ПРОФХОЛОД

# TECHNICAL SPECIFICATIONS

## CONTENTS

# CHAPTER 1. WALL AND ROOFING PANELS MANUFACTURED BY PROFHOLOD

## §1.1. POLYURETHANE FOAM. BASIC INFORMATION ON PUR AND PIR

*Polyurethanes* are chemical polymer compounds, which are formed as a result of the reaction between liquid isocyanates and liquid polyols. This is the most complex and multifarious group of polymers. At a certain ratio of isocyanate and polyol, either soft and elastic foams, or solid polyurethane foams with closed cells and excellent heat insulation properties can be obtained. Usually, the density of solid polyurethane foams ranges within 24 – 96 kg/m3 and has the structure consisting of small closed cells, filled with the foaming gas (view fig. 1).

Along with excellent heat insulation properties, the solid polyurethane foams have sufficient hardness and can withstand noticeable mechanical loads, which make them rather attractive from the point of view of the application as the core in the three-layer structural sandwich panels. Solid polyurethane foam's heat conduction generally, is determined by the heat conduction of the foaming gas, which fills the cells, by the heat conduction of the solid fraction and by the heat conduction provided by convection. When the size of the cells is relatively small, the convection heat transfer is negligible, meanwhile the contribution of the solid fraction is about 20%. The main contribution to the heat conduction of polyurethane foam belongs to the gas fraction. For this reason, the nature of the foaming agent used in the manufacture of solid polyurethane foams, plays an extremely important role. The following table shows the main properties of the foaming agents used today for solid polyurethane foams. It should be noted also, that according to the experimental tests, at the same density, the sample with the minor cell size has the lower heat conductivity [1]. At the same time, either the heat conduction, or the material's hardness grow with the increase of the density.

Figure 1.Cellular structure of the polyurethane foam:

а — at 200x enlargement,

б —at 20x enlargement

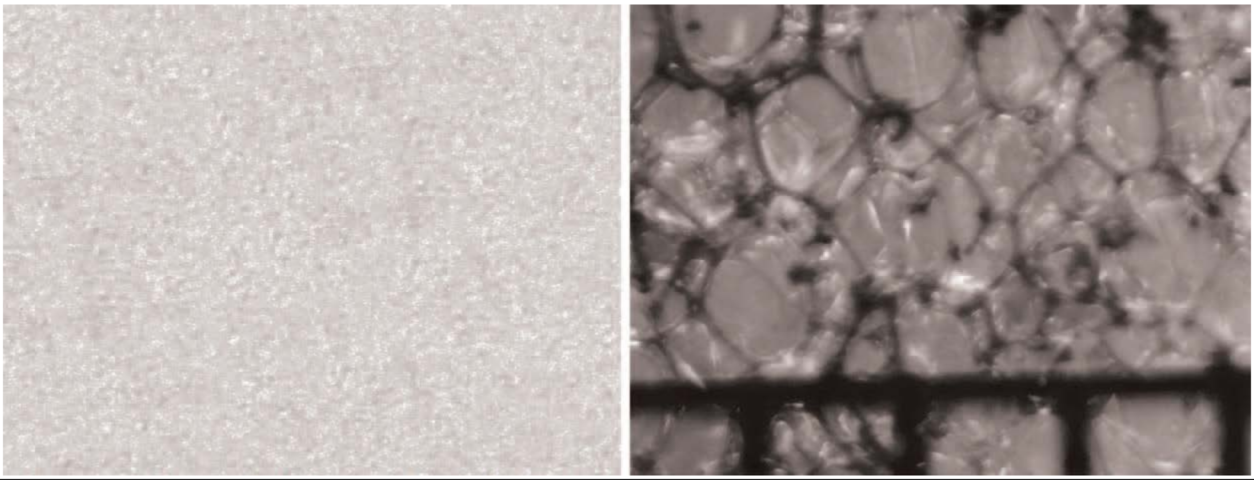
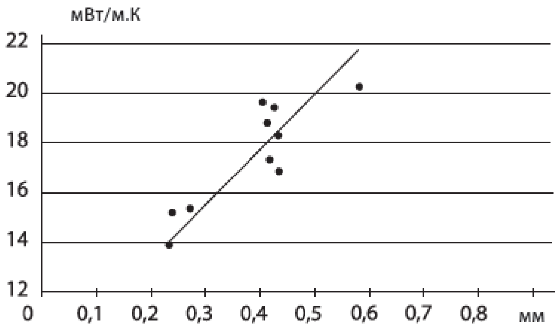


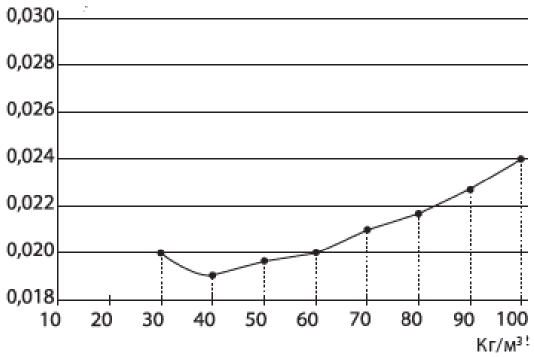
Table 1. Physical and chemical characteristics of different foaming agents

| Name | Molecular formula | Molecular weight (g/mol) | Heat conduction at 25°C (mW/m•K) | Boiling point (°C) | Saturated vapor pressure at 20°C (Bar) | Combustibility limit (% of volume in the air) |
|---|---|---|---|---|---|---|
| Freon-11 | C—CI3F | 137,5 | 7,8 | 24 | 0,88 | None |
| Freon -141b | CH3C—CI2F | 116,9 | 9,8 | 32 | 0,69 | 5,6—17,6 |
| Freon -134a | CH2FCF3 | 102,0 | 14,3 | -26 | 5,62 | None |
| Freon -245fa | CHF2CH2CF3 | 134,0 | 12,2 | 15 | 1,24 | None |

| | | | | | | |
|---|---|---|---|---|---|---|
| Freon -365mfc | CH3CF2CH2CF3 | 148,0 | 10,6 | 40 | 0,47 | 3,5—9,0 |
| N-Pentane | C5H12 | 72,0 | 14,6 | 36 | 0,65 | 1,4—8,3 |
| Isopentane | C5H12 | 72,0 | 13,8 | 28 | 0,80 | 1,4—7,6 |
| Cyclopentane | C5H10 | 70,0 | 12,6 | 50 | 0,34 | 1,4—7,8 |
| Carbon dioxide | CO2 | 44,0 | 16,3 | -78 | 56,55 | None |
| Air | N2/O2 | 28,8 | 26,5 | -193 | 624,03 | None |

Figure 2. Dependence of the heat conduction upon the polyurethane foam's density.
Figure 3. Dependence of the polyurethane foam's heat conduction upon the average cell size [1].




Thus, in order to obtain good heat insulation, it is better to use polyurethane foam with lower density, but in this case, we will have a rather fragile material. The above plot (view fig. 2) shows the experimentally revealed dependence of the solid polyurethane foams' heat conduction upon their density [1]. As we see, the best heat insulation is obtained at the polyurethane foam density of 40 kg/m3. As demonstrated below, at this filler density, the panels have the sufficient structural stiffness. The above



described properties of the solid polyurethane foams allow to apply them widely in the construction sphere as the heat insulating material. Recently, the prefabricated buildings made of metalwork and sandwich panels, acquired the continuously growing popularity. Sandwich panels represent a three-layer structure with a layer of heat insulating material between two metal sheet layers. As the "core", different materials with low heat conduction are used. The technological process of sandwich panel manufacture is divided in two stages. At the first stage the profile of the sheets is formed, having the tongue-and-groove lock, at the second stage, under the press, the space between the sheets is filled with the liquid polyurethane, which creates the core when it gets solid. As the filler, we use only high quality two-component polyurethane (PUR) or polyisocyanurate (PIR) manufactured by Dow Chemical according to the specially developed exclusive recipe.

Polyurethane foam (PUR) and polyisocyanurate (PIR) are two classes of related polymers, obtained by the reaction of several components. Polyurethane foam (PUR) is formed as the result of the reaction between polyol and isocyanate with the creation of urethane links. As for the polyisocyanurate (PIR), along with the above process, the particular "trimmer" net structures appear, as the result of the reaction of di-isocyanate molecules between each other. The peculiarity of these trimmers (polyisocyanurates) is their coalification when exposed to flame, accompanied with the creation of a "porous" carbon matrix. Such a matrix serves to protect the inner layers and to obstacle the fire spread. Besides, thanks to carbon matrix formation, the heat emission is much lower than in case of polystyrene, which burns out completely. So, the PIR panels have better fire-proof properties than the traditional PUR panels. The operation temperature of PIR panels is up to 140°C, meanwhile the PUR panels can be used only at a temperature below 100°C. Both PUR panels and PIR panels have high moisture-resistance properties and are practically totally steam tight.

### §1.2. WALL SANDWICH PANELS WITH POLYURETHANE FOAM (PUR) AND POLYISOCYANURATE FOAM (PIR) FILLER, MANUFACTURED BY PROFHOLOD. GEOMETRY OF SANDWICH PANELS.

*Sandwich panels* represent a three layer structure consisting of two layers of metal (or other sheet material), between which there is a core of solid polyurethane foam. The effective length of the wall

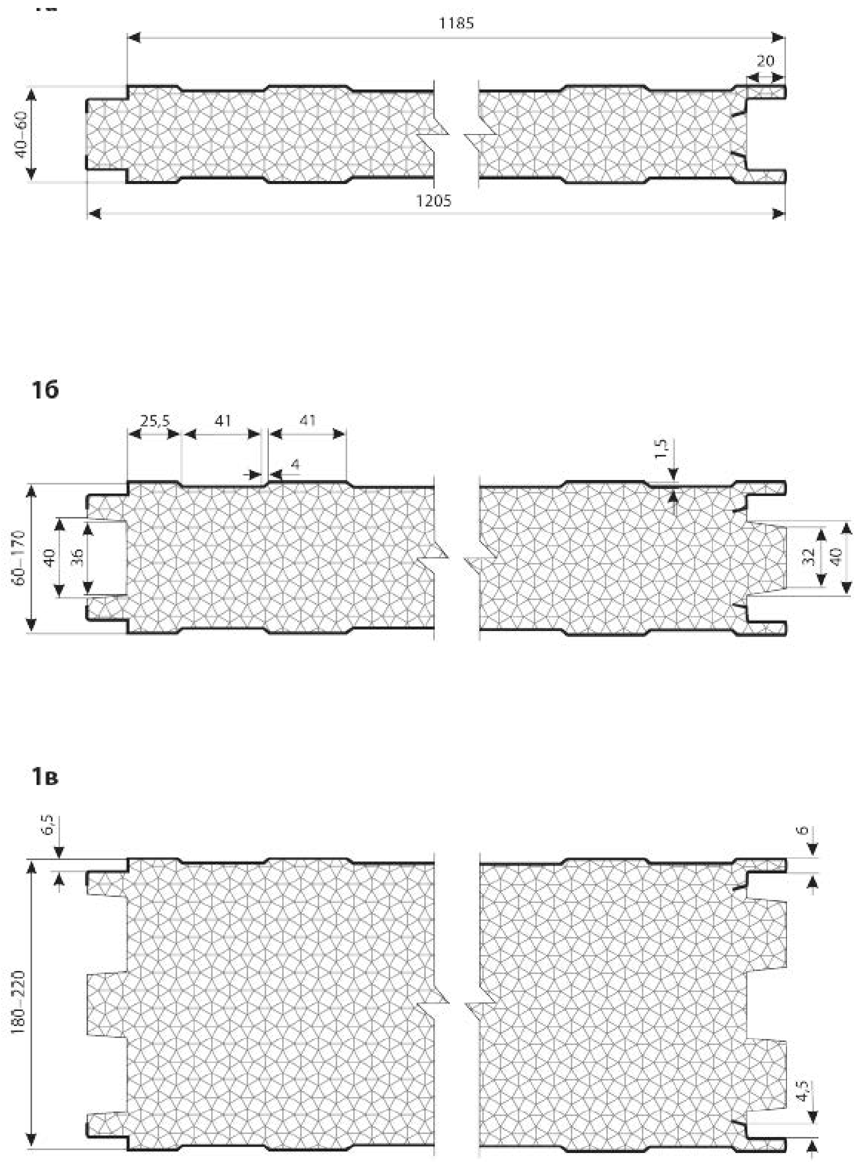
sandwich panels manufactured at present by ProfHolod LLC company, is 1185 mm. The maximum length of the panels produced on the periodical lines, doesn't exceed 9300 mm (the maximum documentary length is 9000 mm). In the meantime the panels manufactured on the continuous line, can be much longer, up to 16000 mm. The company has developed and produces the panels with the following range of thickness: 40 mm, 50 mm, 60 mm, 80 mm, 100 mm, 120 mm, 140 mm, 150 mm, 160 mm, 180 mm,
200 mm. As the facings of the sandwich panels we have tested and use the following materials:

- roll galvanized steel, thickness 0,45-0,8 mm;
- roll galvanized steel with polymeric coating;
- roll or sheet stainless steel AISI 304*;
- roll or sheet stainless steel AISI 430;
- zinc-aluminum**;
- paper, density 180—190 g/m2;
- foiled paper
- OSB – oriented strand board

The below figure 4 (view page 6) represents the geometrical dimensions of wall panels manufactured by ProfHolod company. The panels with the thickness of 40-60 mm can be produced on the periodical lines and have the single junction locking profile of tongue-and-groove type. As for the continuous line, it manufactures the panels with the thickness of 60-150 mm, with the lock of “double tongue-and-groove” type.

* AISI (American Iron and Steel Institute) which developed the AISI standard for stainless and alloyed steel. AISI 304 represents the main sort in the stainless steels family and contains min. 18 % of Cr и 8 % of Ni. Such a content of Cr provides for the forming on surface of the oxide layer, which makes the steel more resistant against various chemical substances. AISI 304 is the most widely used general-purpose ferrite chromium anti-corrosion steel.
**Zinc-aluminum – alloy of aluminum (55%), zinc (43,5) and silicon (1,5%). Used as an anti-corrosion coating for steel sheets. The composition was first patented by the American company Bethlehem
Steel in the early sixties of the XX century.

Figure 4. Geometric parameters of Profholod wall sandwich panels.




It should be noted, that the shapes of the lock, shown on the fig. 4, ensure sufficiently secure fit between the metal sheet and the polyurethane core, due to the fact, that in the groove the rim of the metal sheet goes inside the core. It is well demonstrated by the photo (view fig. 5). Such a construction of the junction lock considerably reduces the risk of the panel damage during transportation or mounting. The panels produced by the periodical lines, also can be provided with strengthening eccentric locks all the way lengthwise for obtaining of a tighter fit during the installation.

The above shown panels are different due to the form of the “tongue-and-groove” junction lock. The 40-60 mm thick panels have the single “tongue-and-groove” junction lock, 80-170 mm have the double “tongue-and-groove” profile, and the 180 and 200 mm thick panels can be manufactured with the triple “tongue-and-groove” (view fig. 6). Either both panel edges can be profiled or only one. Note that the more “deeply” the metal surface is profiled, the more it stiffens the panel.

Figure 5. View of the "tongue-and-groove" junction lock. The photo clearly demonstrates how the metal sheet goes inside the polyurethane core in the "groove".

Figure 6. Types of "tongue-and-groove" junction lock.

The following notation has been adopted for ProfHolod's wall panels:

| | Panel's length (cm) | Panel's width (mm) | Panel's thickness (mm) | Side 1 material | | Side 2 material | Filler |
|---|---|---|---|---|---|---|---|
| PST | XXX | XXXX | XXX | XXXX | / | XXXX | PUR or PIR |

PST here is an abbreviation meaning "panel, structural, three-layer". In some cases the panels are provided with strengthening eccentric locks all the way lengthwise in order to obtain a tighter fit during the installation. In this case we often use the abbreviation PSTZ. We use RAL* color scale (view fig. 7) to denote the color of ProfHolod's sandwich panels. As the standard color, ProfHolod company usually uses white – RAL 9003. For example, PST 900 1185 100 RAL9003 / Zn denotes a sandwich panel, 9 meters long, 1185 mm wide, 100 mm thick, with the coated RAL 9003 metal facing on one side, and galvanized, non-coated metal (Zn) on the other. The polyester coating's thickness is 25-30 micrometers. More expensive panels (ordered individually) are manufactured from metal list coated with Plastisol (coating thickness up to 200 micrometers). Such panels have better decorative qualities and are more resistant against mechanical and chemical impacts. They also differ for their higher anti-corrosion resistance. AISI 304 stainless steel panels are certified for the use in the food industry.

We use for our sandwich panels the cold rolled steel manufactured by the leading Russian companies: Severstal and NLMK. The thickness of the steel used for sandwich panels is 0,45-0,7 mm.

* RAL – German color standard developed in 1927 by the Imperial Commission for Delivery Terms and Quality Assurance (*Reichs-Ausschuß für Lieferbedingungen und Gütesicherung*).

Table 2. Technical features of the sandwich panel facing metal sheet

| Characteristic | Value |
|---|---|
| Yield point, min | 280 MPa |
| Yield point, max | 320 Mpa |
| Ultimate tensile strength, min | 360 Mpa |
| Specific elongation, min | 0,00% |
| Total mass of zinc coating on both sides of sheet, min | 275 g/m2 |
| Average thickness of zinc coating, min | 20 µm |
| Standard thickness of metal sheet | 1250 mm |
| Average thickness of polyester coating (for painted sheets) | 25-30 µm |

The samples of polyurethane foam that we use (both PUR and PIR) are regularly tested in the Dow Isolan research center. Below we demonstrate the results of such tests (Table 3).

*Table 3. Polyurethane foam samples test results(component A Voracor CD443, component B - Voracor CD 345*

| Parameter | | Sample # 1 | | Regulation document |
|---|---|---|---|---|
| | | Edge with deformation | Edge without deformation | |
| Apparent density (in core), kg/m3 | | 39,4 | 37,8 | GOST 409 |
| Compression stress at 10% deformation, kPa | | 158,3 | 208,8 | GOST 17177-87 |
| Rupture stress at bending, kPa | | 330 | | GOST 18564 |
| Bending value at breaking point, mm | | 13,2 | | GOST 18564 |
| Water absorption in 24 hours, % | | 1,6 | | GOST 17177-87 |
| Cohesive strength of polyurethane foam with sheets, at uniform detachment | upper | 117,4 | | GOST 23486-79 |
| | lower | 207,4 | | |
| Heat conduction coefficient, W/m*K 10/35 | | 0,022 | | GOST 7076-99 |
| Dimensional stability, +75°C, 24 h, % | ΔL | <1 | | GOST 20989-75 |
| | ΔB | | | |
| | ΔH | | | |

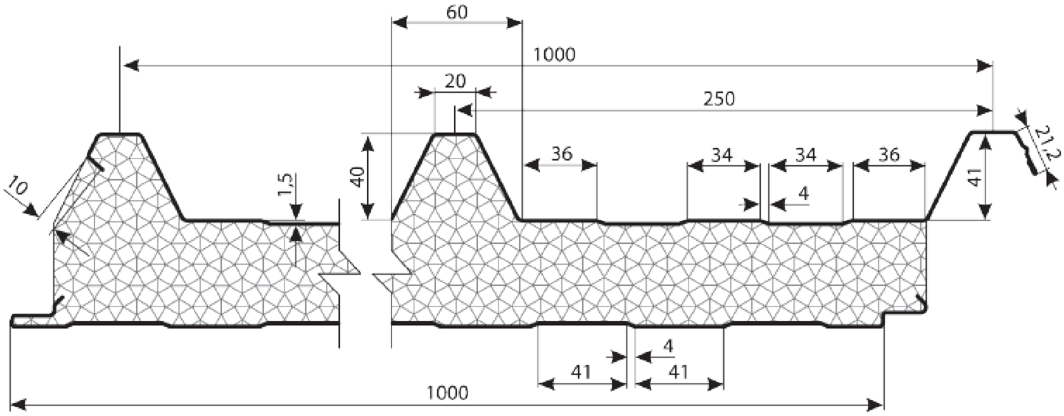
*Table 4. Test results of a fragment of PIR sandwich panel (component A - Voraterm CN815 with no primer used)*

| Parameter | | tongue | center | groove | Regulation document |
|---|---|---|---|---|---|
| General density, kg/m3 | | 40,8 | 41,2 | 40,9 | GOST 409 |
| Apparent density (in core), kg/m3 | | 39,5 | 39,4 | 39,2 | GOST 409 |
| Compression stress at 10% deformation, kPa | hight | 116,17 | 99,97 | 115,25 | GOST 23206-78 |
| | length | 318,87 | 317,48 | 317,53 | |
| | width | 125,41 | 125,25 | 119,88 | |
| Water absorption in 24 hours, % | | | 1,50 | | GOST 20869-75 |
| Cohesive strength of polyurethane foam with sheets, at uniform detachment | upper | 134,39 | 110,77 | 132,16 | GOST 22695-77 |
| | lower | 118,12 | 111,54 | 100,32 | |
| Heat conduction coefficient, W/m*K 10/35 | | | 0,021 | | GOST 7076-99 |

### §1.3. GEOMETRY OF PROFHOLOD'S ROOFING SANDWICH PANELS.

ProfHolod's manufacture of roofing panels is based exclusively on continuous technology. View below the geometrical parameters of roofing sandwich panels (fig. 8).

Figure 8. Geometry of ProfHolod's roofing panels.




The filler for the roofing panels can be either polyurethane foam (PUR), or polyisocyanurate foam (PIR).

| | Panel's length (cm) | Panel's width (mm) | Panel's thickness (mm) | Side 1 material | | Side 2 material | Filler |
|---|---|---|---|---|---|---|---|
| PKT | XXX | XXXX | XXX | XXXX | / | XXXX | PUR or PIR |

In this case, the abbreviation PKT should be interpreted as "panel roofing three-layer", then goes the panel's length in centimeters, the working width in millimeters (in our case 1000 mm) and the thickness, also in millimeters. The notation for the upper and the lower layers and for the filler is the same as for the wall panels.

### §1.4. THERMO-PHYSICAL PROPERTIES OF POLYURETHANE FOAM (PUR/PIR) SANDWICH PANELS. HEAT CONDUCTION, HEAT TRANSFER AND HEAT RESISTANCE

In recent years, the increasing importance in the civil and industrial construction is acquired by the heat insulation of buildings and structures. In a series of countries, there are very strict legislative limitations concerning the minimum heat insulation level of the buildings. Such restrictions have been existing for a long time in Scandinavian countries and Canada. These severe measures are connected, of course, with the rise in the price of fuel and, as the result, the increase of the expenses for the heating of buildings. Evidently, the similar tendency will remain in the future too, that's why more and more importance will be given to the heat insulation of buildings in the most of the developed countries.

The heat quantity, which is necessary to maintain an acceptable temperature inside the building, depends mainly on two factors:

- loss of heat, caused by the heat conduction of the enclosing structures (floor, walls and ceiling);

• loss of heat due to the air transfer through the natural pores of the enclosing structures (natural ventilation);

The loss of heat, caused by the first factor, can be reduced using the materials with lower heat conduction, and the losses connected to the second factor – using air proof materials for the enclosing structures and efficient methods of mechanical ventilation.

Sandwich panels have the ideal properties for the prevention of heat losses caused by the above factors along with such qualities as, high strength, quick and easy installation. This makes them irreplaceable in many cases. The definition of the heat insulator thickness for the buildings of different duties in different climatic conditions in the Russian Federation is based on the SNiP (building code) 23-02-2003 "Heat protection of buildings". Here we are going to focus in detail on the basic physical concepts, describing the heat insulation properties of different materials and structures.

The main concept in thermodynamics is the concept of heat conduction (not to be confused with the heat conduction coefficient).

Heat conduction is the transfer of heat by the structural particles of the substance (molecules, atoms, electrons) during the process of their heat motion. Such a heat exchange can occur in any body with a not uniform distribution of temperatures, but the procedure of the heat transfer will depend on the aggregate state of the substance. The phenomenon of heat conduction consists in the fact that the kinetic energy of atoms and molecules, which determines the temperature of the body, is transferred to another body during their interaction, or it is transferred from the more heated parts of the body to its less heated parts. In the certain state, the flow of energy, transmitted by means of heat conduction through the area S per unit time is proportional to the temperature difference between the two sides of the wall and inversely proportional to the wall's thickness. If we are speaking about a steady heat flow from one side of the sandwich panel to the other, for the loss of heat we have [2], [3]:

$$Q = -\alpha \frac{S \cdot \Delta T}{\delta}, \quad (1)$$

where Q is the full power of heat loss, S is the area of the analyzed wall, ΔT – the temperature difference between the both sides of the panel, δ - the thickness of the heat insulating layer. The multiplier α is called heat conduction coefficient and serves for quantification of the material's ability to transfer heat. The heat conduction coefficient is measured in W/(m*K). It is important to understand that heat conduction coefficient is a physical characteristic of material and it is determined only by its internal structure but not by the form or dimensions. The Table 5 reports the values of the heat conduction coefficient of different construction materials. The average heat conduction coefficient of the polyurethane foam (both PUR and PIR) is commonly considered: α = 0,021 – 0,022 W/(m*K). Although some manufacturers declare that their panels have the heat conduction α = 0,018 W/(m*K), those statements do not seem completely persuasive and should be considered only as a marketing or publicity campaign.

*Table 5. Heat conduction coefficient of main construction materials*

| Material | Heat conduction coefficient W/(m*K) |
|---|---|
| Alluminum | 202—236 |
| Steel | 47-60 |
| Glass | 1,15 |
| Structural bricks | 0,87 |
| Solid concrete | 1,7 |
| Foamed concrete | 0,14—0,3 |
| Wood | 0,15 |
| Mineral wool | 0,045 |
| Geofoam (expanded polystyrene) | 0,04 |
| Urea formaldehide polystyrene | 0,035 |
| Air (dry, still) | 0,024—0,031 |
| Polyurethane foam (PUR, PIR) | 0,021-0,023 |

Let’s examine an example of heat transfer through the layer of solid polyurethane foam, having the thickness of 100 mm and surface area of 1 m2. One side has the temperature 20 °C and the other - 0 °C. According to the formula (1), we have:

$$Q = 0{,}021 \; \frac{1 \cdot (20 - 0)}{0{,}1} = 4.2 \text{ W/m2}$$

It is interesting to compare this value with the heat flow running through a layer of concrete of the same thickness. Q = 340 W/m2, i.e. 81 times more heat passes through one square meter of the concrete wall of the same thickness per unit time.

Heat conduction coefficient is not a constant quantity during the whole life of a material, but it depends on many factors. The most important factors, influencing the heat conduction coefficient value of the heat insulating materials, are the following:

- *Temperature*. Normally, the coefficient α grows slightly with the temperature rise
- *Humidity*. Elevated humidity also brings to the increase of the heat conduction coefficient
- *Ageing.* Some heat insulating materials contain gas (foaming agent) with low heat conduction. Even if all the pores are closed, the gas diffuses and is replaced by the air, so, the material’s heat conduction alters respectively.

For the description of heat conduction of various materials and sandwich panels in particular, the technical literature uses the concepts of heat transfer coefficient K and thermal resistance R. The heat flow, transferring the heat through the chamber’s wall, in this case is determined by the following formula:

$$Q = K \cdot S \cdot \Delta T \qquad (2)$$

where K – heat transfer coefficient of the sandwich panel, which now will depend on its thickness (measured $W/m^2 \cdot K$); S – wall surface area in square meters; and ΔT – temperature difference between the both sides of the sandwich panels, which is also called “temperature pressure”.

The heat transfer coefficient K in a more general case is determined as

$$K = \frac{1}{1/\beta_{(in)} + \Sigma\ (\delta_i/\alpha_i) + 1/\beta_{(out)}} \qquad (3)$$

Where βin – is heat transfer coefficient from the inner surface of the wall, the value of which depends upon the air motion speed inside the room and upon the casing material, and βout - is the heat transfer coefficient from the outer wall, which depends upon the air motion speed near the walls outside and upon the outer casing material.

The quantity, inversely proportional to the heat transfer coefficient, i.e. the quantity 1/K is also called thermal resistance and denoted with the letter R.

$$R = \frac{1}{\beta_{(in}} + \Sigma \frac{\delta_i}{\alpha_i} + \frac{1}{\beta_{(out)}} \qquad (4)$$

Thermal resistance characterizes the ability of a body (its surface or one of its layers) to obstacle the spread of heat and numerically is equal to the temperature pressure which is necessary for the transfer of a unit of heat flow (equal to 1 W/m2) to the body surface or through the substance layer. The thermal resistance of a complex system (for example, multilayer heat insulation) is equal to the sum of thermal resistances of its components. The empirical values of the heat transfer coefficient from the walls βin and βout are the following:

- Still air – 9,4 W/m2*K.
- Air speed 3,35 m/s – 22,7 W/m2*K.
- Air speed 6,7 m/s – 34,1 W/m2*K.

Now let's make a calculation of the thermal resistance of a sandwich panel wall with the thickness of 100 mm enclosing an inner room, seen as a three-layer structure.

Supposing the metal thickness as 0,5 mm and the polyurethane core as 99 mm, for the panel's thermal resistance, we have:

• outside air speed 3,35 m/s – resistance 1/22,7 = 0,044053;
• steel sheet 0,5 mm – resistance 0,0005/47= 0,000011;
• polyurethane core (PUR or PIR) 99 mm – resistance 0,099/0,021 = 4,714286;
• steel sheet 0,5 mm – resistance 0,0005/47= 0,000011;
• inside air (still) – resistance 1/9,4=0,106383.

So, in all, the thermal resistance will be determined by the following sum:
R = 0,044053 + 0,000011 + 4,714286 + 0,000011 + 0,106383 = 4,864744.

As we see, the sandwich panel's thermal resistance is determined mainly, by the resistance of the polyurethane core. For this reason, it's rather interesting to make a comparative analysis of heat insulation properties of various construction materials, comparing them with polyurethane. The below table 6 represents the heat conduction coefficients of various construction materials and gives a visual demonstration of their thickness, which could ensure the heat insulation equivalent to 100 mm thick polyurethane (PUR / PIR).

Table 6. Heat conduction of construction materials and graphical visualization.

| Материал | α, Вт/м.К | Толщина, мм | |
|---|---|---|---|
| Polyurethane foam (PUR, PIR) | 0,021 | 100 | Polyurethane foam (PUR, PIR) |
| Geofoam (expanded polystyrene) | 0,04 | 190 | Geofoam (expanded polystyrene) |
| Mineral wool | 0,06 | 285 | Mineral wool |
| Wood | 0,15 | 714 | Wood |
| Expanded clay concrete | 0,3 | 1430 | Expanded clay concrete |
| Structural bricks | 0,37 | 1760 | Bricks |

All the construction materials at the thickness indicated in the table, have the same heat transfer resistance, which is equal to 4,76 m2*K/W.

It is interesting to examine the issue related to the heat conduction of profiled panels (with profile depth more than 5 mm). Such are, first of all, the roofing panels (view fig. 8). Since the thickness of the heat-insulating core is not a constant value, it is convenient to introduce a certain "effective thickness" of the panel, i.e. the profiled panel is equated with a slightly thicker smooth one. Profiled panels, depending on the profiling depth, are devided in 5 classes [4]. The main parameter which determines the profiling "depth" is the quantity $r=(b_1+b_2)/2b$ (view fig. 9).

- Class 1: r ≤ 0,25
- Class 2: 0,25 ≤ r ≤ 0,5
- Class 3: 0,5 ≤ r ≤ 0,6
- Class 4: 0,6 ≤ r ≤ 0,7
- Class 5: r > 0,7

As we see, our roofing panels belong to the Class 1 (r=0,16). It is clear that the thermal resistance of the roofing panel will be some higher than the smooth one of the same thickness, considering as the thickness the main thickness without "humps". Let's denote the panel's thickness with d, the "hump's" height as $d_1$ and suppose, that the heat transfer resistance, conditioned by the presence of "humps", is equivalent to the increase in thickness of the whole panel of a certain quantity Δd:

$$R_t = R_1 + \frac{\Delta d}{\alpha} \qquad (5)$$

where $R_1$ is the thermal resistance of the main part of the panel "without hump". The quantity $d_1$ is determined by the following table [4]

Table 7. Additional thickness Δd for the roofing panel

| Class | Panel's "hump" height d1 (mm) | | | |
|---|---|---|---|---|
| | 10 ≤ d1 ≤ 25 | 25 ≤ d1 ≤ 50 | 50 ≤ d1 ≤ 70 | d1 ≥ 70* |
| 1 | 1 | 2 | 2 | 2 |
| 2 | 3 | 5 | 6 | 7 |
| 3 | 5 | 9 | 12 | 14 |
| 4 | 7 | 12 | 16 | 19 |
| 5 | 8 | 15 | 20 | 24 |

* At the "hump's" height of more than 120 mm a more detailed analysis is necessary.

That means that the heat resistance of the roofing panel represented on the page 9 (view fig. 8), is equivalent to the heat resistance of the 2 mm thicker smooth wall panel. Such a "win" in heat insulation of roofing panels is not the purpose of the deep profiling, but a collateral property. Meanwhile, the main purpose of the deep profiling of the roofing panels is giving them a high bearing capacity.

## §1.5. HEAT CAPACITY OF SANDWICH PANELS

Sandwich panels are light structural units, which means that they have a relatively small capacity of accumulating heat in comparison with traditional materials, such as, for example, concrete. The heat capacity C of some part of a structure is determined by its average specific heat capacity (the material's heat capacity W/(kg*K)) and the mass m (kg):

$$C = mc \ [W/ (kg \cdot K)]$$

The below table presents the specific heat capacity of some construction materials (data taken from [4])

*Table 8. Specific heat capacity of construction materials*

| Material | Density, kg/m3 | Specific heat capacity, W/kg °K |
|---|---|---|
| Concrete | 2300 | 900 |
| Light concrete | 500 | 1000 |
| Wood | 500 | 2300 |
| Steel | 7800 | 500 |
| Mineral wool | 70-150 | 1030 |
| PUR, PIR | 40-42 | 1400 |

Let's compare now the heat capacity of a 100 mm thick concrete wall with the heat capacity of a PUR sandwich panel having the same thickness (for simplicity, we consider the core thickness 100 mm, and the metal facings' – 0,5 mm).

| | |
|---|---|
| Concrete (100 mm) | C= 2300 × 0,1 × 900=207 × 103 (W/°K) |
| Sandwich panel PUR (100 mm) | C=40 × 0,1 × 1400+7800 × 0,001=5607,8≈5,61 × 103 (W/°K) |

As we see, the concrete's heat capacity is more than 36 times higher than the heat capacity of sandwich panels. It is certainly convenient to use high heat capacity walls and ceilings in modern buildings, as they can accumulate a significant heat quantity. However, it refers more to the internal walls and ceilings, meanwhile for the external walls it is more convenient to choose more heat-insulating materials than those with higher heat capacity. In this case, considerably less energy is needed for the maintenance of the desired indoor temperature. And it is true either in case of low temperatures (refrigerators etc), or of administrative and residential buildings. If these walls are also lightweight structures with low heat capacity, as sandwich panels are, it is much quicker to heat or refrigerate the room they enclose.

## §1.6. COLD BRIDGES AND HEAT LOSS MINIMIZATION

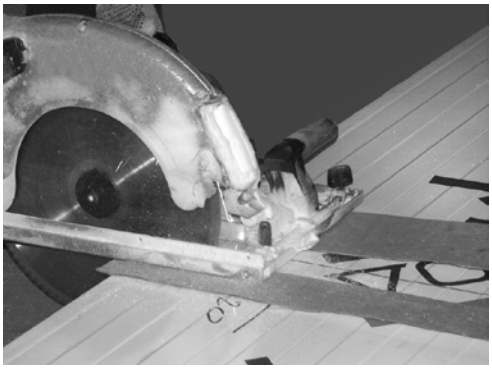
The cold bridges usually appear in sandwich panel's installation, when a very heat conductive material, metal for example, gets in touch with the internal and internal sides of the sandwich panel at the same time. The cold bridges bring either to the increase of the loss of heat, or to the risk of condensate on the panel surface. For this reason, the installation of the panels is performed according to the specific rules, with the use of specially developed elements preventing the forming of cold bridges. Door and window apertures are framed with the special interrupting profile. As the fixing screws, it is necessary to use steel screws with low heat conduction, and if possible, with small cross-section and with a rubber gasket. Cold bridges prevention is the main task in erection of sandwich panel buildings, and it's the installation quality that determines how effectively sandwich panels will exercise their main function – the heat insulation.

## §2.1. CUTTING THE PANELS

It is strongly recommended to cut PUR/PIR sandwich panels with jigsaw or circular saw with the special cutting disc intended for sandwich panels. Only in this case the precise cut line without big notches is guaranteed (view fig. 10, 11). Moreover, the panels should be cut before the protective polyethylene film is removed.

Figure 10. Cutting of the panel with the jigsaw and the resulting cutting line.


Figure 11. Cutting of the panels with the circular saw with the special disk for sandwich panels (on the right – the "ideal" cutting line is demonstrated).




**! It is strictly prohibited to cut the panels with the use of disc grinder**

### §2.2. PACKING, TRANSPORTATION AND STORAGE OF SANDWICH PANELS

The original packaging, in case of observing the appropriate requirements of the present instruction, excludes the damage of the panels during the loading and transportation. The package with the panels is put on solid polystyrene blocks with the thickness of 9 cm and density of 20 kg/m3. The quantity of the blocks depends on the panels' length. Depending on the transportation distance, ProfHolod company offers four different packaging types:

| | |
|---|---|
| Packing for storage | The panel stack is wrapped in two layers of stretch film all over its length, with the overlap of 25-30% of roll's width. |
| Light transportation packing | 1. Panels are stacked on polystyrene blocks. The stacks are wrapped in two layers of stretch film.<br><br>2. The resulting stack is wrapped in two layers of stretch film all over its length, with the overlap of 25-30% of roll's width. |
| Transportation packing | 1. Panels are stacked on polystyrene blocks.<br><br>2. The resulting stack is wrapped in two layers of stretch film all over its length, with the overlap of 25-30% of roll's width.<br><br>3. The pack is pulled together with the PVC strip applied lengthwise the polystyrene block. The rigid plastic angle protection is placed under the PVC strip. |
| Maximum transportation packing | 1. Panels are stacked on polystyrene blocks.<br><br>2. The resulting stack is wrapped in two layers of stretch film all over its length, with the overlap of 25-30% of roll's width.<br><br>3. The pack is pulled together with the PVC strip applied lengthwise the polystyrene block. The rigid plastic angle protection is placed under the PVC strip.<br><br>4. 0,8 mm thick vertical metal angles with fiberboard inserts are put on four pack angles.<br><br>5. Metal angles are pulled together with PVC strip lengthwise the pack. |

In the points of contact between the packing strip and lock edges, the additional plastic or cardboard angles are put under the packing strip. The vertical angles of the whole stack are protected with the 0,45 mm thick galvanized metal angles. Then the whole package is wrapped in stretch film and is provided with the packing list containing the order number, type of the panels and total weight. We remind You also, that the metal surfaces of every panel are protected with the film which must be removed only after the installation of every single panel.

Figure 12. Sandwich panels packed at the plant

Table 9. Standard original packing of ProfHolod's panels

| Panel type | Panel thickness | Quantity in package | Package height, mm | package weight, kg |
|---|---|---|---|---|
| Wall | 40 | 28 | 1210 | 328 |
| | 50 | 22 | 1190 | 268 |
| | 60 | 18 | 1170 | 228 |
| | 80 | 14 | 1210 | 190 |
| | 100 | 11 | 1190 | 160 |
| | 120 | 9 | 1170 | 140 |
| | 140 | 8 | 1210 | 132 |
| | 150 | 7 | 1140 | 118 |
| | 180 | 6 | 1170 | 110 |
| | 200 | 5 | 1090 | 96 |
| | | 6 | 1290 | 116 |
| Roofing | 40 | 18 | 1170 | 182 |
| | 60 | 14 | 1210 | 153 |
| | 80 | 10 | 1090 | 118 |
| | | 12 | 1290 | 142 |
| | 100 | 8 | 1050 | 101 |
| | | 10 | 1290 | 126 |
| | 120 | 8 | 1210 | 107 |
| | 150 | 6 | 1110 | 81 |

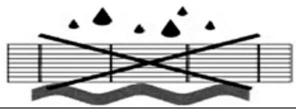
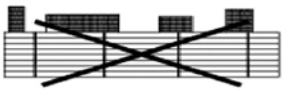
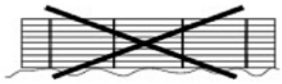
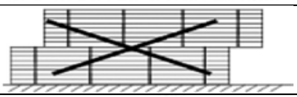
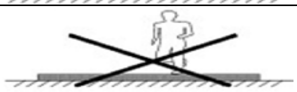
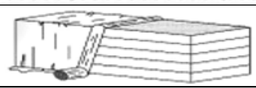
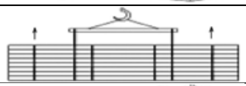
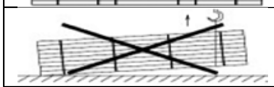
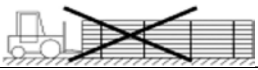
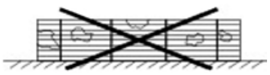
Table 9 contains the number of wall and roofing panels in the original package depending on the panel thickness, and the approximate weight of a running meter. The transportation of panels in the original package can be performed by any kind of transport ensuring the safety of the items in the package. The package transfer can be performed by the tower or truck crane or by the forklift. It is forbidden to transfer or to push the packages by the sharp fork of the forklift. It is prohibited to use steel rope or wire when transferring the packages. When lifting the package, pay attention to the center of gravity. Always lift and transfer only one package at a time. The unloading of the packages with the panels from the truck must be made from the side. The unloaded packages must be put on a flat surface, which should be prepared in advance. In order to avoid longitudinal or transverse displacement, the bars are put between the packages. During the transportation, the driver should check the stability of the cargo and the tightness of fixing. In case of loose fixing, it has to be tightened.

The package carries the transport label containing the information on the order number, panels description including the length, width and the type of the steel panel facings.

It is forbidden during the transportation and storage, to put other goods on the package surface, because it may cause various kinds of damage to the items. In case the order contains shaped profiles, they should be packed separately and and should not be in contact with the panel's surface during the transportation. Prior to unloading, the consignee must check the conditions of the original packs. In case any damage is revealed, the appropriate report has to be drawn up which is signed by the representatives of the transporter and consignee.

The packages with sandwich panels should be stored on the construction site on a plane surface, prepared in advance. It is forbidden to push or pull the packages, since their surface may be damaged in this case. The packages are placed in one or two tiers, with the total height not exceeding 2,4 m. It is desirable to provide for a slight declivity in order to avoid accumulation of water in case of rain. The below table represents sketchily the main recommendations for the storage of sandwich panels.

Table 17. Main recommendations for the storage of sandwich panels

| | |
|---|---|
|  | The panels must be kept away from moisture. Always check the integrity of the packages. |
|  | It is forbidden to store any other items on the surface of the panels. |
|  | The panels should be stored only on plane surface. |
|  | When storing the panels in two tires, avoid the tier displacement. |
|  | Do not walk on the panels. |
|  | Protect the panels against direct sunlight. |
|  | Lift only one package at a time. |
|  | Do not lift the packages pulling only one side. |
|  | It is forbidden to transfer the packages by means of pushing. |
|  | Do not permit the dirtying of the panels. |

The panels should be stored in original packages which protect them against water in warehouses of the open or semi-open type, eliminating the direct influence of the atmospheric precipitations. All the fire-safety regulations must be observed. During intermediate storage in the open sites, panels must be protected from direct sunlight, dust and atmospheric precipitations.

## CHAPTER 2. SANDWICH PANELS HANDLING RULES: CUTTING, TRANSPORTATION, STORAGE

Table 18. Main characteristics of the wall sandwich panels, manufactured by ProfHolod, with polyurethane foam and polyisocyanurate (PUR/PIR) filler.

| Filler type | PUR/PIR | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Density | 40±2 kg/m3 | | | | | | | | | | |
| Panel thickness (mm) | 40 | 50 | 60 | 80 | 100 | 120 | 140 | 150 | 160 | 180 | 200 |
| Weight (kg/m2) | 8,5-9,5 | 8,9-9,9 | 9,7-10,7 | 10,4-11,6 | 11,2-12,4 | 11,9-13,2 | 12,7-14,1 | 13,1-14,5 | 13,5-14,9 | 14,2-15,8 | 15-16,6 |
| Maximum length | 16000 mm | | | | | | | | | | |
| Width | 1200 mm | | | | | | | | | | |
| Working width | 1185 mm | | | | | | | | | | |
| Metal thickness | ≥ 0,4 mm | | | | | | | | | | |
| Metal surface | profiled or smooth | | | | | | | | | | |
| Standard version | RAL 9003 or Zn (non coated galvanized sheet) | | | | | | | | | | |
| Heat conduction coefficient | 0,021 W/m*K | | | | | | | | | | |
| Thermal resistance coefficient | 1,9 | 2,38 | 2,56 | 3,81 | 4,76 | 5,71 | 6,67 | 7,14 | 7,62 | 8,57 | 9,52 |
| Fire resistance | View Table 20 | | | | | | | | | | |
| Water absorption in 24 hours at relative humidity 96% | 1%-2,5% | | | | | | | | | | |
| Water absorption in 24 hours at full immersion, % of volume | 2,50% | | | | | | | | | | |
| Sound proofing | 35 dB | | | | | | | | | | |

Table 19. Main characteristics of the roofing sandwich panels, manufactured by ProfHolod, with polyurethane foam and polyisocyanurate (PUR/PIR) filler.

| | | | | | | |
|---|---|---|---|---|---|---|
| Filler type | PUR/PIR | | | | | |
| Density | 40±2 kg/m3 | | | | | |
| Panel thickness (mm) | 40 | 60 | 80 | 100 | 120 | 150 |
| Weight (kg/m2) | 9,8 | 10,7 | 11,5 | 12,3 | 13,1 | 14,4 |
| Maximum length | 16000 mm | | | | | |
| Width | 1071 mm | | | | | |
| Working width | 1000 mm | | | | | |
| Metal thickness | ≥ 0,45 mm | | | | | |
| Metal surface | profiled as on figure 8, page 9 | | | | | |
| Standard version | RAL 9003 or Zn (non coated galvanized sheet) | | | | | |
| Heat conduction coefficient | 0,021 W/m*K | | | | | |
| Thermal resistance coefficient | 2,0 | 2,95 | 3,90 | 4,86 | 5,81 | 7,24 |
| Fire resistance | View Table 20 | | | | | |
| Water absorption in 24 hours at relative humidity 96% | 1%-2,5% | | | | | |
| Water absorption in 24 hours at full immersion, % of volume | 2,50% | | | | | |
| Sound proofing | 35 dB | | | | | |

Table 20. Fire resistance of wall and roofing PUR and PIR panels

| | Description | 40 | 60 | 80-120 | 150-200 |
|---|---|---|---|---|---|
| Fire resistance limit | Wall panels PUR | EI 15 | | | |
| | Wall panels PIR | EI 15 | EI 30 | | EI 45 |
| Fire resistance limit | Roofing panels PIR | RE 15 | RE 15 | RE 30 | RE 30 |
| Class of fire danger | Roofing panels PIR | K 1 (15) | | | |
| Combustibility group | Wall panels PIR | G 2 | | | |
| Flammability group | | V 1 | | | |
| Smoke-forming ability | | D 3 | | | |
| Combustion products toxicity group | | T 2 | | | |
| Surface flame spreading group | | RP 1 | | | |

### §3.1. PANEL DEFORMATION DUE TO THE TEMPERATURE DIFFERENCE ON ITS SURFACES

We underlined before, that when choosing the color of the panels, it is necessary to consider their possible deformation as the result of heating of the outer side due to the strong light absorption. Actually, this problem is very much wider and in the general case is always present, when there is a considerable temperature difference between the sandwich panel's facings. This phenomenon is caused mainly by the thermal deformation of the steel facings of the sandwich panel. This deformation is characterized by the coefficient of thermal linear expansion of metal αL:

$$\Delta L = \alpha_L \cdot L \cdot \Delta T, \qquad (6)$$

Where L is the linear length (width) of the panel, ΔL – value of thermal elongation, ΔT – temperature change.

Depending on the composition of steel, the coefficient αL of the metal sheets is equal to (11–13) · 10–6(1/°C) and it stays approximately unaltered with the temperature fluctuations. When the temperatures on the panel's sides are different and are equal respectively to T1 and T2, in this case the panel will be subject to transversal deformation, and the deflection value in the center of the panel with the length L will be equal to:

$$\Delta X = \frac{\theta \cdot L_2}{8} \qquad (7)$$

where $\theta = (\alpha_2 T_2 - \alpha_1 T_1) / D$ (D – the distance between the centers of metal sheets). For the panel having the thickness d, with facings of the same kind with the thickness δ, we have the following deformation value:

$$\Delta X = \frac{\alpha_L \cdot \Delta T \cdot L_2}{8\,(d - \delta)} \qquad (8)$$

Thus, at the 55 °C temperature difference between the inner and outer sides of the panel, at the section length of 6 meters, we'll have the following deformation:

Table 21. "Thermal" deformation of the panels with the length of 3 m and 6 m at the temperature difference between the facings 55°C

| Panel thickness (mm) | Thermal deformation (at ΔT = 55°C), mm | |
|---|---|---|
| | at L=6 m | at L=3 m |
| 40 | 7,43 | 1,86 |
| 50 | 5,94 | 1,49 |
| 60 | 4,95 | 1,24 |
| 80 | 3,71 | 0,93 |
| 100 | 2,97 | 0,74 |
| 120 | 2,48 | 0,62 |
| 150 | 1,98 | 0,5 |
| 200 | 1,49 | 0,37 |

As already noted before, one should take into account the potential thermal deformation when choosing the color of the panels. It is necessary to use short spans for the dark colors.

### §3.2. BEARING CAPACITY OF WALL PANELS

Below you will find the main mechanical features of the three-layer sandwich panels.

In contrast to the traditional building techniques, which use the thermo-insulating materials only as heat insulators, sandwich panels can be used as self-bearing structures in relatively small constructions, such as, refrigerating chambers.

Evidently, two thin layers of metal and a layer of solid polyurethane, each individually, do not have such a bearing capacity as the entire sandwich panel has. The both thin metal facings can hardly bear their own weight, for the reason of the insignificant flexural rigidity. In the same way, the intermediate polyurethane layer has a rather high deformability, due to its low modulus of elasticity. But when the metal facings and the intermediate polyurethane layer are put together, we obtain a multilayer structure having a strong bearing capacity. The transversal load distribution in such a structure occurs in the following way: the bending moment is perceived only by the external layers, because the intermediate layer has a lower stiffness at tension and compression.

And on the contrary, the transversal effort is perceived by the intermediate layer, because the external layers can't bear the transversal load for the reason of their small thickness. Thus, the shearing force acts on the intermediate layer, which provides for the bearing capacity of the whole three-layer structure. The higher is its shearing strength, the higher is the stiffness of the whole panel. We should note that in case of profiled outer panel layers, the proper flexural rigidity of the metal facings cannot be ignored, and for this reason, the transversal load is distributed in a different way. One part of the bending moment and of the transversal effort is perceived directly by the facings and the other – by the entire panel: the upper layer perceives the compression effort, the lower one – the tension effort, and the intermediate one – the shearing force [5].

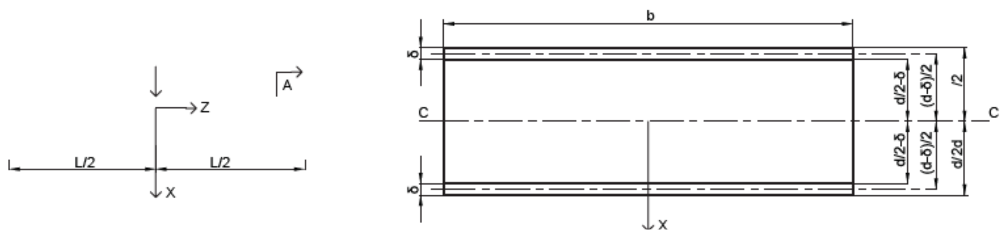
To make it possible for the intermediate layer to play its main role, meaning to perceive the shearing efforts and thus provide for the stability of the outer layers, it is necessary to have a solid junction between the layers (i.e. a high adhesion degree must be ensured).

When describing the mechanical characteristics of sandwich panels, the beam theory with certain modifications is normally used. The common double T beam theory has to be integrated with the effects, caused by the "shearing" characteristics of the panel's core. In the first place, it is necessary to determine the flexural rigidity of the panel D. While for the normal beam the flexural rigidity is calculated as the product of multiplication of the modulus of elasticity by the moment of inertia I, in the case of the sandwich panel, the flexural rigidity will consist of the summation of the rigidity of different components relatively to the central axis (view Figure 13, on the right):

$$D = \frac{E_F \cdot b\delta^3}{6} + \frac{E_F \cdot b\delta \cdot (d-\delta)^2}{2} + \frac{E_C \cdot b \cdot (d/2-\delta)^3}{12}, \qquad (9)$$

where $E_F$ and $E_C$ are the moduli of elasticity of the metal sheets and polyurethane core respectively, the rest of the quantities correspond to the Figure 13. The first addend in the above expression (9) corresponds to the flexural rigidity of the metal facings relatively to their own central axis; the second addend expresses the flexural rigidity of the metal sheets relatively to the panel's central axis; meanwhile the third addend describes the flexural rigidity of the of the polyurethane core relatively to its own central axis, which, as a matter of fact, corresponds to the central axis of the entire panel.

Figure 13. Sandwich panel as "beam". On the right – section A-A



The contribution of the first addend of the expression (9) amounts to less than 1% of the contribution of the second addend, if the following condition is respected:

$$\frac{d}{\delta} > 6{,}7 \qquad \frac{E_F \cdot \delta \cdot (d-\delta)^2}{E_C \cdot (d/2-\delta)^3} > 16{,}7, \qquad (10)$$

i.e. when the condition (10) is respected, we can write the following:

$$D = \frac{E_F \cdot b\,\delta \cdot (d-\delta)^2}{2} + \frac{E_C \cdot b\,(d/2-\delta)^3}{12} \qquad (11)$$

Even for the “thinnest” 40 mm sandwich panel the quantity d/δ ≈ 80 > 6,7 and the formula (11) are correct.

Due to the supposed low thickness of the metal facings, compared to the thickness of the sandwich panel, the first addend is negligible in comparison to the last two, and thus, it can be ignored. The loads cause the tension forces in the panel, which can be described, with some assumptions, with the use of the classical beam theory. During the bending process, above the neutral axis C-C the compressive forces appear, and below the C-C axis – the tension forces.

$$\varepsilon_x = \frac{M \cdot x}{D}, \qquad (12)$$

where $\varepsilon_x$ is the tension or compression at the x distance from the neutral axis C-C; M – the shearing momentum and D – the panel’s flexural rigidity.

In order to calculate the tension force, which is generated by the bending of the panel, the deformation value (12) must be multiplied by the modulus of elasticity. Since the sandwich panel is not a homogeneous structure, the product of this multiplication should be referred to different panel parts (view fig. 13):

$$\sigma_m = \frac{M \cdot x}{D} \cdot E_F; \quad \frac{d}{2} - \delta < x < \frac{d}{2}; \quad -\frac{d}{2} < x < -\frac{d}{2} + \delta . \qquad (13)$$

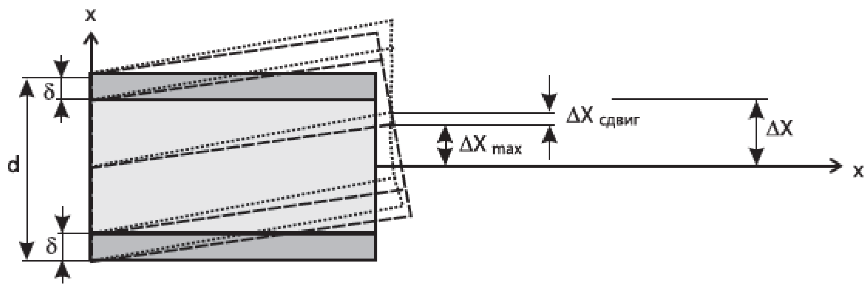
$$\sigma_p = \frac{M \cdot x}{D} \cdot E_F; \quad \sigma_{p\,max} = \frac{M \cdot (d/2-\delta)}{D} \cdot EC . \qquad (15)$$

The bearing properties of sandwich panels are determined by the maximum deflection of the panel with the loads of different nature, and are described with the relation [[4], [6], [7]]:

$$x = \frac{k_1 \cdot F \cdot L^3}{E_F \cdot J_F} + \frac{k_2 \cdot F \cdot L}{G_C \cdot S_C}, \qquad (16)$$

where F is the applied force, $E_F \cdot J_F$ — the product of multiplication of the metal facings’ modulus of elasticity by their moment of inertia (or else, the flexural rigidity of the metal facings); $G_c$ – the shear modulus of the polyurethane foam core; $S_c$ – the core’s cross section area.

*Figure 14. Bending of the three-layer panel*




As we can see on the figure 14, the total panel deflection is conditioned by the bending and shearing. In the above expression, the first addend, which is well-known thanks to the beam theory, reflects the panel bending and the second describes its shearing, conditioned by the shearing of the core. The coefficients $k_1$ and $k_2$ depend on the panel's "boundary conditions" and are determined by the following table:

| Load scheme | $k_1$ | $k_2$ | Description |
|---|---|---|---|
| | 1/384 | 1/8 | Uniformly distributed load. Ends are fixed. |
| | 5/384 | 1/8 | Uniformly distributed load. Loose ends. |
| | 1/192 | 1/4 | Load localized in the center. Ends are fixed. |
| | 1/48 | 1/4 | Load localized in the center. Loose ends. |

For the moment of inertia J and the insulator's cross section area we have: S = 118,5 · (d–2δ), where 118,5 is the panel's width in cm, δ – metal facing's thickness, d – panel's thickness. It should be noted that for simplicity, here and hereinafter, we presume the panel's metal facings to be smooth, i.e. not profiled. The moment of inertia of profiled sheets is much bigger (it depends on the profiling depth), and gives the additional stiffness to the panels. One of the main indexes, characterizing the elastic properties of sandwich panels, is the shear modulus of the core, in this case – polyurethane foam. According to the results of the tests made in Dow Chemical laboratory, the shear modulus of the PUR samples is equal to 21 kg/cm2. In all the calculations, we take into account the panel's bending under its own uniformly distributed weight, i.e. we mean as the load the purely external load, acting vertically down on the horizontally placed panel. We consider equal here the temperatures on the both sandwich panel's sides. According to the SNiP regulation II-23-81 "Steel structures", the allowable deflection of the bearing wall and ceiling panels is considered equal to L/200 (where L is the span length). Assuming x = L/200, we'll have the following values for the allowable load, shown in the Tables 22-25.

*Table 22. Allowable loads for ProfHolod's structural panels at the uniformly distributed load with fixed ends.*

| Panel thicktess, mm | Allowable net load, kgf/m2 | | | | | Load scheme, allowable deflection is considered L/200 |
|---|---|---|---|---|---|---|
| | Panel length, m | | | | | |
| | 2 | 3 | 4 | 5 | 6 | |
| 40 | 141 | 82 | 52 | 33 | 21 | |
| 50 | 183 | 109 | 71 | 48 | 33 | |
| 60 | 224 | 136 | 91 | 63 | 44 | |
| 80 | 307 | 191 | 131 | 94 | 69 | |
| 100 | 390 | 246 | 171 | 125 | 94 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 120 | 473 | 301 | 212 | 157 | 120 | |
| 140 | 556 | 356 | 253 | 189 | 146 | |
| 150 | 598 | 383 | 273 | 206 | 160 | |
| 160 | 640 | 411 | 294 | 222 | 173 | |
| 180 | 723 | 466 | 335 | 254 | 199 | |
| 200 | 806 | 521 | 376 | 287 | 226 | |

Table 23. Allowable loads for ProfHolod's structural panels at the uniformly distributed load with loose ends.

| Panel thicktess, mm | Allowable net load, kgf/m2 | | | | | Load scheme, allowable deflection is considered L/200 |
|---|---|---|---|---|---|---|
| | Panel length, m | | | | | |
| | 2 | 3 | 4 | 5 | 6 | |
| 40 | 106 | 47 | 21 | 8 | 2 | |
| 50 | 144 | 68 | 34 | 16 | 7 | |
| 60 | 183 | 91 | 48 | 26 | 13 | |
| 80 | 263 | 139 | 79 | 46 | 27 | |
| 100 | 344 | 189 | 113 | 69 | 43 | |
| 120 | 426 | 241 | 148 | 94 | 61 | |
| 140 | 508 | 293 | 184 | 120 | 80 | |
| 150 | 549 | 320 | 202 | 133 | 90 | |
| 160 | 590 | 346 | 221 | 147 | 100 | |
| 180 | 673 | 399 | 259 | 175 | 121 | |
| 200 | 755 | 453 | 297 | 204 | 143 | |

Table 24. Localized load in the middle of the panel with fixed ends.

| Panel thicktess, mm | Allowable load in the middle of the panel, kgf | | | | | Load scheme, allowable deflection is considered L/200 |
|---|---|---|---|---|---|---|
| | Panel length, m | | | | | |
| | 2 | 3 | 4 | 5 | 6 | |
| 40 | 167 | 146 | 123 | 100 | 78 | |
| 50 | 216 | 194 | 170 | 145 | 119 | |
| 60 | 265 | 242 | 215 | 186 | 158 | |
| 80 | 363 | 339 | 309 | 278 | 245 | |
| 100 | 462 | 436 | 405 | 371 | 335 | |
| 120 | 560 | 534 | 502 | 466 | 427 | |
| 140 | 659 | 632 | 598 | 561 | 520 | |
| 150 | 708 | 680 | 647 | 608 | 567 | |
| 160 | 757 | 729 | 695 | 656 | 614 | |
| 180 | 856 | 827 | 792 | 752 | 708 | |
| 200 | 954 | 925 | 890 | 848 | 803 | |

Table 25. Localized load in the middle of the panel with loose ends.

| Panel thicktess, mm | Allowable load in the middle of the panel, kgf | | | | | Load scheme, allowable deflection is considered L/200 |
|---|---|---|---|---|---|---|
| | Panel length, m | | | | | |
| | 2 | 3 | 4 | 5 | 6 | |
| 40 | 133 | 91 | 56 | 29 | 7 | |
| 50 | 180 | 132 | 91 | 56 | 29 | |

| | | | | | |
|---|---|---|---|---|---|
| 60 | 227 | 175 | 127 | 86 | 53 |
| 80 | 323 | 264 | 206 | 154 | 110 |
| 100 | 420 | 356 | 289 | 228 | 174 |
| 120 | 517 | 449 | 376 | 306 | 243 |
| 140 | 614 | 544 | 465 | 388 | 317 |
| 150 | 663 | 591 | 511 | 430 | 355 |
| 160 | 712 | 639 | 556 | 473 | 394 |
| 180 | 810 | 735 | 648 | 559 | 474 |
| 200 | 908 | 831 | 741 | 647 | 555 |

Let’s note one more time that all the data in the above tables are the design data. Also, in all the tables as the load, the purely external load, uniformly distributed on the surface is intended. So, all the tables, besides the above loads, take into account the deflection caused by the panel’s own weight, which is essential for the ceiling panels. Also, it is considered that the adhesion of polyurethane with metal sheets is ideal, which actually is a rather bold assumption. The deflection of L/200 is considered permissible, and in all the data, as already mentioned, the panel deflection caused by its own weight is taken into account. The data shown in the Table 25 is very important for the choice of the possible thickness of ceiling panels, in case the mounting works are planned to be performed when standing on the same panels. Choosing the span length of the ceiling panels, it is necessary to consider that the panel must bear the installer’s weight, plus the evenly distributed own weight.

Let’s see below the values of the panel deflection caused only by the own weight, depending on the span length. The below table will be useful when calculating the panels, when no people should walk on them neither during the installation, nor during the operation, and the panel deflection is caused only by the own weight.

Table 26. Deflection value of the ceiling panels under the influence of their own weight at the equal indoor and outdoor temperature.

| Panel thicktess, mm | Deflection value in the middle, mm | | Panel's weight, kg |
|---|---|---|---|
| | Panel span length = 6 m | | |
| | Fixed ends | Loose ends | |
| 60 | 5,8 | 13,6 | 75,7 |
| 80 | 4,3 | 8,9 | 81,3 |
| 100 | 3,4 | 6,6 | 87 |
| 120 | 2,9 | 5,3 | 92,7 |
| 140 | 2,6 | 4,4 | 98,4 |
| 150 | 2,4 | 4 | 101,3 |
| 160 | 2,3 | 3,8 | 104,1 |
| 180 | 2,1 | 3,4 | 109,8 |
| 200 | 2 | 3 | 115,5 |

It is necessary to note that in addition to the shown values, the panel may have the original allowable deviation equal to 1/500 of its length.

We should also note that, according to the European regulations EN 14509 [8] the initial panel deflection is allowed equal to 1/500 of its length.

### §3.3. BURSTING STRESS AT TRANSVERSAL BENDING

As we already noted before, the transversal load causes the moment of forces, which brings to the compression of the panel's upper layer and tension of the lower one. The compression stress in the upper panel's facing is determined by the following formula (view formula 15):

$$\sigma_{m\ max} = \frac{M \cdot d}{2D} \cdot E_F = \frac{M \cdot d}{b \cdot \delta \cdot (d - \delta)^2} \quad (17)$$

We cited before the theoretical quantities of the so-called "allowable" load values, at which the panel's deflection is equal to 1/200 of its length. However, in fact the load is limited with some critical value, at which the panel's "destruction" is occurred. The most frequent is the damage when a "fold" is formed in the upper panel facing (View Figure 15). The stress, causing the "fold forming" - $\sigma_{fold}$ - can be calculated with the formula [4], [8], [6]:

$$\sigma_{fold} = k \cdot \sqrt[3]{E_F \cdot E_C \cdot G_C} \quad (18)$$

As before, here $E_F$ is the modulus of elasticity of the steel facings, $E_C$ is the modulus of elasticity of the polyurethane core, and $G_C$ is the shear modulus of the core. It is considered that the empirical coefficient k, apparently, defining the "quality of the panel" is dependent on the panel's manufacturing method:

• k = 0,65 for the polyurethane foam sandwich panels produced with the use of the continuous method;
• k = 0,5-0,65 for the rest of the sandwich panels, including the mineral wool ones and the polyurethane foam sandwich panels produced with the use of the periodical method.

According to the Eurocode EN 14509[8], k = 0,5 is suggested for all types of sandwich panels.
The moment of forces, generated by the impact of the transversal uniformly distributed force F on the non fixed panel, can be calculated by the formula [8]:

$$M = \frac{F \cdot L}{8} \quad (19)$$

where F is the total acting force, including the own weight of the panel, and L – the panel's length.

Figure 15. Forming of a fold on the sandwich panel's surface at the compression of the upper layer.

Combining the formulas 17 and 19, we have the following data of the stress value:

$$\sigma_m = \frac{F \cdot L \cdot d}{8 \cdot \delta \cdot b \cdot (d - \delta)^2} \quad (20)$$

From here it's already easy to arrive to the "collapsing" force, bringing to the fold forming on the sandwich panel's upper layer:

$$F = \frac{8 \cdot b \cdot \delta \cdot (d - \delta)^2}{L \cdot d} \cdot k \cdot \sqrt[3]{E_F E_C G_C}\,. \quad (21)$$

Let's note one more time that the expression 21 is correct if the panel is considered non fixed and F is the total acting force including the panel's own weight.

*Table 27. Collapsing force (kgf) for the panels of different thickness at the length of 3 and 6 meters. (The pure external force, excluding the panel's weight is indicated in the table).*

| Panel's thickness, mm | L = 3 m | L = 6 m |
|---|---|---|
| 40 | 390 | 143 |
| 50 | 499 | 194 |
| 60 | 607 | 247 |
| 80 | 822 | 350 |
| 100 | 1038 | 454 |
| 120 | 1250 | 557 |
| 140 | 1469 | 661 |
| 150 | 1577 | 712 |
| 180 | 1900 | 868 |
| 200 | 2115 | 971 |

The above collapsing force values also presume the panel to be simply leaned against the supports but not fixed.

## §3.4. UNIFORMLY DISTRIBUTED FRONTAL LOAD ON THE VERTICALLY FIXED PANEL. WIND LOADS ON THE SANDWICH PANEL ENCLOSURES.

In spite of the fact that the calculations demonstrated in § 3.3 have an exclusively theoretical character, they give however a good idea of strength characteristics of sandwich panels with the polyurethane foam filler. In practice, the external walls of the buildings assume mainly the temperature and wind loads.

The effects of the temperature difference have been already examined in § 3.1, meanwhile here we will analyze the action of wind loads on the fixed panel. The pressure of the wind on the wall panel is determined by Bernulli's formula:

$$P = \frac{1}{2} \cdot \rho v^2\,, \quad (22)$$

where $\rho$ = 1,25 kg/ $m^3$, v – the average wind speed in this area.

Designing the sandwich panel buildings, it is necessary to follow the SNiP regulation 2.01.07-85 "Loads and impacts" which explains in detail the calculation methods of the wind load depending on the region, building height etc. And here we are going to focus on the allowable uniformly distributed load on the vertically fixed sandwich panel. In fact, the wind load can be considered, with certain assumptions, a uniformly distributed load, and for this reason, the resulting panel bend will be determined by the following formula:

$$\Delta x = \frac{5 \cdot F \cdot L^3}{\quad} + \frac{F \cdot L}{\quad} \quad (23)$$

$384 \cdot E_F \cdot J_F \qquad 8 \cdot E_C \cdot S_C$

The influence of the panel's own weight must be excluded from the calculation, because it acts in the perpendicular direction. According to the European recommendations for sandwich panels [9], the allowable load for sandwich panels is the load when the panel's deflection is not more than L/100 (where L is the panel's length) [9].

*Table 28. Allowable loads on the single- span wall panel*

| Panel thicktess, mm | Allowable wind load, kgf/m2 | | | | | Load scheme, allowable deflection is considered L/100 |
|---|---|---|---|---|---|---|
| | Panel span length, m | | | | | |
| | 2 | 3 | 4 | 5 | 6 | |
| 40 | 264 | 126 | 67 | 39 | 25 | |
| 50 | 355 | 176 | 97 | 58 | 37 | |
| 60 | 448 | 230 | 131 | 80 | 51 | |
| 80 | 638 | 344 | 203 | 128 | 85 | |
| 100 | 831 | 463 | 282 | 182 | 123 | |
| 120 | 1026 | 585 | 365 | 240 | 165 | |
| 140 | 1220 | 710 | 452 | 302 | 210 | |
| 150 | 1320 | 773 | 496 | 334 | 234 | |
| 160 | 1418 | 837 | 540 | 367 | 258 | |
| 180 | 1615 | 964 | 630 | 433 | 308 | |
| 200 | 1813 | 1092 | 722 | 500 | 360 | |

*Table 29. Allowable loads on the double- span wall panel*

| Panel thicktess, mm | Allowable wind load, kgf/m2 | | | | | Load scheme, allowable deflection is considered L/100 |
|---|---|---|---|---|---|---|
| | Panel span length, m | | | | | |
| | 2 | 3 | 4 | 5 | 6 | |
| 40 | 298 | 164 | 100 | 65 | 44 | |
| 50 | 389 | 219 | 137 | 91 | 63 | |
| 60 | 481 | 276 | 176 | 119 | 84 | |
| 80 | 670 | 393 | 258 | 179 | 129 | |
| 100 | 860 | 514 | 343 | 242 | 177 | |
| 120 | 1053 | 636 | 429 | 307 | 228 | |
| 140 | 1245 | 760 | 518 | 375 | 280 | |
| 150 | 1345 | 823 | 563 | 408 | 307 | |
| 160 | 1440 | 885 | 607 | 443 | 335 | |
| 180 | 1640 | 1010 | 698 | 512 | 390 | |
| 200 | 1834 | 1139 | 790 | 583 | 446 | |

For example, at the wind speed V=20 m/s, the value of the wind load will be equal to:

$$P_0 = \frac{1}{2} \cdot 1{,}25 \cdot 20^2 \,(kg/м \cdot sec^2) = 250\ N/m^2 = 25\ kgf / m^2 \qquad (24)$$

For example, the 6 meter long panel with the thickness of 100 mm will deflect of 6 mm with such a load.

According to the SNiP regulation 2.01.07–85. "Loads and impacts", the force of the wind must be calculated with some correctional coefficients:

$$P = P_0 \cdot C_e(z) \cdot Cp, \qquad (25)$$

where $C_e(z)$ – the coefficient depending on the type of region and altitude, and $C_p$ is a certain aerodynamic coefficient depending on the structure form etc. The SNiP regulation 2.01.07–85 gives the detailed instructions on the calculation methods of these correctional coefficients, depending on the location. And as the location is intended not only the geographic latitude, but also the “local” position of the structure – its proximity to the sea, to other structures, to the mountains etc.

Having defined, according to the SNiP regulation 2.01.07–85, the wind load in this region and area, it is possible to choose the length of the wall panel of certain thickness according to the table of allowable loads (view Table 28).

## §3.5. BEARING CAPACITY OF ROOFING PANELS

Roofing panels significantly differ from the wall ones for the fact that one of their surfaces is deeply profiled, and this factor has to be taken into account during the calculations.

A great deal of theoretical research is dedicated to the bearing characteristics of profiled panels [4], [7], [6]. It is all based on rather complex mathematic computations which we are not going to cite here, but we’ll focus on the “approximate” theory [4], based on a rather simple but illustrative assumption that the applied load is distributed between two “independent” parts of the sandwich panel:
The first part corresponds to the “flat” part of the panel, and the second part – to the “ridges”. The shear of the intermediate layer, among other things, plays a certain role for the first part, meanwhile only the deflection of the metal facings is taken into account in the “ridged” part, herewith presuming that the both parts bend identically.

In this case, according to [4], we have a relatively simple relationship for the value of the panel deflection in its middle at the uniformly distributed load:

$$\Delta x = \frac{5F \cdot L_3}{384B_s} \cdot (1 - \beta) \cdot (1 + k) \qquad (26)$$

$$\beta = \frac{(1 + k)B_D}{B_s + (1 + k)B_D}; \quad k = \frac{9,6 \cdot B_S}{A_C G_{eff} L_2}; \quad B_D = E_{F2} I_{F2} \qquad (27)$$

$$B_S = \frac{E_{F1}A_{F1}E_{F2}A_{F2}}{E_{F1}A_{F1}+E_{F2}A_{F2}} \cdot e_2; \qquad S = \frac{G_C \cdot e_2 \cdot b}{d_C} = A_C \cdot G_{eff} \qquad (28)$$

$B_S$ is the rigidity to the bending (flexural rigidity), and S is the rigidity to shear of the “smooth” part of the panel;

$B_D = E_{F1} \cdot I_{F1} + E_{F2} \cdot I_{F2} \approx E_{F2} \cdot I_{F2}$ — flexural rigidity of the “ridged” part of the panel, since we consider flat the lower layer. $A_C = b \cdot e$ – the effective section area of the intermediate layer, e – the effective thickness of the intermediate layer, $E_{F1} = E_{F2}$ are the moduli of elasticity of the upper and lower layers, which in this case are considered equal; $G_C$ is the shear modulus of the intermediate layer (according to the tests made by Dow Chemical’s research lab this parameter is equal to 16-17 kgf/cm2 for PIR panels and 20-21 kgf/cm2 for PUR panels).

In the below Table 30 we can see the loads in kgf (they are NET, meaning the own weight is excluded) at which the single-span roofing panel deflects in the middle of 1/200 of its length.



Table 30. Allowable load values for roofing panels, corresponding to the deflection of L/200
(The load is considered uniformly distributed)

| Panel thicktess, mm | Panel span length, m | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1,5 | 2 | 3 | 4 | 5 | 6 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 40 | 475 | 254 | 106 | 56 | 32 | 20 |
| 60 | 583 | 333 | 154 | 86 | 53 | 34 |
| 80 | 690 | 414 | 200 | 119 | 76 | 51 |
| 100 | 800 | 490 | 250 | 150 | 97 | 69 |
| 120 | 910 | 570 | 310 | 192 | 128 | 89 |
| 150 | 1075 | 700 | 389 | 249 | 170 | 120 |

We should underline once more that the values shown in the Table 30 do not bring at all to the collapse of the panel, but they only correspond to the allowable panel deflection equal to 1/200 of its length, and since the loads have been calculated supposing the roof to be horizontal and flat, in case there is an inclination ἀ, the data in the table must by multiplied by cos ɑ.

The data shown in the above table can give the idea of the amount of the allowable snow load on the sandwich panel roof, meanwhile for a more precise calculation it is necessary to take into account the potential panel deflection caused by the temperature difference between its facings. The final calculation of the allowable snow load on the roofing panel should be compared to the snow load values in this area. According to the SNiP regulation 2.01.07-85* “Loads and impacts”, the territory of the Russian Federation is divided in eight snow areas. The approved values of snow load in these zones are shown in the below table:

| Russian Federation snow areas | Ia | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|
| Sg, kgf/m2 | 80 | 120 | 180 | 240 | 320 | 400 | 480 | 560 |

The amount $S_g$ corresponds to the weight of 1 m2 of the snow cover. The estimated value of snow load on the roof is calculated with the following formula:

$$S = Sg \cdot \mu. \quad (29)$$

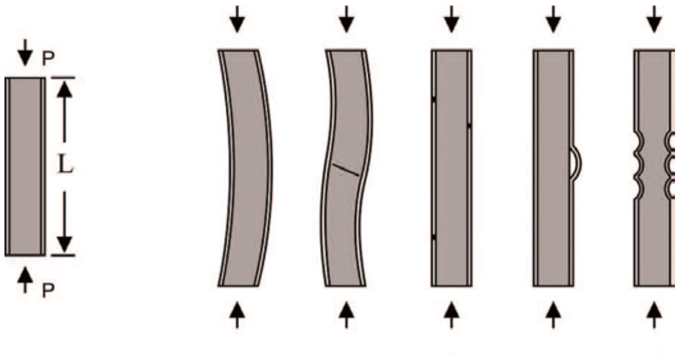
Coefficient μ depends of the roof inclination. To be precise, this is exactly the cosine of the roof inclination angle cos(ἀ), which was mention above, but the SNiP regulation 2.01.07-85* suggests to base on the more strict requirements and consider:

μ = 1 at the inclination angle < 25°
μ = 0,7 at the inclination angle from 25° to 60° (30)
μ = 0 at the inclination angle > 60°

## §3.6. VERTICAL LOAD ON THE WALL SANDWICH PANEL

A great deal of theoretical and experimental research [4], [6], [10] is dedicated to the issue of the strength of the sandwich panel at vertical (longitudinal) compression. We are going to examine here the main deductions of such research, which demonstrate the sufficient strength of the panels for the assembling of frameless structures of relatively small dimensions. According to this research, with the vertical pressure on the sandwich panel, at least four kinds of deformation are possible (view Figure 17)

Figure 17. Axial (longitudinal) pressure on sandwich panel and possible kinds of deformation:
A – general bending;
B – core fracture;
C – forming of microfolds and indentations on the metal surface;
D – fold forming.




Since the rigidity of the panel's metal facings is many times superior to the rigidity of the polyurethane foam core, just like in the case with the transversal load, the whole load of the longitudinal (axial) pressure on the sandwich panel is assumed by the panel's metal facings. If we consider the sandwich panel absolutely smooth, the uniform panel deflection is possible (Figure 17, A), up to the critical load, the so-called Euler's load, after which the deflected panel cannot return back to the initial state and the deviation grows "to infinity".

$$F_A = \frac{\pi^2 \cdot B_S}{\beta L^2} = \frac{\pi^2 \cdot b \cdot \delta \cdot (d - \delta)^2}{\beta \cdot L^2} \cdot E_F \qquad (31)$$

Here $B_S$ – as before, is the flexural rigidity of the panel. The coefficient β depends on the method of fixing of the panel:

- β = 2 if the panel is rigidly fixed at the bottom;
- β = 1 if the panel is hinged at the top and bottom;
- β = 1/√2 if the panel is rigidly fixed at the bottom and hinged at the top;
- β = 1/2 if the panel is rigidly fixed at the top and bottom;

The core "fracture" is defined by its shear modulus:

$$F_B = b \cdot (d - \delta) \cdot G_C \qquad (32)$$

Here, as before, b is the panel's width (in our case it is 1185 mm), δ is the metal sheet's thickness (= 0,5 mm), $G_C$ is the core's (polyurethane foam) shear modulus.

We must note right from the start, that the Euler's deflection of the panel may occur at a minor load, than the core's "fracture" can. Although any of above deformation types is easier to describe separately, in fact, on reaching a certain critical value, they start to interact, which brings to the total collapse of the panel. The amount of this critical load is defined by the following relationship [4]:

$$\frac{1}{F_{cr}} = \frac{1}{F_A} + \frac{1}{F_B} \qquad (33)$$

Table 31. Critical collapsing force for the vertically loaded panel, bringing to the global deflection (collapse)

| Thickness, mm | $F_{cr}$ (at β = 2) | | |
|---|---|---|---|
| | L = 2,5 m | L = 3 m | L = 6 m |
| 40 | 4065 | 3230 | 1070 |
| 50 | 5700 | 4680 | 1630 |
| 60 | 7620 | 6270 | 2300 |

| | | | |
|---|---|---|---|
| 80 | 11600 | 9800 | 3900 |
| 100 | 15800 | 13600 | 5820 |
| 120 | 20200 | 17700 | 8400 |
| 140 | 24700 | 21600 | 10400 |
| 150 | 27000 | 24100 | 11700 |
| 180 | 34000 | 30700 | 15900 |
| 200 | 38700 | 35300 | 18900 |

The fold forming or bulging of the panel, as already mentioned, occurs when a certain critical stress value is reached (18). If we consider the vertically positioned panel absolutely smooth and fixed at the bottom (excluding rotation and torsion), the critical value, which causes the bulging of the panel (the fold forming) (of course, if the global panel collapse doesn't occur before), should be considered the following:

$$F_C = 2 \cdot \delta \cdot b \cdot k \cdot \sqrt{\ } E_C \cdot E_F \cdot G_C \approx \delta \cdot b \cdot \sqrt{\ } E_C \cdot E_m \cdot G_C \approx 6620 \text{ kgf} \qquad (34)$$

Here, as previously, the panel facings are considered identical and k = 0,5.

# CHAPTER 4. FRAMELESS SANDWICH PANEL CHAMBERS

## §4.1. STATIONARY AND PREFABRICATED-DEMOUNTABLE CHAMBERS BUILT OF SANDWICH PANELS. BASIC CONCEPTS

So far, we have been analyzing the sandwich panel exclusively as an enclosing structure, mounted on a solid metal framework and having as the basic function the transmission of the wind and other loads to that very solid framework. However, sandwich panels have some self-bearing properties, which allow to build of them the frameless chambers, such as, refrigerating (freezing) chambers, and also small climatic rooms.

Refrigerating and freezing rooms and climatic rooms (in particular, the so-called "flower chambers"), offered by Profholod company – are prefabricated structures built of sandwich panels and shaped profiles, intended for the maintenance of a certain temperature in a closed space. Generally speaking, refrigerating chambers can be both prefabricated-demountable, and stationary. Prefabricated-demountable refrigerating and freezing chambers are assembled of sandwich panels with built-in eccentric locks for fixing the panels to each other. Today, prefabricated-demountable (with "eccentric locks") chambers make up almost 50% of the present day refrigerating chamber market. Their success is due to the fact that it is easy to assembly the chamber of appropriate dimensions (there is a certain dimension scale) using the standard panels. It can be installed practically anywhere and if necessary, to be quickly disassembled and moved to a different location.

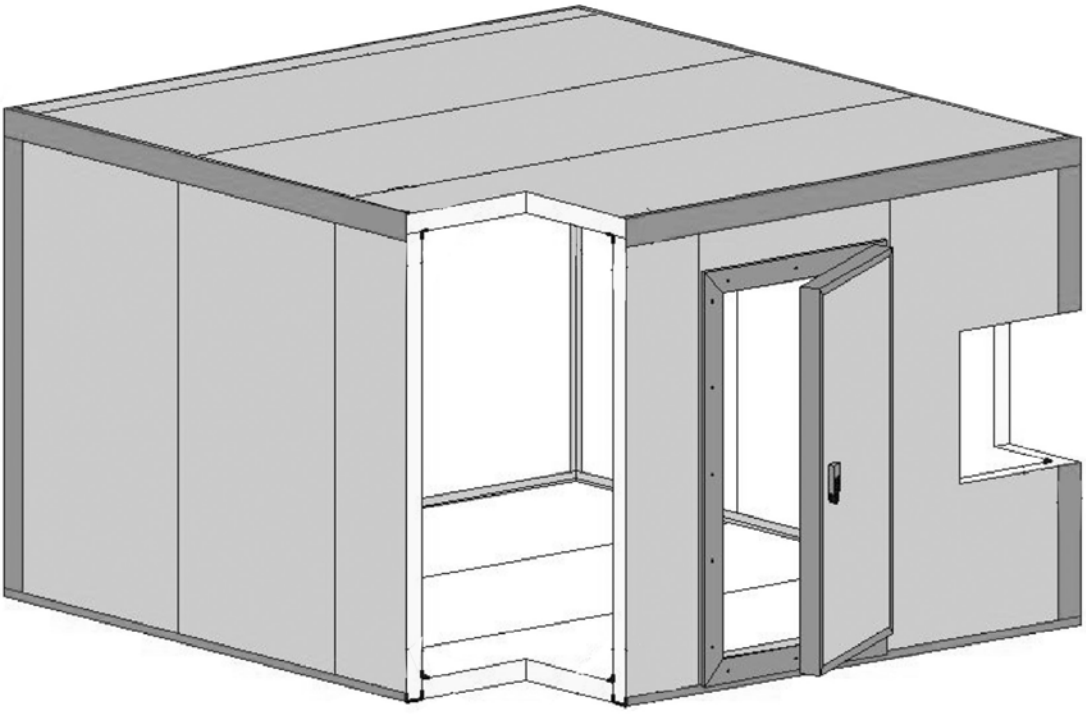
Meanwhile the stationary chambers, are originally designed by qualified experts, considering all the operation particularities, they give the possibility of saving in cost, installation time and occupied area. In addition, such chambers have no limitations in dimensions and form, and with proper installation noticeably outperform the "eccentric" prefabricated chambers, as the heat insulation properties. ProfHolod company has a rich experience of design and installation of stationary refrigerating chambers. The full chamber kit consists of wall, floor and ceiling panels supplemented with the shaped profiles made of the metal of the same type and color as the panel facings. On demand, the chamber kit can be supplemented with such expendable items as fixing screws for the shaped profiles, anchor bolts, silicon sealant and spray foam. Thanks to their technical features and special design, our stationary chambers not only guarantee the best thermal insulation, but also meet all the high environmental and hygienic requirements for the food storage.

Figure 18. Stationary refrigerating chamber built of structural sandwich panels.

## §4.2. REFRIGERATING CHAMBERS WITH SHAPED PROFILES. DESIGN PARTICULARITIES AND INSTALLATION PROCEDURE

Refrigerating chambers, assembled of sandwich panels and of 0,5 mm thick galvanized steel shaped profiles, are self bearing structures and with the properly performed installation (without "cold bridges", guarantee the best thermal insulation allowing to have noticeable savings in operation costs. Refrigerating and freezing chambers of this type also meet all the hygienic requirements for the food storage. Also, as mentioned previously, an important advantage of such chambers in comparison with the prefabricated "eccentric" ones, is the freedom in dimensions. The Figure 20 presents a sketch of a "chamber with shaped profiles" indicating the three main junctions it consists of.

Figure 20. Sketch of ProfHolod's refrigerating chamber :
I – Junction between the floor and ceiling sandwich panels
II – Wall panels junction
II – Junction between the ceiling and wall panels (view Figure 21).



The kit of sandwich panels and shaped profiles for the installation of such a chamber is completed with a detailed assembly drawing and packing list. Prior to the beginning of the installation of a refrigerating o freezing chamber completed with shaped profiles, it is necessary to check all the panels and accessories for completeness. The installation of the chamber begins with the preliminary preparation of the ground it will be mounted on, because the stationary chamber is not intended for the subsequent moving, however, may cause a series of difficulties.

The wall panel guides are fixed with anchor bolts to the previously leveled floor (usually, concrete) around all the perimeter of the chamber (View Figure 21.) Several variants of the junction of the floor and wall panels with the concrete floor are possible (view Figure 21, I (A-C)).

*Figure 21. Main junctions of sandwich panels for the installation of refrigerating chambers (beginning):*
*I – variants of fixing of the wall and floor panels,*
*II – variants of fixing of wall panels in the chamber corners,*
*III – variants of fixing of wall and ceiling panels;*
*1 – wall panel, 2 – floor panel, 4 – guide (channel) for wall panels, 5 – internal angle 40 x 40 mm, 6 – non- equilateral external horizontal outer angle, 8 – anchor wedge d 6, L = 40 mm with 450 mm spacing, 9 – screws for fixing of shaped profiles and flashings d 4,2, L = 13 mm, with 200-300 mm spacing, 10 – sanitary sealant, 11 – spray foam, 12 –metal cut to prevent the "cold bridge", 13 – partition sandwich panel, 14 – flashing.*

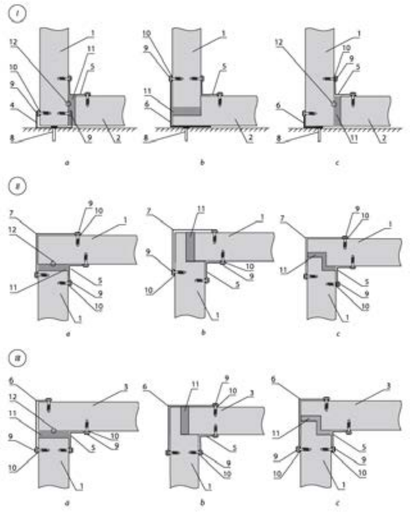
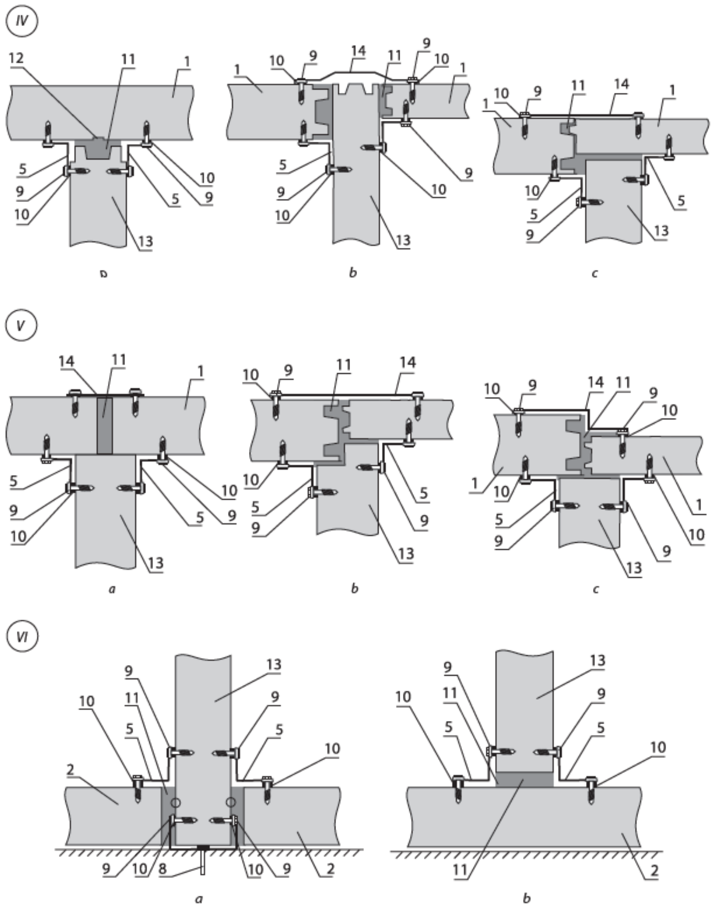


Figure 22. Main junctions of sandwich panels for the installation of refrigerating chambers (ending):
*IV – variants of fixing of wall panels to the partition panels,*
*V – fixing of partition panels to the ceiling panels,*
*VI - variants of fixing of partition panels to the floor panels.*
*1 – wall panel, 2 – floor panel, 4 – guide (channel) for wall panels, 5 – internal angle 40 x 40 mm, 6 – non- equilateral external horizontal outer angle, 8 – anchor wedge d 6, L = 40 mm with 450 mm spacing, 9 – screws for fixing of shaped profiles and flashings d 4,2, L = 13 mm, with 200-300 mm spacing, 10 – sanitary sealant, 11 – spray foam, 12 –metal cut to prevent the "cold bridge", 13 – partition sandwich panel, 14 – flashing.*

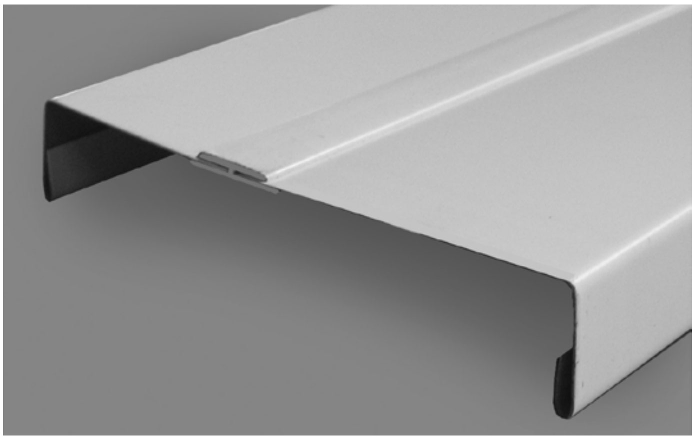


The variants I-B and I-C are preferable for smaller refrigerating chambers because in this case no thermal bridges are created, meanwhile the metal guides require a particular way of mounting of sandwich panels, breaking the "cold bridge" as shown on the Figure 21 I-A. On this purpose, a cut is made on the inner sandwich panel's facing, and it breaks the "cold bridge". It is recommended for the chambers with the floor panels, to make the cut of the sandwich panel's inner facing slightly above the guide, making sure that the cut line is not higher than the surface of the floor panels. Further, starting from any corner (or a door aperture, if the kit includes a panel with the door aperture) the panels are placed in accordance with the supplied drawing.

Variants of wall panels junction in the chamber corners are shown on the Figure 21 II (A-C). The placement of the panels should be performed making sure that the "tongue" of the placed panel is turned towards the direction of the panel placement. With such a procedure, a small quantity of spray foam is put into the "groove" lock, after which the panel is placed into the guide and pressed against the other panel, which is already mounted. The panels are pulled together and fixed with the wood screws inside the guide, making sure that the assembled wall is exactly vertical. Then, after the final chamber assembly, all "tongue and groove" junctions are sealed with the silicon sanitary sealant. If according to the supplied assembly drawing the kit includes some panels which should be cut, it must be performed with the use of the electric jigsaw or circular saw with the special cutting disk. Floor and ceiling panels are cut in the same way. The door aperture is also cut with the use of the electric jigsaw and is framed with the special U-shaped element made of two metal angles and the "junction" plastic profile (view Figure 23).

Floor and ceiling panels must correspond exactly to one of the transversal dimensions (internal or external) of the chamber, lengthwise or widthwise the chamber (the way of placement is specified in the assembly drawing). The vertical corners of the chamber are closed with the metal angle, usually of the same color as the wall panels outside.

Figure 23. The profile for the framing of the aperture in the sandwich panel.

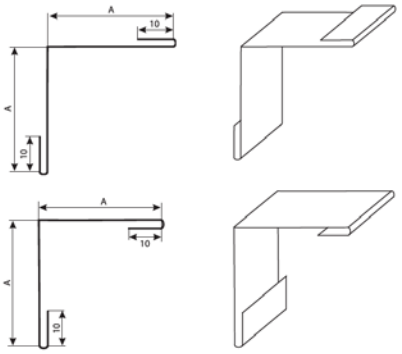


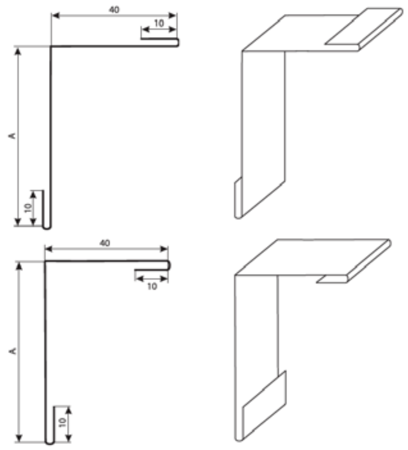
The size of the sides of the vertical external angles is 40 mm bigger than the wall panel's thickness, which allows to hide the edge of the panel at any type of mounting. The angles are fixed to the panels with the wood screws or rivets. The ceiling panels are joined to the wall ones with the use of the "horizontal angle" (view Figure 21 III (A-C)).

The chamber can contain some sections, enclosed with the partitions. In some cases, with the purpose of economy, different panel thickness is chosen for different sections. Let's suppose that in one of the sections the chamber should be low-temperature and should consist of 100 mm thick panels. The next section, in its turn, can be a middle-temperature chamber and can consist of 80 mm thick panels. In this case some inconvenience may be encountered during the installation, but it can be overcome. You just should know what the priority is: to maintain the external height or the internal one. All the internal corners of the chambers are closed with the 40 x 40 mm metal angle, as shown on the drawings. The floor panels, if necessary, can be "reinforced" with 1,5 – 5 mm thick metal sheets of the "Quintet" type. The dimensions are specified by the customer, but obviously, these dimensions are limited by the bearing capacity of the wall and ceiling (roofing) panels. The limits depend on where the frameless chamber is going to be located. If the chamber is indoors, we do not have any snow or wind loads. If it is located outdoors, it is necessary to take into account the snow or wind loads, which depend on the specific region. In both of these cases we should take into consideration the panel deformation due to the temperature difference between its facings. And depending on the season, this deformation can go both ways. Nevertheless, if the transversal dimensions of the chamber are more than 6000 mm and the height is more than 4000 mm, we strongly recommend to erect the metalwork skeleton. Moreover, building the outdoor chamber with the ceiling panels, it is necessary to ensure the 100% pressurization of the ceiling with the use of hydro-insulating materials, because the ceiling panels are not intended for the use as the roofing, but in certain cases they can exercise this function, if the hydro-insulation is made properly.

## §4.3. SHAPED PROFILES (FLASHINGS) FOR THE ASSEMBLING OF REFRIGERATING CHAMBERS

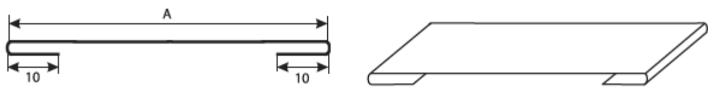
| Guide (channel) for the sandwich panels | | | |
|---|---|---|---|
| | | | |
| A | B | Notation | Weight of 1 m, kg |
| 40 | 42 | W 40x42x40 Zn-0,45 (10-10) | 0,5 |
| | 52 | W 40x52x40 Zn-0,45 (10-10) | 0,54 |
| | 62 | W 40x62x40 Zn-0,45 (10-10) | 0,57 |
| | 82 | W 40x82x40 Zn-0,45 (10-10) | 0,64 |
| | 102 | W 40x102x40 Zn-0,45 (10-10) | 0,71 |
| | 122 | W 40x122x40 Zn-0,45 (10-10) | 0,78 |
| | 142 | W 40x142x40 Zn-0,45 (10-10) | 0,85 |
| | 152 | W 40x152x40 Zn-0,45 (10-10) | 0,89 |
| | 162 | W 40x162x40 Zn-0,45 (10-10) | 0,93 |
| | 182 | W 40x182x40 Zn-0,45 (10-10) | 0,99 |
| | 202 | W 40x202x40 Zn-0,45 (10-10) | 1,07 |
| 50 | 42 | W 50x42x50 Zn-0,45 (10-10) | 0,57 |
| | 52 | W 50x52x50 Zn-0,45 (10-10) | 0,61 |
| | 62 | W 50x62x50 Zn-0,45 (10-10) | 0,64 |
| | 82 | W 50x82x50 Zn-0,45 (10-10) | 0,71 |
| | 102 | W 50x102x50 Zn-0,45 (10-10) | 0,78 |
| | 122 | W 50x122x50 Zn-0,45 (10-10) | 0,85 |
| | 142 | W 50x142x50 Zn-0,45 (10-10) | 0,89 |
| | 152 | W 50x152x50 Zn-0,45 (10-10) | 0,93 |
| | 162 | W 50x162x50 Zn-0,45 (10-10) | 0,99 |
| | 182 | W 50x182x50 Zn-0,45 (10-10) | 1,07 |
| | 202 | W 50x202x50 Zn-0,45 (10-10) | 1,13 |

| Equilateral angles (flat) | | |
|---|---|---|
|  | | |
| A | Notation (УВ - internal, УН - external) | Weight of 1 m, kg |
| 40 | УВ (УН) 40x40 Zn -0,45 (10-10) | 0,35 |
| 60 | УВ (УН) 60x60 Zn -0,45 (10-10) | 0,49 |
| 80 | УВ (УН) 80x80 Zn -0,45 (10-10) | 0,64 |
| 100 | УВ (УН) 100x100 Zn -0,45 (10-10) | 0,77 |
| 120 | УВ (УН) 120x120 Zn -0,45 (10-10) | 0,92 |
| 140 | УВ (УН) 140x140 Zn -0,45 (10-10) | 1,05 |
| 160 | УВ (УН) 160x160 Zn -0,45 (10-10) | 1,2 |
| 180 | УВ (УН) 180x180 Zn -0,45 (10-10) | 1,34 |
| 200 | УВ (УН) 200x200 Zn -0,45 (10-10) | 1,48 |
| 220 | УВ (УН) 220x220 Zn -0,45 (10-10) | 1,62 |
| 240 | УВ (УН) 240x240 Zn -0,45 (10-10) | 1,77 |

| Non-equilateral angles (for ceiling and wall panels junction) | | |
|---|---|---|
|  | | |
| A | Notation (УВ - internal, УН - external) | Weight of 1 m, kg |
| 60 | УВ (УН) 40x60 Zn-0,45 (10-10) | 0,42 |
| 80 | УВ (УН) 40x80 Zn-0,45 (10-10) | 0,49 |
| 100 | УВ (УН) 40x100 Zn-0,45 (10-10) | 0,56 |
| 120 | УВ (УН) 40x120 Zn-0,45 (10-10) | 0,66 |
| 140 | УВ (УН) 40x140 Zn-0,45 (10-10) | 0,7 |
| 160 | УВ (УН) 40x160 Zn-0,45 (10-10) | 0,78 |
| 180 | УВ (УН) 40x180 Zn-0,45 (10-10) | 0,85 |

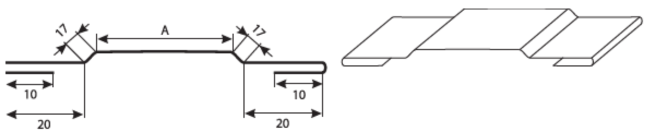
| | | |
|---|---|---|
| 190 | УВ (УН) 40x190 Zn-0,45 (10-10) | 0,88 |
| 200 | УВ (УН) 40x200 Zn-0,45 (10-10) | 0,92 |
| 220 | УВ (УН) 40x220 Zn-0,45 (10-10) | 0,99 |
| 240 | УВ (УН) 40x240 Zn-0,45 (10-10) | 1,06 |

Flat flashing




| A | Notation | Weight of 1 m, kg |
|---|---|---|
| 40 | Н 40 Zn-0,45 (10-10) | 0,21 |
| 60 | Н 60 Zn-0,45 (10-10) | 0,28 |
| 80 | Н 80 Zn-0,45 (10-10) | 0,35 |
| 100 | Н 100 Zn-0,45 (10-10) | 0,42 |
| 120 | Н 120 Zn-0,45 (10-10) | 0,49 |
| 140 | Н 140 Zn-0,45 (10-10) | 0,56 |
| 150 | Н 150 Zn-0,45 (10-10) | 0,6 |
| 160 | Н 160 Zn-0,45 (10-10) | 0,64 |
| 180 | Н 180 Zn-0,45 (10-10) | 0,7 |
| 200 | Н 200 Zn-0,45 (10-10) | 0,77 |

Shaped flashing




| A | Notation | Weight of 1 m, kg |
|---|---|---|
| 40 | Н 20x17x40x17x20 10-10 | 0,47 |
| 60 | Н 20x17x60x17x20 10-10 | 0,54 |
| 80 | Н 20x17x80x17x20 10-10 | 0,61 |
| 100 | Н 20x17x100x17x20 10-10 | 0,69 |
| 120 | Н 20x17x120x17x20 10-10 | 0,76 |
| 140 | Н 20x17x140x17x20 10-10 | 0,83 |
| 160 | Н 20x17x160x17x20 10-10 | 0,9 |
| 180 | Н 20x17x180x17x20 10-10 | 0,97 |
| 200 | Н 20x17x200x17x20 10-10 | 1,04 |
| 220 | Н 20x17x220x17x20 10-10 | 1,11 |

### §4.4. HEAT INSULATION (PANELING) OF THE WALLS WITH SANDWICH PANELS

This is the most frequent situation, when a refrigerating or freezing chamber must be created in already existing premises having concrete or brick walls. This situation is remarkable due to the fact that the chamber's wall becomes built-up now and it consists both of the brick (concrete) wall and of the sandwich panels. In some cases, there is an air space between these two layers. All these layers have their own heat conduction coefficients and give different heat insulation, which necessarily must be taken into account when choosing the panel thickness. If the panels with the thickness $\delta_1$ and thermal resistance $R_1$ tightly bear against the wall, which has the thickness $\delta$ and heat conduction $\alpha$, the total thermal resistance of the built-up wall will be equal to:

$$R_{tot} = \frac{\delta}{\alpha} + R_1 \qquad (9)$$

This relationship demonstrates that if we make the heat insulation for example, of a 450 mm thick brick wall (the heat conduction coefficient of the bricks is 0,37 W/m . K), so

$$R_{tot} = 1{,}22 + R_1. \qquad (10)$$

Taking into account that the heat conduction coefficient of polyurethane foam is 0,021 W/m . K, we can see that the additional insulation, given by the brick wall, allows to use the panels which are 25 mm thinner than it would be necessary if we had a free-standing chamber. Nevertheless, it is necessary to remember that the sandwich panels must bear very tightly against the brick wall in order to keep the above assumption true. Otherwise, the undesirable refrigeration loss and freezing of the space between the brick wall and the sandwich panels are possible. Moreover, it could cause damage of the panels.

We should also point out that for the heat insulation of the walls and for building of refrigerating chambers, we have tested and we are offering the sandwich panels having the outer side consisting of foiled paper with the total density equal to 160 g/m2 (meanwhile, the density of the paper is 120 g/m2). The use of such panels noticeably reduces the structure's cost. In this case, the panels are fixed to the previously leveled walls with the use of the special wood screws with the anticorrosive protection. The screws are at least 3 cm longer than the thickness of the panels.

Figure 25. Room made with sandwich panels

## §4.5. CHOOSING THE PANELS' THICKNESS FOR THE REFRIGERATING CHAMBER

Very frequently, we face the problem of the choice of the panels' thickness when implementing a concrete project. A lot of factors must be taken into account here. Both the mechanical properties of sandwich panels and their heat insulation characteristics are essential for this issue. The mechanical parameters, which determine the thickness of the panels to be used for the assembly of a frameless chamber, are the following:

• wind load on the walls and the ceiling (if this is an outdoor chamber);
• the load of the ceiling panels on the wall ones (depends on the length and thickness of the ceiling panels);
• excess pressure from outside in case of the pressure equalization valve's breakdown;
• deflection (bulge) of the panels as the result of the temperature gradient on their sides;
• panel deflection caused by the own weight;
• possible loads on the panels during the installation works.

As for the thermal insulation factors, influencing the thickness choice for the panels of the refrigerating chamber, here are the following examples:

• temperature inside the chamber;
• outside temperature;
• inner volume of the refrigerating chamber;
• material and thickness of the building's structures (if available);
• type of stored products and their daily turnover etc.

We have already made a sufficiently detailed examination of the issues associated with the mechanical strength of the panels, meanwhile now we are going to concentrate on the purely thermodynamic aspect of the choice of thickness of the refrigerating chamber's walls.

The detailed calculation of the thermal balance of the refrigeration chamber is a separate and a rather complicated task which should be dealt with by the heat engineers. Nevertheless, even a simple reasoning may be sufficient to make the necessary conclusions about the appropriate thickness of the panels. Evidently, in any case, the thicker the panels are, the better heat insulation they give, and so, here we are speaking, first of all, about the economic convenience. It is commonly accepted that the optimal heat insulation for the refrigerating chamber maintains the heat losses at the level of 10 W/m2 per hour. This quantity is also called beat demand, i.e. these are the refrigeration "losses" which are necessary to compensate in order to maintain the needed temperature inside the chamber.

The Table 32 shows the calculation data on the heat loss for the panels of different thickness, depending on the difference between the temperatures inside and outside the refrigerating chamber. The specified thickness values are recommended only for refrigerating chambers and warehouses and they absolutely are not the recommendations for administrative or logistic buildings, which have their own approved norms of allowable heat loss depending on the region they are located in.

Table 32. Choice of the wall thickness of the refrigerating chamber conditionally on the temperature difference inside and outside the chamber

| | | Panel thickness, mm | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 40 | 50 | 60 | 80 | 100 | 120 | 140 | 150 | 160 | 180 | 200 |
| Temperature difference | 10 °C | 5,3 | 4,2 | 3,5 | 2,6 | 2,1 | 1,7 | 1,5 | 1,4 | 1,3 | 1,2 | 1 |
| | 15 °C | 7,9 | 6,3 | 5,25 | 3,9 | 3,15 | 2,55 | 2,25 | 2,1 | 1,95 | 1,8 | 1,5 |
| | 20 °C | 10,5 | 8,4 | 7 | 5,2 | 4,2 | 3,4 | 3 | 2,8 | 2,6 | 2,4 | 2 |
| | 25 °C | 13,1 | 10,5 | 8,75 | 6,5 | 5,25 | 4,25 | 3,75 | 3,5 | 3,25 | 3 | 2,5 |
| | 30 °C | 15,8 | 12,6 | 10,5 | 7,8 | 6,3 | 5,1 | 4,5 | 4,2 | 3,9 | 3,6 | 3 |
| | 35 °C | 18,4 | 14,7 | 12,25 | 9,1 | 7,35 | 5,95 | 5,25 | 4,9 | 4,55 | 4,2 | 3,5 |
| | 40 °C | 21 | 16,8 | 14 | 10,4 | 8,4 | 6,8 | 6 | 5,6 | 5,2 | 4,8 | 4 |
| | 45 °C | 23,6 | 18,9 | 15,75 | 11,7 | 9,45 | 7,6 | 6,75 | 6,3 | 5,85 | 5,4 | 4,5 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 °C | 26,3 | 21 | 17,5 | 13 | 10,5 | 8,5 | 7,5 | 7 | 6,5 | 6 | 5 |
| | 55 °C | 28,9 | 23,1 | 19,25 | 14,3 | 11,55 | 9,35 | 8,25 | 7,7 | 7,15 | 6,6 | 5,5 |
| | 60 °C | 31,5 | 25,2 | 21 | 15,6 | 12,6 | 10,2 | 9 | 8,4 | 7,8 | 7,2 | 6 |
| | 65 °C | 34,1 | 27,3 | 22,75 | 16,9 | 13,65 | 11,05 | 9,75 | 9,1 | 8,45 | 7,8 | 6,5 |
| | 70 °C | 36,8 | 29,4 | 24,5 | 18,2 | 14,7 | 11,9 | 10,5 | 9,8 | 9,1 | 8,4 | 7 |
| | 75 °C | 39,4 | 31,5 | 26,2 | 19,5 | 15,7 | 12,7 | 11,25 | 10,5 | 9,75 | 9 | 7,5 |
| | 80 °C | 42 | 33,6 | 28 | 20,8 | 16,8 | 13,6 | 12 | 11,2 | 10,4 | 9,6 | 8 |
| | 85 °C | 44,6 | 35,7 | 29,8 | 22,1 | 17,9 | 14,5 | 12,8 | 11,9 | 11 | 10,2 | 8,5 |
| | 90 °C | 47,3 | 37,8 | 31,5 | 23,4 | 15,3 | 15,3 | 13,5 | 12,6 | 11,7 | 10,8 | 9 |
| | 95 °C | 49,9 | 39,9 | 33,3 | 24,7 | 19,9 | 16,2 | 14,3 | 13,3 | 12,4 | 11,4 | 9,5 |

- optimal panel thickness (black)
- excess panel thickness (possible to use) (grey)
- panels of this thickness are not recommended for use (white)

## §4.6. PRESSURE EQUALIZATION VALVES

The pressure equalization valves are necessary mainly for the installation in the low-temperature refrigerating chambers. During the process of air refrigeration inside the low-temperature refrigerating chambers, the air rarefaction occurs and it brings to the reduced pressure inside. Meanwhile the pressure reduction is not a serious danger for small refrigerating chambers, having the volume of several tens of cubic meters and having the sufficient structural strength, - in big refrigerating chambers with the sufficiently pressurized doors such pressure fluctuations may require excessive efforts for the door opening (locks and handles are often broken). Also, it is important for the low-temperature refrigerating chambers to use the pressure equalization valves provided with the freeze protection in order to guarantee their failure free performance at any condition. For the sake of reliability in big chambers several valves are installed. Today one can purchase either metal or silicon valves, and there design is not the same. The operation of the metal valves is based on the closing caused by the gravity, for this reason they should be installed horizontally, i.e. in the refrigeration chamber's ceiling panels. Naturally, it is not always easy. The silicon pressure equalization valves operate in vertical position, which makes their installation easier, allowing to place them on the side panels. The pressure equalization valves differ for their capacity, so they must be selected depending on the chamber volume. The formula defining the air quantity, which is necessary for the equalization of the external and internal pressures, is the following:

$$Q = K \cdot V \cdot \Delta T \quad (11)$$

where Q is the required air quantity l/min, K = 3,66 (constant), V – is the volume of the refrigerated room, m3, ΔT - is the maximum temperature variation in the refrigerated room, °C
**(not to be confused with the difference in temperature outside and inside the chamber!)**

It is necessary to remember, that the neglect of these inexpensive devices can lead to serious consequences. The pressure equalization valve is mounted with the use of the fixing screws, making sure that the space between the wall panel and the valve is pressurized. The valve should be placed transversally to the airflow from the coolers near the doors. The valve placement relatively the ceiling: for the chambers with the volume up to 120 m3 – min 30 cm, for the chambers with the volume up to 600 m3 – min 50 cm from the ceiling or the floor. It is forbidden to obstacle or limit the air passage through the valve. The pressure release valve is powered by the electricity network 230.

Figure 26. Pressure equalization valve KVD-4-60

**Incorrect placement of the valve during the installation may cause its freezing and the subsequent malfunction!**

# CHAPTER 5. DOORS FOR PROFHOLOD'S REFRIGERATING AND FREEZING CHAMBERS

## §5.1. BASIC DATA ON REFRIGERATION DOORS MANUFACTURED BY PROFHOLOD

Refrigeration doors manufactured by ProfHolod are produced in the complete accordance with the drawings and other documentation, developed by the Company: TU 5284-004-77983254-2012. The doors are intended for the enclosing and heat insulation of the door apertures of middle- and low-temperature chambers of any dimensions. In case of the low-temperature version, the doors are provided with the heating wire in order to prevent the freezing of the sealing gasket. All the elements of the door leaves are manufactured without the "cold bridges" in order to prevent the "refrigeration loss". The company produces refrigeration doors of four types:

- RDO – hinged single;
- RDOP – hinged single semi-hidden;
- OD – sliding;
- RDD – hinged double.

The following notation is used for the doors description:

| Door type: RDO, RDOP, OD or RDD | Aperture width, mm | Aperture height, mm | Door leaf thickness, mm | Door leaf's inner side material | Door leaf's outer side material | Threshold height, mm | Temperature conditions (L or M) | Hinges location (Пр - right, Лев - left) |
|---|---|---|---|---|---|---|---|---|
| XXXX | XXXX | XXXX | XXX | XXXX-XXX | XXXX-XXX | XXX | X | XX |

The following notation is used for the description of the materials the door is made of:

- RAL 9003-0,5 — Sheet metal with 0,5 mm thickness, with polymeric coating RAL 9003;
- Zn-0,5 — Galvanized sheet metal with 0,5 mm thickness;
- AISI 304-0,5 — Stainless steel AISI304 (for food products) with 0,5 mm thickness;

• AISI 430-0,5 — Stainless steel AISI430 (general purpose) with 0,5 mm thickness.
The door leaves for all the door types are made as a sandwich panel with the facing produced from the above materials, filled with the solid polyurethane foam (PUR) with the density 40 kg/m3 and heat conduction 0,021 W/K . m2.

## §5.2. HINGED DOORS RDO. GENERAL INFORMATION

Single hinged doors RDO consist of the door leaf made as a sandwich panel and equipped with the Italian MTH hardware and a lay on profiled frame made of 2 mm thick metal, otherwise the door is supplied together with the wall panel with the aperture. (For the lock and the hinges view Figure 28).

Figure 27. Hinged lay on doors manufactured by ProfHolod.

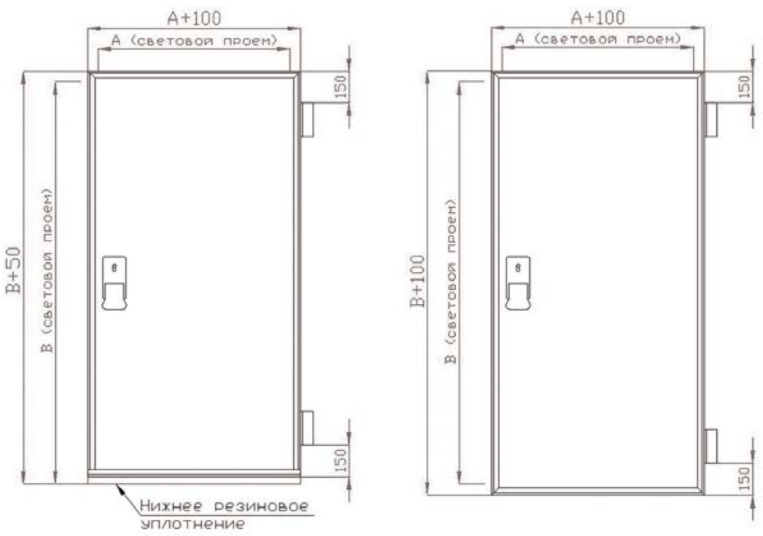


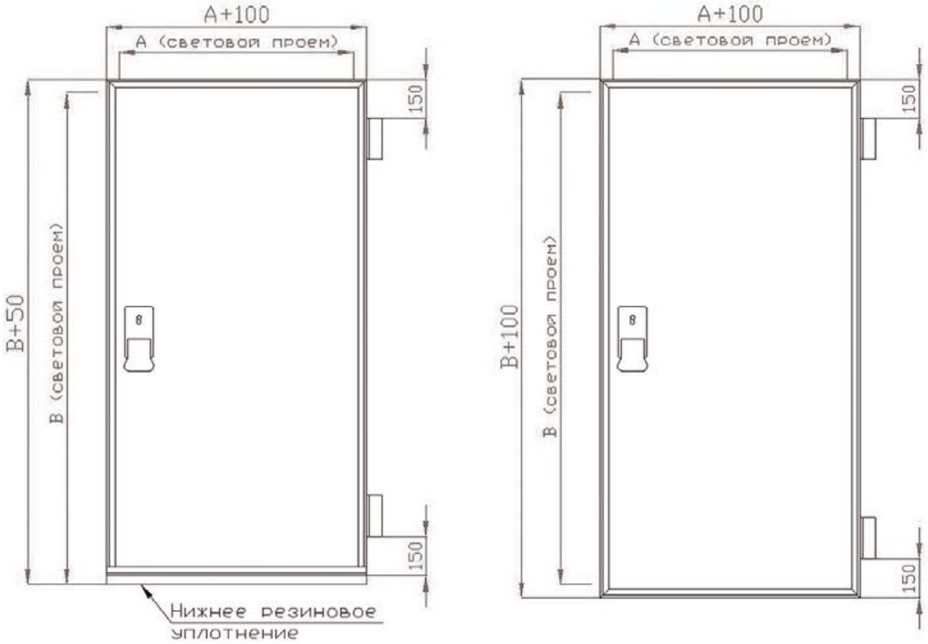

Table 33. Standard sizes of ProfHolod's doors (XX in the notation means the door leaf thickness: 80, 100 or 120 mm)

| Door type | Aperture width | Aperture height | Leaf width | leaf height | |
|---|---|---|---|---|---|
| | | | | with threshold | without threshold |
| RDO 800 1800 XX | 800 | 1800 | 900 | 1900 | 1830 |
| RDO 800 1900 XX | 800 | 1900 | 900 | 2000 | 1930 |
| RDO 800 2000 XX | 800 | 2000 | 900 | 2100 | 2030 |
| RDO 800 2100 XX | 800 | 2100 | 900 | 2200 | 2130 |
| RDO 800 2200 XX | 800 | 2200 | 900 | 2300 | 2230 |
| RDO 900 1800 XX | 900 | 1800 | 1000 | 1900 | 1830 |
| RDO 900 1900 XX | 900 | 1900 | 1000 | 2000 | 1930 |
| RDO 900 2000 XX | 900 | 2000 | 1000 | 2100 | 2030 |
| RDO 900 2100 XX | 900 | 2100 | 1000 | 2200 | 2130 |
| RDO 900 2200 XX | 900 | 2200 | 1000 | 2300 | 2230 |
| RDO 1000 1800 XX | 1000 | 1800 | 1100 | 1900 | 1830 |
| RDO 1000 1900 XX | 1000 | 1900 | 1100 | 2000 | 1930 |
| RDO 1000 2000 XX | 1000 | 2000 | 1100 | 2100 | 2030 |
| RDO 1000 2100 XX | 1000 | 2100 | 1100 | 2200 | 2130 |
| RDO 1000 2200 XX | 1000 | 2200 | 1100 | 2300 | 2230 |
| RDO 1100 1800 XX | 1100 | 1800 | 1200 | 1900 | 1830 |

| | | | | | |
|---|---|---|---|---|---|
| RDO 1100 1900 XX | 1100 | 1900 | 1200 | 2000 | 1930 |
| RDO 1100 2000 XX | 1100 | 2000 | 1200 | 2100 | 2030 |
| RDO 1100 2100 XX | 1100 | 2100 | 1200 | 2200 | 2130 |
| RDO 1100 2200 XX | 1100 | 2200 | 1200 | 2300 | 2230 |
| RDO 1200 1800 XX | 1200 | 1800 | 1300 | 1900 | 1830 |
| RDO 1200 1900 XX | 1200 | 1900 | 1300 | 2000 | 1930 |
| RDO 1200 2000 XX | 1200 | 2000 | 1300 | 2100 | 2030 |
| RDO 1200 2100 XX | 1200 | 2100 | 1300 | 2200 | 2130 |
| RDO 1200 2200 XX | 1200 | 2200 | 1300 | 2300 | 2230 |

*A (Aperture)* *A (Aperture)*

Figure 29. RDO door panels (on the left – without threshold, on the right – with threshold).




*B (Aperture)* *B (Aperture)*

*Lower rubber sealing gasket* *Threshold height*

**Kit of a hinged door with the lay on profiled frame.**

The standard lay on frame is produced from the sheet cold-rolled steel having the thickness of 2 mm. It is coated with the powder enamel of the RAL 9003 white color. The manufacturing of the frame from the AISI 304 or AISI 430 stainless steel is also possible. The frame is mounted to the external wall of the door aperture with the use of the mounting hardware kit, supplied with the door.

The dimensions of the metal frame depend on the dimensions of the aperture:

• Frame width = aperture width + 240 mm,

• Frame height = aperture height + 120 + threshold height.

*Figure 30. Layout of metal frame for the hinged door (on the left – without threshold, on the right – with threshold).*

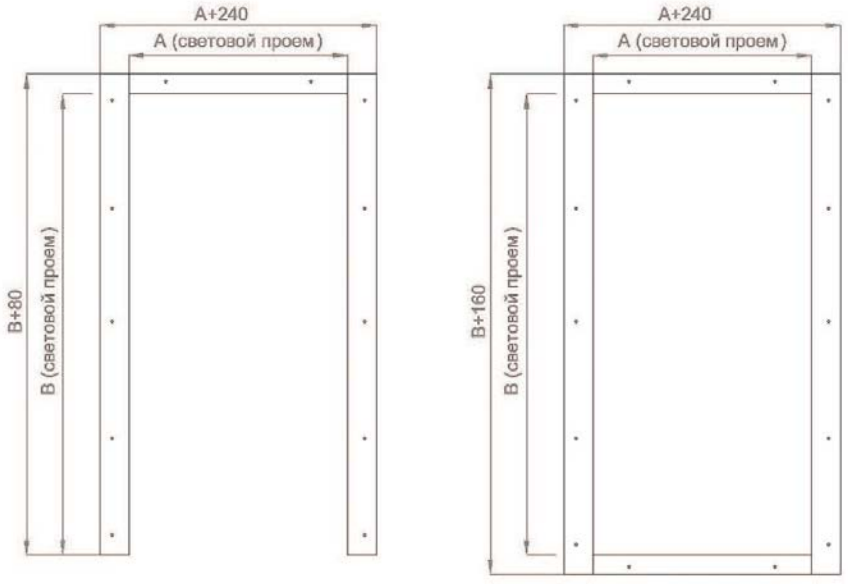
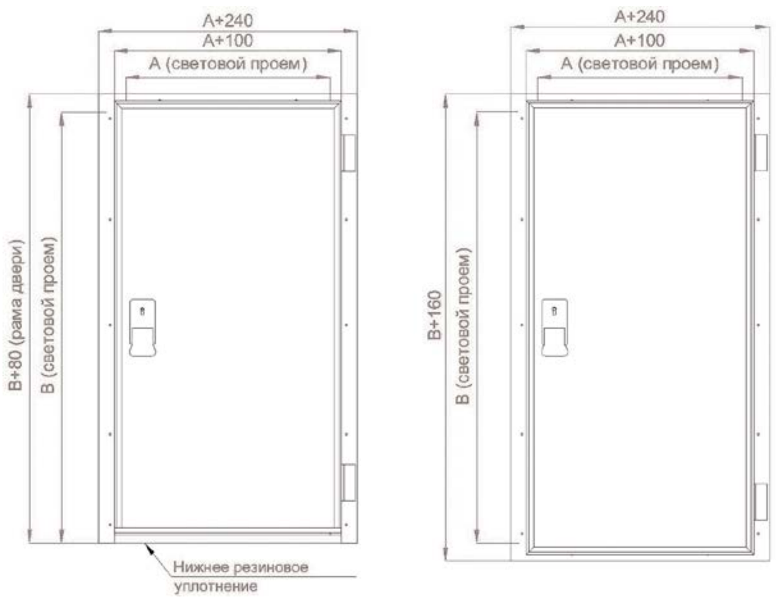



Figure 31. Single hinged door RDO with the lay on frame




*Threshold height*

**Mounting hardware kit**

The metal frame together with the door panel is fixed to the wall with the use of the supplied mounting hardware kit consisting of a certain quantity (according to the Table 34) of fixing elements (in case when it is fixed to a sandwich panel wall) or anchor bolts (in case it is fixed to a concrete or brick wall).

*Table 34. Items included in the mounting hardware kit*

| Description | Fixing to sandwich panel | | Fixing to concrete wall | |
|---|---|---|---|---|
| | Quantity | | Quantity | |
| | aperture width < 1200 mm | aperture width = 1200 mm | aperture width < 1200 mm | aperture width = 1200 mm |
| Insulating nut | 12 | 13 | 0 | 0 |

| | | | | |
|---|---|---|---|---|
| Insulating washer | 12 | 13 | 0 | 0 |
| Ericson's nut | 12 | 13 | 0 | 0 |
| Stud M8* | 12 | 13 | 0 | 0 |
| Anchor bolt D 10 | 0 | 0 | 12 | 13 |

* The length of the stud is equal to the thickness of the panel, on which the door is fixed + 20 mm. For the detailed description of the variants of refrigeration doors fixing, view .§ 5.6.

In case the door is supplied together with the sandwich panel with the framed aperture, the item is supplied assembled and is not completed with additional accessories.

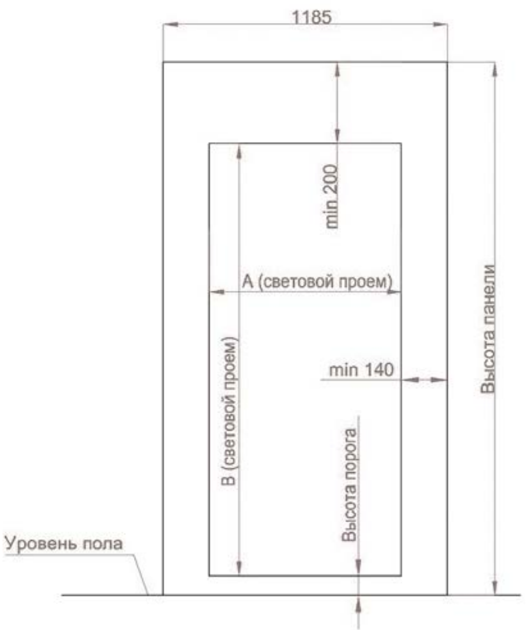
This door unit can be part of a wall of the refrigerating (freezing) chamber, assembled with the sandwich panels manufactured by ProfHolod LLC.

ProfHolod LLC does not guarantee the compatibility of the door unit with the panels supplied by other manufacturers for the reason of the differences in the design of the locking “tongue-and-groove” profile.

**Kit of a single hinged door with the wall sandwich panel having the aperture (heat insulated door unit).**

In case the aperture has the width of 800 or 900 mm, the door panel can be supplied together with the wall sandwich panel having the framed aperture. In this case, the door panel is fixed directly to the sandwich panel with the built-in embedded fittings. The length of the sandwich panel in this case is determined by the height of the refrigerating chamber and is limited only by ProfHolod’s manufacture capabilities. The “standard” door set is produced of a wall sandwich panel if the aperture’s height is up to 2200 mm and the width is up to 900 mm. The height of the unit, i.e. of the sandwich panel with the cut and framed aperture is coordinated with the customer (view Figure 33). In the low-temperature version, the door’s sealing gasket around the perimeter is equipped with the electric heating system (heating wire). The frame’s aperture is completed with the U-type “cold-breaking” profile.

Figure 33. Panel with the aperture for the heat-insulated door unit




## §5.3. SEMI-HIDDEN HINGED DOORS RDOP

Semi-hidden hinged doors “RDOP” (View Figure 34) are supplied only with the lay on profiled frame and are equipped with the Fermod (France) or Rahrabach (Germany) hardware.

Figure 34. Semi-hidden single hinged doors manufactured by ProfHolod.

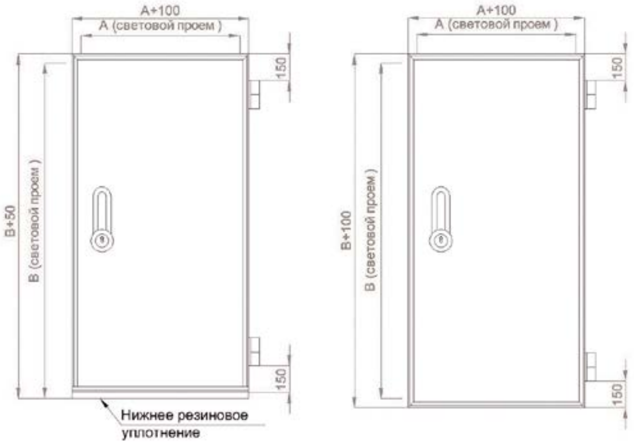



Table 35. Standard sizes of the RDOP doors manufactured by ProfHolod.

| Door type (XX - panel's thickness) | Aperture width | Aperture height | Leaf width | leaf height | |
|---|---|---|---|---|---|
| | | | | with threshold | without threshold |
| RDOP 800 1800 XX | 800 | 1800 | 900 | 1900 | 1830 |
| RDOP 800 1900 XX | 800 | 1900 | 900 | 2000 | 1930 |
| RDOP 800 2000 XX | 800 | 2000 | 900 | 2100 | 2030 |
| RDOP 800 2100 XX | 800 | 2100 | 900 | 2200 | 2130 |
| RDOP 800 2200 XX | 800 | 2200 | 900 | 2300 | 2230 |
| RDOP 900 1800 XX | 900 | 1800 | 1000 | 1900 | 1830 |
| RDOP 900 1900 XX | 900 | 1900 | 1000 | 2000 | 1930 |
| RDOP 900 2000 XX | 900 | 2000 | 1000 | 2100 | 2030 |
| RDOP 900 2100 XX | 900 | 2100 | 1000 | 2200 | 2130 |
| RDOP 900 2200 XX | 900 | 2200 | 1000 | 2300 | 2230 |
| RDOP 1000 1800 XX | 1000 | 1800 | 1100 | 1900 | 1830 |
| RDOP 1000 1900 XX | 1000 | 1900 | 1100 | 2000 | 1930 |
| RDOP 1000 2000 XX | 1000 | 2000 | 1100 | 2100 | 2030 |
| RDOP 1000 2100 XX | 1000 | 2100 | 1100 | 2200 | 2130 |
| RDOP 1000 2200 XX | 1000 | 2200 | 1100 | 2300 | 2230 |
| RDOP 1100 1800 XX | 1100 | 1800 | 1200 | 1900 | 1830 |
| RDOP 1100 1900 XX | 1100 | 1900 | 1200 | 2000 | 1930 |
| RDOP 1100 2000 XX | 1100 | 2000 | 1200 | 2100 | 2030 |
| RDOP 1100 2100 XX | 1100 | 2100 | 1200 | 2200 | 2130 |
| RDOP 1100 2200 XX | 1100 | 2200 | 1200 | 2300 | 2230 |
| RDOP 1200 1800 XX | 1200 | 1800 | 1300 | 1900 | 1830 |
| RDOP 1200 1900 XX | 1200 | 1900 | 1300 | 2000 | 1930 |

| | | | | | |
|---|---|---|---|---|---|
| RDOP 1200 2000 XX | 1200 | 2000 | 1300 | 2100 | 2030 |
| RDOP 1200 2100 XX | 1200 | 2100 | 1300 | 2200 | 2130 |
| RDOP 1200 2200 XX | 1200 | 2200 | 1300 | 2300 | 2230 |

In standard version the door panel's thickness XX – 80, 100 or 120 mm.

### Hinged lay on door kit with the profiled frame

The standard lay on frame is produced of 2 mm thick cold rolled sheet steel and it is coated with the powder enamel of the RAL 9003 white color. The manufacturing of the frame from the AISI 304 or AISI 430 stainless steel is also possible. The frame is mounted to the external wall of the door aperture with the use of the mounting hardware kit, supplied along with the door.
The dimensions of the metal frame depend on the dimensions of the aperture (view Figure 38):

- Frame width = aperture width + 240 mm,
- Frame height = aperture height + 120 + threshold height.

*Figure 37. Door panels RDOP (on the left – without threshold, on the right – with threshold).*

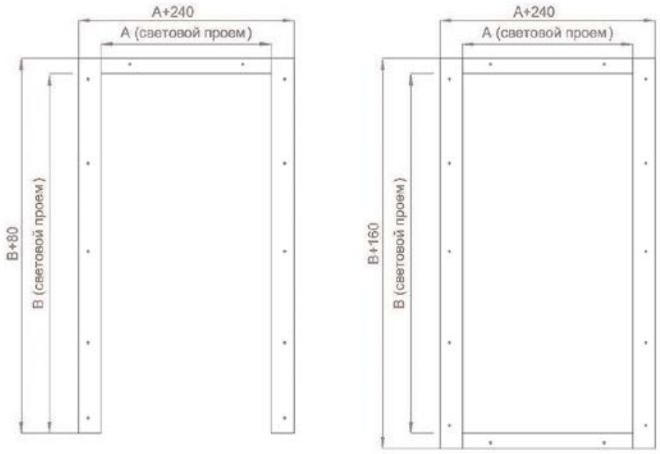



*Table 36. Items included in the mounting hardware kit*

| Description | Fixing to sandwich panel | | Fixing to concrete wall | |
|---|---|---|---|---|
| | Quantity | | Quantity | |
| | aperture width < 1200 mm | aperture width = 1200 mm | aperture width < 1200 mm | aperture width = 1200 mm |
| Insulating nut | 12 | 13 | 0 | 0 |
| Insulating washer | 12 | 13 | 0 | 0 |
| Ericson's nut | 12 | 13 | 0 | 0 |
| Stud M8* | 12 | 13 | 0 | 0 |
| Anchor bolt D 10 | 0 | 0 | 12 | 13 |

* The length of the stud is equal to the thickness of the panel, on which the door is fixed + 20 mm.

For the detailed description of the variants of refrigeration doors fixing, view § 5.6.

## §5.4. SLIDING DOORS (OD). GENERAL INFORMATION

Figure 40. Light sliding door manufactured by ProfHolod

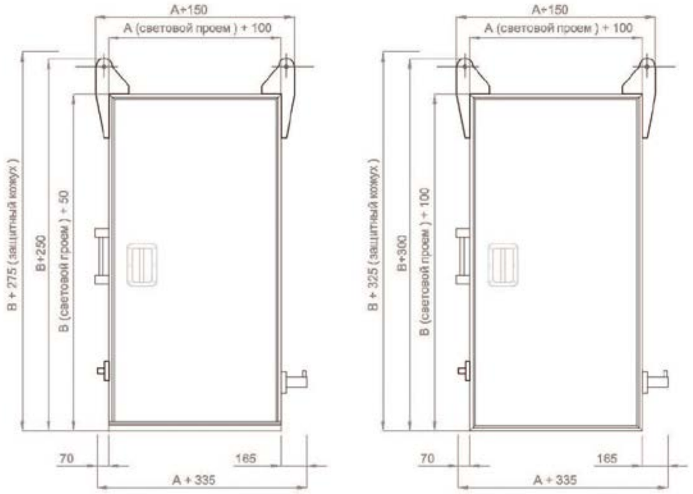



Figure 40. “Heavy” sliding door manufactured by ProfHolod

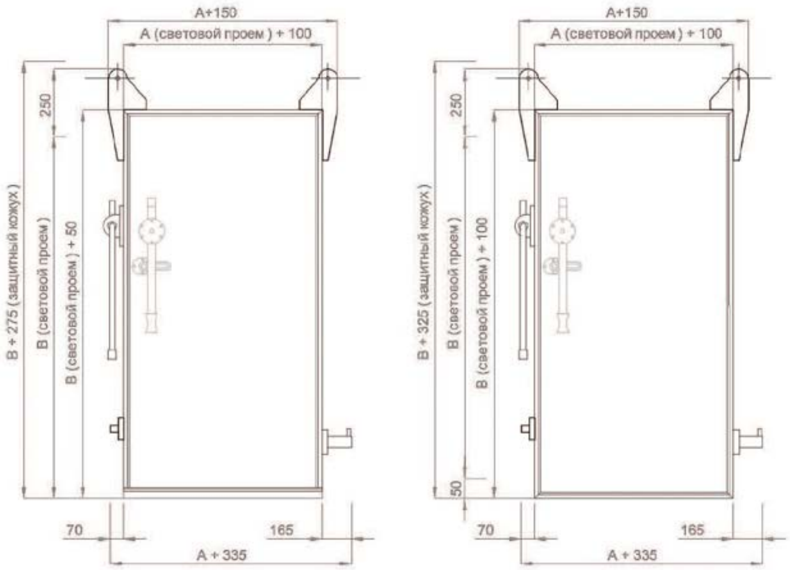



Figure 41. Sliding door hardware for Light Doors

Figure 42. Sliding door hardware for Heavy Doors

Table 37. Standard sizes of ProfHolod's doors

| Door type | Aperture width | Aperture height | Leaf width | leaf height | |
|---|---|---|---|---|---|
| | | | | with threshold | without threshold |
| OD 800 1800 XX | 800 | 1800 | 900 | 1900 | 1820 |
| OD 800 2000 XX | 800 | 2000 | 900 | 2100 | 2020 |
| OD 800 2200 XX | 800 | 2200 | 900 | 2300 | 2220 |
| OD 800 2400 XX | 800 | 2400 | 900 | 2500 | 2420 |
| OD 800 2600 XX | 800 | 2600 | 900 | 2700 | 2620 |
| OD 800 2800 XX | 800 | 2800 | 900 | 2900 | 2820 |
| OD 800 3000 XX | 800 | 3000 | 900 | 3100 | 3020 |
| OD 1000 1800 XX | 1000 | 1800 | 1100 | 1900 | 1820 |
| OD 1000 2000 XX | 1000 | 2000 | 1100 | 2100 | 2020 |
| OD 1000 2200 XX | 1000 | 2200 | 1100 | 2300 | 2220 |
| OD 1000 2400 XX | 1000 | 2400 | 1100 | 2500 | 2420 |
| OD 1000 2600 XX | 1000 | 2600 | 1100 | 2700 | 2620 |
| OD 1000 2800 XX | 1000 | 2800 | 1100 | 2900 | 2820 |
| OD 1000 3000 XX | 1000 | 3000 | 1100 | 3100 | 3020 |
| OD 1200 1800 XX | 1200 | 1800 | 1300 | 1900 | 1820 |
| OD 1200 2000 XX | 1200 | 2000 | 1300 | 2100 | 2020 |
| OD 1200 2200 XX | 1200 | 2200 | 1300 | 2300 | 2220 |
| OD 1200 2400 XX | 1200 | 2400 | 1300 | 2500 | 2420 |
| OD 1200 2600 XX | 1200 | 2600 | 1300 | 2700 | 2620 |
| OD 1200 2800 XX | 1200 | 2800 | 1300 | 2900 | 2820 |
| OD 1200 3000 XX | 1200 | 3000 | 1300 | 3100 | 3020 |
| OD 1400 1800 XX | 1400 | 1800 | 1500 | 1900 | 1820 |

| | | | | | |
|---|---|---|---|---|---|
| OD 1400 2000 XX | 1400 | 2000 | 1500 | 2100 | 2020 |
| OD 1400 2200 XX | 1400 | 2200 | 1500 | 2300 | 2220 |
| OD 1400 2400 XX | 1400 | 2400 | 1500 | 2500 | 2420 |
| OD 1400 2600 XX | 1400 | 2600 | 1500 | 2700 | 2620 |
| OD 1400 2800 XX | 1400 | 2800 | 1500 | 2900 | 2820 |
| OD 1400 3000 XX | 1400 | 3000 | 1500 | 3100 | 3020 |
| OD 1600 1800 XX | 1600 | 1800 | 1700 | 1900 | 1820 |
| OD 1600 2000 XX | 1600 | 2000 | 1700 | 2100 | 2020 |
| OD 1600 2200 XX | 1600 | 2200 | 1700 | 2300 | 2220 |
| OD 1600 2400 XX | 1600 | 2400 | 1700 | 2500 | 2420 |
| OD 1600 2600 XX | 1600 | 2600 | 1700 | 2700 | 2620 |
| OD 1600 2800 XX | 1600 | 2800 | 1700 | 2900 | 2820 |
| OD 1600 3000 XX | 1600 | 3000 | 1700 | 3100 | 3020 |
| OD 1800 1800 XX | 1800 | 1800 | 1900 | 1900 | 1820 |
| OD 1800 2000 XX | 1800 | 2000 | 1900 | 2100 | 2020 |
| OD 1800 2200 XX | 1800 | 2200 | 1900 | 2300 | 2220 |
| OD 1800 2400 XX | 1800 | 2400 | 1900 | 2500 | 2420 |
| OD 1800 2600 XX | 1800 | 2600 | 1900 | 2700 | 2620 |
| OD 1800 2800 XX | 1800 | 2800 | 1900 | 2900 | 2820 |
| OD 1800 3000 XX | 1800 | 3000 | 1900 | 3100 | 3020 |
| OD 2000 1800 XX | 2000 | 1800 | 2100 | 1900 | 1820 |
| OD 2000 2000 XX | 2000 | 2000 | 2100 | 2100 | 2020 |
| OD 2000 2200 XX | 2000 | 2200 | 2100 | 2300 | 2220 |

Table 37 (ending). Standard sizes of ProfHolod's doors

| Door type | Aperture width | Aperture height | Leaf width | leaf height | |
|---|---|---|---|---|---|
| | | | | with threshold | without threshold |
| OD 2000 2400 XX | 2000 | 2400 | 2100 | 2500 | 2420 |
| OD 2000 2600 XX | 2000 | 2600 | 2100 | 2700 | 2620 |
| OD 2000 2800 XX | 2000 | 2800 | 2100 | 2900 | 2820 |
| OD 2000 3000 XX | 2000 | 3000 | 2100 | 3100 | 3020 |
| OD 2200 1800 XX | 2200 | 1800 | 2300 | 1900 | 1820 |
| OD 2200 2000 XX | 2200 | 2000 | 2300 | 2100 | 2020 |
| OD 2200 2200 XX | 2200 | 2200 | 2300 | 2300 | 2220 |
| OD 2200 2400 XX | 2200 | 2400 | 2300 | 2500 | 2420 |
| OD 2200 2600 XX | 2200 | 2600 | 2300 | 2700 | 2620 |
| OD 2200 2800 XX | 2200 | 2800 | 2300 | 2900 | 2820 |
| OD 2200 3000 XX | 2200 | 3000 | 2300 | 3100 | 3020 |
| OD 2400 1800 XX | 2400 | 1800 | 2500 | 1900 | 1820 |
| OD 2400 2000 XX | 2400 | 2000 | 2500 | 2100 | 2020 |
| OD 2400 2200 XX | 2400 | 2200 | 2500 | 2300 | 2220 |
| OD 2400 2400 XX | 2400 | 2400 | 2500 | 2500 | 2420 |

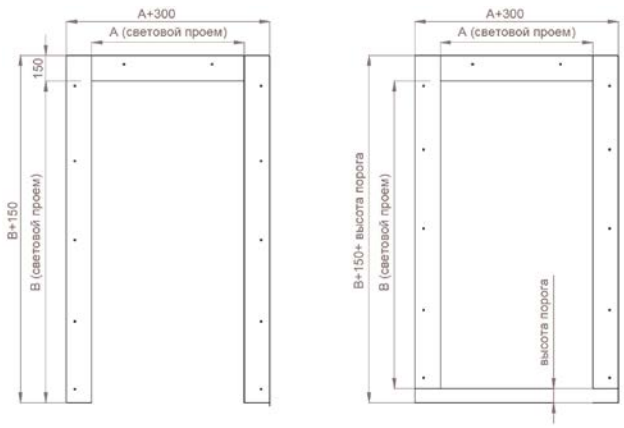
| | | | | | |
|---|---|---|---|---|---|
| OD 2400 2600 XX | 2400 | 2600 | 2500 | 2700 | 2620 |
| OD 2400 2800 XX | 2400 | 2800 | 2500 | 2900 | 2820 |
| OD 2400 3000 XX | 2400 | 3000 | 2500 | 3100 | 3020 |
| OD 2600 1800 XX | 2600 | 1800 | 2700 | 1900 | 1820 |
| OD 2600 2000 XX | 2600 | 2000 | 2700 | 2100 | 2020 |
| OD 2600 2200 XX | 2600 | 2200 | 2700 | 2300 | 2220 |
| OD 2600 2400 XX | 2600 | 2400 | 2700 | 2500 | 2420 |
| OD 2600 2600 XX | 2600 | 2600 | 2700 | 2700 | 2620 |
| OD 2600 2800 XX | 2600 | 2800 | 2700 | 2900 | 2820 |
| OD 2600 3000 XX | 2600 | 3000 | 2700 | 3100 | 3020 |
| OD 2800 1800 XX | 2800 | 1800 | 2900 | 1900 | 1820 |
| OD 2800 2000 XX | 2800 | 2000 | 2900 | 2100 | 2020 |
| OD 2800 2200 XX | 2800 | 2200 | 2900 | 2300 | 2220 |
| OD 2800 2400 XX | 2800 | 2400 | 2900 | 2500 | 2420 |
| OD 2800 2600 XX | 2800 | 2600 | 2900 | 2700 | 2620 |
| OD 2800 2800 XX | 2800 | 2800 | 2900 | 2900 | 2820 |
| OD 2800 3000 XX | 2800 | 3000 | 2900 | 3100 | 3020 |
| OD 3000 1800 XX | 3000 | 1800 | 3100 | 1900 | 1820 |
| OD 3000 2000 XX | 3000 | 2000 | 3100 | 2100 | 2020 |
| OD 3000 2200 XX | 3000 | 2200 | 3100 | 2300 | 2220 |
| OD 3000 2400 XX | 3000 | 2400 | 3100 | 2500 | 2420 |
| OD 3000 2600 XX | 3000 | 2600 | 3100 | 2700 | 2620 |
| OD 3000 2800 XX | 3000 | 2800 | 3100 | 2900 | 2820 |
| OD 3000 3000 XX | 3000 | 3000 | 3100 | 3100 | 3020 |

XX — the door panel's thickness (in the standard version 80, 100 or 120 mm).

*Figure 42. Door panels OD (on the left – without threshold, on the right – with threshold).*

*Aperture width (A) + 100 mm* *Aperture width (A) + 100 mm*

*Aperture Height (B) + 20 mm* *Aperture Height (B) + 20 mm*




Door panels OD are equipped with the lay on metal frame (View Figures 43, 44), which in this case is not a bearing element but serves for the tighter fit of the door leaf to the aperture. The standard lay on frame is produced of 2 mm thick cold rolled sheet steel and it is coated with the powder enamel of the RAL 9003 white color. The manufacturing of the frame from the AISI 304 or AISI 430 stainless steel is also possible. The frame is mounted to the external wall of the door aperture with the use of the mounting hardware kit, supplied along with the door.

The dimensions of the metal frame depend on the dimensions of the aperture (view Figure 43):

- Frame width = aperture width + 300 mm,
- Frame height = aperture height + 150 + threshold height.

*Figure 43. Metal frame for the sliding door with the aperture width ≤ 1200 mm (on the left – without threshold, on the right – with threshold).*

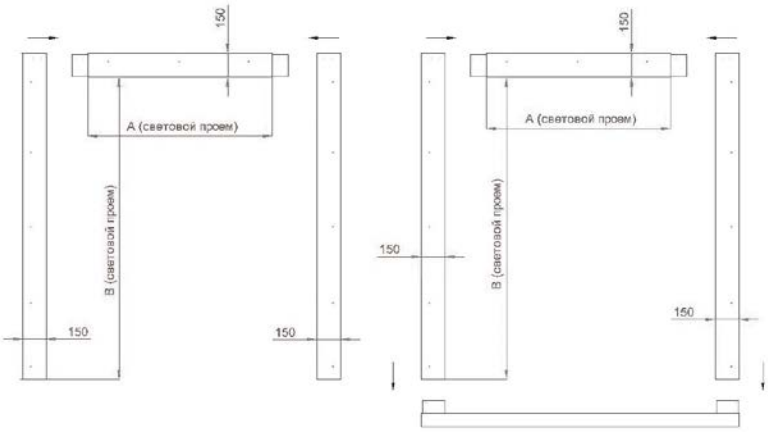



Figure 44. Metal frame for the sliding door with the aperture width >1200 mm (on the left – without threshold, on the right – with threshold).

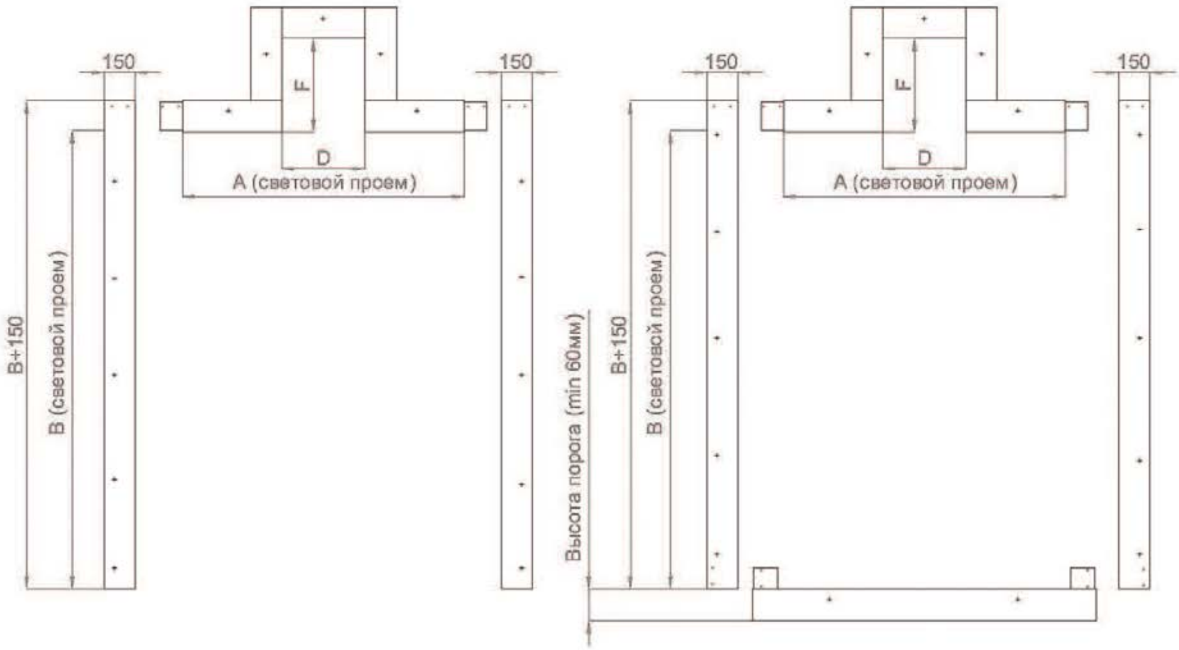
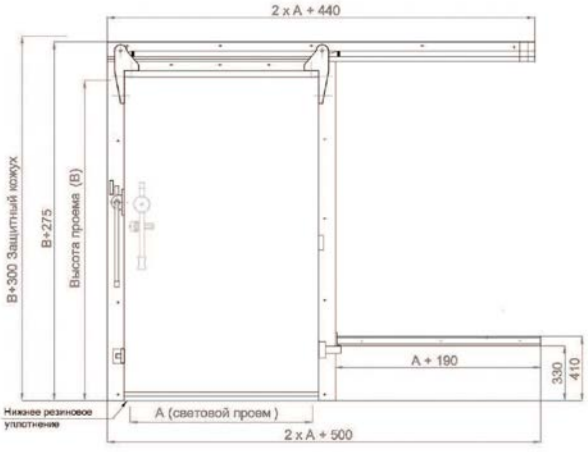


Figure 45. OD sliding door equipped with the lay on metal frame, lower and upper guides: 1 – upper guiding profile, 2 – lower guiding profile.

A (Aperture)
B (Aperture)

A (Aperture)
B (Aperture)
Threshold height




**Installation procedure of the sliding door guides.**

The upper guide is supplied assembled and is completely ready for installation.
- Set the guide by level and mark the holes for the fixing bolts (drill the wall through, d11 mm).
- Enlarge the holes d10 inside the chamber up to d20 with the depth 20-30 mm for the insulating nuts.
- Fix the guide with the Ericson's nut outside and with the insulating nut and washer inside.
- Check the frame's level and tighten the nuts (do not exaggerate).
- Fix the lower guide to the frame in the previously drilled holes, using the wood screws 4,2 x 30.
- Mark the holes for the fixing of the lower guide to the wall.
- Remove the lower guide and drill the holes through the wall, d10 mm, and enlarge them up to d20 with the depth 20-30 mm for the insulating nuts.
- Perform the final installation of the lower guide, check the level and tighten (view Figure 48).
- Unpack the door and hang it on the guides.
- Regulate the clearance between the rubber sealing gasket and the frame by means of the upper rollers (up-down regulation and further or closer to the frame), of the lower roller (only further or closer to the frame), and of the lower catcher (further or closer to the frame).

*Figure 46. Fixing of the upper guide and protective shell:*
*1 – Wall sandwich panel, 2 – lay on metal frame of the door,*
*3 – screw, 4 – guide's protective shell.*

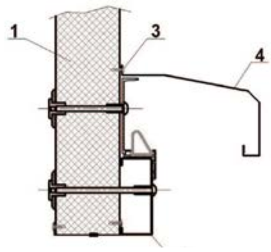


*Figure 47. Fixing of the upper guide from the door opening side:*
*1 – Wall sandwich panel, 2 – sliding door's upper guide, 3 – A wooden fillet is "hammered" inside the guide which holds the flank of the protective shell.*

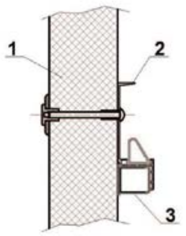



*Figure 48. Fixing of the door's lower guide:*
*1 – Wall sandwich panel, 2 – sliding door's lower guide, 3 – the lower guide is fixed on both sides with the insulating nut (an insulating washer is put under the nut on the internal side).*

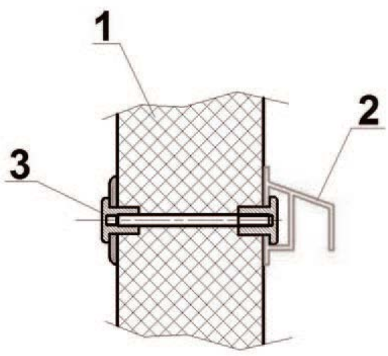



Table 36. Items included in the mounting hardware kit for the sliding doors

| | Aperture height < 2800 mm | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 200 | 2200 | 2400 | 2600 | 2800 |
| Insulating nut | 20 | 20 | 24 | 25 | 25 | 25 | 26 | 30 | 34 | 35 | 35 |
| Insulating washer | 18 | 18 | 21 | 22 | 22 | 22 | 23 | 26 | 29 | 30 | 30 |
| Ericson's nut | 16 | 16 | 18 | 19 | 19 | 19 | 20 | 22 | 24 | 25 | 25 |
| Stud M8* (XX+40) mm | 12 | 12 | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 15 | 15 |
| Stud M8* XX mm | 6 | 6 | 9 | 9 | 9 | 9 | 9 | 12 | 15 | 15 | 15 |
| Anchor bolt D 10** | 18 | 18 | 21 | 22 | 22 | 22 | 23 | 26 | 29 | 30 | 30 |
| | Aperture height > 2800 mm | | | | | | | | | | |
| Insulating nut | 22 | 22 | 26 | 27 | 27 | 27 | 28 | 32 | 36 | 37 | 37 |
| Insulating washer | 20 | 20 | 23 | 24 | 24 | 24 | 25 | 28 | 31 | 32 | 32 |
| Ericson's nut | 18 | 18 | 20 | 21 | 21 | 21 | 22 | 24 | 26 | 27 | 27 |
| Stud M8* (XX+40) mm | 14 | 14 | 14 | 15 | 15 | 15 | 16 | 16 | 16 | 17 | 17 |
| Stud M8* XX mm | 6 | 6 | 9 | 9 | 9 | 9 | 9 | 12 | 15 | 15 | 15 |
| Anchor bolt D 10** | 20 | 20 | 23 | 24 | 24 | 24 | 25 | 28 | 31 | 32 | 32 |

*XX — thickness of the sandwich panel on which the door is fixed.

**Anchor bolt is used when fixing the door to the concrete or brick wall. In this case, the mounting hardware kit consists only of anchor bolts.

For the detailed description of the variants of refrigeration doors fixing, view § 5.6.

## §5.5. DOUBLE HINGED DOORS RDD. GENERAL INFORMATION ON THE ITEM.

*Table 39. Standard sizes of Profholod's double hinged doors*

| Door type (XX - panel's thickness) | Aperture width | Aperture height | Leaf width | leaf height | |
|---|---|---|---|---|---|
| | | | | with threshold | without threshold |
| RDD 1200 1800 XX | 1200 | 1800 | 1300 | 1900 | 1830 |
| RDD 1200 1900 XX | 1200 | 1900 | 1300 | 2000 | 1930 |
| RDD 1200 2000 XX | 1200 | 2000 | 1300 | 2100 | 2030 |
| RDD 1200 2100 XX | 1200 | 2100 | 1300 | 2200 | 2130 |
| RDD 1200 2200 XX | 1200 | 2200 | 1300 | 2300 | 2230 |
| RDD 1200 2300 XX | 1200 | 2300 | 1300 | 2400 | 2330 |
| RDD 1200 2400 XX | 1200 | 2400 | 1300 | 2500 | 2430 |
| RDD 1400 1800 XX | 1400 | 1800 | 1500 | 1900 | 1830 |
| RDD 1400 1900 XX | 1400 | 1900 | 1500 | 2000 | 1930 |
| RDD 1400 2000 XX | 1400 | 2000 | 1500 | 2100 | 2030 |
| RDD 1400 2100 XX | 1400 | 2100 | 1500 | 2200 | 2130 |
| RDD 1400 2200 XX | 1400 | 2200 | 1500 | 2300 | 2230 |
| RDD 1400 2300 XX | 1400 | 2300 | 1500 | 2400 | 2330 |
| RDD 1400 2400 XX | 1400 | 2400 | 1500 | 2500 | 2430 |
| RDD 1600 1800 XX | 1600 | 1800 | 1700 | 1900 | 1830 |
| RDD 1600 1900 XX | 1600 | 1900 | 1700 | 2000 | 1930 |
| RDD 1600 2000 XX | 1600 | 2000 | 1700 | 2100 | 2030 |
| RDD 1600 2100 XX | 1600 | 2100 | 1700 | 2200 | 2130 |
| RDD 1600 2200 XX | 1600 | 2200 | 1700 | 2300 | 2230 |
| RDD 1600 2300 XX | 1600 | 2300 | 1700 | 2400 | 2330 |
| RDD 1600 2400 XX | 1600 | 2400 | 1700 | 2500 | 2430 |
| RDD 1800 1800 XX | 1800 | 1800 | 1900 | 1900 | 1830 |
| RDD 1800 1900 XX | 1800 | 1900 | 1900 | 2000 | 1930 |
| RDD 1800 2000 XX | 1800 | 2000 | 1900 | 2100 | 2030 |
| RDD 1800 2100 XX | 1800 | 2100 | 1900 | 2200 | 2130 |
| RDD 1800 2200 XX | 1800 | 2200 | 1900 | 2300 | 2230 |
| RDD 1800 2300 XX | 1800 | 2300 | 1900 | 2400 | 2330 |
| RDD 1800 2400 XX | 1800 | 2400 | 1900 | 2500 | 2430 |
| RDD 2000 1800 XX | 2000 | 1800 | 2100 | 1900 | 1830 |
| RDD 2000 1900 XX | 2000 | 1900 | 2100 | 2000 | 1930 |
| RDD 2000 2000 XX | 2000 | 2000 | 2100 | 2100 | 2030 |
| RDD 2000 2100 XX | 2000 | 2100 | 2100 | 2200 | 2130 |
| RDD 2000 2200 XX | 2000 | 2200 | 2100 | 2300 | 2230 |
| RDD 2000 2300 XX | 2000 | 2300 | 2100 | 2400 | 2330 |
| RDD 2000 2400 XX | 2000 | 2400 | 2100 | 2500 | 2430 |
| RDD 2200 1800 XX | 2200 | 1800 | 2300 | 1900 | 1830 |
| RDD 2200 1900 XX | 2200 | 1900 | 2300 | 2000 | 1930 |

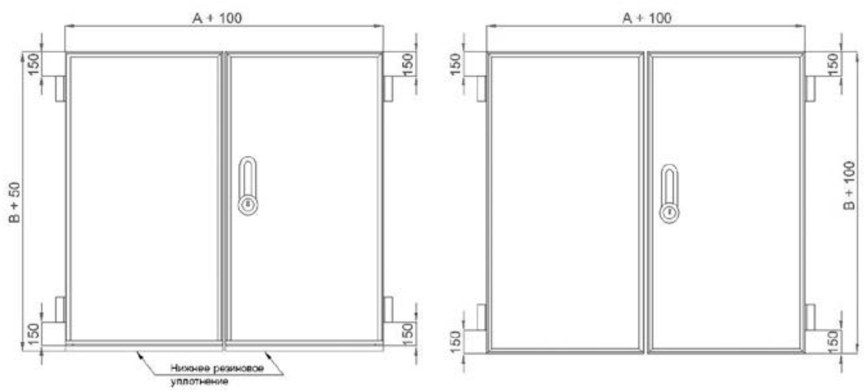
| | | | | | |
|---|---|---|---|---|---|
| RDD 2200 2000 XX | 2200 | 2000 | 2300 | 2100 | 2030 |

Table 39 (ending). Standard sizes of Profholod's double hinged doors

| Door type (XX - panel's thickness) | Aperture width | Aperture height | Leaf width | leaf height | |
|---|---|---|---|---|---|
| | | | | with threshold | without threshold |
| RDD 2200 2100 XX | 2200 | 2100 | 2300 | 2200 | 2130 |
| RDD 2200 2200 XX | 2200 | 2200 | 2300 | 2300 | 2230 |
| RDD 2200 2300 XX | 2200 | 2300 | 2300 | 2400 | 2330 |
| RDD 2200 2400 XX | 2200 | 2400 | 2300 | 2500 | 2430 |
| RDD 2400 1800 XX | 2400 | 1800 | 2500 | 1900 | 1830 |
| RDD 2400 1900 XX | 2400 | 1900 | 2500 | 2000 | 1930 |
| RDD 2400 2000 XX | 2400 | 2000 | 2500 | 2100 | 2030 |
| RDD 2400 2100 XX | 2400 | 2100 | 2500 | 2200 | 2130 |
| RDD 2400 2200 XX | 2400 | 2200 | 2500 | 2300 | 2230 |
| RDD 2400 2300 XX | 2400 | 2300 | 2500 | 2400 | 2330 |
| RDD 2400 2400 XX | 2400 | 2400 | 2500 | 2500 | 2430 |

XX — the door panel's thickness (in the standard version 80, 100 or 120 mm).

Figure 49. RDD door panels (on the left – without threshold, on the right – with threshold).
A (Aperture) A (Aperture)
B (Aperture) B (Aperture)
*Threshold height*




Double hinged doors are fixed only with the use of the lay on metal frame. The standard lay on frame is produced of 2 mm thick cold rolled sheet steel and it is coated with the powder enamel of the RAL 9003 white color. The manufacturing of the frame from the AISI 304 or AISI 430 stainless steel is also possible. The frame is mounted to the external wall of the door aperture with the use of the mounting hardware kit, supplied along with the door.

The dimensions of the metal frame depend on the dimensions of the aperture:

• Frame width = aperture width + 240 mm,
• Frame height = aperture height + 120 + threshold height.

Table 36. Items included in the mounting hardware kit

| Description | Fixing to sandwich panel | Fixing to concrete wall |
|---|---|---|
| | Quantity | Quantity |

| | aperture width < 1200 mm | aperture width = 1200 mm | aperture width < 1200 mm | aperture width = 1200 mm |
|---|---|---|---|---|
| Insulating nut | 12 | 13 | 0 | 0 |
| Insulating washer | 12 | 13 | 0 | 0 |
| Ericson's nut | 12 | 13 | 0 | 0 |
| Stud M8* | 12 | 13 | 0 | 0 |
| Anchor bolt D 10 | 0 | 0 | 12 | 13 |

* The length of the stud is equal to the thickness of the panel, on which the door is fixed + 20 mm.

## §5.6. GENERAL PRINCIPLES OF PROFHOLOD'S REFRIGERATION DOORS MOUNTING

Door mounting procedure and aperture preparation:

1. Mark the aperture's location on the sandwich panel wall with the +5 mm allowance in width and height.
2. Drill the d10 mm through holes in the angles and cut the aperture contour with the electric jigsaw.
3. Prepare the aperture framing and install it (fig. 53).
4. Install the frame on its place by level and mark the holes for the fixing bolts (make the through holes in the wall through the hole in the frame with the d10 mm drill).
5. Enlarge from inside the chamber the d10 mm holes up to d20 mm with the depth of 20-30 mm, to put the insulating nuts.
6. If necessary, after the frame assembling and hole marking, the frame heating element is placed on the internal side of the frame (with the use of the aluminum adhesive band) (view fig. 54).
7. Fix the frame to its location, put the Ericson's nut on the external side and on the internal side – the insulating nut and insulating washer.
8. Check the frame level and tighten the nuts (do not exaggerate).
9. The connection of the heating element is made according to the attached scheme (view fig. 58).

Every fixing element consists of an insulating nut, insulating washer, Ericson's nut and threaded stud M8, whose length is determined by the thickness of the wall (view fig. 52).

The door panels should not be exposed to the sun light; the distance from the nearest heating units during the operation must be at least 2 meters. Maintenance, regulation, trouble shooting and sanitary treatment works should be performed with the door unit disconnected from the main power system. At the end of the service life, it is strictly forbidden to dispose of the heat insulation material - polyurethane - through incineration.

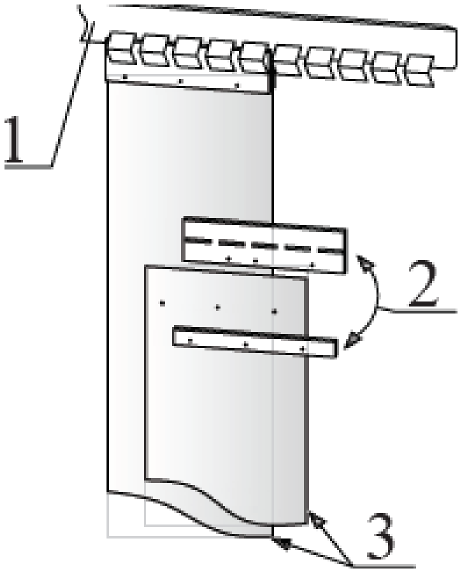
The variant of the lay on metal frame fixing, when we have a heat-insulated "deep aperture" in the existing brick or concrete wall, is demonstrated above (figure 57).

## §5.7. PVC STRIP CURTAINS

Heating or refrigerating of industrial, commercial, storage facilities, refrigerating warehouses and chambers, - are among the main energy consumption factors. Such costs grow considerably due to the frequent door opening. Installing the transparent PVC strip curtain in the door aperture helps to reduce noticeably the energy consumption in such cases.

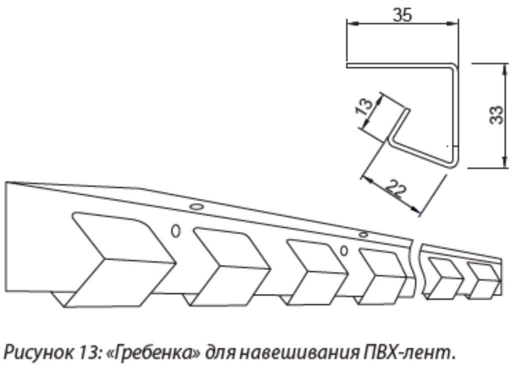
- the use of the PVC strip curtains reduces the loss of heat and chill up to 50%;
- the use of the PVC strip curtains protects against dust and odor;
- PVC strip curtains do not reduce the illumination intensity of the room due to its transparent material;
- The curtains do not obstacle the passage of people and transport thanks to their flexibility;
- PVC curtains are simple in cleaning (water and detergents).

*Figure 59. PVC curtain fixing in the door aperture*



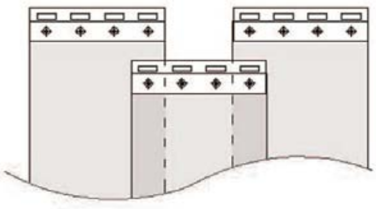

The PVC curtains offered by “ProfHolod represent a metal “comb” made of 1,5 mm thick stainless steel AISI 304, on which are hanged the strips of transparent PVC having the thickness of 2 or 3 mm, and the width of 200 or 300 mm.

Figure 60. “Comb” for hanging the PVC strips.

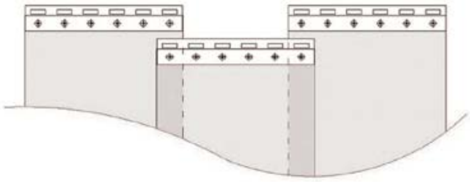



To be hanged, the PVC strips are clamped between the stainless steel plates by means of blind rivets.

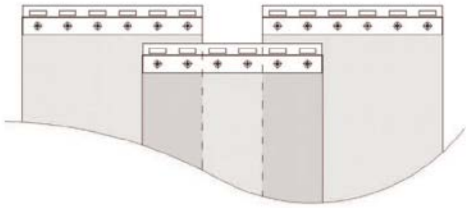
*PVC 200 x 2 Overlap 50 mm (50%)*



*PVC 300 x 3 Overlap 50 mm (33%)*



*PVC 300 x 3 Overlap 100 mm (67%)*



*PVC 300 x 3 Overlap 150 mm(100%)*

*Figure 61. 200 and 300 mm wide PVC strips with different overlaps.*

We use the following notation for the description of PVC curtains:

| Door type: RDO, RDOP, RDD or OD | Total curtain width, mm | Door aperture height, mm | Low-temperature | PVC strips width, mm | PVC strips thickness, mm | Overlap (%) |
|---|---|---|---|---|---|---|
| PVC (AISI) | XXXX | XXXX | H | XXX | X | XXX |

**§5.8. ARRANGEMENT OF THE DOOR APERTURE IN THE REFRIGERATING CHAMBERS EQUIPPED WITH THE MONORAIL**

All the hinged (RDO, RDOP, RDD) doors manufactured by ProfHolod, can be equipped with the metal frame with the pilot hole for the monorail.

*Figure 62. Preparation of the aperture for the door with the monorail*

Such a frame is fixed in the same way as the normal one, as described in § 5.6 on page 77.

The frames with the aperture width up to 1200 mm and not more than 2800 inclusive, are supplied completely assembled (view Figure 22).

The frames with the aperture width more than 1200 mm are disassembled and the number of the parts they consist of depends on the aperture height.

The parts of the fabricated frame are fixed with each other with the use of supplied bolts.

## §5.9. TRANSPORTATION AND STORAGE OF REFRIGERATION DOORS

The transportation of the door kits must be performed in original packages. Shocks and blows on the door panel surface during the loading and unloading are not allowed. The transportation can be carried out by any kind of transport, allowing the rigid fixation of the items. Doors and door units should not be exposed to intense sun light. The distance to the nearest heating units must be at least 2 meters.

# CHAPTER 6. MOUNTING OF SANDWICH PANELS (STRUCTURAL UNITS)

## §6.1. MOUNTING THE PUR/PIR SANDWICH PANELS ON THE METALWORK. STRUCTURAL UNITS

Structural and roofing sandwich panels offered by ProfHolod company are an excellent solution for the erection of:
• industrial facilities;
• agricultural buildings;
• food industry premises;
• logistic centers;
• office buildings;
• sport facilities etc.

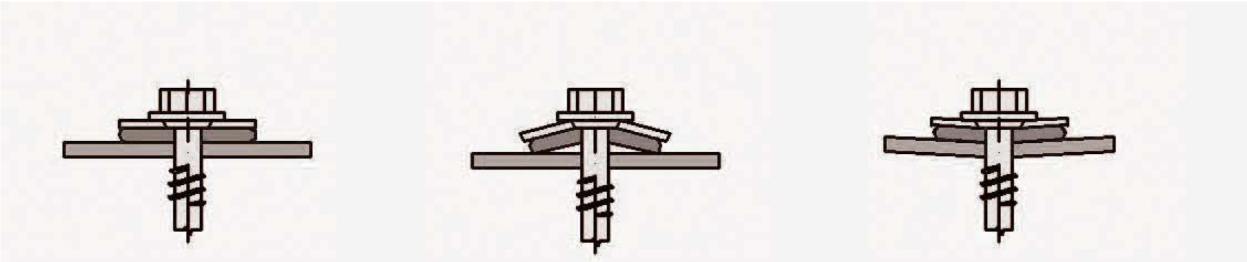
Wall sandwich panels can be also used both as the façade enclosures and partitions and as the ceiling panels. Due to their light weight and easy mounting, the sandwich panel buildings are erected very quickly and have a relatively low cost.

The mounting of the sandwich panels can be either vertical, or horizontal, depending on the design. According to the common rule, the horizontal panel placement must be carried out from the bottom to the top putting the “tongue” up, and the vertical mounting should start from the corner of the building. Prior to the mounting, it is necessary to check the mounted panel’s surface. The sealing band should be stuck on the external side of the metal columns and beams. The sealing band is stuck in order to ensure the air permeability and reduction of sound vibration. The sealing band should be stuck on the edge of the structures so that consequently the screws don’t touch it. The panel is mounted on the metalwork with the self-drilling wood screws, the quantity of which is normally specified in the design documentation (normally, the panel is fixed to every vertical column or horizontal beam with three screws with the 400 mm spacing). The length of the screws is determined by the metalwork thickness and the thickness of the mounted panels (view Table 41). It is important to make sure that the screws are fixed correctly (view Figure 68).

Figure 66. Industrial building with the horizontal panel placement (Moscow region, Shelkovo town).

Figure 67. Sandwich panel building with the vertical placement (Moscow region, Reutov town).

Figure 67. Correct screw positions. 1 – correct, 2 – too loose, 3 – too tight.



Between the edges of two panels a technological gap should be left, which is also filled with the spray foam. In case of the building with elevated fire safety requirements, it is filled with asbestos or basalt cloth or mineral wool and consequently, is closed with the flashing. After the panel mounting all the gaps between the panels and also, between the panels and shaped profiles are sealed with the sealant for outdoor works. Since the supplied flashings have the standard length of 2500 mm, they should be fixed with the overlap, sealing the junctions. Normally, the placement of flashings starts from the bottom of the building and ends up at the ridge.

Here are the main requirements for the mounting:

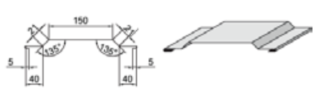
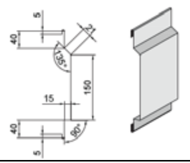
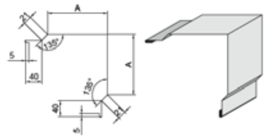
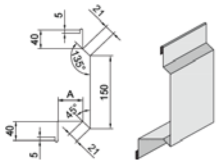
• The cutting of the panels with the thermal lance during the mounting is not allowed.
• The hole drilling in the panels while placing the fixing hardware should be performed with electric instruments. The hole axes must be perpendicular to the plane of the panels.
• Not allowed are the blows to the panels during the mounting, hardware placement, gaps and junctions sealing.
• It is forbidden to fix to the panels: stairs, industrial wiring, production equipment and structural reinforcements.
• The surface of the panel's metal sheets should be cleaned from the dirt and dust with the use if detergents, which do not cause damage to the sheet's protection layer.
• It is forbidden to clean and wash the surface of the panels with the use of sand, alkali and other substances which may cause damage to the sheet's protection layer.

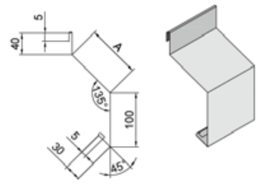
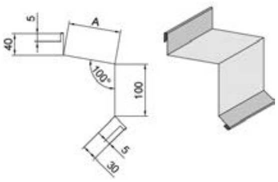
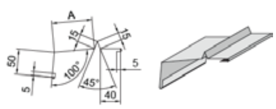
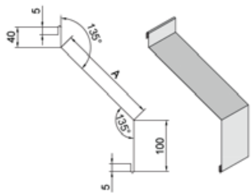
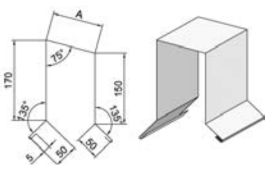
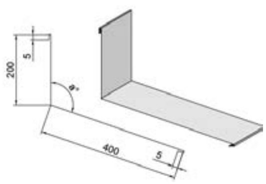
Table 41. Self-drilling screws with the chilled carbon steel double thread, steel washer and vulcanized GUNNEBO gasket.

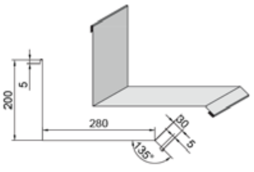
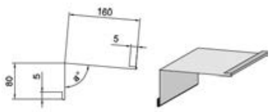
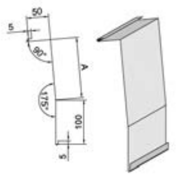
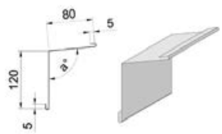
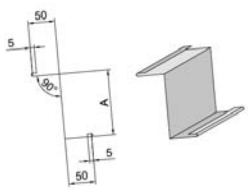
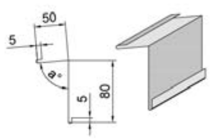
| Panel thickness | Diameter and length d x L, mm | Article code (structure thickness up to 6 mm) | Article code (structure thickness up to 12mm) |
|---|---|---|---|
| 60-80 | 5,5 × 110 | P1531100PL | P1P1551100PL |
| 80-100 | 5,5 × 125(130) | P1531250PL | P1P1551300PL |
| 100-120 | 5,5 × 150 | P1531500PL | P1P1551500PL |
| 120-150 | 5,5 × 175 (185) | P1531750PL | P1P1551850PL |
| 140-180 | 5,5 × 200(230) | P1532000PL | P1P1552300PL |
| 150-200 | 5,5 × 230 | P1532300PL | P1P1552300PL |

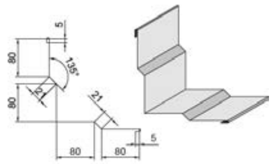
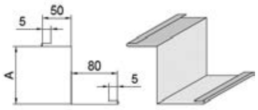
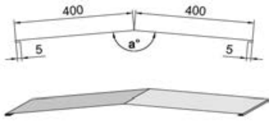
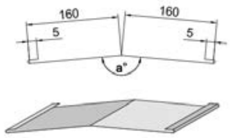
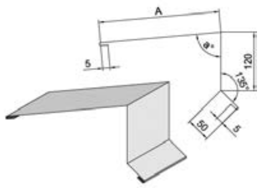
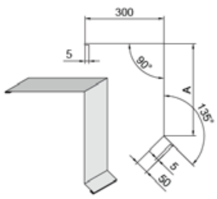
We demonstrate below the main units inherent in the erection of the structures built with sandwich panels and metalwork, either with the horizontal, or the vertical mounting.

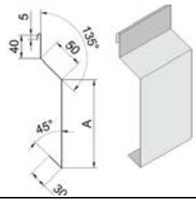
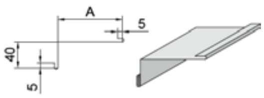
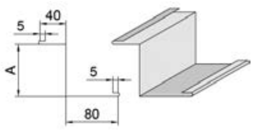
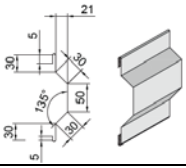
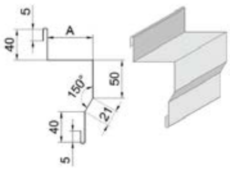
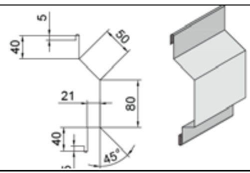
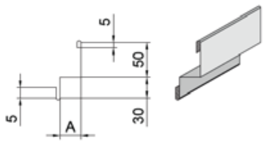
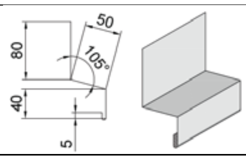
Structural units and shaped profiles(flashings)

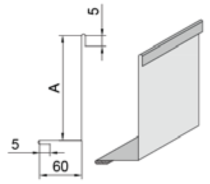
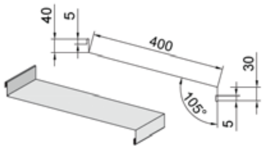
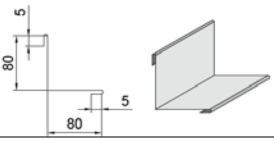
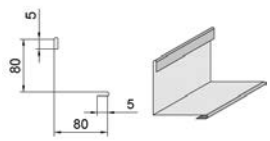
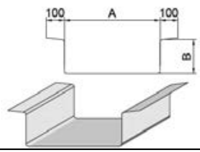
| Shaped profile number (FE No) | Nomenclature | Sketch | A (mm) / α (degrees | Weight of 1 meter (kg) | Location (Unit No) |
|---|---|---|---|---|---|
| FE 1 | FE 40x21x150x21x40 Zn-Ral 9003* (10-10) |  | - | 1,03 | Sandwich panels vertical junction (Unit 1) |
| FE 2 | FE 40x21x150x21x40 Zn-Ral 9003* (10-10) |  | - | 0,96 | Sandwich panels horizontal junction (Unit 1) |
| FE 3 | FE 40x21xAxAx21x40 Zn-Ral 9003* (10-10) |  | 100 | 0,85 | External building corner (Unit 2) |
| | | | 120 | 0,93 | |
| | | | 140 | 1,00 | |
| | | | 160 | 1,07 | |
| | | | 180 | 1,14 | |
| | | | 200 | 1,21 | |
| | | | 220 | 1,28 | |
| | | | 240 | 1,35 | |
| | | | 260 | 1,42 | |
| | | | 280 | 1,49 | |
| FE 4 | FE 40x21x150x21xAx40 Zn-Ral 9003* (10-10) |  | According to the design | - | Socle (Unit 4) |

| | | | | | |
|---|---|---|---|---|---|
| FE 5 | FE 40xAx100x30 Zn-Ral 9003* (10-10) |  | According to the design | - | Socle (Unit 3) |
| FE 6 | FE 40xAx100x30 Zn-Ral 9003* (10-10) |  | According to the design | - | Socle (Unit 4) |
| FE 7 | FE 50xAx15x15x40 Zn-Ral 9003* (10-10) |  | According to the design | - | Socle (Unit 3) |
| FE 8 | FE 40xAx100 Zn-Ral 9003* (10-10) |  | According to the design | - | Socle (Unit 3, Unit 4) |
| FE 9 | FE 50x170xAx150x50 Zn-Ral 9003* (10-10) |  | 84 | 1,85 | Parapet (Unit 5, Unit 6) |
| | | | 105 | 1,93 | |
| | | | 126 | 2,00 | |
| | | | 146 | 2,07 | |
| | | | 157 | 2,11 | |
| | | | 167 | 2,15 | |
| | | | 188 | 2,22 | |
| | | | 208 | 2,29 | |
| FE 10 | FE 200x400 Zn-Ral 9003* (10-10) |  | According to the design | 2,19 | Parapet adjacency to the roof (Unit 5) |

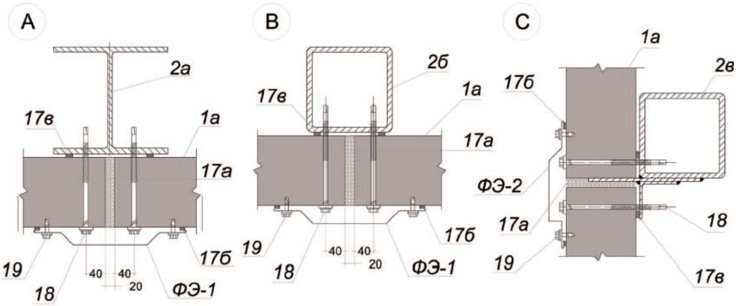
| | | | | | |
|---|---|---|---|---|---|
| FE 11 | FE 200x280x30 Zn-Ral 9003* (10-10) |  | According to the design | 1,77 | Parapet adjacency to the roof from the side of the building (Unit 6) |
| FE 12 | FE 80x160 Zn-Ral 9003* (10-10) |  | According to the design | 0,92 | Adjacency of the roof to the wall (Unit 5, Unit 6) |
| FE 13 | FE 50xAx100 Zn-Ral 9003* (10-10) |  | According to the design | - | Junction between the longitudinal walls and roof (Unit 7) |
| FE 14 | FE 80x120 Zn-Ral 9003* (10-10) |  | According to the design | 0,78 | Adjacency of the roof to the wall (Unit 7, Unit 8) |
| FE 15 | FE 50xAx50 Zn-Ral 9003* (10-10) |  | According to the design | - | Junction between the longitudinal walls and roof (Unit 8) |
| FE 16 | FE 50x80 Zn-Ral 9003* (10-10) |  | According to the design | 0,53 | Junction between the longitudinal walls and roof (Unit 8) |

| | | | | | |
|---|---|---|---|---|---|
| FE 17 | FE 80x21x80x80x21x80 Zn-Ral 9003* (10-10) |  | - | 1,35 | Junction between the walls and roof at the building's height difference point (Unit 9) |
| FE 18 | FE 50xAx80 Zn-Ral 9003* (10-10) |  | According to the design | - | Junction between the walls and roof at the building's height difference point (Unit 9) |
| FE 19 | FE 400x400 Zn-Ral 9003* (10-10) |  | According to the design | 2,90 | Ridge junction (Unit 10) |
| FE 20 | FE 160x160 Zn-Ral 9003* (10-10) |  | According to the design | 2,90 | Ridge junction (Unit 10) |
| FE 21 | FE Ax120x50 Zn-Ral 9003* (10-10) |  | According to the design | - | Wall and roof junction on the building's side (Unit 12) |
| FE 22 | FE 300xAx50 Zn-Ral 9003* (10-10) |  | According to the design | - | Wall and roof junction on the building's side (Unit 13) |
| FE 23 | FE 40x50xAx30 Zn-Ral 9003* (10-10) | | 80 | 0,78 | Door or window drip cap (Unit 14, Unit 16) |
| | | | 100 | 0,85 | |
| | | | 120 | 0,92 | |

| | | | | | |
|---|---|---|---|---|---|
| | |  | 140 | 0,99 | |
| | | | 160 | 1,06 | |
| FE 24 | FE 30x20xA Zn-Ral 9003* (10-10) |  | According to the design | - | Window flashing (Unit 14, Unit 15) |
| FE 25 | FE 40xAx80 Zn-Ral 9003* (10-10) |  | According to the design | - | Window flashing (Unit 14) |
| FE 26 | FE 30x30x50x30x30 Zn-Ral 9003* (10-10) |  | - | 0,67 | Window or door flashing (Unit 15, Unit 17) |
| FE 27 | FE 40xAx50x21x40 Zn-Ral 9003* (10-10) |  | According to the design | - | Window flashing (Unit 15, Unit 16) |
| FE 28 | FE 40x50x80x30x5 Zn-Ral 9003* (10-10) |  | - | 0,95 | Drip cap (Unit 16) |
| FE 29 | FE 30x30x50 Zn-Ral 9003* (10-10) |  | - | 0,46 | Window flashing (Unit 16) |
| FE 30 | FE 80x50x40 Zn-Ral 9003* (10-10) |  | - | 0,67 | Door upper drip cap (Unit 17) |

| | | | | | |
|---|---|---|---|---|---|
| FE 31 | FE 60xA Zn-Ral 9003* (10-10) |  | According to the design | 0,81 | Gate frame adjacency (Unit 18) |
| FE 32 | FE 40xx400x40 Zn-Ral 9003* (10-10) |  | - | 1,77 | Gate upper drip cap (Unit 18) |
| FE 33 | FE 80x80 Zn-Ral 9003* (10-10) |  | - | 0,64 | Internal angle for partitions fixing (Unit 19) |
| FE 34 | FE 80x80 Zn-Ral 9003* (10-10) |  | - | 0,64 | Internal angle for partitions fixing (Unit 19) |
| FE 35 | FE 100 B A B A 100 |  | - | - | Drain water gutter (Unit 20) |

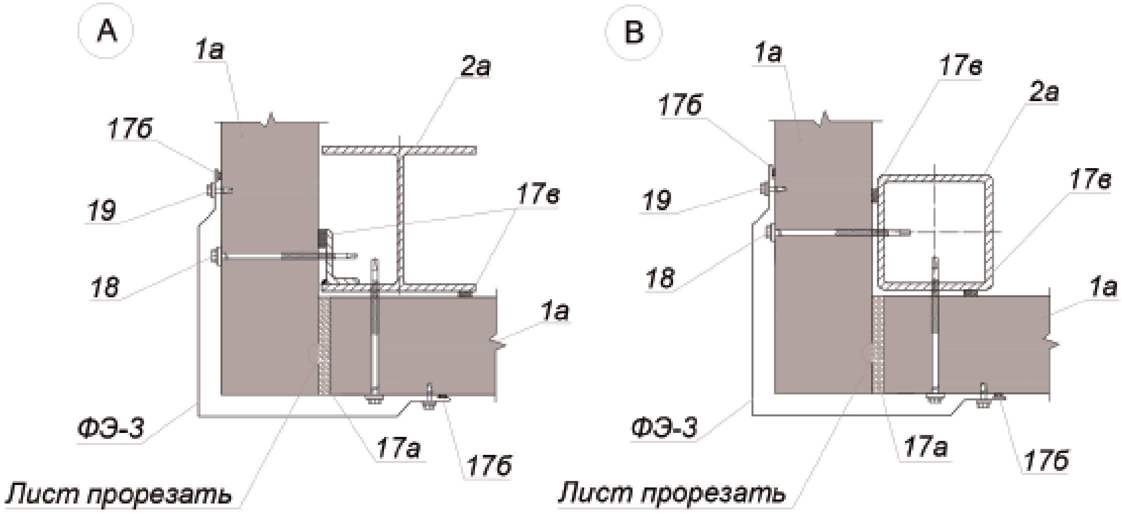
**UNIT 1**
A,B – vertical junction at horizontal mounting of wall panels,
C - horizontal junction at vertical mounting of wall panels.




Shaped profiles (flashings):
FE 1, 2
17a – spray foam;
1a — wall panel;
2 — metal skeleton structures:
2a — skeleton column;
2b— framework post;
2c — framework crossbar;
2d – surface sector;
2e – support angle (crossbar);

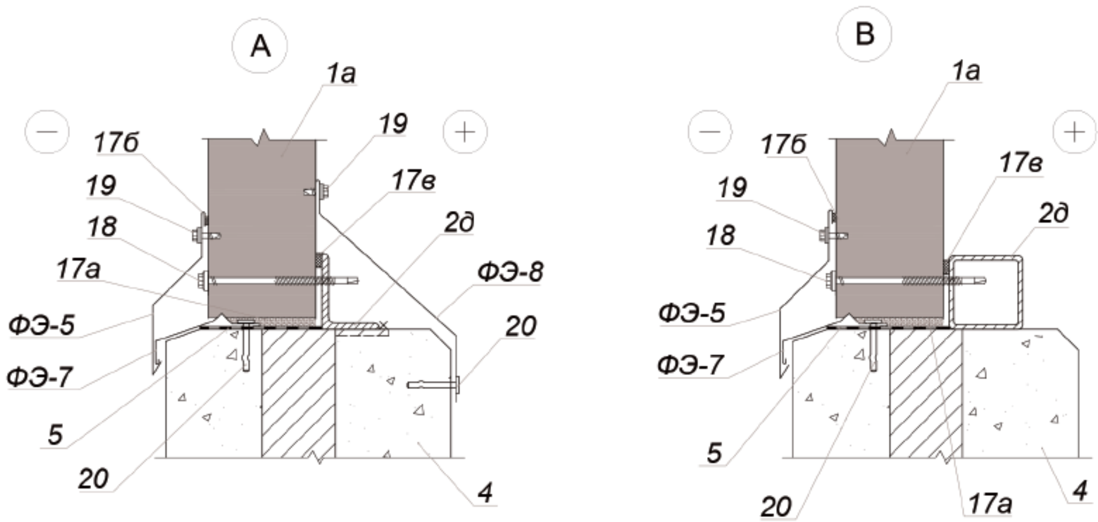
17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

**UNIT 2**
A,B – vertical angular junction at horizontal mounting of wall panels.




Shaped profiles (flashings):
FE 3
1a — wall panel;
2a — skeleton column;
17a – spray foam;
17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;
20 – anchor fixing hardware;
22 – removable part of the panel's facing

**UNIT 3**
A,B – fixing of the vertical panels to the building socle.



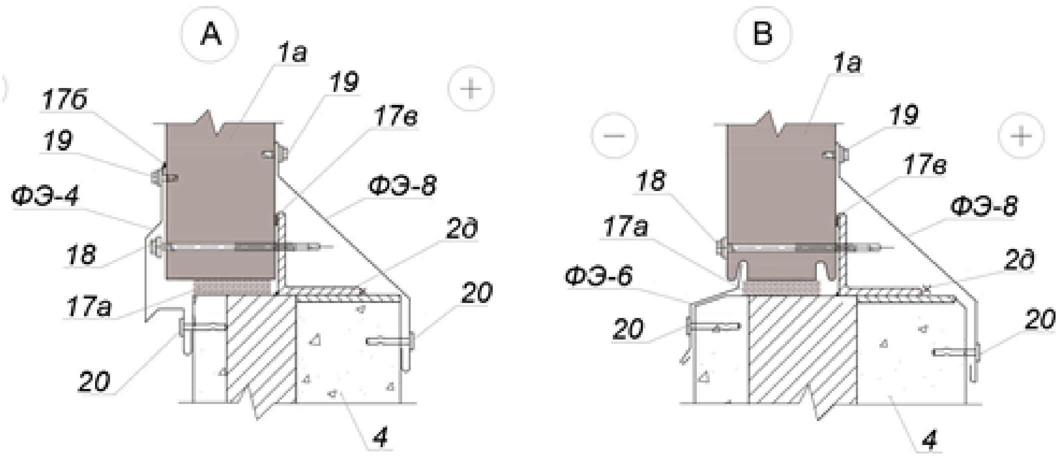

Shaped profiles (flashings): FE 5, 7, 8

5 – hydro-insulation;
17a – spray foam;
17b – silicon sealant for outdoor works;
1a — wall panel;
2 — metal skeleton structures:
2e – support angle (crossbar);
4 – socle with efficient heat insulator
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;
20 – anchor fixing hardware;

**UNIT 4**

A — fixing of the vertical panels to the building socle.

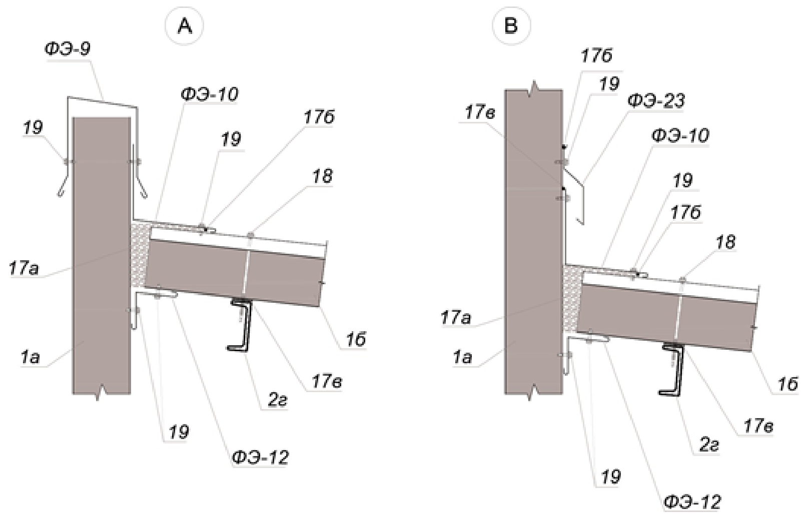
B — fixing of the horizontal panels to the building socle.




Shaped profiles (flashings): FE 4, 6, 8
5 – hydro-insulation;
17a – spray foam;
17b – silicon sealant for outdoor works;
1a — wall panel;
2e – support angle (crossbar);
4 – socle with efficient heat insulator
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;
20 – anchor fixing hardware;

**UNIT 5**

A — adjacency of the roof to the wall, B – adjacency of the roof to the wall (roof version with metal profiled sheets).

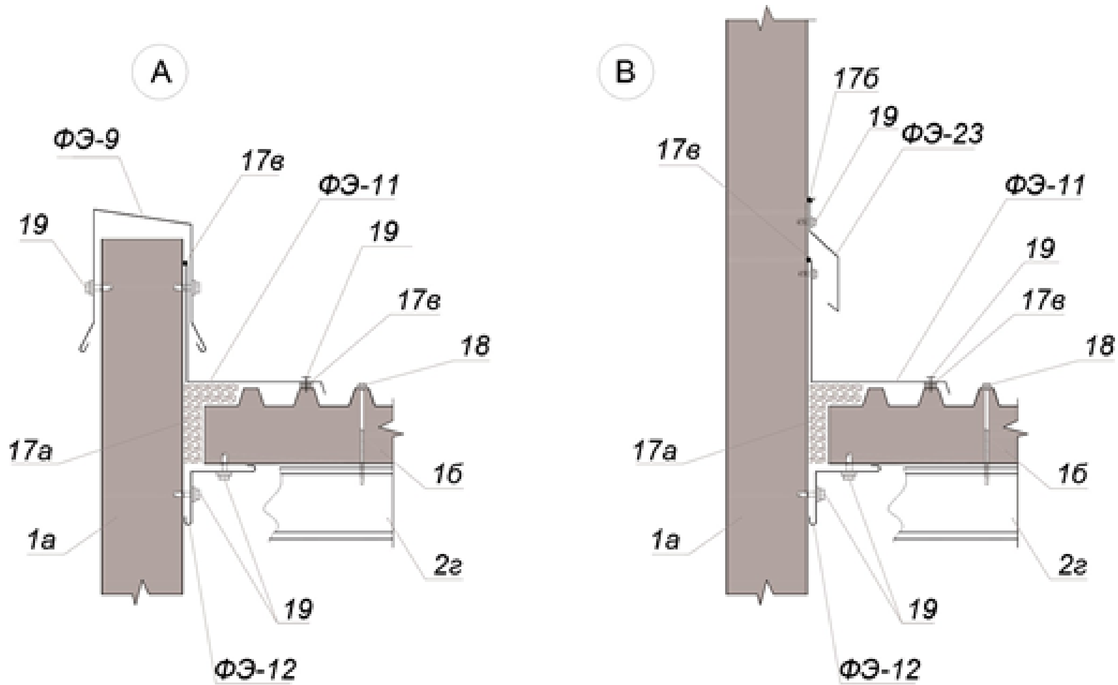



Shaped profiles (flashings): FE 9, 10, 12
13 – galvanized profiled sheet;
14 – steel band;
17a – spray foam;
17b – silicon sealant for outdoor works;
1a — wall panel;
1b – roofing panel;
2d – surface sector;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

**UNIT 6**

A — adjacency of the roof to the wall on the side of the building,

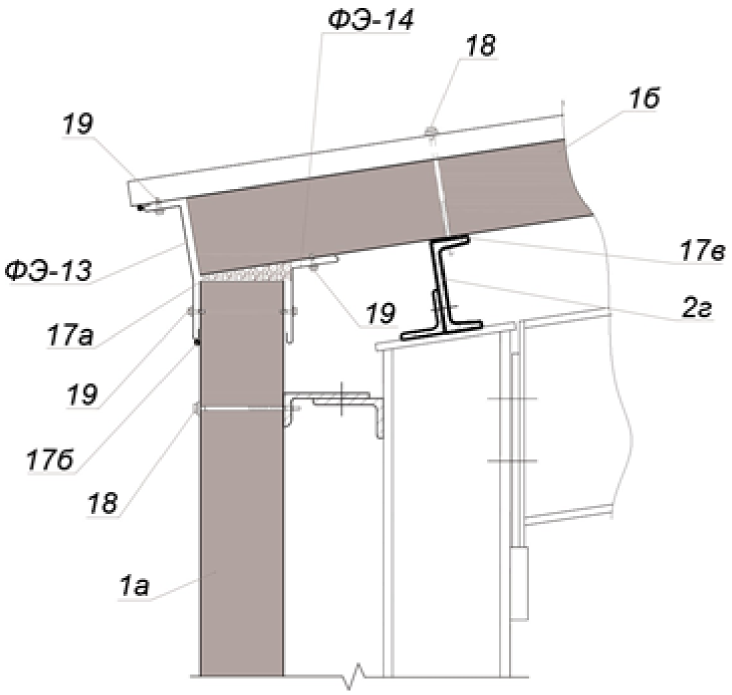
B —adjacency of the roof to the wall on the side of the building (roof version with metal profiled sheets).




Shaped profiles (flashings): FE 9, 11, 12
13 – galvanized profiled sheet;
14 – steel band;
17a – spray foam;
17b – silicon sealant for outdoor works
1a — wall panel;

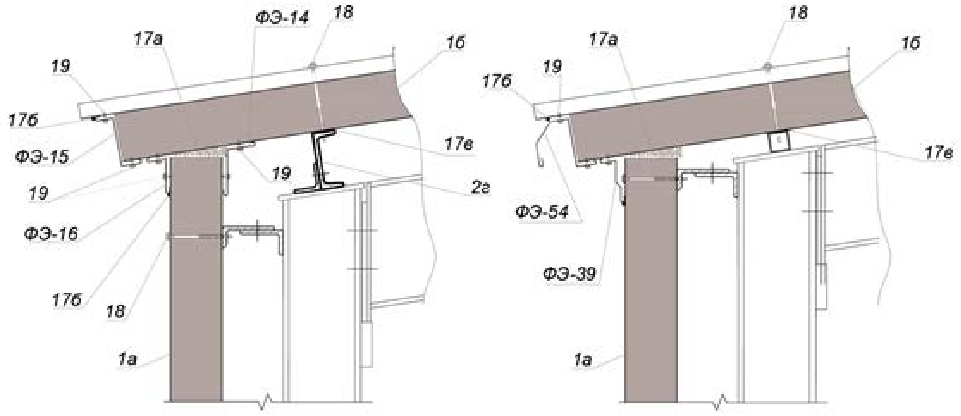
1b – roofing panel;
2d – surface sector;
2e – support angle (crossbar);
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

**UNIT 7**
Longitudinal junction between walls and roof (variant 1 of the building’s cornice).




Shaped profiles (flashings): FE 13, 14
2c — framework crossbar;
2d – surface sector;
2e – support angle (crossbar);
1 – “Sandwich” type panels:
1a – wall panel;
1b – roofing panel;
2 — metal skeleton structures:
2a — skeleton column;
2b— framework post;
13 – galvanized profiled sheet;
17a – spray foam;
17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

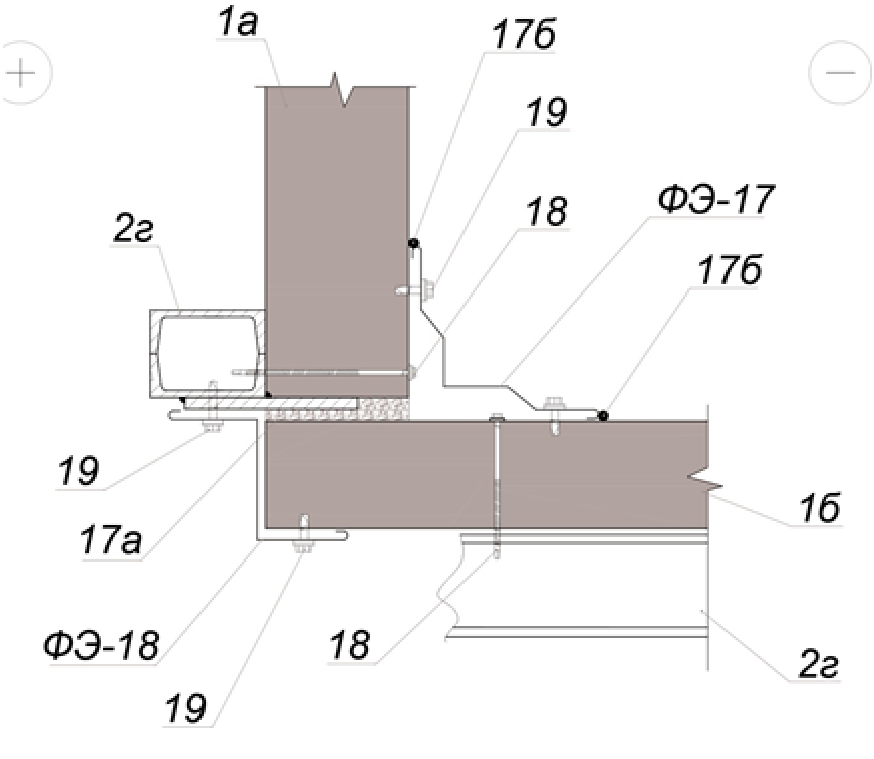
**UNIT 8**
Longitudinal junction between walls and roof (variant 2 of the building’s cornice).




Shaped profiles (flashings): FE 14, 15, 16
2b— framework post;
2d – surface sector;
2e – support angle (crossbar);
17a – spray foam;
1 – “Sandwich” type panels:
17b – silicon sealant for outdoor works
1a – wall panel;
1b – roofing panel;
2 — metal skeleton structures:
2a — skeleton column;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

**UNIT 9**

Junction between the walls and roof at the building's height difference point .

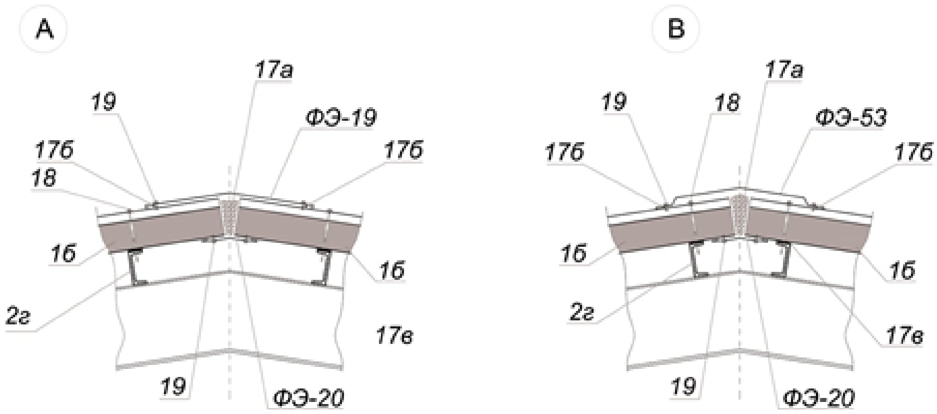



Shaped profiles (flashings): FE 17, 18
2c — framework crossbar;
2d – surface sector;
2e – support angle (crossbar);

1 – “Sandwich” type panels:
1a – wall panel;
1b – roofing panel;
2 — metal skeleton structures:
2a — skeleton column;
2b— framework post;

17a – spray foam;
17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

**UNIT 10**
A — building's ridge unit,
B — building's ridge unit (roof version with metal profiled sheets).




Shaped profiles (flashings):
FE 19, 20
2d – surface sector;
2e – support angle (crossbar);
13 – galvanized profiled sheet;
1 – “Sandwich” type panels:
1a – wall panel;
1b – roofing panel;
2 — metal skeleton structures:
2a — skeleton column;
2b— framework post;
2c — framework crossbar;

14 – steel band;
17a – spray foam;
17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

**UNIT 11**
A — roofing panels junction unit,
B —roofing panels junction unit, (roof version with the wall (roofing panels) and profiled metal sheets).


“1” Cut the heat insulator layer and the lower steel facing by the total width of the upper panel.
The junction previously must be filled with

2c — framework crossbar;
2d – surface sector;
2e – support angle (crossbar);

the spray foam.

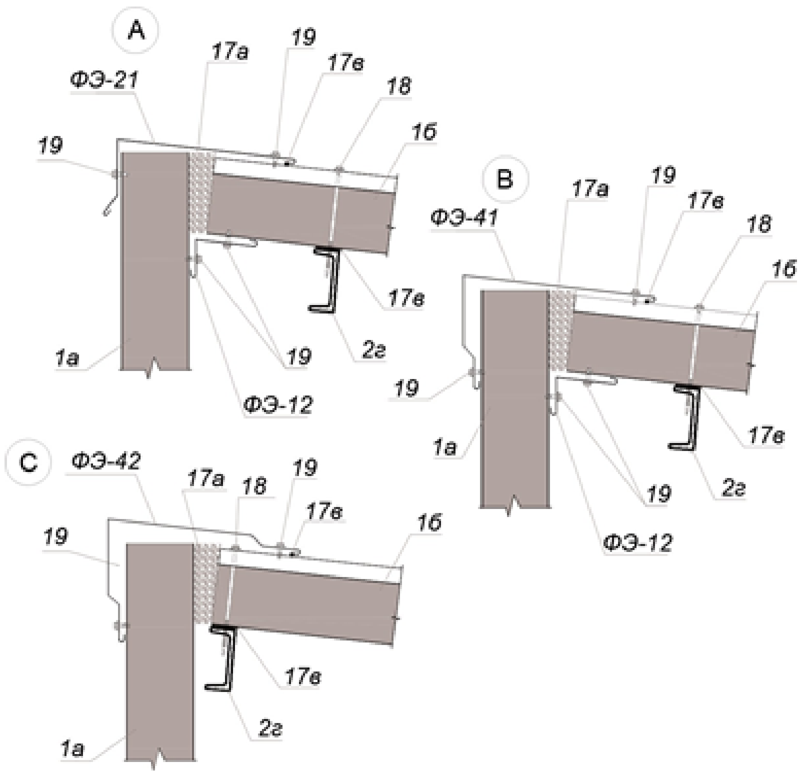
1 – “Sandwich” type panels:
1a – wall panel;
1b – roofing panel;
2 — metal skeleton structures:
2a — skeleton column;
2b— framework post;

14 – steel band;
17a – spray foam;
17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

**UNIT 12**

A —adjacency of the roof to the wall with the one slope roof,

B —adjacency of the roof to the wall with the one slope roof (roof version with metal profiled sheets).



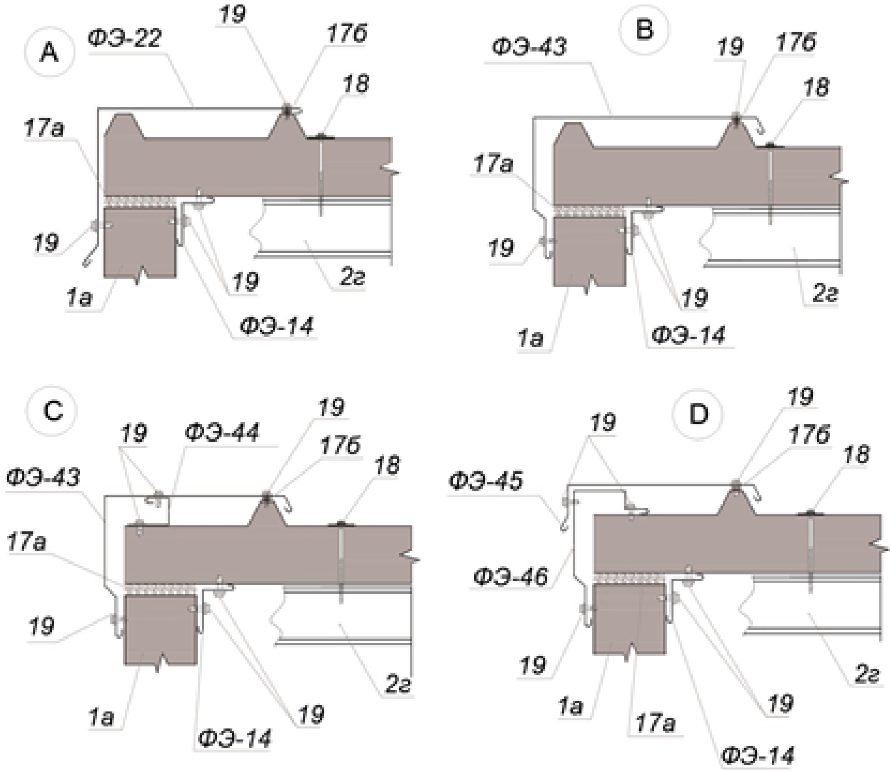

Shaped profiles (flashings):
FE 12, 21
2d – surface sector;
2e – support angle (crossbar);
5 – hydro – insulation;

1 – “Sandwich” type panels:
1a – wall panel;
1b – roofing panel;
2 — metal skeleton structures:
2a — skeleton column;
2b— framework post;
2c — framework crossbar;

13 – galvanized profiled sheet;
14 – steel band;
17a – spray foam;
17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

**UNIT 13**

A —adjacency of the roof to the wall at the side of the building with the one slope roof,
B —adjacency of the roof to the wall at the side of the building with the one slope roof (roof version with metal profiled sheets).




Shaped profiles (flashings):
FE 14, 22
2c — framework crossbar;
2d – surface sector;
2e – support angle (crossbar);

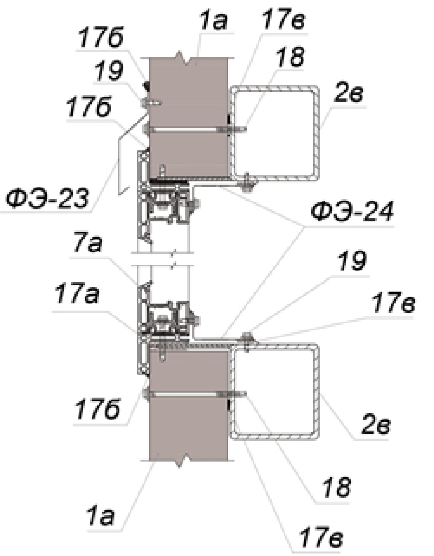
1 – “Sandwich” type panels:
1a – wall panel;
1b – roofing panel;
2 — metal skeleton structures:
2a — skeleton column;
2b— framework post;

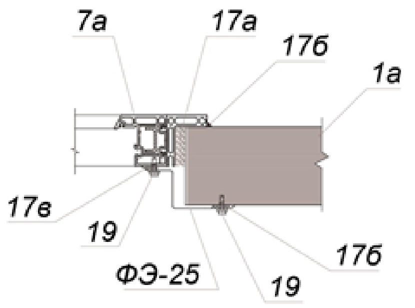
13 – galvanized profiled sheet;
14 – steel band;
17a – spray foam;
17b – silicon sealant for outdoor works;
18 – self-drilling wood screw;
19 – self-drilling screw;

## UNIT 14

A — plastic window fixing to the panels (vertical section),

B —plastic window fixing to the panels (horizontal section),



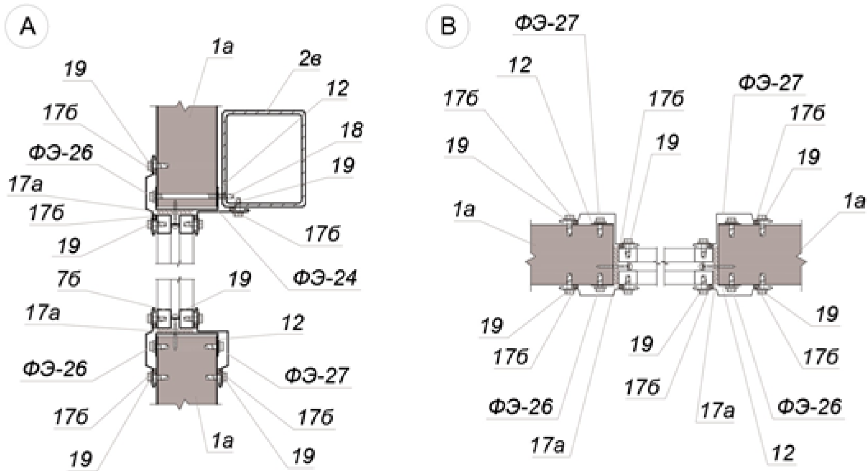




Shaped profiles (flashings):
FE 23, 24, 25
2d – surface sector;
2e – support angle (crossbar);
7 – window unit;
7a – plastic window unit;

1 – “Sandwich” type panels:
1a – wall panel;
1b – roofing panel;
2 — metal skeleton structures:
2a — skeleton column;
2b— framework post;
2c — framework crossbar;

7b – steel window unit;
17a – spray foam;
17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

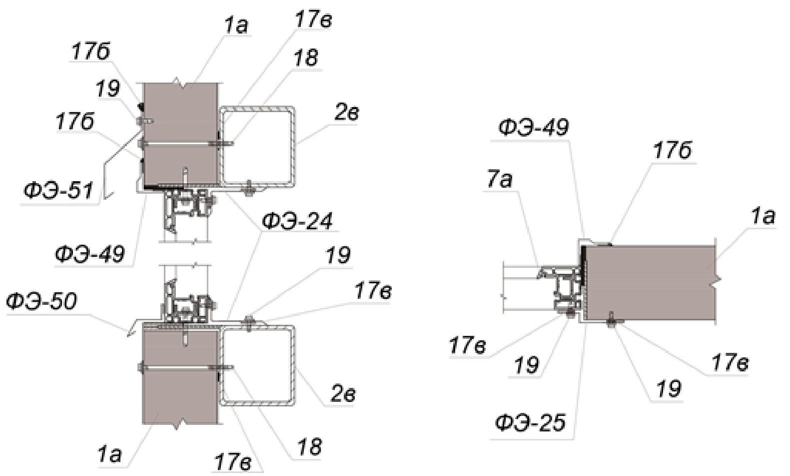
**UNIT 15**
A — steel window unit fixing to the panels (vertical section),
B —steel window unit fixing to the panels (horizontal section).




Shaped profiles (flashings): FE 24, 26, 27
2d – surface sector;
2e – support angle (crossbar);
7 – window unit;
7b – steel window unit;

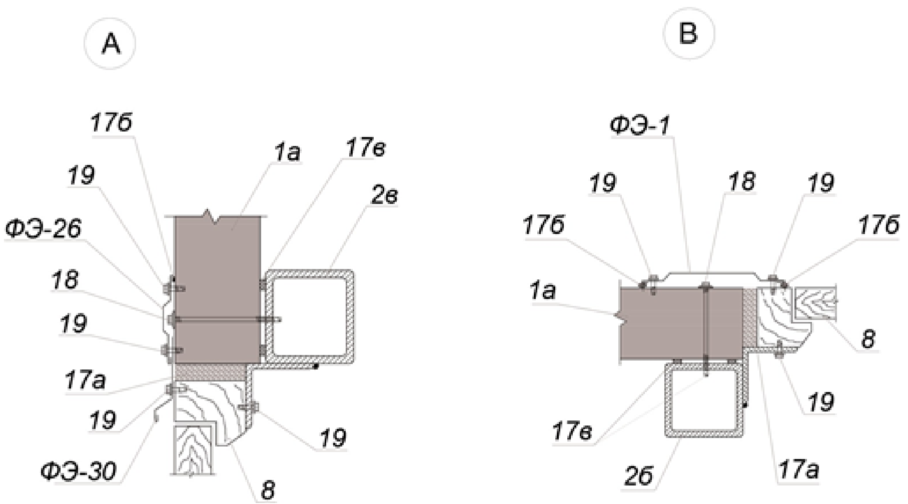
12 – mounting hardware element;
1 – “Sandwich” type panels:
1a – wall panel;
1b – roofing panel;
2 — metal skeleton structures:
2a — skeleton column;
2b— framework post;
2c — framework crossbar;
17a – spray foam;
17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
19 – self-drilling screw;

**UNIT 16**
Fixing of the unit's glass A – variant 1, B – Variant 2.




Shaped profiles (flashings): FE 23, 27, 28, 29
12 – mounting hardware element;
15 – vertical window bar;
16 – horizontal window bar;
17a – spray foam;
17b – silicon sealant for outdoor works;
1a – wall panel;
6 – glass;
17c – sealing band or mastic;
19 – self-drilling screw;

**UNIT 17**
A — fixing of the door unit (vertical section),
B —fixing of the door unit (horizontal section).




Shaped profiles (flashings): FE 1, 5, 30
2d – surface sector;
2e – support angle (crossbar);
8 – door unit;

17a – spray foam;

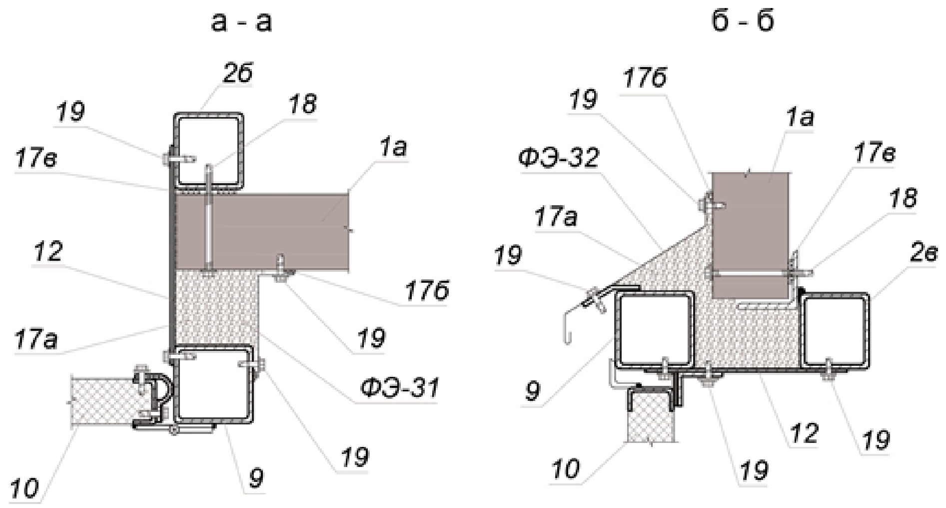
1a – wall panel;
2 — metal skeleton structures:
2a — skeleton column;
2b— framework post;
2c — framework crossbar;

17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

**UNIT 18**

Gate fixing units:

A – a and b – b, - the corresponding sections which are shown below.

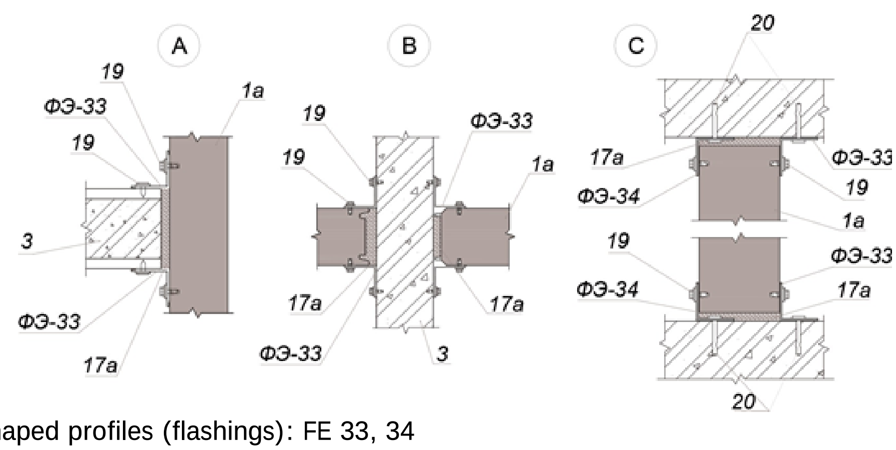



Shaped profiles (flashings): FE 31, 32
12 – mounting hardware element;
17a – spray foam;
17b – silicon sealant for outdoor works;
1a – wall panel;
2b— framework post;
9 – gate frame;
10 — gate leaf.

17c – sealing band or mastic;
18 – self-drilling wood screw;
19 – self-drilling screw;

**UNIT 19**

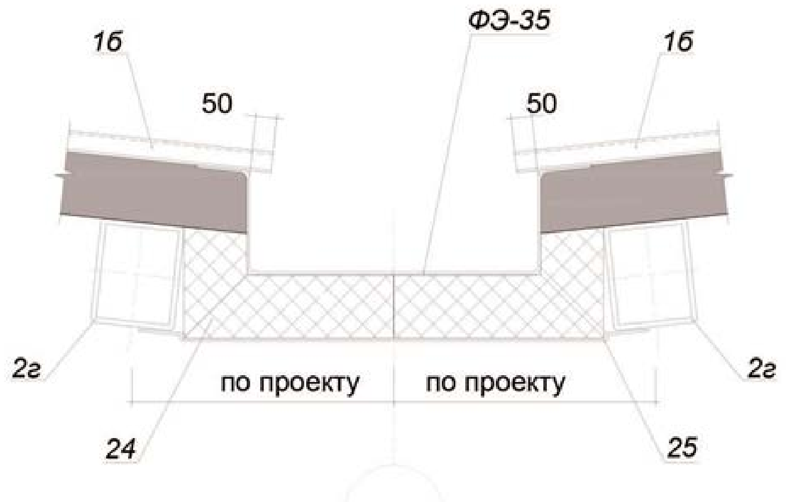
A, B — partition panel fixing to the concrete (brick) wall,
C —partition panel fixing to the ceiling and floor.




Shaped profiles (flashings): FE 33, 34
17a – spray foam;

17b – silicon sealant for outdoor works;
17c – sealing band or mastic;
1a – wall panel;
19 – self-drilling screw;
3 – concrete wall.

**UNIT 20**
Design of the drain gutter: C – partition panel fixing to the ceiling and floor.




Shaped profiles (flashings): FE 35
24 – gutter made of sandwich panels;
25 – metalwork, supporting the drain gutter (according to the project);
1b – wall panel;
19 – self-drilling screw;
2d – surface sector.

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