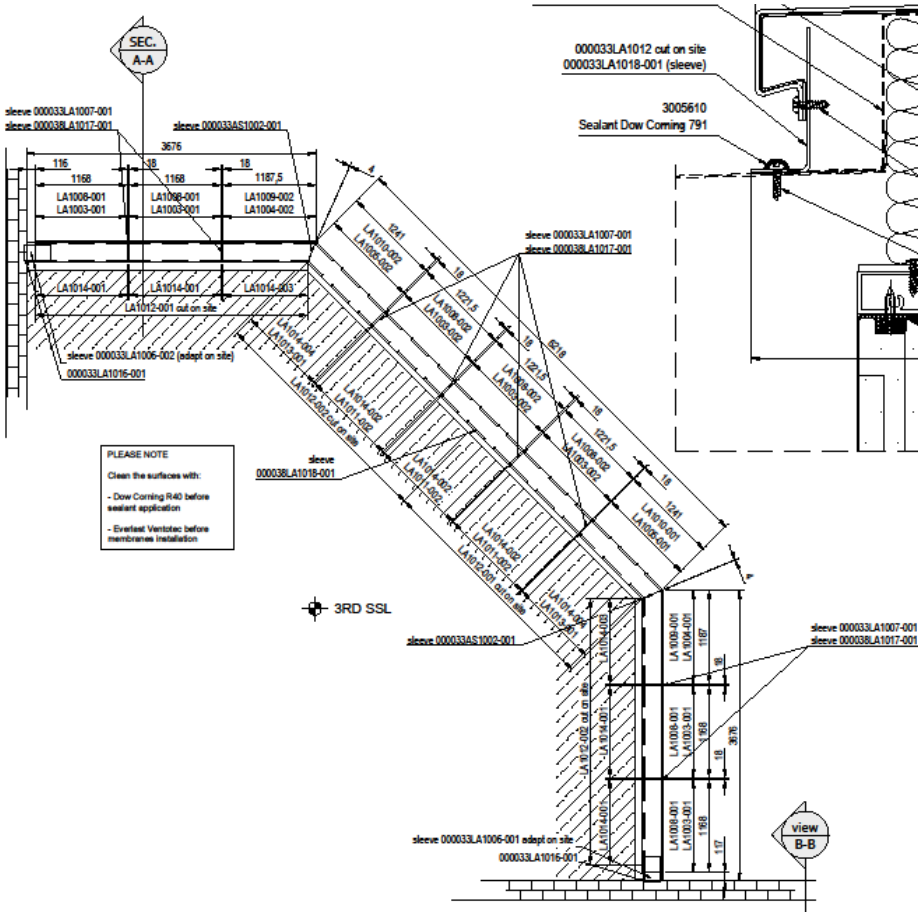


Figure 54 Coping plan

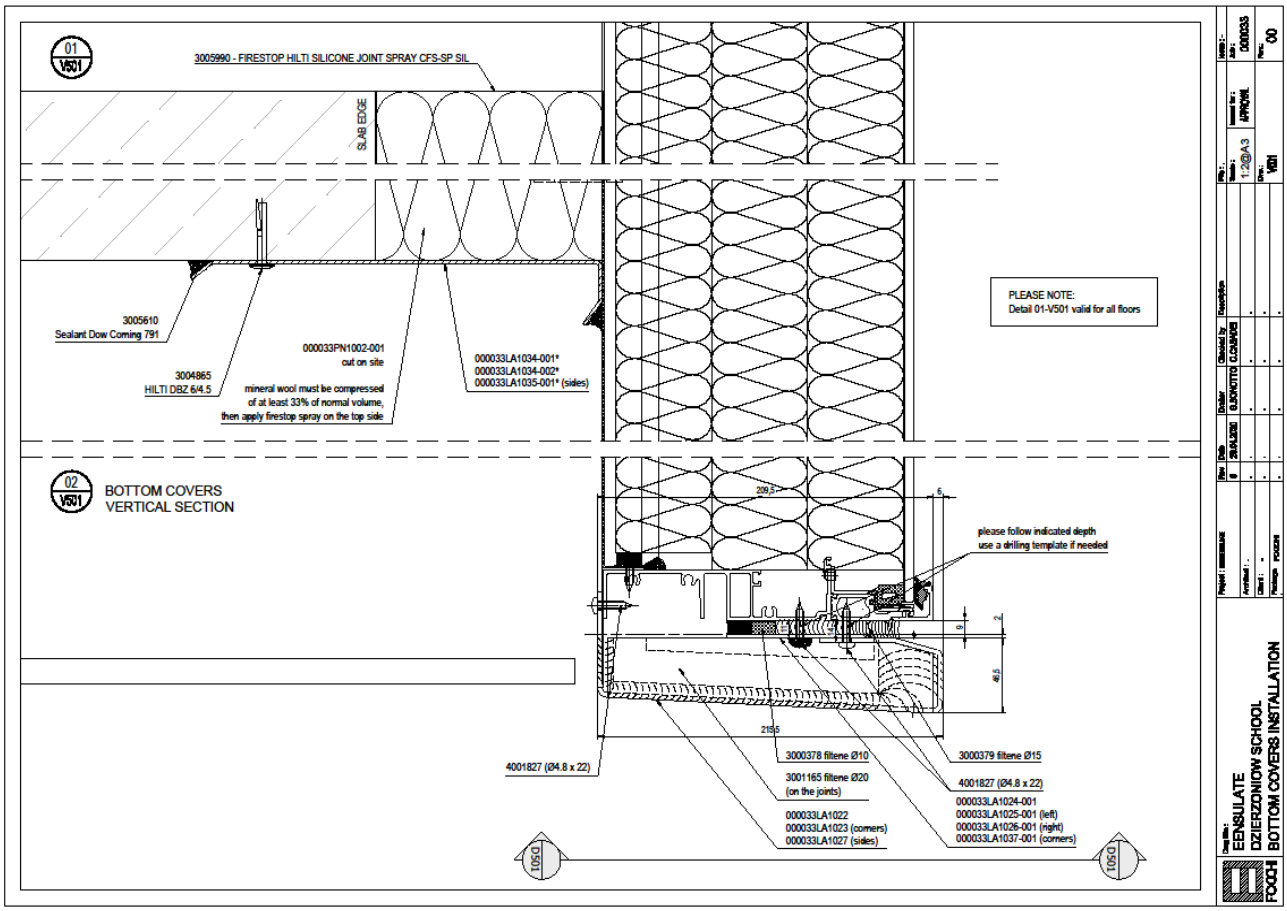


Figure 55 Bottom covers installation

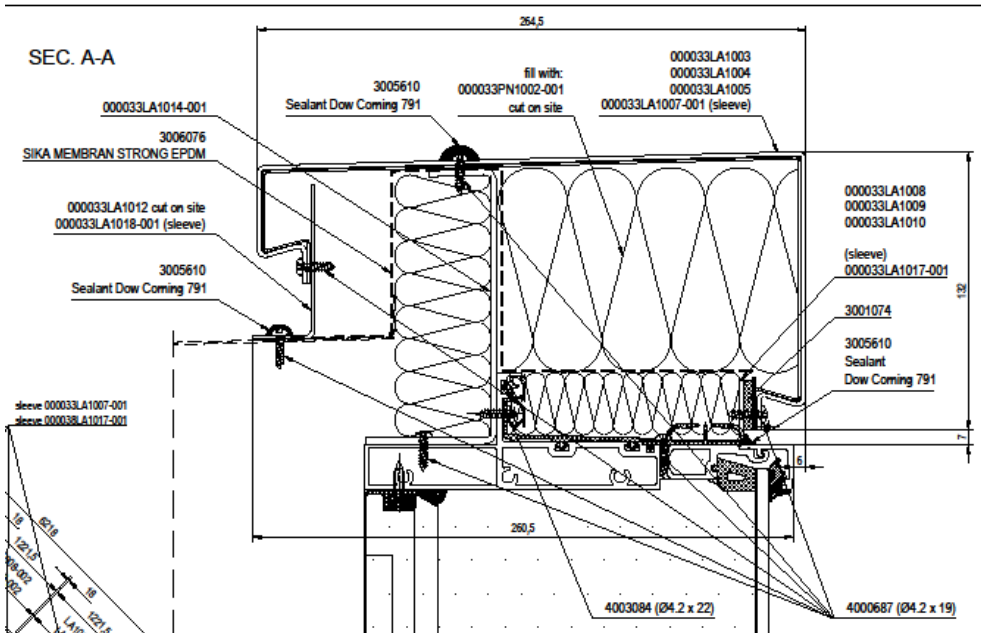


Figure 56 Flashing installation

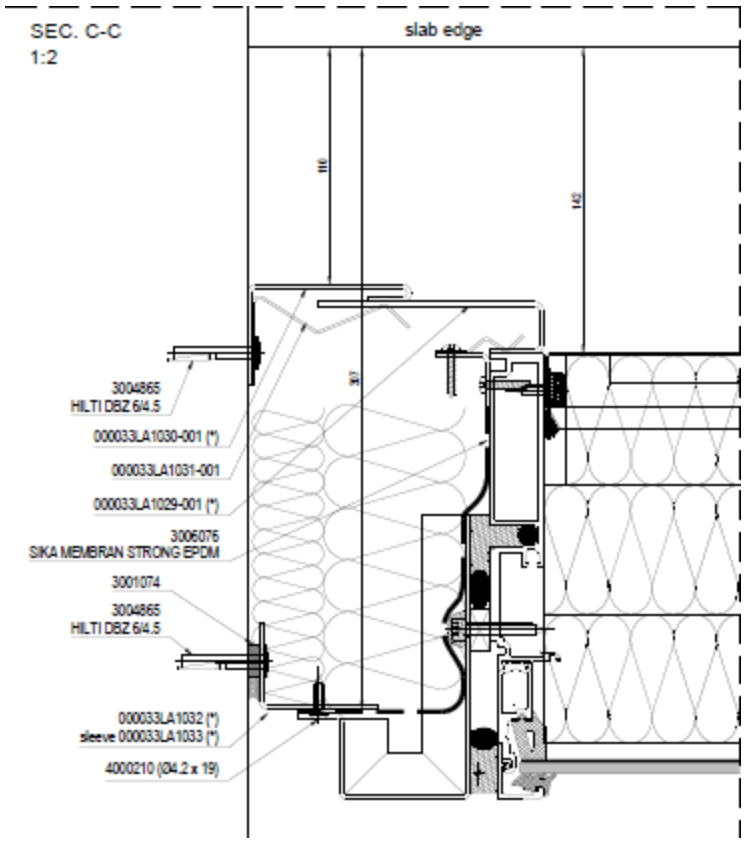


Figure 57 Flashing installation

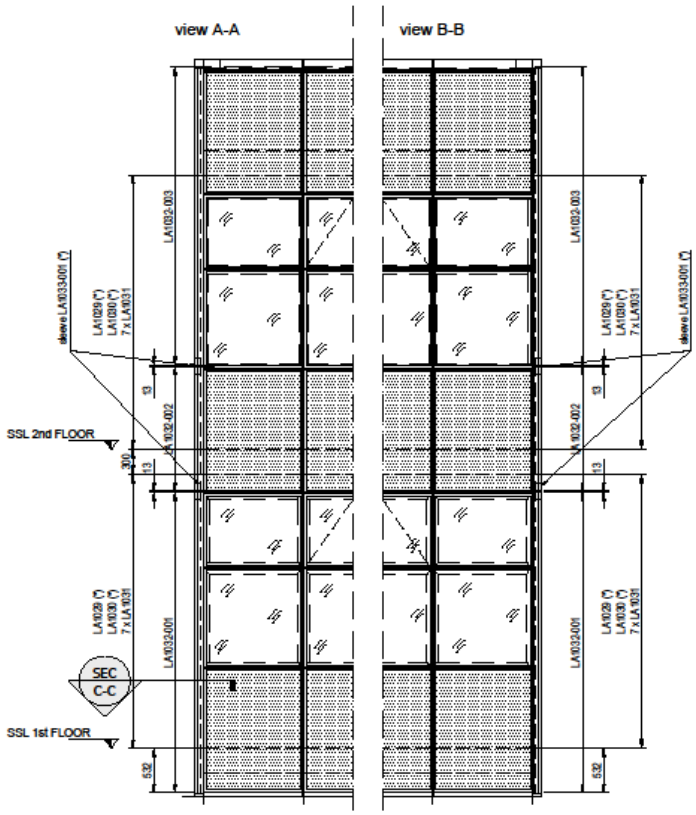


Figure 58 Flashing installation

The disassembly procedures of the façade are briefly described below.

Disassembly of the module

- Detachment of the module from the façade
- Removal and staking of the anchorages for possible recycle and reuse
- Detachment of the Vacuum glazing from the frame
- Disassembly of the frame (see the procedure for the disassembly of the frame)

Disassembly of the VIG

- Removal of bonding sealant from the inner glass
- Detachment of the external sheet from the inner one
- Removal of the sealant and transportation to landfill
- Detachment of the coatings from the laminated glass
- Removal of the pillars for possible recycle or reuse
- Separation of the glass from the PVB and recycling of both of them

Disassembly of the frame

- Removal of the ethylene propylene diene monomer and transportation to a landfill
- Removal and staking of the low density polyethylene foam for possible recycle
- Removal of the polyamide (thermal breaks) and transportation to a landfill
- Removal of the EENSULATE foam and transportation to a landfill
- Removal of the steel plate for recycle
- Scrap preparation, staking and transportation of the aluminium for recycle

3.1.4 Equipment to be used for particular installation step

Unitized method is based on prefabricated units assembled in the production workshops off site and then installed on site. The main equipment used for the installation phase are listed below:

1) Placement units on stillage (using vacuum cups lifter)
2) Loading on flatbed lorry and transport (Forklift, crane)
3) Unloading from lorry (crane, vacuum lifter, ropes)
4) Unloading on a platform (forklift, crane)
5) Surveying positions of the brackets (theodolites)
6) Bracket fitting (tool cart)
7) Putting units on the trolleys (vacuum cups, manipulators)
8) Inspection of units and cleaning (Tool cart)
9) Safety harness are necessary for crew working at height (Self-retracting lifeline)
10) Applying joints between two units (rubber systemized solutions)
11) Installation of units (spider cranes, tower crane or manipulators, manpower)

- Type of installation should be adjusted to the building requiremets and size of units

3.1.5 Maintenance

A periodic maintenance and cleaning of system is essential to ensure durability of performance and proper functionality of the new installed elements for the façade renovation. Main maintenance recommendations are listed below:

- Aluminium profiles require the regular treatment of non aggressive cleaning agents. Avoid to use hard materials (knives, metal scrapers, sandpaper) not to damage surface finishes
- Fittings operation to be checked periodically
- Loose or damaged screws should be fixed or replaced
- Checking of continuity and undamaged shape of sealants applied to all joints

Moreover, it is recommended to perform the inspections during the first 5 years after installation as detailed below:

- 1st inspection - upon completion of sealing (visual inspection of joints and connections)
- 2nd inspection - after 1 or 2 years (visual inspection of gaskets, joints, screws, drainage and cleaning)
- 3rd inspection - 5 years after completion (visual inspection of gaskets, joints, screws, drainage and cleaning)

After 5 years, periodical controls on site (visual inspection and checking with replacing of damaged parts) Every 5 years it is recommended to monitor the status of the main façade elements. An additional advice is cleaning every 12 months.
According to the outcomes of the on site inspections the planning of the ordinary and straordinary maintenance interventions has to be updated.

3.2 Window retroffiting - Dzierżoniow City Museum case

3.2.1 Overview

Regarding historical buildings it is crucial that the intervention does not change visual aspect of the building. Usually in case of that type of constructions, windows are poor performed filled with single or double glazing. In case of VIG solution it is possible to substitute old glass not changing the contruction of the windows sash. Vacuum glazing provides possibility to insert glazing pane because of its thin and light construction.

Figure 59 View of the exisiting windows – Dzierzoniow Museum

3.2.2 Retrofitting process

Existing windows are old box windows with double sash opening to the inside, filled with a single glass. As whole window construction is deteriorated and needs renovation, frame and sash will be repaired by sealing, painting, changing gasket and performing all necessary works required for its proper functioning assessed after evaluation of the particular frames on site.

Old single glass will be replaced with EENSULATE VIG of thickness 8,25mm (4+0.25+4mm) and weight 20kg/m2, by dismantling the window sash.

Window sash will be removed carefully in order to perform renovation works, it will be sealed and painted, hardware will be renew and new gaskets will be attached then single glass will be replaced by VIG. The same sash will be installed in renewed, existing frame. During this intervention, the window opening will be protected against damaging and weather conditions.

Additional as originally windows were equipped with old roller shutters no longer used, existing coffers will be filled with insulating foam developed by project partner, in order to minimize thermal bridges.

Insulating one component foam (OCF) developed within the project is dedicated for application to seal the air gap between construction and existing building.

3.2.3 Replacement strategy

Window renovation works starting with removing window sash. During the works temporary board will be installed to the window opening in order to protect the room against the weather conditions.

Sash will be subjected upgrading in the production worshop (outside of the building site) by removing of existing paint and glazing putty (using steam - process not impacting much the window sash orin some cases heat or chemical paint strippers).

Next step is conducting any necessary repairs, such as gluing joints, replacing broken parts.

Then preparation of the surface by sanding, applying oil-based primer, application of coating layers depending on requirements and condition of the window.

Replacing of the glass and sealing by adjusting glazing bads and putty or when applicable gaskets to set the glass. For the opening parts of the widow hardware upgrading necessary.

Before reinstalling the windows, necessary repairs or modifications to the window frame will be made.

During the window sash installation it is important to make sure that hardware is working properly.

3.2.4 Permitions

Implementation of projects for retroffiting of demonstration buildings rules different procedures. The projects should be prepared in accordance with the national Regulations with subsequent amendments with the detailed description of scope of the works to be performed, detailed drawings, structural calculations and technical specifications of the performance. Based on the finished design, it is possible to determine whether the intervation can be considered as a renovation (simplified procedure) and only notification is required or construction implementation to obtain a building permit (longer/more complex procedure for approval requiring more technical details).

The standard procedure is submission of an application for a building permit or work notification (to be submitted at least 1 month before the planned commencement of works). In case of a project in a foreign language, it is necessary to prepare the project in accordance with the abovementioned Regulation and to make a sworn translation into national language.

Information of the scope of works together with the technology of implementation and the process should be also provided (e.g. in the case of museum tanning, painting, restoration of damaged elements, replenishment of defect).

Taking into account additional works like processing, disassembly and assembly of the lightning protection system, etc.Declaration whether materials that will be used are approved for use in the country where building is located is needed.

In the case of a building permit it will be necessary to supervise the Construction Supervision Inspector who have building and construction qualifications.

It is important the building to be secured against weather conditions during assembly.

The contractor is responsible for employing a designer with appropriate permissions, who will prepare the project in accordance with the guidelines of the building and Architecture office, on the appropriate forms and obtaining a permit to carry out works on the historic building from the conservator in case of Museum and construction manager who will be responsible for the correctness of the performed works with the project assumptions.

For the Museum two levels of permission are necessary to obtain the permits to perform the works:

- Restaurateur permission (first)
- Building permission (after restaurateur permission)

In case of historical buildings (as in the case of City Museum), it is necessary to submit an application to the Conservator of Monuments for permission to perform works on the monument (at least 1 month before the planned date of submission of the building permit or work submission).

For the non historical buildings (as for the School) only building permission is necessary.

3.3 Door window replacement – Pesaro Public Library

San Giovanni Public Library located in Pesaro (Italy) is example of possible replacement of not efficient double glazing unit with well performing VIG during retroffiting of the contemporary door window.
The historical building has been object of a full renovation in 2000 and many contemporary elements have been introduced. As the building is an example of coexistence of historical and contemporary architecture elements, the technological progress can push in the adoption of new solution like the EENSULATE ones.

San Giovanni Public Library, as well as museum in Dzierżoniów, is historical building protected by the regimentation of Architectural Superintendence. Therefore, the possible application of EENSULATE solutions

has been evaluated to be in line with the existing architectural appearance of the building. For that reason, only one of the wooden door-window along the main corridor of the Library is selected to be retroffited. The retrofitting includes substitution of the existing DGU with EENSULATE VIG without affecting the aesthetic of the building. Additional details about the intervention are reported in the following part of the document. The figures below represent the door window where EENSULATE VIG will be installed.

Figure 60 Photo of the existing door widow – Pesaro library

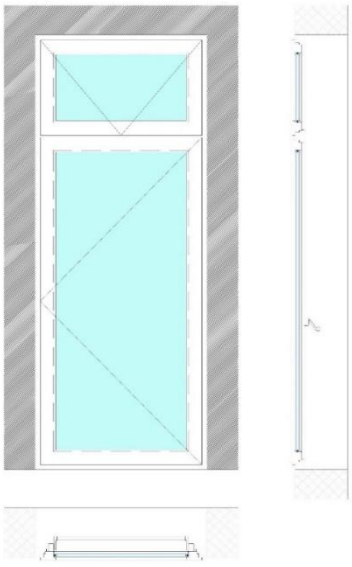


Figure 61 View and sections - technical drawing of library door widow

The objective of the door-window retroffiting is to preserve the overall window frame. The intervention is focused only on replacement of the 28mm of thickness DGU with the 18mm thin VIG. The works will be conducted removing the internal aluminium frame which restrains the DGU, cleaning the area from the existing sealant, placing the VIG, sealing the edge to create air and water tightness performance and repositioning the aluminium restrain in their initial position.

4 Conclusions

The products developed within the EENSULATE project allows to improve performace and aesthetics of the building where they are implemented.

EENSULATE modules, VIG and foam are developed to be used in facade and window systems. The system is flexible enough in design to be applied to various building typologies and both new and retroffited buildings. The wide application to different cases is well demonstrated thanks to the implementation in the project pilot sites: school and museum in Poland and public library in Italy.

Vacuum glass VIG because of its light and thin construction and good performace is a valuable competition for standard double (DGU) and triple glazing (TGU). It is also a good alternative to be applied in problematic retroffiting of building with historical heritage providing light and thin solution for substitution of single glass without changing visual aspect of the old widows which is crucial in this type of the buildings.

From the installation point of view, procedures do not differ much comparing with products exisiting on the market. This is an advantage, since no special work force is necessary to carry out the installation on site.

Lighter and thiner construction gives more geometrical possibilities, its easier to handle, takes less place for storaging and transportation.

All the details about the procedure for performing the installation of the EENSULATE solution in a real environment (demo buildings) are extensively described in the present document, as guidelines including drawings and photos as well as recommendations where necessary.