

ALUMINIUM AS MATERIAL

ALUMINIUM IS A RATHER NEWFOUND METAL, EXTRACTED FOR THE FIRST TIME IN 1854. COMMERCIALY PRODUCED AS A PRECIOUS METAL FROM 1886, ITS' INDUSTRIAL PRODUCTION FOR CIVIL APPLICATIONS ONLY ACHIEVED WIDE USE IN THE 1950'S.

NOW ALUMINIUM PLAYS A KEY ROLE FOR THE SUSTAINABILITY OF NEW BUILDINGS AND THE RENOVATION OF EXISTING ONES. THANKS TO ITS' PERFORMANCE PROPERTIES ALUMINIUM CONTRIBUTES TO THE ENERGY PERFORMANCE, SAFETY AND COMFORT OF NEW BIULDINGS.

ADVANTAGES

DESIGN FLEXIBILITY

The extrusion process offers an almost infinite range of forms and sections, allowing designers to integrate numerous functions into one profile

LONG SERVICE LIFE

Aluminium building products are made from alloys that are weatherproof, corrosion-resistant and immune to the harmful effects of UV rays, ensuring optimal performance over a very long period of time

HIGH STRENGTH-TO-WEIGHT RATIO

Thanks to the metal's inherent strength and stiffness, aluminium window and curtain wall frames can be very narrow. Material's light weight makes it easier to transport and handle on-site, reducing the risk of work-related injury

HIGH-REFLECTIVITY

This characteristic feature makes aluminium a very efficient material for light management. Aluminium shading devices can be used to reduce the need for air conditioning in summer

FIRE SAFETY

Aluminium does not burn and therefore is classified as a non-combustible construction material (European Fire Class A1). Aluminium alloys will nevertheless melt at around 6500 C, but without releasing harmful gases

NO RELEASE OF DANGEROUS SUBSTANCES

Several studies have proved that aluminium building products do not present a hazard to occupants or the surrounding environment. Aluminium building products have no negative impact, either on indoor air quality or on soil, surface and groundwater

OPTIMAL SECURITY

Where high security is required, specially designed, strengthened aluminium frames can be used. While the glass for such applications may well be heavy, the overall weight of the structure remains manageable, thanks to the light weight of the aluminium frames.

ALLOYS

Aluminium in its' pure form is a very soft metal. Thanks to the addition of alloying elements such as copper, manganese, magnesium, zinc, etc. and thanks to suitable production processes, the physical and mechanical properties can be varied in a wide range to satisfy the requirements of a large number of different applications.

ETEM profiles are extruded from the following alloys:

EN AW-1050 [Al 99.5]
EN AW-6060 [Al Mg Si]
EN AW-6063 [Al Mg0,7 Si]
EN AW-6061 [Al Mg1 Si Cu]
EN AW-6005 [Al Si Mg]
EN AW-6082 [Al Si1 Mg Mn]

The most common aluminium alloys used by ETEM are EN AW-6063 and EN AW-6060. Here are the properties of these alloys according to EN 755-2 and Eurocode 9

MATERIAL PROPERTIES

Aluminium alloy	EN AW-6063 T6	EN AW-6060 T66
Ultimate tensile strength	$R_m = 215 \text{ MPa}$ (wall thickness $\leq 10 \text{ mm}$) $R_m = 195 \text{ MPa}$ (10 mm < wall thickness $\leq 25 \text{ mm}$)	$R_m = 215 \text{ MPa}$ (wall thickness $\leq 3 \text{ mm}$) $R_m = 195 \text{ MPa}$ (3 mm < wall thickness $\leq 25 \text{ mm}$)
Tensile yield strength	$R_{p0,2} = 170 \text{ MPa}$ (wall thickness $\leq 10 \text{ mm}$) $R_{p0,2} = 160 \text{ MPa}$ (10 mm < wall thickness $\leq 25 \text{ mm}$)	$R_{p0,2} = 160 \text{ MPa}$ (wall thickness $\leq 3 \text{ mm}$) $R_{p0,2} = 150 \text{ MPa}$ (3 mm < wall thickness $\leq 25 \text{ mm}$)
Modulus of elasticity	$E_{al} = 70\,000 \text{ N/mm}^2 = 7 \cdot 10^9 \text{ kg/m}^2$	
Coefficient of thermal expansion	$\alpha = 0.023 \text{ mm/m} \cdot \text{K}$ (up to 1.2 mm/m for difference up to 50°C)	

EXTRUSION PROCESS

ETEM profiles are obtained through extrusion process, which consists of pushing a hot cylindrical bullet of aluminium through a shaped die. The extrusion process offers almost infinite range of forms and sections, allowing our designers to integrate numerous functions into one single profile.

aluminium surface, increasing hardness, corrosion and abrasion resistance. Anodizing gives a very typical silver matt surface finish, and colors can also be obtained by sealing metallic dyes into the anodized layer.

FINISHING

POWDER COATING

It is a type of paint that is applied as a dry powder. Coating is applied on ETEM profiles electrostatically and then is cured under heat to allow it to flow and form a "skin".

ETEM is authorized to use the quality sign QUALICOAT for powder coatings on aluminium for architectural applications. A wide range of colors and gloss levels can be achieved.

ETEM also offers timber imitations painting, in addition to all RAL colors. The technology EZY provides the following colors: Golden Oak, Acero, Betulla, Mogano, Verde Scuro, Wenge, Noce Fiammato, Noce Chiaro, Ciliegio Rosso, Acacia Scuro, Ciliegio Antico, Noce Reale, Ciliegio Reale.

ANODIZING

It is an electrochemical process which thickens the natural oxide film on the

MAINTENANCE

Apart from routine cleaning for aesthetic reasons, ETEM aluminium profiles do not require any maintenance, which translates into a major cost and ecological advantage over the lifetime of the product

RECYCLING

Aluminium scrap can be repeatedly recycled without any loss of value or properties. In many instances, aluminium is combined with other materials such as steel or plastics, which are most frequently mechanically separated from aluminium before being molten.

WIND LOAD

Wind actions

The main influence over the façade is wind action, which depends mainly on the height of the curtain wall and location.

As a guideline, the wind pressure values with respect to the structure height are given in the table below:

h (m)	v (m/s)	q		wind pressure	suction in middle zone		suction in edge zone
		(kg/m ²)	(kN/m ²)	$c_p = 0,8$	$c_p = 0,5$ $h/b \leq 0,25$	$c_p = 0,7$ $h/b \geq 0,5$	$c_p = 2,0$ $b/8 \leq 2 \text{ m}$
				$w_p = 1,25 \times 0,8 \times q$	$w_s = 0,5 \times q$ kN/m ²	$w_s = 0,7 \times q$ kN/m ²	$w_s = 2,0 \times q$ kN/m ²
0 - 8	28,3	50	0,5	kN/m ²	0,25	0,35	1,0
8 - 20	35,8	80	0,8		0,4	0,56	1,6
20 - 100	42,0	110	1,1		0,55	0,77	2,2
> 100	45,6	130	1,3		0,65	0,91	2,6

where:

h - building height, m

b - building width, m

v - wind velocity, m/s

q - wind load, kg/m² / kN/m²

$w_{p/s}$ - wind pressure / suction, kN/m²

c_p - correction factor

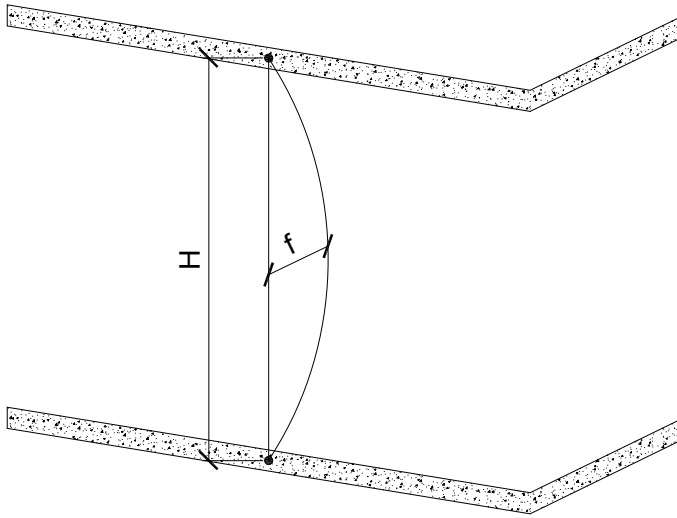
Note: These values and calculations are exemplary and should not be taken into account in actual projects.

All actual calculations should be prepared and verified by qualified personnel in accordance with the relevant standards and regulations.

ALLOWABLE DEFLECTION

Allowable deflection of substructure

According to the requirements of the CWCT Standard for systemized building envelopes, at both positive and negative applications of the peak test pressure, the maximum deflection of the substructure generally should not exceed:



Length	Allowable deflection
$H \leq 3000 \text{ mm}$	$f \leq H/200 \text{ mm}$
$3000 \text{ mm} < H < 7500 \text{ mm}$	$f \leq 5 + H/300 \text{ mm}$
$7500 \text{ mm} \leq H$	$f \leq H/250 \text{ mm}$

Allowable deflection of some cladding materials

- Allowable deflection of **brittle materials** (e.g. plasterboard):
1/360 of the extent of the board, or 10 mm whichever is the lesser;
- Allowable deflection of **natural stone units**:
1/360 of their length measured along the stone edge, or 3 mm, whichever is the lesser (smaller) deflections may be appropriate depending on the size of stone and method of fixing;
- Allowable deflection of **rainscreen panel**:
At both positive and negative applications of the peak test pressure, the maximum deflection shall not exceed:
 - 1/90 of the span measured between the points of attachment of the panel for aluminium, glass and steel, or
 - 1/360 of the span measured between the points of attachment, or 3 mm whichever is the lesser, for stone and similar brittle materials, or
 - More restrictive limits set by the panel manufacturer.

Greater deflections may also be allowable.

N.B! The deflection limits should be agreed with the material supplier.

COMPARTMENTS

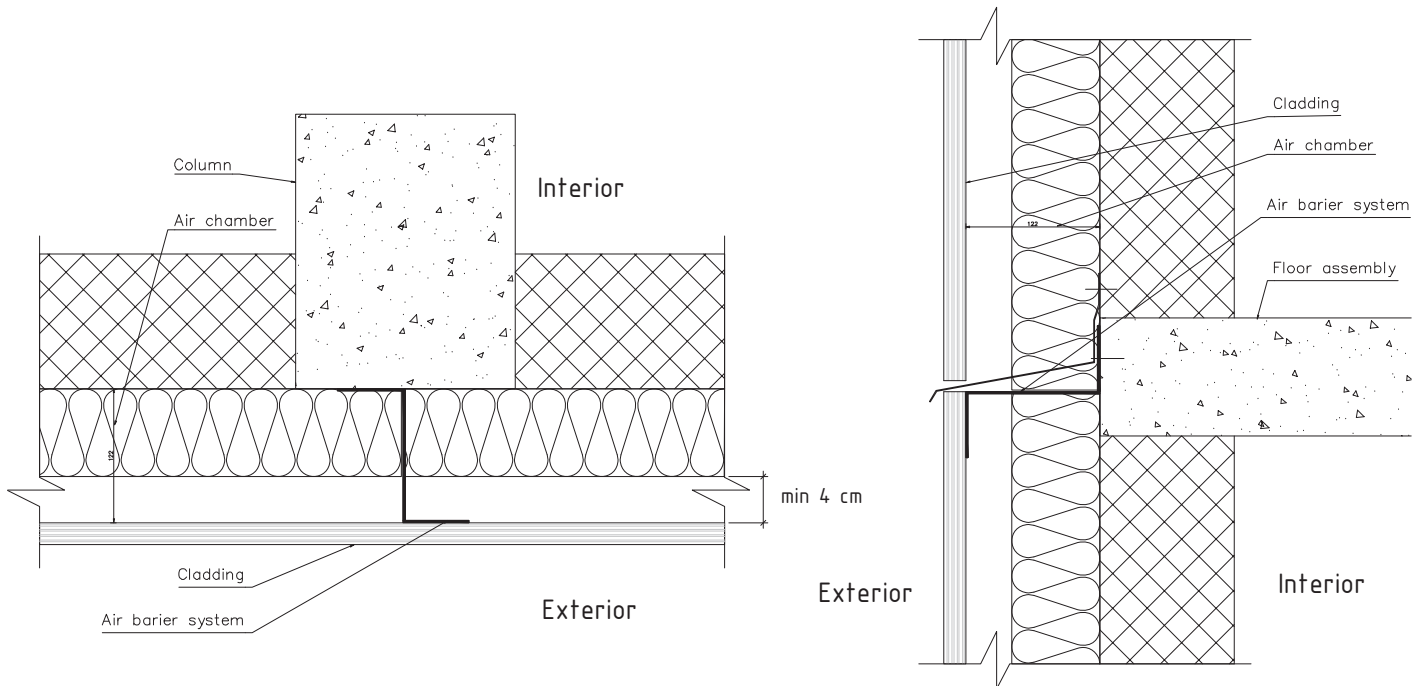
Some water may penetrate into the cavity, but the rainscreen/VFS is intended to provide protection from direct rain.

The cavity normally contains the insulation and rainscreen/VFS substructure. The volume of cavity is bounded by horizontal and vertical cavity closers, which form compartments within the cavity.

Compartmentation is necessary to:

- Control the airflow through cavities at corners, parapets where wind pressure varies across the surface
- Achieve dynamic and static pressure equalization
- Build an effective air barrier system, which prevent spread of fire

Compartments focus on the control of air pressure difference across the rainscreen, and the particular elements of wall assemblies instrumental in obtaining such control.



Typically, the wall assembly must comprise of three components:

- a rainscreen (i.e., vented cladding)
- a compartmented air chamber
- an air barrier system.

In General, the wall assembly must be designed to tolerate the entry of a small amount of water without damage. Preliminary studies indicate that for practical purposes, “adequate pressure equalization” for rain penetration control may be defined as not more than 25 Pa pressure differential across the rainscreen.

THERMAL PERFORMANCE

Thermal properties shall be selected in order to reduce the total in-service energy consumption of the building. These limit the levels of carbon emissions resulting from operation of the building.

Carbon emissions will be lower if the following are reduced:

- Heat transfer through the building envelope.
- Air leakage through the building envelope.
- Cooling loads arising from solar gain.

Heat transfer within an aluminum cladding system mainly affected by three highly correlated factors:

- The external cladding surface material (thermal resistance, solar and heat absorption, etc.)
- The characteristics of the air cavity between the external cladding and the main wall element (air movement, air temperature, dimensions)
- The material and characteristics of the brackets that thermally connects the exterior cladding (geometry, material, anchors) with the façade.

Breather membrane

A breather membrane may be placed on the outer face of insulation that should not be wetted. If it is acceptable for the insulation to be wetted a breather membrane may be placed behind the insulation to protect the backing wall.

A breather membrane has to withstand the full positive and negative wind loads, without tearing and without joints opening up.

Thermal bridging

The thermal bridges caused by subframe mechanical fixing devices and air spaces shall be taken into account, using the appropriate calculation method defined in EN ISO 6946 and EN ISO 10211 standards.

Particular attention shall be given to limiting thermal bridges. Thermal breaks can be used to reduce both U-value and condensation risk. To reduce the risk of condensation, thermal breaks should be placed, so as to form warm fingers and not cold fingers.

Thermostop elements serve only thermal spacers between consoles and structure.

The use of these elements in the two constructions of metal convincingly reduced heat losses and thus are suitable from the viewpoint of building physics.

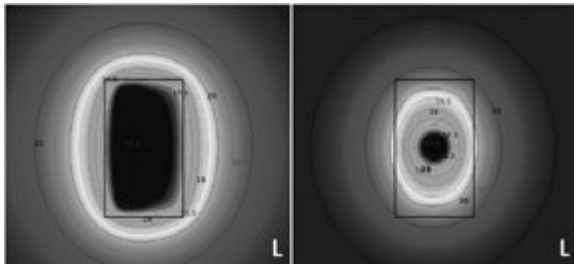
Such elements (consisting of plastic or wood) are particularly effective when you want to achieve thermal resistance. $R = \left(\frac{d}{\lambda}\right)$
Where:

d is the thickness of the material layer in the component;

λ is the design thermal conductivity of the material in accordance with ISO 10456

ETEM proposes designed Therminsulation pads to separate fixing brackets from the structure. Thus, the losses are reduced, but should not be ignored because of the installed fasteners that penetrate the solid wall element.

The characteristics of the bracket are of great importance, since the bracket penetrates the insulation protection and creates a three-dimensional thermal bridge. The contact area between the bracket and the solid wall is a significant factor in thermal losses due to point thermal bridges.



without thermal brake

with thermal brake

THERMAL RESISTANCE OF HOMOGENEOUS LAYER

The principle of the calculation method is as follows:

- To obtain the thermal resistance of thermally homogenous part of the component;
- To combine these individual resistances so as to obtain the total thermal resistance of the component, including the effect of surface resistances.

The total thermal resistance, R_T of a plane building component consisting of thermally homogeneous layers, perpendicular to the heat flow shall be calculated by the following expression:

$$R_T = R_i + R_1 + R_2 + \dots R_n + R_e$$

where

R_i is the internal surface resistance;

R_1, R_2, \dots, R_n are the design thermal resistances of each layer;

R_e is the external surface resistance.

Thermal transmittance (U-values)

Calculation of U-value of a zone of the building envelope shall be calculated using the weighted U-value method. The thermal transmittance is given by

$$U = \frac{1}{R_T}$$

The calculation shall be carried out as described below.

- a) Calculate R_e as the total thermal resistance of the component excluding the tapered layer, using above equation if all layers are thermally homogenous.
- b) Subdivide the area with tapered layers into individual parts, as necessary.
- c) Calculate R_1 and R_2 for each tapered layer, using

$$R_1 = \frac{d_1}{\lambda_1}$$

$$R_2 = \frac{d_2}{\lambda_2}$$

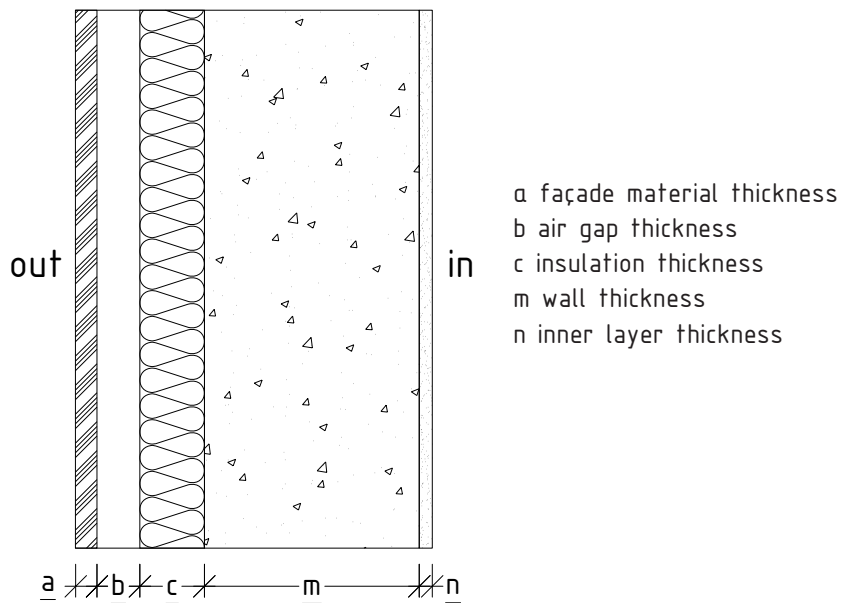
- d) Calculate the thermal transmittance of each individual part U_i in accordance with the relevant equation
- e) Calculate the overall thermal transmittance for the whole area using

$$U = \frac{\sum U_i A_i}{\sum A_i}$$

If total thermal resistance of a component with tapered layers is required, then

$$R_T = \frac{1}{U}$$

Example: U-value calculation of thermally homogeneous VFS layers



if	a	ceramic tile thickness is	0,015 m
	b	air gap thickness is	0,05 m
	c	insulation thickness is	0,08 m
	m	brick wall thickness is	0,25 m
	n	plaster thickness is	0,02 m

then

$$1/U = 1/R_e + \sum d/\lambda + 1/R_i$$

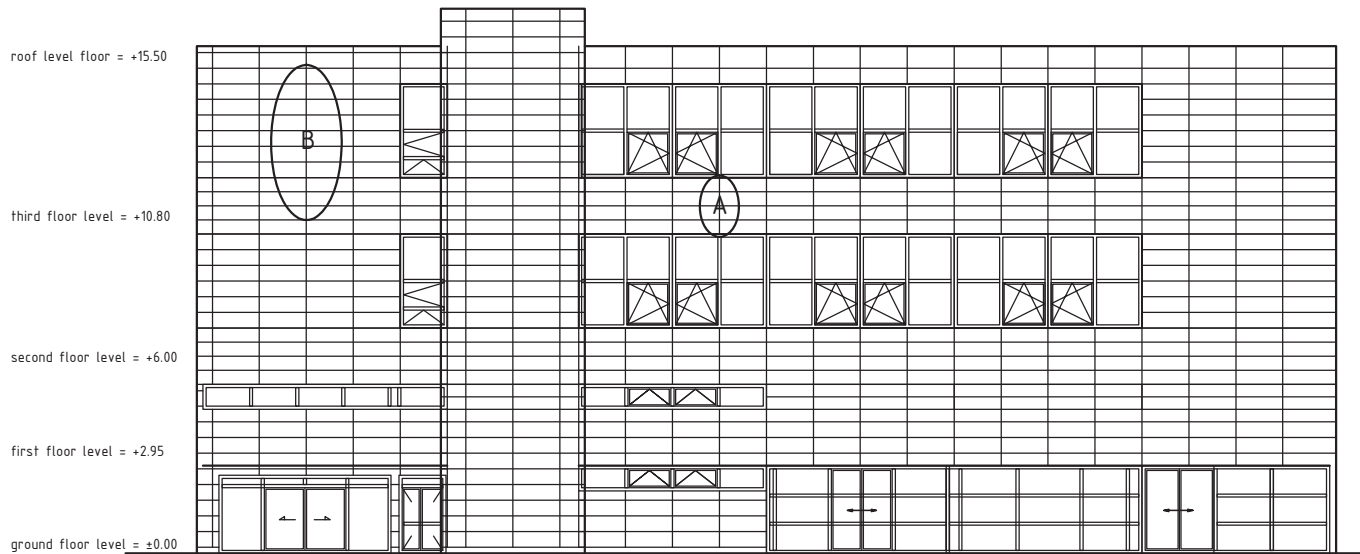
$$1/U = 0,05 + 0,015/0,064 + 0,05/0,025 + 0,08/0,05 + 0,25/0,44 + 0,02/0,9 + 0,13 = 4,605$$

U = 0,217 W/m²K

where	U	thermal transmittance (W/m ² K)
	1/R _e	external surface transmittance (W/m ² K)
	d	layer thickness (m)
	λ	design thermal conductivity (W/mK)
	1/R _i	internal surface transmittance (W/m ² K)
	R	design thermal resistance (m ² K/W)

Note: This is a simplified method. For a more comprehensive calculation method, see EN ISO 6946:2007 *Building components and building elements - Thermal resistance and thermal transmittance - Calculation method* (ISO 6946:2007).

DIMENSIONING OF MAIN SUPPORTING PROFILE



Initial data:

Project = Office building
Building location = Plovdiv, Bulgaria
Structure base = concrete/brick
Type of façade material = etalbond®
Cladding system = BRAVO W

Façade height = 15.5 m
Floor height = 4.80 m
Length of the main profile = 4.80 m
Thermal insulation: mineral batt = 80 mm

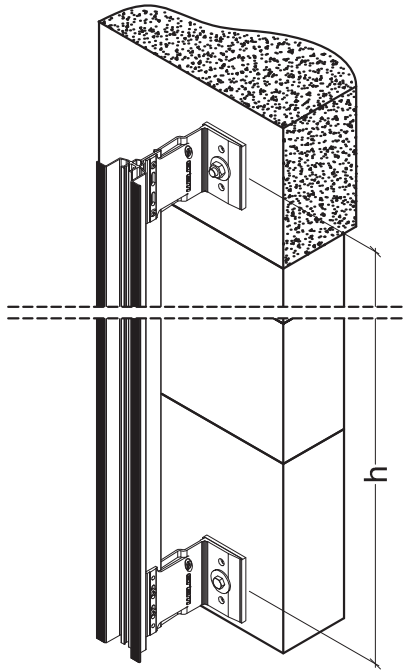
Façade raster = 1500x500 mm
Distance between main profiles = 1500 mm
Distance between fixing brackets = 1616 mm
Fixing brackets = ET 710011.00 - 100 mm

Loads:

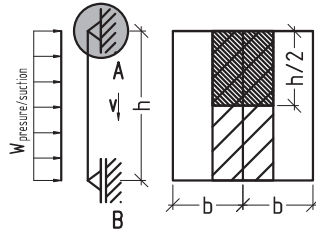
Façade material weight = 5.5 kg/m²
Wind load (normative) = 0.41 kN/m²

CHOOSING THE APPROPRIATE FIXING BRACKET

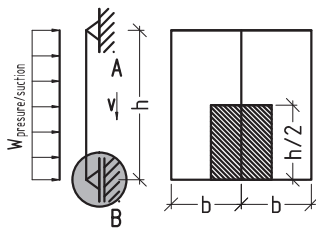
Simply supported beam with one fixed and one movable support - area A



- wind load
- dead load
- fixed support
- movable support



Fixed support



Movable support

Fixed support

- Self weight - dead load
 $V = g \cdot 3h \cdot b$

For determining the maximum permissible wind load the following formulae apply:

- Wind load-pressure
 $W_p = f_1 \cdot q \cdot c_p \cdot h/2 \cdot b$

- Wind load-suction
 $W_s = q \cdot c_p \cdot h/2 \cdot b$

where:

- V - load, kN
- g - weight of main vertical profiles and façade material, kN/m²
- W_p - wind pressure, kN
- W_s - wind suction, kN
- k_z - correction factor (height)
- q - dynamic load, kN/m²
- c_p - correction factor (wind pressure)
- h - distance between fixing brackets, m
- b - distance between main vertical profiles, m
- H - building height, m

Movable support

For determining the maximum permissible wind load the following formulae apply:

- Wind load-pressure
 $W_p = f_1 \cdot q \cdot c_p \cdot h/2 \cdot b$

- Wind load-suction
 $W_s = q \cdot c_p \cdot h/2 \cdot b$

Example

- Initial data:
- H = 0-15 m (middle zone)
 - g = 0,41 kN/m²
 - f₁ = 1,25
 - q = 0,5 kN/m²
 - c_p = 0,8 (wind pressure)
 - c_p = -0,5 (wind suction)
 - h = 1,828 m
 - b = 1,5 m

- Own weight - dead load

$$V = g \cdot h \cdot b = 0,065 \cdot 1,828 \cdot 1,5 = 0,178 \text{ kN}$$

- Wind load

$$W_p = f_1 \cdot q \cdot c_p \cdot h/2 \cdot b = 1,25 \cdot 0,41 \cdot 0,8 \cdot 0,914 \cdot 1,5 = 0,562 \text{ kN}$$

$$W_s = q \cdot c_p \cdot h/2 \cdot b = 0,41 \cdot (-0,6) \cdot 0,914 \cdot 1,5 = (-0,337) = 0,337 \text{ kN}$$

- Wind load

$$W_p = f_1 \cdot q \cdot c_p \cdot h/2 \cdot b = 1,25 \cdot 0,41 \cdot 0,8 \cdot 0,914 \cdot 1,5 = 0,562 \text{ kN}$$

$$W_s = q \cdot c_p \cdot h/2 \cdot b = 0,41 \cdot (-0,6) \cdot 0,914 \cdot 1,5 = (-0,337) = 0,337 \text{ kN}$$

Finally, we choose the appropriate fixing bracket with greater bearing capacity than the calculated value.

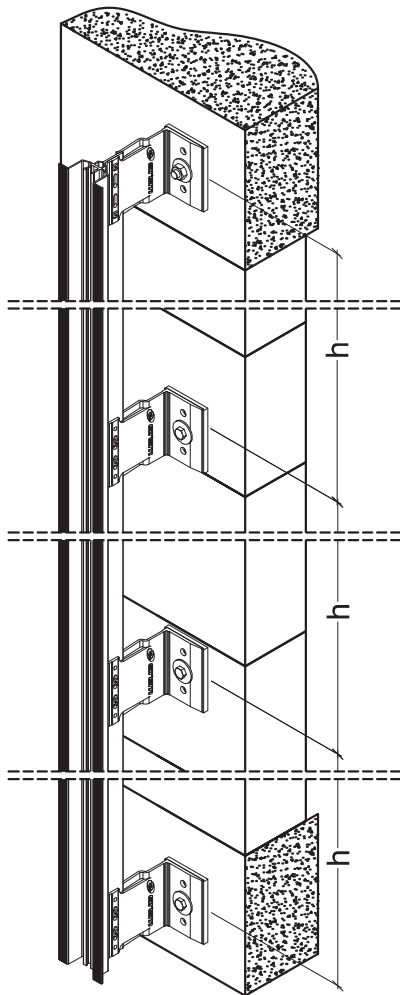
Fixing bracket for fixed support must bear both calculated values for dead load and wind load.

Fixing bracket for movable support must bear just wind load.

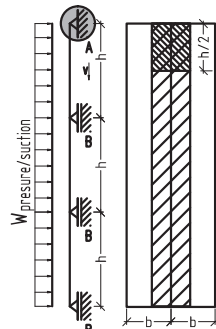
All static calculations must be verified by a responsible structural/façade engineer on site.

CHOOSING THE APPROPRIATE FIXING BRACKET

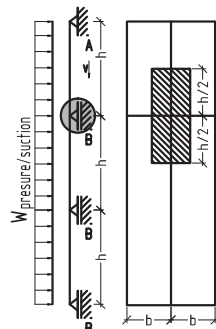
Continuous supported beam with one fixed and three movable supports – area B



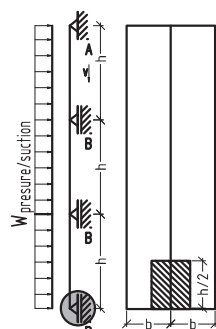
- wind load
- dead load
- A** fixed support
- B** movable support



Fixed support



Movable support (middle)



Movable support (end)

Fixed support

- Self weight – dead load
 $V = g \cdot 3h \cdot b$

For determining the maximum permissible wind load the following formulae apply:

- Wind load-pressure
 $W_p = f_1 \cdot q \cdot c_p \cdot h/2 \cdot b$

- Wind load-suction
 $W_s = q \cdot c_p \cdot h/2 \cdot b$

where:

- V – load, kN
- g – weight of main vertical profiles and façade material, kN/m²
- W_p – wind pressure, kN
- W_s – wind suction, kN
- κ_z – correction factor (height)
- q – dynamic load, kN/m²
- c_p – correction factor (wind pressure)
- h – distance between fixing brackets, m
- b – distance between main vertical profiles, m
- H – building height, m

Movable support (middle)

For determining the maximum permissible wind load the following formulae apply:

- Wind load-pressure
 $W_p = f_1 \cdot q \cdot c_p \cdot h \cdot b$

- Wind load-suction
 $W_s = q \cdot c_p \cdot h \cdot b$

Example

- Initial data:
 H = 0–15 m (middle zone)
 g = 0.065 kN/m²
 f₁ = 1,25
 q = 0,41 kN/m²
 c_p = 0,8 (wind pressure)
 c_p = -0,6 (wind suction)
 h = 1,616 m
 h/2 = 0,808 m
 b = 1,5 m

- Own weight – dead load

$$V = g \cdot 3h \cdot b = 0,065 \cdot 4,85 \cdot 1,5 = 0,472 \text{ kN}$$

- Wind load

$$W_p = f_1 \cdot q \cdot c_p \cdot h/2 \cdot b = 1,25 \cdot 0,41 \cdot 0,8 \cdot 0,808 \cdot 1,5 = 0,496 \text{ kN}$$

$$W_s = q \cdot c_p \cdot h/2 \cdot b = 0,41 \cdot (-0,6) \cdot 0,808 \cdot 1,5 = 0,298 \text{ kN}$$

- Wind load

$$W_p = f_1 \cdot q \cdot c_p \cdot h \cdot b = 1,25 \cdot 0,41 \cdot 0,8 \cdot 1,616 \cdot 1,5 = 0,994 \text{ kN}$$

$$W_s = q \cdot c_p \cdot h \cdot b = 0,41 \cdot (-0,6) \cdot 1,616 \cdot 1,5 = (-0,596) = 0,596 \text{ kN}$$

Movable support (end)

For determining the maximum permissible wind load the following formulae apply:

- Wind load-pressure
 $W_p = f_1 \cdot q \cdot c_p \cdot h/2 \cdot b$
- Wind load-suction
 $W_s = q \cdot c_p \cdot h/2 \cdot b$

- Wind load

$$W_p = f_1 \cdot q \cdot c_p \cdot h/2 \cdot b = 1,25 \cdot 0,41 \cdot 0,8 \cdot 0,808 \cdot 1,5 = 0,497 \text{ kN}$$

$$W_s = q \cdot c_p \cdot h/2 \cdot b = 0,41 \cdot (-0,6) \cdot 0,808 \cdot 1,5 = (-0,298) = 0,298 \text{ kN}$$

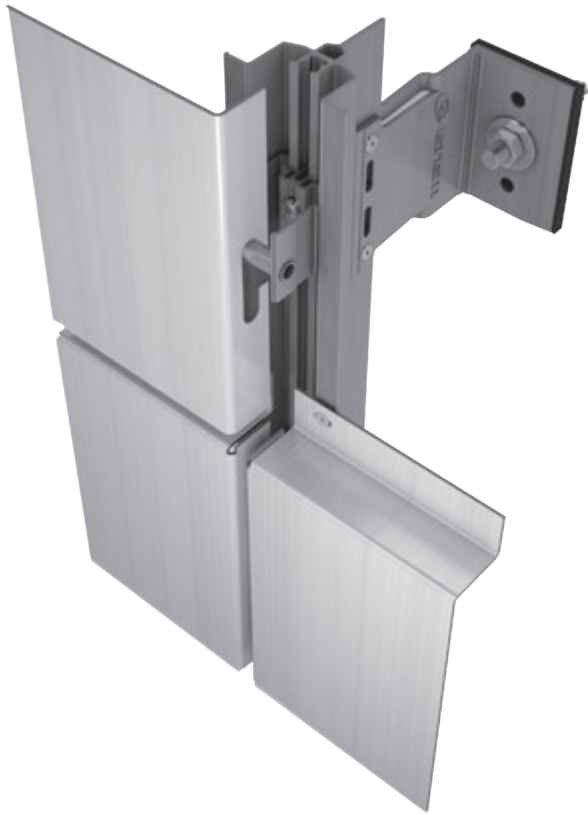
Finally we choose the appropriate fixing bracket with bigger bearing capacity than the calculated value.

Fixing bracket for fixed support must bear both calculated values for dead load and wind load.

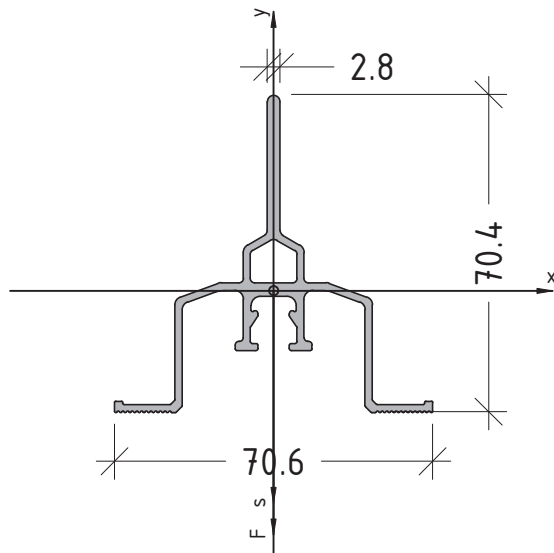
Fixing bracket for movable support must bear just wind load.

All static calculations must be verified by a responsible structural/façade engineer on site.

DIMENSIONING OF MAIN SUPPORTING PROFILE



BRAVO W – ventilated façade system for hanging etalbond® and ENF®:



Profile characteristics:

profile code – E97101
standard length – 6,01 m
weight of the profile – 1103g/m
material – aluminum EN AW 6060 T66
Yield point – 160N/mm²
Young's Modulus – 70000N/mm²

Geometrical characteristics:

moment of inertia

$$I_x = 13.249\text{cm}^4$$

$$I_y = 8.896\text{cm}^4$$

section modulus

$$W_x = 3.039\text{cm}^3$$

$$W_y = 2.250\text{cm}^3$$

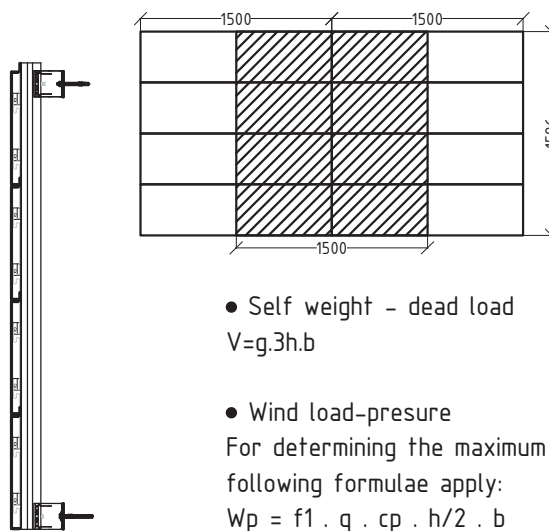
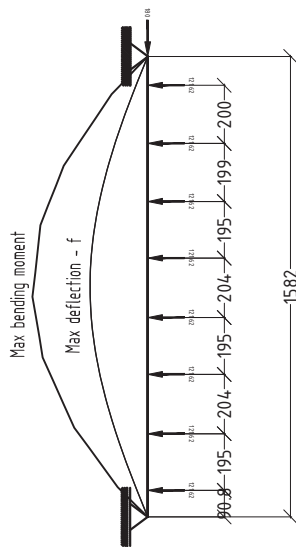
area

$$A = 4.069\text{cm}^2$$

All static calculations must be verified by a responsible structural/façade engineer on site.

DIMENSIONING OF MAIN SUPPORTING PROFILE

Simply supported beam with one fixed and one movable supports – area A



- Self weight – dead load
 $V = g \cdot 3h \cdot b$

- Wind load–pressure
For determining the maximum permissible wind load the following formulae apply:
 $W_p = f_1 \cdot q \cdot c_p \cdot h/2 \cdot b$

- Wind load–suction
 $W_s = q \cdot c_p \cdot h/2 \cdot b$

where:
 V – load, kN
 g – weight of main vertical profiles and façade material, kN/m²
 W_p – wind pressure, kN
 W_s – wind suction, kN
 f₁ – correction factor
 q – dynamic load, kN/m²
 c_p – correction factor (wind pressure)
 h – distance between fixing brackets, m
 b – distance between main vertical profiles, m
 H – building height, m
 s – distance between fixing brackets

Dimensioning of profile E97101

Initial data:

H = 0–15 m (middle zone)
 g = 0.065 kN/m²
 f₁ = 1,25
 q = 0,41 kN/m²
 c_p = 0,8 (wind pressure)
 c_p = - 0,6 (wind suction)
 h = 1.828 m
 b = 1,5 m
 s = 1.828 m

Defining the loads:

- Self weight – dead load

$$V = g \cdot 3h \cdot b = 0,066 \cdot 1.828 \cdot 1,5 = 0.180 \text{ kN}$$

- Wind load of the profile area

$$W_p = f_1 \cdot q \cdot c_p \cdot h \cdot b = 1,25 \cdot 0,41 \cdot 0,8 \cdot 1,582 \cdot 1,5 = 0,973 \text{ kN}$$

$$W_s = q \cdot c_p \cdot h \cdot b = 0,41 \cdot (-0,6) \cdot 1,582 \cdot 1,5 = (-0,584) = 0,584 \text{ kN}$$

$$F = W_p / \text{quantity of the hangers}$$

$$F = 0,973 / 8 = 0,122 \text{ kN} = 121,6 \text{ N}$$

Permissible deflection:

$$[f] = s / 200$$

$$[f] = 1582 / 200 = [7,91 \text{ mm}]$$

Results of the calculation

$$\text{Max deflection} = 5,41 \text{ mm} < [7,91 \text{ mm}]$$

$$\text{Max Stress} = 62,949 \text{ N/mm}^2 < [160 \text{ N/mm}^2]$$

$$\text{Max bending moment} = 191,29 \text{ Nm}$$

$$\text{Safety Factor} = 2,5417 > [2]$$

Conclusion:

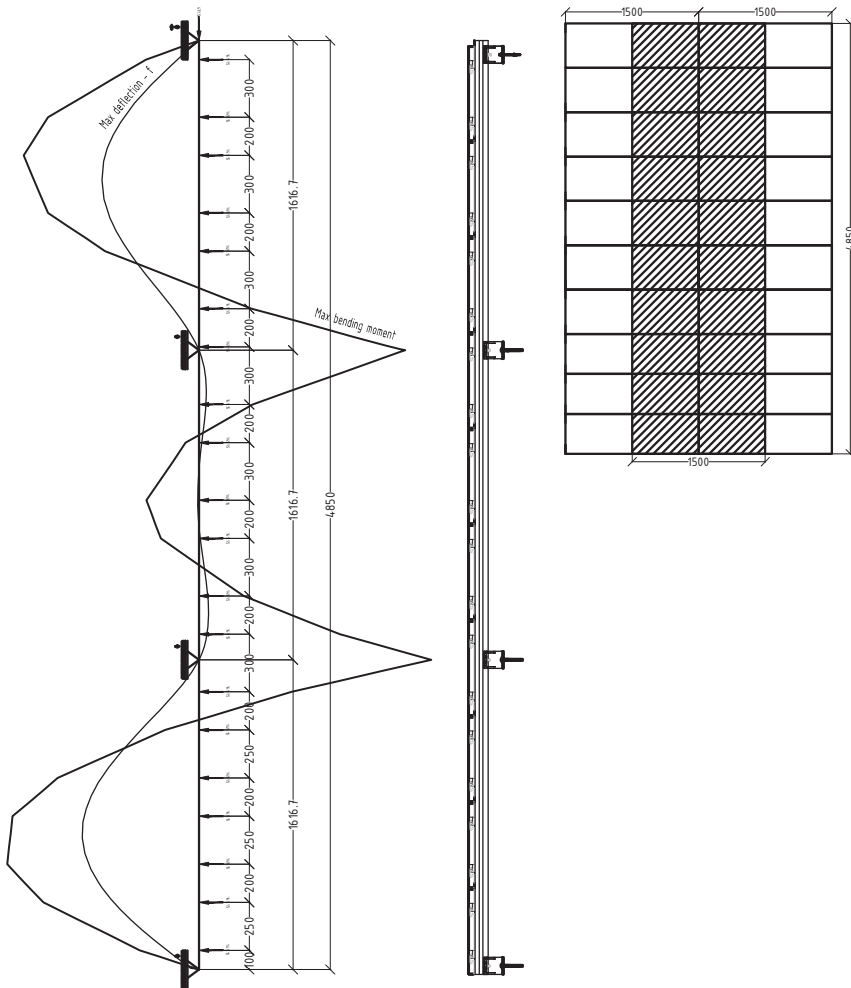
Based on the conditions above, profile E97101 provides the necessary bearing capacity.

The calculation was made using Autocad Mechanical static module.

Application point of the force F from the wind load on the profile is physically the hanger.
 All static calculations must be verified by a responsible structural/façade engineer on site.

DIMENSIONING OF MAIN SUPPORTING PROFILE

Continuous beam with one fixed and three movable supports – area B



- Own weight - dead load
 $V = g \cdot 3h \cdot b$

- Wind load-pressure
 For determining the maximum permissible wind load the following formulae apply:
 $Wp = f1 \cdot q \cdot cp \cdot h/2 \cdot b$

- Wind load-suction
 $Ws = q \cdot cp \cdot h/2 \cdot b$

where:
 V - load, kN
 g - weight main vertical profiles and façade material, kN/m²
 Wp - wind pressure, kN
 Ws - wind suction, kN
 f1 - correction factor
 q - dynamic load, kN/m²
 cp - correction factor (wind pressure)
 h - distance between fixing brackets, m
 b - distance between main vertical profiles, m
 H - building height, m
 s - distance between fixing brackets

Dimensioning of profile E97101

Initial data:
 H = 0-15 m (middle zone)
 g = 0.065 kN/m²
 f1 = 1,25
 q = 0,41 kN/m²
 cp = 0,8 (wind pressure)
 cp= - 0,6 (wind suction)
 h = 4.85 m
 b = 1,5 m
 s = 1.616 m

Defining the loads:

- Own weight - dead load
 $V = g \cdot 3h \cdot b = 0,065 \cdot 4,85 \cdot 1,5 = 0,472 \text{ kN}$
- Wind load of the profile area
 $Wp = f1 \cdot q \cdot cp \cdot h \cdot b = 1,25 \cdot 0,41 \cdot 0,8 \cdot 4,85 \cdot 1,5 = 2,983 \text{ kN}$
 $Ws = kz \cdot q \cdot cp \cdot h \cdot b = 0,41 \cdot (-0,6) \cdot 4,85 \cdot 1,5 = (-1,342) = 1,789 \text{ kN}$

F = Wp/quantity of the hangers
 F = 2,983/20 = 0,149 kN = 149,1 N

Permissible deflection:
 [f] = s/200
 [f]= 1616/200 = [8.08mm]

Results of the calculation

Max deflection = 3,45 mm < [8.08 mm]
 Max Stress = 55,924N/mm² < [160N/mm²]
 Max bending moment = 169,94 Nm
 Safety Factor = 2,8610 > [2]

Conclusion:
 Based on the conditions above, profile E97101 provides the necessary bearing capacity.

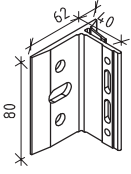
The calculation was made using AutoCad Mechanical deflection line module.

Application point of the force F from the wind load on the profile is physically the hanger.
 All static calculations must be verified by a responsible structural/façade engineer on site.

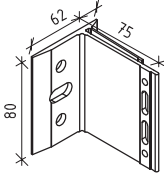
FIXING BRACKETS AND ACCESSORIES

E TEM FIXING BRACKETS

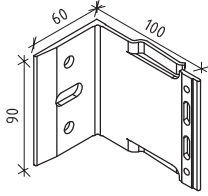
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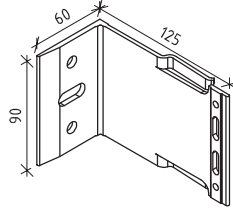
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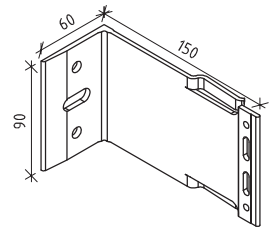
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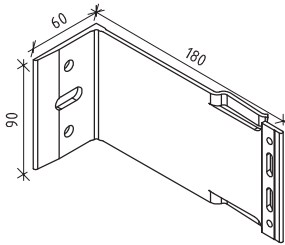
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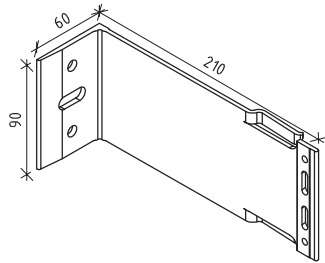
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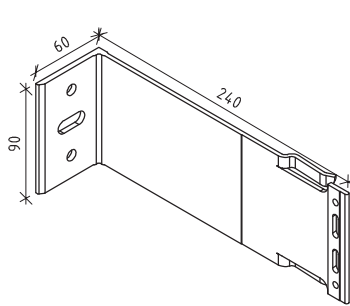
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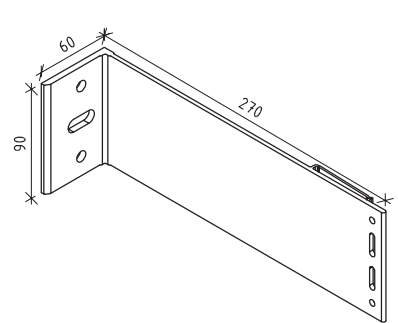
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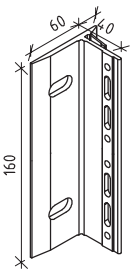
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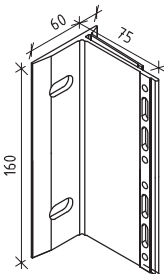
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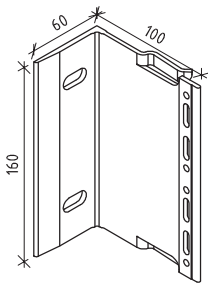
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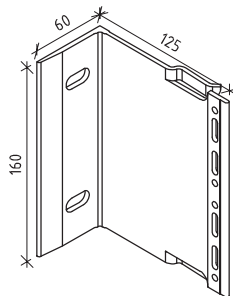
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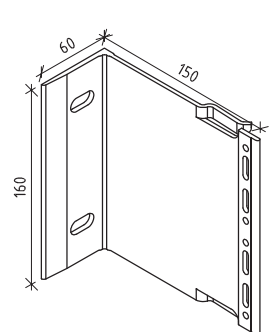
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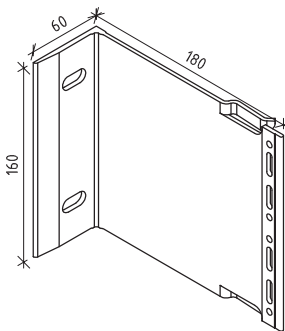
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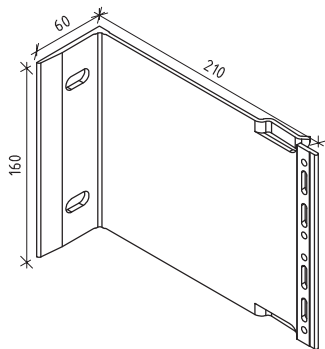
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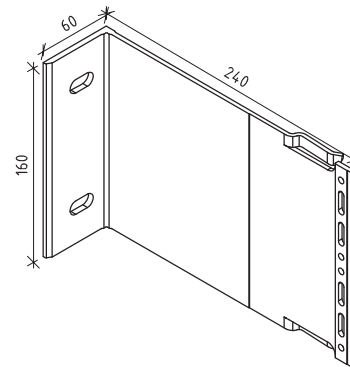
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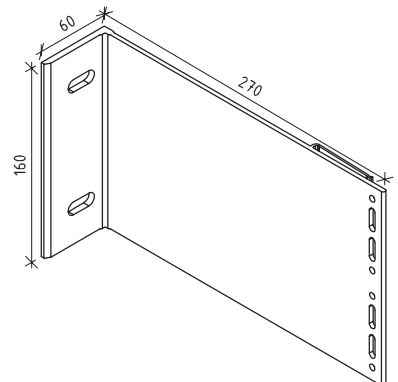
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ET710017.00



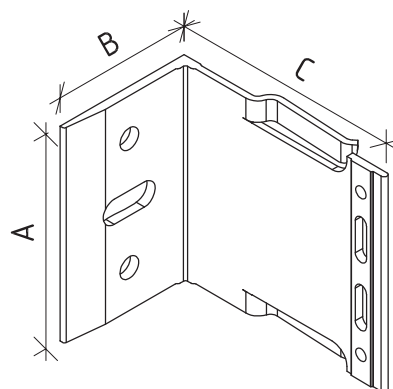
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ETEM FIXING BRACKETS & THERMO INSULATION PADS

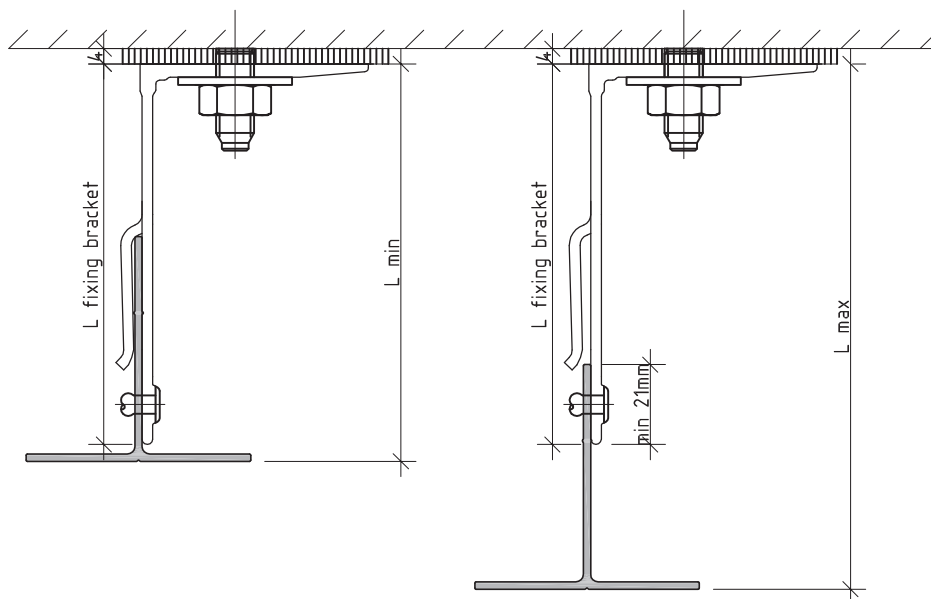
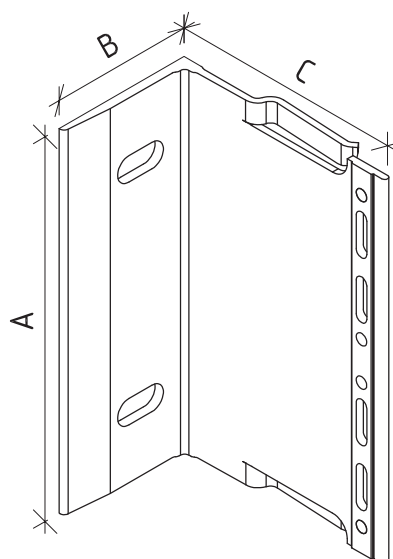
Fixing brackets					Suitable Thermo pads
Code	Type	A (mm)	B (mm)	C (mm)	Type
ET710008.00	single	80	60	40	ET730031.00 single
ET710010.00	single	80	60	75	
ET710011.00	single	90	60	100	ET730033.00 double
ET710013.00	single	90	60	125	
ET710012.00	single	90	60	150	
ET710014.00	single	90	60	180	
ET710015.00	single	90	60	210	
ET710016.00	single	90	60	240	
ET710038.00	single	90	60	270	

Single fixing bracket



Fixing brackets					Suitable Thermo pads
Code	Type	A (mm)	B (mm)	C (mm)	Type
ET710001.00	double	160	60	40	ET730032.00 single
ET710002.00	double	160	60	75	
ET710003.00	double	160	60	100	ET730034.00 double
ET710004.00	double	160	60	125	
ET710005.00	double	160 <td 60	150		
ET710006.00	double	160	60	180	
ET710007.00	double	160	60	210	
ET710017.00	double	160	60	240	
ET710039.00	double	160	60	270	

Double fixing bracket



ETEM's fixing brackets allow to distance the cladding material from the backing wall from min 68mm up to max 312mm with 60mm T profile
It's possible to adjust the profile up to 33mm (Lmin to Lmax).

FIXING BRACKETS AND ACCESSORIES

The performance characteristics of all ETEM fixing brackets is tested in laboratory conditions for the worst case scenario.

The aim of the test is to determine the load bearing capacity and wind resistance of the brackets and their fixings to the subframe under tension and shear loads.

Summary of results from testing of brackets for ETEM VFS systems

Code	Type	Size(mm)	Support	Loading direction	Loadbearing capacity	
					At elastic behavior of material (without residual displacement)	At displacement 2 mm
ET710001.00 (07vario072)	double	62/40/160	fixed	vertical	6,40 kN	14,45 kN
ET710002.00 (07vario082)	double	62/75/160	fixed	horizontal	6,07 kN	10,86 kN
ET710002.00 (07vario082)	double	62/75/160	movable	horizontal	5,04 kN	10,95 kN
ET710002.00 (07vario082)	double	62/75/160	fixed	vertical	6,04 kN	10,33 kN
ET710003.00 (07varioQ102)	double	60/100/160	fixed	vertical	4,65 kN	7,03 kN
ET710003.00 (07varioQ102)	double	60/100/160	fixed	horizontal	1,45 kN	6, 38 kN
ET710005.00 (07varioQ152)	double	60/150/160	fixed	vertical	3,67 kN	5,03 kN
ET710004.00 (07varioQ172)	double	60/125/160	fixed	vertical	3,42 kN	6,67 kN
ET710004.00 (07varioQ172)	double	60/125/160	fixed	horizontal	5,17 kN	10,93 kN
ET710004.00 (07varioQ172)	double	60/125/160	movable	horizontal	7,15 kN	10,15 kN
ET710014.00 (07varioQ18)	single	60/180/90	fixed	vertical	0,38 kN	0,46 kN
ET710006.00 (07varioQ182)	double	60/180/160	fixed	vertical	2,40 kN	3,32 kN
ET710015.00 (07varioQ21)	single	60/210/90	fixed	vertical	0,36 kN	0,41 kN
ET710015.00 (07varioQ21)	single	60/210/90	fixed	horizontal	1,37 kN	3,11 kN
ET710015.00 (07varioQ21)	single	60/210/90	movable	horizontal	1,65 kN	3,04 kN
ET710007.00 (07varioQ212)	double	60/210/160	fixed	vertical	2,15 kN	2,67 kN
ET710007.00 (07varioQ212)	double	60/210/160	fixed	horizontal	7,23 kN	10,21 kN
ET710007.00 (07varioQ212)	double	60/210/160	movable	horizontal	8,30 kN	11,45 kN

NOTE: All codes in brackets are the old ones!