

Saimaa University of Applied Sciences
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**DEVELOPMENT OF ALUMINUM THERMAL
BREAK SYSTEM**

Bachelor's Thesis 2011

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ABSTRACT

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Development of thermal brake system

45 pages, 4 appendices

Saimaa University of Applied Sciences, Lappeenranta

Technology, Degree Programme in Civil and Construction Engineering

Structural Engineering

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The main purpose of the study was the development of a new system of aluminum profiles with thermal brakes R102 TERMO. The system must be based on the previous modification R72 TERMO. The system must be developed due to an early tightening of European regulations on thermal efficiency of buildings and structures which will take effect in 2012. Another purpose was to evaluate the possibility of production and sales of the new system in the Russian market.

The theoretical part of the study consists of three main points. The first is a description of the current system of aluminum profiles (analysis, identifying strengths and weaknesses). The second is development of a new system (a score of ways to decrease the thermal conductivity and analysis of results). The third is an assessment of the implementation of the products in the Russian market. It includes searching for extrusion plants and the ability to manufacture them profiles of the new system. A list of the main competitors of the new profile system in the Russian market was made also. Calculations of thermal conductivity were based on the catalogs of Nokian Profiilit Oy as well as software Winlso 2D (Demo). Calculations were conducted jointly with the German company Technoform.

The result of the study could be a new system of aluminum profiles with high thermal resistance. The final work is not finished. The plan is to manufacture prototypes and their testing at the Hot Box facility. However, they are expected to be in full correspondence with new Euronorms.

Keywords: aluminum profiles, thermal conductivity

1 INTRODUCTION

Aluminium is the most common metal in the world. It is produced from the mineral bauxite.

Aluminium deposits are practically inexhaustible. It is a lightweight, strong and good looking building material. It is an environmentally friendly material that does not contain any admixtures and does not emit any harmful substances under ultraviolet influence. It can keep work in all weather conditions with temperature changes from -80C up to +100C. Aluminum is oxidized in contact with oxygen and automatically creates the protection layer on its surface. It is better than any other material saving its structural properties under temperature changes. Fire properties of aluminium are also high. Aluminum does not evaporate any substance during the heating. This is very important for any buildings and especially for public. One more useful property of aluminum structures is that they do not collect dust on the surface. In this case the care for those kinds of structures is minimized.

The using area of aluminium in the world is very wide. It is used in construction industry, transport, electrical engineering, packing and all kinds of equipment.

Aluminium is a good construction material. However, in construction industry mostly aluminum alloys are used. In Russia and Europe it is quite often used in construction industry.

After the surface treatment of aluminum products, they are becoming resistant to corrosion caused by rain, snow, heat and smog. Aluminium can be used during 80 years without any renovation and special maintenance. Problems with aluminum recycling do not exist, because aluminum scrap can be restored, retaining its original properties.

One of the most common areas of using aluminium is a production of fencing constructions such as windows, doors, wall and roof profile systems. In this case the thermal conductivity properties of aluminum are getting more important. But unfortunately it is the main flaw of aluminum constructions – the

low level of thermal resistance. That is why improving thermal resistance is the main in a question of aluminum constructions designing and keeping energy inside a building.

The main goals of the study are development of a new system of aluminum profiles with thermal brakes R102 TERMO and evaluation the possibility of production and sales of the new system in the Russian market. The new system must be based on R72 TERMO thermal brake system. In this case the main idea to save profiles scheme. Big changes are not allowed.

The work includes the presentation of R72 TERMO system, description of the production line, the work for development of a new thermal brake system and analysis of Russian market in this product area.

2 BASIC TERMINOLOGY

Aluminum alloys are alloys in which aluminium is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, and zinc. Selecting the right alloy for a given application entails considerations of its tensile strength, density, ductility, formability, workability, weldability, and corrosion resistance. In aluminum profiles systems the most used alloys are 6060 and 6063.

Table 1.1 Wrought aluminium alloy composition limits (% weight)

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
6060	0.3-0.6	0.1-0.3	0.1	0.1	0.35–0.6	0.05	0.15	0.1	remainder
6063	0.2-0.6	0.35	0.1	0.1	0.45–0.9	0.10	0.10	0,1	remainder

Source: Wikipedia.org

Table 1.2 6060(6063) aluminum alloy typical properties

Yield strength	150(172) N/mm ²
Elasticity module	70000 N/mm ²
Sliding factory	27000 N/mm ²
Thermal conductivity	209 W/(m×K)
Density	2700 kg/m ³
Coefficient of thermal expansion	23×10 ⁻⁶ /°C

Source: Wikipedia.org

EPDM (ethylene propylene diene monomer rubber) is a type of synthetic rubber, is elastomer. The main properties of EPDM are excellent heat, ozone and weather resistance. It is widely used as a thermal and water insulator.

Table 1.3 EPDM typical properties

Hardness	80±5 °Sh
Tensile strength	10 N/mm ²
Breaking strain	150% (minimum)
Compression(22h/70 °C)	25% (maximum)

Source: Wikipedia.org

Extrusion is a process used to create objects of a fixed cross-sectional profile. A material is pushed by press or drawn through a die of the desired cross-section. The two main advantages of this process over other manufacturing processes are its ability to create very complex cross-sections forms and finished parts with an excellent surface finish. It is widely used in aluminum profiles production.

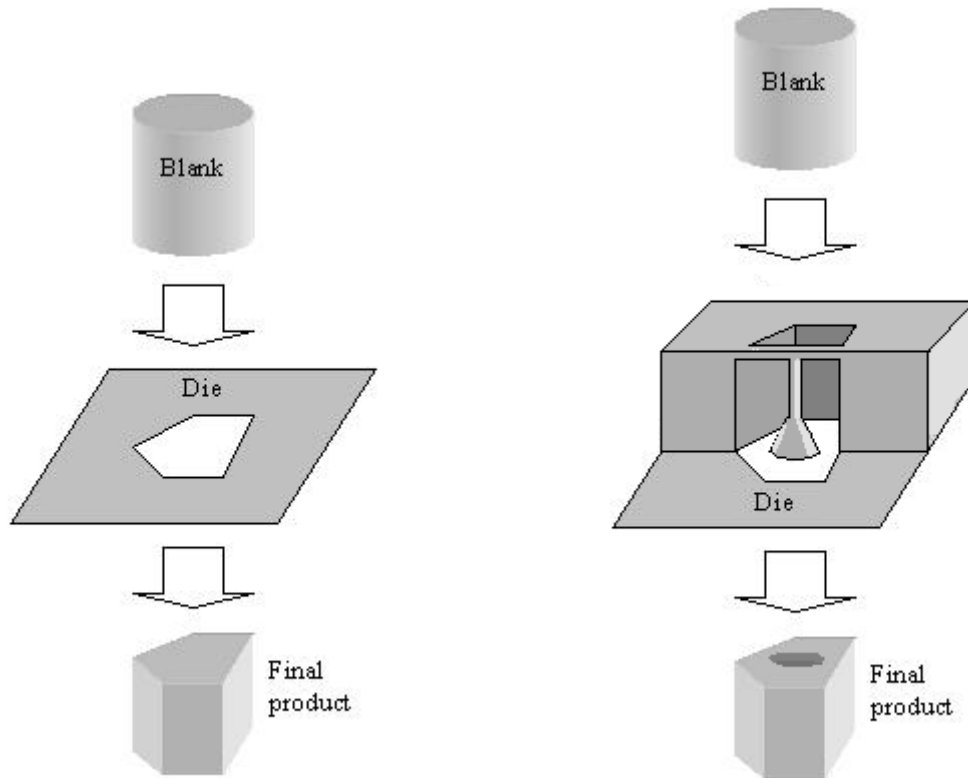


Figure 1. The scheme of the extrusion process to produce corpulent and hollow profiles.

PA66 GF25 - is a polymer which has good thermal insulation, lightweight, water proof properties but quite low characteristics against ultraviolet radiation. It is often used as a building insulation material.

Table 1.4 Typical properties:

Density	115 kg/m ³
Thermal conductivity	0.25 W/(m·K)
Tensile strength	40 MPa
Coefficient of thermal expansion	14,4×10 ⁻⁵ / °C

Source: Wikipedia.org

Polystyrene is a polymer which has good thermal insulation and frost-resistance properties. It is often used as building insulation materials.

Table 1.5 Typical properties:

Density	105 kg/m ³
Thermal conductivity	0.08 W/(m·K)
Tensile strength	46–60 MPa
Coefficient of thermal expansion	$8 \times 10^{-5} / ^\circ\text{C}$

Source: Wikipedia.org

Anodizing is an electrochemical process of obtaining a protective or decorative coating on the surface of various alloys. Aluminium alloys are anodized to increase corrosion resistance, to increase surface hardness, and to allow dyeing (coloring), improved lubrication, or improved adhesion. The anodic layer is non-conductive.

Painting (polyamide powder painting) is powdered composition based on polymer, curing agent, pigment, fillers and some other special components. It is applied for a painting of aluminum profiles. The thickness of the layer is several microns.

3 NOKIAN PROFILES

3.1. Nokian Profiles history

Manufacturing of aluminum profiles in Finland has a long history. In 1962 the Finnish cable industry started to produce aluminum products in a factory in Pikkala. There was a thin wire. But it was produced by extrusion. In one year the second extrusion line was started.

In 1966 Oy Nokia Ab was established. It was quite a big concern which consisted of several companies and manufacturing. The aluminum manufacturing was also included. Oy Nokia Ab was fused from three companies. The oldest one being Nokia Aktiebolag which was founded in 1865.

Since 1969 the company started to apply anodizing of aluminum products. During 1970th the third extrusion line has started to work. Also the foundry manufacturing was begun.

In 1985 the aluminum manufacturing was included in Nokia Metal Products department. In four years the company was returned to cable production and renamed Nokia Cables and Machinery. In 1987 the color plot was founded.

Since the 1990 the aluminum manufacturing was separated and in 1996 the company was renamed Nordic Aluminium Ltd. After that the company opened new factories in Kirkkonummi, Espoo and Nivala. The component production was separated in self-direction. The international market entering is going on. New anodizing line with more efficient material handling equipment was started in 2008 and the new extrusion line (2500 MT) was started in 2010 also.

Nokian Profiles was founded to manage “architectural systems” from Nordic Aluminium. Nokian Profiles bought those systems in 2010. Nokian Profiles Oy is a wholesaler of aluminum profiles. Aluminum systems and related accessories are delivered from the central storage. It is located in Nummela. Currently Nokian profiles architectural systems are used for approximately 300 client companies. The company also develops the systems further.

The history of architectural systems is quite interesting too. Nokia Aluminium bought a license to fabricate thermal braked systems from Swissalu in the 1960. However, quite soon the cooperation with Swissalu diminished, and Nokia Aluminium took more responsibility of the development to itself. First “own” systems were non-thermal braked R12 and thermal braked R65. Very soon R52-serie for facades was introduced. The only system still in production from the early days is R12, though it has of course developed a lot from those days.

3.2 Architectural systems

Architectural system consists of many profiles and other elements. They are interconnected by special equipment. There are two basic types of the profiles’ systems. The first one is with thermal brakes elements (“warm” system) and the other (“cold” system) is without. Thermal brake is a profile which is made from polyurethane or polyamide. It is installed between two profiles. All those elements form the single system. “Cold” systems are applied when it is not necessary to keep the warmth. It can be indoor doors, windows, stair-glass windows and partitions. Otherwise, “warm” systems are used if there is need to save the warm inside. It is applied to external doors, windows and some kind of balcony systems.

Nokian Profiles Oy uses the following architectural systems of Nordic Aluminium Oy.

R72 TERMO

This is the new thermal brake system for doors, windows and stained-glass windows. The system does not have a design solution but its thermal resistance properties are perfect. Gaskets do not reduce the aperture and bend around corners. It is possible to produce curved constructions based on R72 TERMO.

R72 TERMO door systems are used for front doors. The doors types can be single, hinged with double or triple glazing. Doors can be opened outside or inside. They can be mounted on hinges or be sliding.

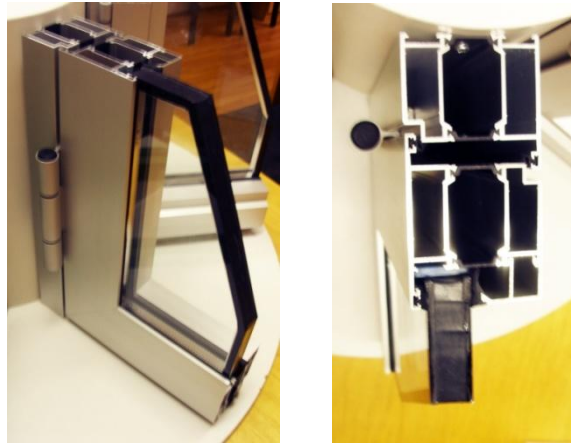


Figure 2 R72 TERMO door system

R72 TERMO windows systems can be outside, inside opened or sliding with structured glazing. The glazing can be double or triple depending on the project.

72EI30 is a 30 minute fire resistance rated door and wall system. The resistance is achieved by adding suitable accessory to normal R72 system. Architecturally R72EI30 looks just like R72. The main structures of R72 TERMO door and window systems are shown in Figure 2 and 2.



Figure 3 R72 TERMO window system

R53 VERTEX

R53 VERTEX is a profile roof system. It is absolutely water proof. This system can be built with single, double or triple glazing. The system includes special profiles for making pyramidal and barrel-shaped structures and modules for

ventilation and exhaust devices. The structure of R53 VERTEX is shown in Figure 4.

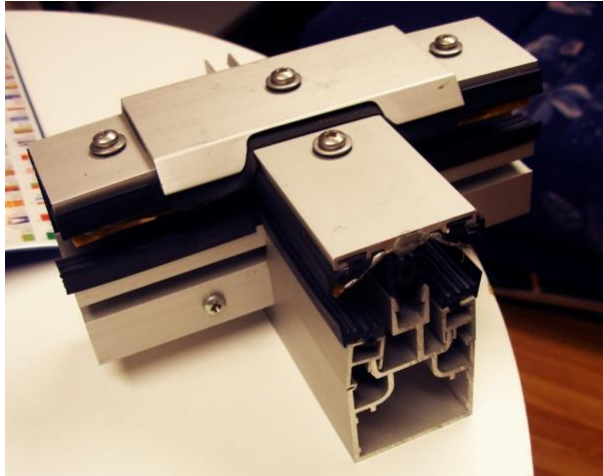


Figure 4 R53 roof system

R54

The system frame is constructed using a lap joint technique. According to the technology horizontal profile is superimposed on the vertical profile of the frame. R54 profile system is supplied with drainage channels for water removing. The additional chamber is built in the way, that fixing bolts do not break its impermeability. R54 has a double chamber system where dry and wet zones are separated.

Thermal brake material is either PA6,6 or PVC. The material provides a high level of thermal insulation. The average U-value of the window 3K4-15 ,float+IplusR (1200mm x 1200mm) is 1.19 W/m²K. R54 system can be used for roof systems where the condense water channels are not necessary. The system offers solutions for walls glazing with angles (-5° ...+10° from vertical) or for curvilinear facades.

R65 BULLET PROOF

R65 BULLET PROOF is an extra strong bullet proof system based on R65 system which includes facades, doors and windows. Applying area is facades and partition walls in banks and other buildings. Sections can be built with thermal insulation or without it. Standard joints (mount with the latch or screws)

are used in this system. The main structures of R65 BULLET PROOF system is shown in Figure 5.

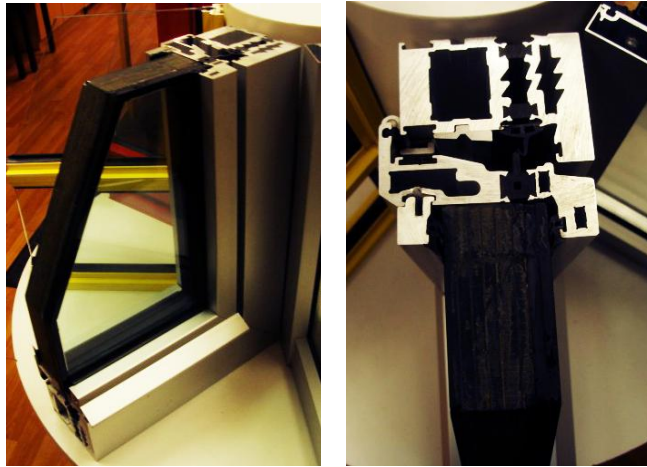


Figure 5 R65 BULLET PROOF system

R28 FILIA

R28 FILIA is an aluminium internal partition walls and doors system. It is designed for single glass (the thickness is 5-10 mm). All the joints are cut straight and fixed with screws. System has inbuilt screw pockets in every profile, so there is no need for corner cleats. Separate sections are installed consistently. Sliding doors are supplied as ready-to-install sections.

R12 LINEA

R12 LINEA is a system for making partition walls and balcony fencings. The system is based on R12 architectural system. R12 Linea is very slender with only 12 mm module (12mm glazing list, 12 mm frame and 12 mm glazing list). LINEA system is used for producing partition walls with single glazing included sliding or hinged doors. R12 LINEA can be used as a cold stained-glass window for balconies glazing. The main structures of R12 LINEA system is shown in Figure 6.



Figure 6 R12 LINEA system

The main used thermal brake systems are R54, R72 TERMO and R65 BULLET PROOF. Nokian Profiles can buy the profiles from where they want. Some of the profiles come from Mäkelä Alu.

4 R72 TERMO PROFILE TYPE ANALYSES

R72 TERMO is the thermal brake aluminum profile system. It means that aluminum profiles are connected between each other by special thermal brakes. This system can be applied for external doors and windows. The windows may be outward and inward. It depends on the project.

4.1 Dimensions

Architectural systems of aluminum profiles R72 TERMO include the following standard types of windows and doors.

Windows can be inward and outward opened. They can be single and double wing. Windows can be hinged-type, swing-type and complex-type. Frame dimensions are ranged from 400x400 mm to 1700x2800 mm in depending on the project. Dimensions are ranged from 400x800 mm to 1700x2800 mm for double-wing windows. The weight of the window system can be ranged from 70 kg to 170 kg.

Doors can be outward-, inward- and double free opening. Frame dimensions are ranged from 400x400 mm to 1700x2800 mm in depending on the project. Dimensions are ranged from 400x800 mm to 2900x2800 mm for double-wing windows. The weight of the window system can be ranged until 170 kg.

However, the most important aspect is the frame's cross section of the window (door) system, because this is the load bearing structure. Heat is going through aluminum carcass mostly. The architectural system consists of many elements.. That is why special designations are applied. There is the special code for each kind of the accessory, profile or the system of the profiles which is joined by thermal brakes.

The idea of R72 TERMO profile with thermal brakes is shown in Figure 5. More detailed drawings of R72 TERMO system are shown in Appendices 1 and 2.

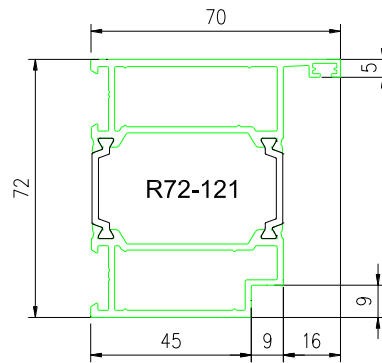


Figure 7 An example of the aluminum profile with thermal brakes

R72 means that this type of the profile is used in R72 TERMO system. In the number “121”, the first figure (one) means that there is the basic type of the profile. There are some other types of elements also: additional profiles (number 2), glazing list (number 3), aluminum connections (number 4), auxiliary profiles (number 5), gasket (number 6), extra thermal insulation (number 7) and plastic elements (number 8 and 9).

The standard dimension of a window which is going to be analyzed is 1200x1200 mm. The horizontal and vertical sections have the same dimensions. The typical cross section of the inward opened window is presented in the Appendix 1.

The window doesn't consist of several profiles only. There are a lot of accessories (for example gaskets and screws). They connect all of the profiles in a single system with a glass and between each other also (Appendix 2).

4.2 Thermal insulation properties

The quality of a thermal brake system depends on how it keeps the warm inside the structure. There are three ways of heat exchange between inside air and outside air: conduction, convection and radiation.

- Conduction – transfer of heat through solid/liquid material.
- Convection – the moving of heat through moving fluid or gas.
- Radiation – transfer of heat by means of electromagnetic waves.

In wall structures the main heat exchange way is conduction. In window systems all three ways are participated in this process. In this case the

complexity of solutions must be used. Those solutions must be applied for each part of the window structure also (light opening area and area of the frame).

“Warm” architectural system R72 TERMO has high thermal insulation properties. It is reached by installing special thermal brakes. Those thermal brakes are thin (good conduction properties) and have a big length (good radiation properties). Good convection measures are reached by applying gaskets (Position 4, Appendix 2)

The example of U-value calculation of R72 TERMO system is presented in Appendix 3. U_f values are defined by the HotBox method.

HotBox is a method of measuring thermal resistance values of a structure. Tests are held in laboratory in accordance with EN ISO 12567-1, EN ISO 12567-2 or EN ISO 8990. The structure is installed in a wall between cold and warm areas of a test room. The temperature of the warm part is 20°C and the temperature of the cold part is 0°C . The heater is situated in the warm part of the room. There is no temperature gradient to drive heat from the warm part. In this case the heat can leave the warm area through the structure only. The scheme of the HotBox plant is presented in Figure 7.

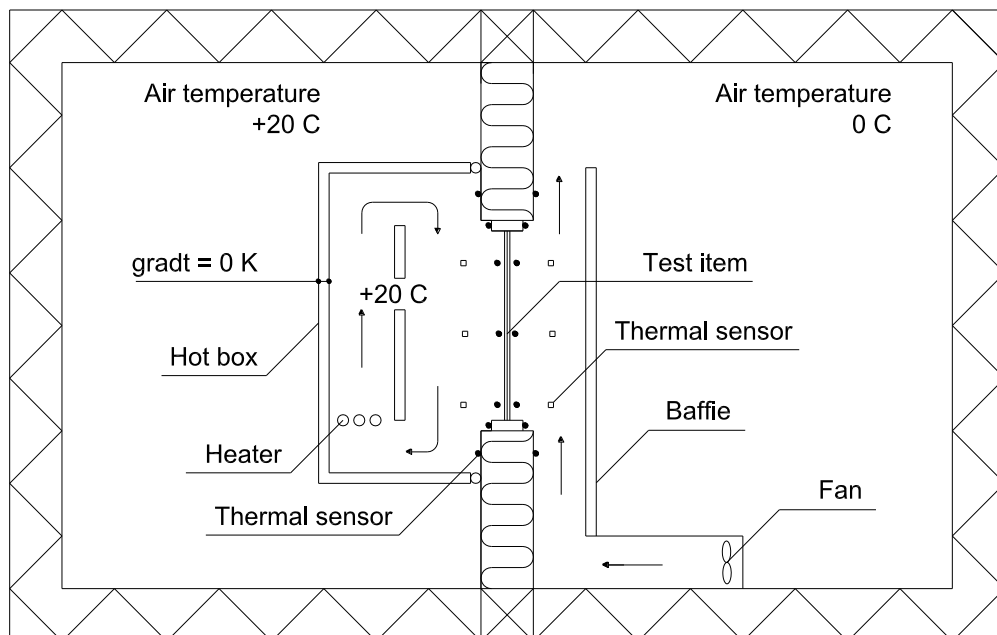


Figure 8 The scheme of Hot Box

Tests are produced on HotBox method equipment by specialists from Technoform (Germany).

4.3 Production

The profiles are made of aluminum alloy 6060. This is the common aluminum alloy for Nokian Profiles systems. The alloy includes magnesium and silicium additives. The alloys with silicium give the profile good corrosion resistance, endurance and extra durability. At the same time magnesium gives the profile good corrosion resistance and extra plasticity. It means that the final product combines all of those properties. In this case aluminum alloy has good plastic and strength characteristics. For extra properties against corrosion anodizing is also applied. The whole technological process of profiles production is produced in the special extrusion plant in Kirkkonummi. There are several press complexes and equipment for cutting, processing and packing of readymade aluminum profiles. 6060 aluminum alloy is subjected to anodizing and extrusion better than 6063 alloy.

Thermal brakes are PVC and PA 66. They are commonly used for other architectural systems also. PVC and PA 66 are based on polymer materials. Thermal brakes come from Technoform Bautec (Germany) and Primo (Finland). They are joined to aluminum profiles by special machines and tools. The process is produced on the production line. It is made by F.O.M. Industrie (Italy). The procedure goes through several stages.

First, there is need to choose profiles and make a thread inside their grooves. The thread provides a good connection between a profile and thermal brake. It can be done on the special machine (Figure 9a). The grooves are measured (Figure 9b). After that, those values should be put to adjustment screws (Figure 9c). They control the depth of grooves and the depth between them.



a

b

c

Figure 9 Preparing stage

The next stage is installing and fixing of the profile. The fixing should be done very well to avoid any mistakes (Figure 10a). Then, the profile goes through machine and ratchet disks (Figure 10b) make the thread inside grooves (one disk per each groove). There is the profile with readymade thread in Figure 10c. Another profile should be processed in the same way.



a

b

c

Figure 10 The stage of thread making

The next step is a preliminary connection of profiles. The process is produced on the connecting machine (Figure 11a). Profiles are fixed above each other (Figure 11b). Special tool sends thermal brakes to grooves in each profile (Figure 11c). Steel supports keep profiles in right position (Figure 11b). They can be rotated in case the thermal brake goes through them.

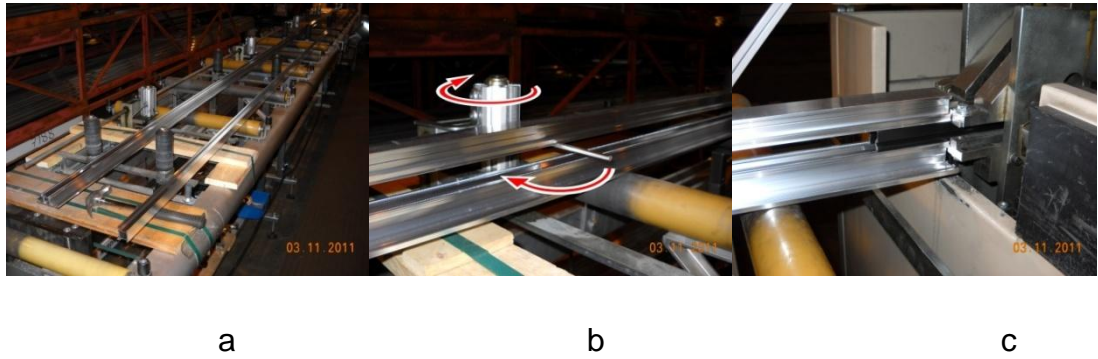


Figure 11 Preliminary connection

This is preliminary connection (Figure 12a). It serves to connect two profiles between each other only. The final connection is produced on the pressing machine under big pressure (Figure 12b). This machine is provided with many adjustment screws. They help to use profiles with any forms. All adjustments are written in the work drawing book. In this case it is not necessary to remember them. Additional fixers can also be used. The capacity of the machine is very big. Even profiles with big cross sections and weight can be processed (for example bulletproof profiles). Tolerance ± 5 mm is available after the pressing. However, experience suggests that optimal dimensions can also be reached.

Thermal brake element is made of polymers (plastic material). In this case the small elastic deformation can be after the element has gone through pressing machine. That is why the index of the main adjustment screw should be 2 mm (approximately) less than optimal before the process is started.

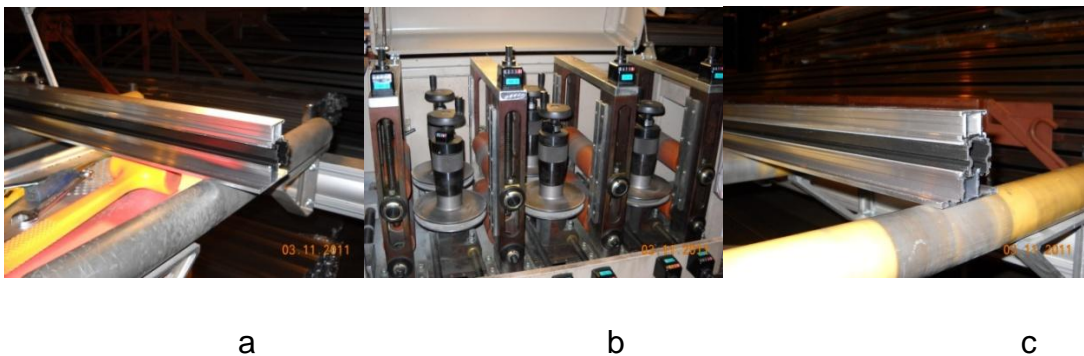


Figure 12 Pressing stage

The final stage is testing. It is produced on the testing machine (small press complex). Several tests are produced if the cross section of the profile is standard. Otherwise, tests should be done more often if the cross section is unique. Profile pieces of 10 mm are used for testing. The required strength is marked on the aluminum surface of each profile (Figure 13a; 971 kg). Then a sample is put in testing machine and tested (Figure 13b). Applied force is shown on the display (Figure 13c). The results of measurements present the quality of connection.

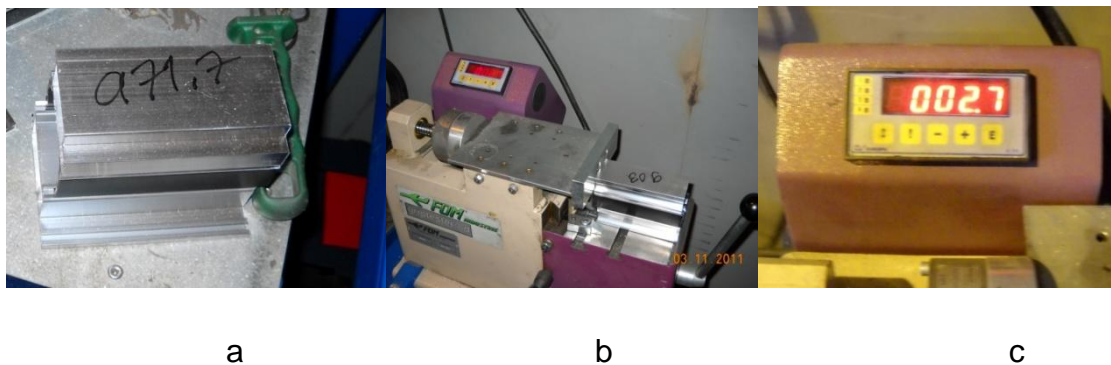


Figure 13 Testing stage

The process of producing systems with thermal brakes is not too hard. But it needs special skills, equipment and high accuracy of manufacturing.

4.4 Moisture protection properties

An important requirement for aluminum systems is condensate removing because the system has two sides – outside (cold) and inside (warm). In this case the system always has a zone where a condensate of the water is possible. The water must be removed. There are special drainage channels in each aluminum block element of R72 TERMO system. They remove water from condensate area to outside. Bad ventilation and little drainage channels can be the reason of mold. Mold can destroy sealant at the end of the glass. That is why it is very important to remove water from the window system and to ventilate it also. There are small holes at the bottom of the frame of the aluminum system for this purpose.

4.5 Connection and capability

The R72 designs are assembled according to given instructions.

The structures are joined to the building frame in such a way that the loads will be securely transferred into the bearing frame, and that the deformations and thermal movements of the frame will not damage the structures. The fixing parts are either ready R72 mountings or made of stainless material. The seam between the R72 structure and the building frame shall be sealed in an appropriate way.

Joining to the building frame can be provided by wood screws and mounting steel (there are some alternatives of joining with shim or with adjuster bolts and welding). Those schemes are presented in Appendix 4.

Other kinds of R72 TERMO systems were developed in the way of capability. That is why R72 TERMO window system has good connection properties with other systems such as door and facade system.

5 DEVELOPMENT OF A NEW THERMAL BRAKE SYSTEM

New European regulations on energy conservation (EnEV) make high demands for thermal protection of buildings. Therefore, the coefficient of heat transfer U_w windows and doors should be lowered. Requirements EnEV 2012 cannot be achieved by improving the quality of glass only. For this purpose the coefficient of heat transfer of the binding U_f should significantly reduce also. This is a serious challenge for modern designs. In standard structures, the goal is difficult to achieve by installation of triple-pane windows. And in aluminum systems, it is attainable in exceptional cases only.

Combinations of different activities improve results for some percent only. For aluminum windows it is very important to focus on insulation and actively use the advantages of material, such as static, simple geometry of a profile and the ability to make various forms for products. If we consider the possibility of built-in appliances, the effect may be much bigger than the improving (in tenths) of a heat transfer coefficient.

Some trends should be considered in the window frames. They do not depend on the choice of a material:

- integration of ventilation devices (hardware, active and passive elements), and devices against sunshine;
- integration of electronic components and their connectivity to the engineering building systems;
- combination of properties such as sound, heat and fire protection with anti-burglary qualities and automation;
- modules for easy maintenance and modification;
- easy disassembly, recycling and the splitting of materials;
- the impact of the applied materials on the environment;
- reduce the likelihood of condensation and heat transfer coefficient.

- reducing of the possibility of condensation inside the structure.

Aluminum structures have a high modulus of elasticity E and provide good opportunities for further integration (including electronic) components. Unfortunately, many of these solutions are still not standardized.

Solutions to meet the requirements of energy saving and easy incorporation of intellectual technology in window construction must be found. The user must know benefits of new constructions:

- saving of primary energy;
- comfort increasing in a room;
- security needs of a building are satisfied;
- cheap and simple maintenance.

5.1 Evaluation

In order to begin developing a new system there is need to find out parameters which should be improved. Obviously, all three factors of heat loss should be kept in mind for the system improvement – conduction, convection and radiation. The development of a new system is based on the old system of R72 TERMO. That is why an additional condition is that aluminum profiles cannot be changed a lot. It helps to save money during ordering profiles from the extrusion plant. It keeps the connection profiles, installation of accessories and mounting systems of profiles in a single facade complex. It can save time too. In this case, improvement is reached by modernization of the thermal brakes insert and other non-metallic components of the system.

The basic ways of reducing heat loss are applying thinner thermal bridge jumpers, using other materials for thermal bridges, increasing the width of the thermal bridge. Furthermore, using of porous materials or systems with airbags is also effective. Air is a very good heat insulator. In addition, the air space saves thermal insulation material. Another important thing - the surface of the insulating material reduces the heat flow also. Moreover, the heat flow can be reduced by internal and (or) external surface. For example, windows have the

system like that. Using of a glass with the thickness “X” is less effective than using of three glasses and two air chambers with the same total thickness. More airbags (therefore more "boundary surfaces") increase thermal insulation properties. In addition, the partitions in the air chambers can support elements with big length.

The development process is shared with the German company Technoform (one of the leaders in this field). The essence of the process is in constant contact and discussion. Consultation and cooperation is taking place from both sides. The result is a system which reaches the highest requirements of thermal insulation and can be produced with minimal cost.

5.2 The way of calculation

Approximated U-value coefficient coe is calculated by “Win Iso 2D” software. This software was produced by Sommer Informatik GmbH (Germany). According to this software, it is possible to find out quite exact U-value coefficient of the frame or the whole system. Nokian Profilit Oy is going to order “Win Iso 2D (professional edition)”, which can help with the development of other systems. It can be useful in the calculation of the U-value of the whole façade also. The example of result of calculation is presented in Figure 13.

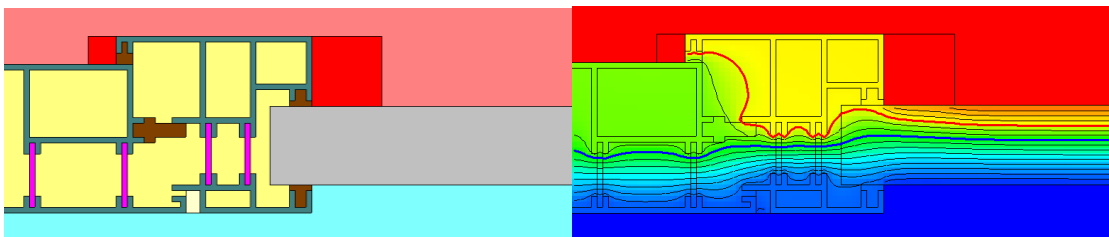


Figure 14 WinIso 2D Software diagrams

5.3 The first test model

The first step is to build a test model. The geometry of the cross section is saved. The basic solution is to upgrade existing systems. In this case, the main objective is to improve convection and radiation. The scheme of designed cross section is presented below (Figure 15).

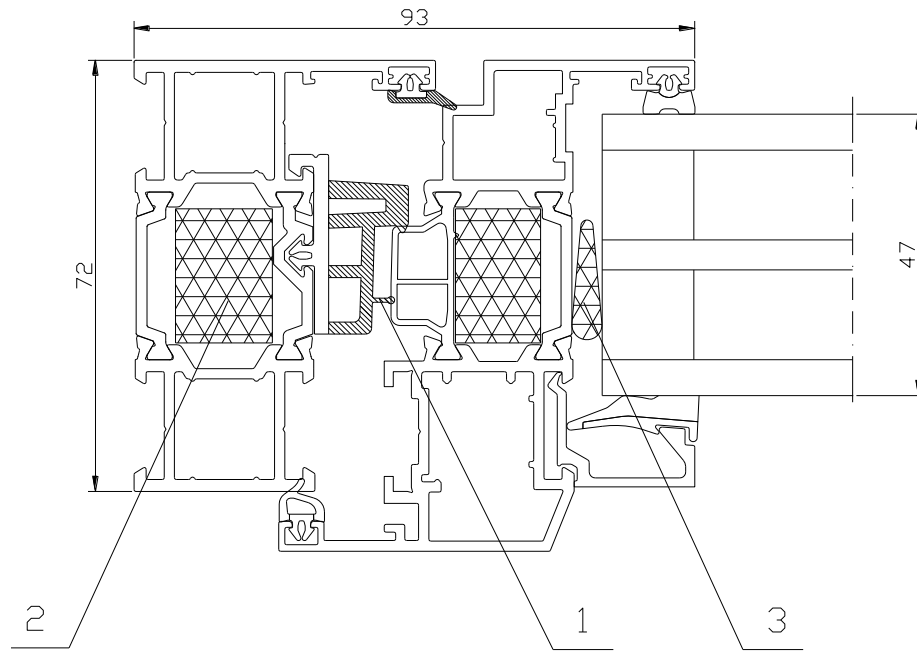


Figure 15 The scheme of the first designed cross section

To improve the convection properties in the central part of the profile EPDM rubber with flexible element is applied (Pos. 1 Figure 15). That element creates one more air chamber and prevents the penetration of cold air. Air chambers provide additional protection against conduction and saves material costs during the production of the item. Those air chambers are very useful also because they “create” a border (rubber/air). This border is a good way to reduce heat flow. Formed polyeten inserts (Pos. 2 Figure 15) are applied in the system also. They reduce the radiation heat flow between aluminum profiles surfaces. There is the sealant (Pos. 3 Figure 15) between the glass and thermal brake element. It prevents the penetration of cold air through this part of the system. The design of the seal is standard, and has not been modified a lot.

6 ALUMINUM PROFILES SYSTEMS MANUFACTURING IN RUSSIA

The aluminum production market in Russia is quite specific because of the economical and political situation. The growth rate of consumption of aluminum in Russia is much higher than the same found in Europe, the USA and Asia, despite of a deep recession in 2008-2009.

Table 6.1. Growth of aluminum consumption in 2008-2011

Region	2008 (growth %)	2009	2010**	2011**
Europe*	3%	-18%	4%	8%
Asia(except China)	2%	-11%	8%	9%
USA	-10%	-23%	7%	7%
Russia	8%	-40%	37%	39%

Source: Brook Hunt. UC RusAl

**Evaluation

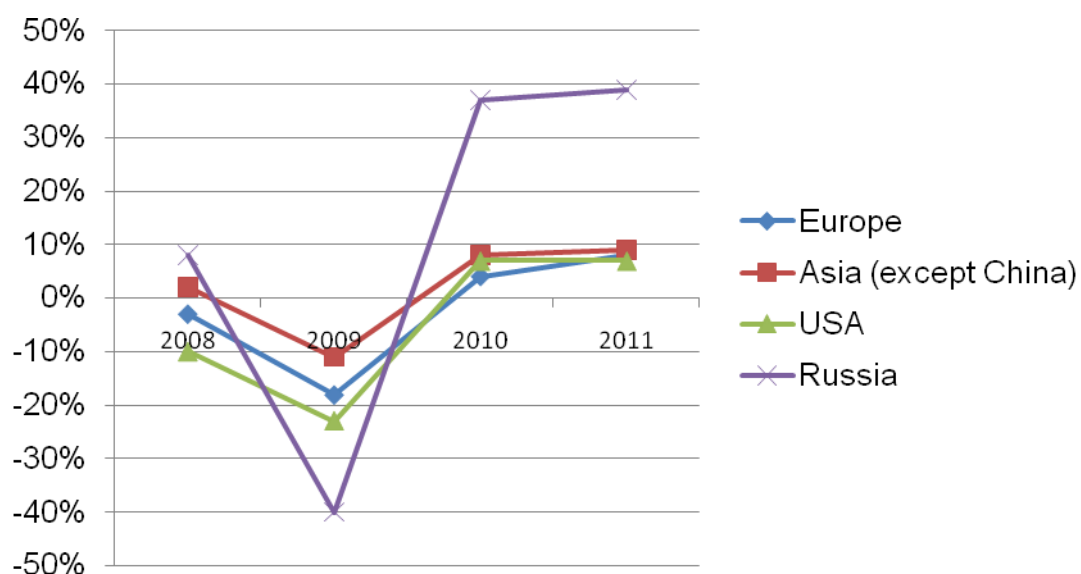


Figure 16 Growth of aluminum consumption in 2008-2011

Significant amount of aluminum production lines in Russia are not used (not loaded). This is a potential for growing. In assessment of RusAl, the capacity of aluminum processing companies does not exceed 45%.

However, the consumption of aluminium per capita in Russia is almost twice less, than in Europe. It means that the prospect for aluminum applying in Russia is quite big.

Table 6.2. Aluminum consumption by region*

Region	2009 (thous. tonnes)	2010		
		1 quarter	2 quarter	3 quarter
Europe	5 558	1 509	1 568	1 479
Russia	869	223	232	241

* Source: UC RusAl web site

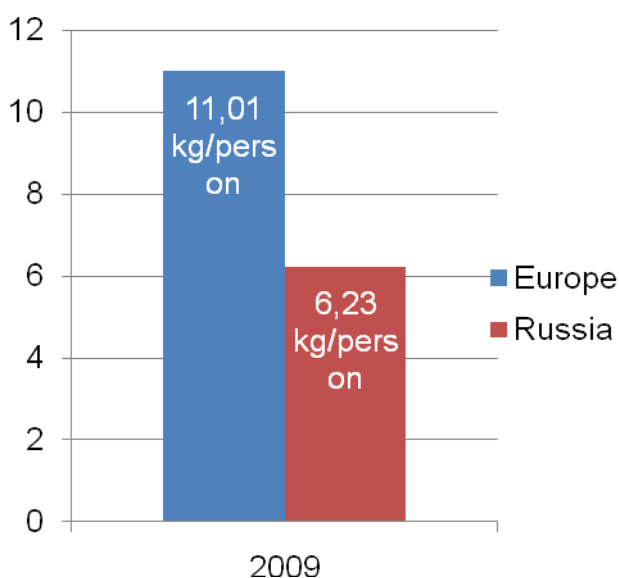


Figure 17 Aluminum consumption per capita 2009.

Condition and prospects for development of the aluminum industry are always discussed. There was a big forum in Naberegnye Chelny in the spring of 2010. Participants of the forum discussed the problems of manufacturing of aluminum products and marked the mains. One of them is the selling policy of UC RusAl. The price of the aluminium inside the country is bigger than in LME (London Metal Exchange). At the same time the custom tax for aluminum alloy import is 10%. In this case companies have to buy aluminum from UC RusAl. Another problem is the deficit of a qualified staff. There are many colleges and universities which are ready to teach students different “target” programs but the quality is not always good. Besides, there are no worked programs. It is not clear how many hours are needed for student training.

However, during 2010 the production volume of aluminum profiles was rising. In forum participant's opinion it is the result of custom policy of Russian Government. Since the 1st of January 2010 the United Custom Union of Russia, Belorussia and Kazakhstan made the 20% custom tax for aluminum profile import, but not less than 4 Euro per 1 kilogram. In this case the import of extrusion profiles in Russia was not profitable. In the result the amount of imported production was decreased in several regions.

In forum participant's opinion the prospects of aluminum market evolution are:

- The stimulation extrusion production consumption
- Providing the clear price formation for aluminum and its alloys
- Applying new technologies

However, nowadays the market of aluminium and aluminium alloys profiles is one of the most dynamically growing markets in Russia. Although extra profile manufacturing has been started, the demand is still bigger than offers. In this case the market is getting attractive and the amount of extrusion companies is increasing. And this leads to an increase of the competition. In 2010 the manufacturing of aluminum profiles and bars was increased for 34%.

The most perspective segment of aluminum profiles consumption is the segment of a lightweight construction production: trade exhibition and advertising equipment from aluminum profiles, facades systems, stained-glass window systems, fences for balconies, room partitions, window and door systems.

There are quite many companies which produce those systems but not a lot of them have their own extrusion and other necessary equipment.

This is the rating of top five Russian producers of aluminium profiles below. It was published by authoritative Russian magazine "Metallosnabzheniye i sbyt" in January 2010. This rating contains the information for the second half-year of 2010. The rating was based on questionnaires from the customers, interviews of the experts of the metal market and complex analyses of the company's activities. During determining the best companies the following aspects are taken into account:

- Business dynamics
- Delivery volume
- Service level
- Production quality
- Reliability and execution of contracts during the economical crisis time

Table 6.3. Top 5 aluminum profiles manufacturing companies in Russia (the 2nd half-year of 2010)

Rank	Company
1	Tatprof
2	LPZ “Segal”
3	Agrisovgaz
4	Realit
5	International Aluminum Company

There is a short characteristic of each company below. Each characteristic includes some basic information about the company, prices, information about products and manufacturing process. Special attention was paid to aluminum profile systems with thermal braked elements (“warm” systems) and extrusion line (press complexes). This information will allow estimating the product’s quality products and to estimate the possibility to use Russian extrusion sides for aluminum profiles ordering.

6.1 Tatprof

Tatprof was founded in 1990. It is a developer and manufacturer of aluminum profile TATPROF systems, interior design, including office partitions, according to customer profile. The company has a factory in Naberezhnye Chelny which includes the whole complex of aluminum profiles producing and processing. They produce building envelope “warm” and “cold” systems (facades, doors, windows, stair-glass windows, roofs, ventilator hatches), fire-resistant translucent structures (stained glass windows, windows and doors, cladding structures, internal partitions), interior structures (office partitions, trade and exhibition equipment, sliding door wardrobes). There is the possibility to make individual design aluminum profiles also.

Table 6.4 U-value some of Tatprof's "warm" systems

System	U-value , W/(m ² ·K) (glazing area/ skylights area)
EK-69 window system	1,605 (0,73)
EK-89 window system	1,852 (0,73)
EK-57 window system	1,786 (0,64)
TP 50300 stair-glass window system	1,852 (0,82)

The most used aluminum alloy is 6060. It corresponds to Russian standard GOST 4784-97 and international standard DIN 1725. Also the special quality control system is used. It corresponds to international standard ISO 9000-2001.

The manufacture of aluminum profiles from the standard cylindrical ingot is performed on the pressing equipment.

Table 6.5 Equipment specifications

Press	P-150	P-280	P-188	P-146	P-147
Manufacturer	Spain	Italy	Taiwan	Taiwan	Taiwan
Used alloys	6060, 6082	AD0, AD1, 6060, 6082	AD0, AD1, 6060	6060	6060
Diameter of a billet	162 mm	203 mm	162 mm	145 mm	145 mm
Max. pressing force	1500 tons	2800 tons	1705 tons	1320 tons	1320 tons
Overall diameter of a circumscribing circle of a profile	182 mm	240 mm	180 mm	160 mm	160 mm
Marketed length of a profile	2000- 7000 mm	1200-7000 mm	2000-7000 mm	2000-7000 mm	2000-7000 mm
Optimum weight of 1 linear running meter	0,4-1,5 kg [*]	1,4-2,0 kg [*]	0,4-1,5 kg [*]	0,3-1,4 kg [*]	0,3-1,4 kg [*]
As-received condition pursuant to GOST 22233- 2001	T, T4, T5, T6	T, T4, T5, T6	T, T4, T5, T6	T, T4, T5, T6	T, T4, T5, T6

*A profile with a linear running meter of 8,0 kg can be produced.

Aluminum profiles are covered by Teknos (Finland) paint. This paint was chosen especially for applied SBF (Germany) paint line. There is the possibility

to paint in all colors from RAL catalogue also. Anodizing is producing on the LUDI Galvanotechnic anodizing line. Its capacity is 50000 m² per month.

The work for buying two more press complexes and one painting line is going on now.

6.2 Realit

The extrusion manufacturing of Realit is one of the most modern in Russia. It consists of engineering center, exhibition and trade center and manufacturing workshop.

The company produces building envelope “warm” and “cold” systems (facades, doors, windows, stair-glass windows, roofs, ventilator hatches), interior structures (office partitions, trade and exhibition equipment, sliding door wardrobes). There is the possibility to make individual design aluminum profiles also.

Table 6.6 U-value some of Realit’s “warm” systems

System	U-value , W/(m ² ·K)
RF 50 façade system	1,92
RW 64 door and window system	2,3
RW 71 door and window system	1,8

The most common aluminum alloys are 6060 and 6063. Since 2000 the manufacturing is certificated according to International ISO-9001 Standard. The Russian norms are also accorded. The producing line consists of three press complexes of Presezzi Extrusion S.R.L(Italy). The pressing maximum force is 2800 tons.

Table 6.7 Equipment specifications

Press	Prezezzi Extrusion	Prezezzi Extrusion	Prezezzi Extrusion
Manufacturer	Italy	Italy	Italy
Diameter of a billet	178 mm	152 mm	203 mm
Max. pressing force	1800 tons	1350 tons	2800 tons
Max. overall diameter of a circumscribing circle of a profile	-	-	220 mm
Speed of extrusion	35 mm/c	35 mm/c	35 mm/c
As-received condition pursuant to GOST 22233-2001	T1, T6, T66.	T1, T6, T66.	T1, T6, T66.



Figure 18 Press-2800 (Realit extrusion line)

There are vertical and horizontal paint lines. Vertical paint line is produced by “Trasmetal” (Italy). The capacity of the line is 40 tons/day. Sprayers (produced by “Nordson”, Germany) are used in the horizontal paint line. There is the possibility to paint in all colors from RAL catalogue also.

6.3 Agrisovgaz (Altim)

Agrisovgaz is an industrial complex which includes a steel factory and a factory of aluminum systems.

The aluminum production has special quality certificate ISO-9001 of Magdeburg laboratory of building materials testing (Landesmaterialprufamt Sachen-Anhalt Magdeburg). The production is according to Russian norms of Gosstroy also. Architectural systems are sent to Russian and International market. Agrisovgaz

exports its systems to Holland, Germany, Finland, Hungary, Belorussia and other countries.

Agrisovgaz produces building envelope “warm” and “cold” systems (facades, doors, windows, stair-glass windows, roofs, ventilator hatches), interior structures (office partitions, trade and exhibition equipment, sliding door wardrobes). The manufacturing of individual design aluminum profiles is also available.

Table 6.8 U-value some of Agrisovgaz’s “warm” systems

System	U-value , W/(m ² ·K)
AGS 68 window & door system	1,92
AGS 68E window & stained-glass window system	1,92
AGS 78C window system (extra thermal brake)	1,56
AGS150 façade system	1,92-1,78
AGS 500 façade system	1,79

The company applies 6060 and 6063 aluminum alloys. The production line is provided by three press complexes. The most powerful of them is made by Breda Danieli. The maximum pressing force is 2200 tonnes which can be applied for producing of profiles with big length and cross section.



Figure 19 Breda Danieli Press-2200 (Agrisovgaz extrusion line)

Table 6.9 Equipment specifications

Press	PRIMA	Breda Danieli	Breda Danieli
Manufacturer	Italy	Italy	Italy
Max. pressing force	640 tons	1600 tons	2200 tons
Max. overall diameter of a circumscribing circle of a profile	-	-	220 mm
Maximum marketed length of a profile	-	-	12000 mm
Maximum weight of 1 linear running meter	-	-	7,5 kg
As-received condition pursuant to GOST 22233-2001	T, T4, T5, T6	T, T4, T5, T6	T, T4, T5, T6

Aluminum profiles are covered by paints Bichon and Akzo Nobel. There are sprayers of GEMA Swiss company also. There is the possibility to paint in all colors from RAL catalogue.

6.4 Extrusion

There are about 30 more extrusion factories in Russia. The biggest part of them has small capacity and low-force press complexes (1500 and less). In this case they cannot produce the wide spectrum of aluminum systems.

The locating area of those factories and companies is wide. There are a lot of productions in the central part (Moscow region and nearby) and south region of the European part of Russia. A big amount of factories is located in Ural region also. They are mostly large plants. There are a couple of extrusion factories in the north-west part of Russia (Saint-Petersburg region). Aluminum profiles are moved from other region commonly (Moscow area etc).

There are five more companies which can be chosen as a producer of aluminum profiles. The location is European part of Russia mostly.

- International Aluminum Company
- Petrokon
- Glavstroy Engineering
- Astek-MT
- FEZ

There is a table with short description of the production of those factories.

Table 6.10 Equipment specifications

Company	International Aluminum Company	Glavstroy Engineering	Petrocon	Astek-MT	FEZ
Manufacturing location	Moscow	Moscow region	Saint-Petersburg	Moscow region	Moscow region
Press	Press-1500	SMS Hasenklever	Press-1100*	Press-1880	Press-2500
Used alloys	6060; 6063	6060; 6063	6060; 6063	6060; 6063	6060, 6063
Max. diameter of a billet	152 mm	-	127 mm	-	-
Max. pressing force	1500 tons	2800 tons	1100 tons	1880 tons	2500 tons
Overall diameter of a circumscribing circle of a profile	-	-	150 mm	-	-
Max. marketed length of a profile	-	-	7000 mm	-	6800 mm
Optimum weight of 1 linear running meter	-	-	0,05-2,5 kg	-	-
As-received condition pursuant to GOST 22233-2001	T, T4, T5, T6	T, T4, T5, T6	T, T4, T5, T6	T, T4, T5, T6	T, T4, T5, T6

*The company is going to buy a press complex with the maximum pressing force of 2200 tons

Except extrusion aluminum profile can be subjected to other types of processing. The availability all of these functions in one place helps to make a lot of profiles. The cost can be lower, because it is not necessary to move profiles from one factory to another. The time of the manufacturing process is decreased also. The evaluation table is presented below.

Table 6.11 Technical possibilities of extrusion factories of aluminum profiles in Russia

Company	Tatprof	ASG	Realit	GE	IAC	Petrokon	Astek-MT	FEZ
Extrusion	x	x	x	x	x	x	x	x
Anodizing	x	no	no	x	no	no	no	no
Painting	x	x	x	x	x	Max 3m	x	x
Thermal brakes connection possibility	x	x	x	x	x	no	x	x
Machining service	x	x	x	x	x	x	x	no

6.5 Foreign producers

There are a lot of foreign producers of aluminum systems in Russian market today. Germany is presented by Hueck, Schuco, Broekelmann, Wicona, Hartmann. Belgium is presented by Reynaers and RS, Italy – All. Co, Metra, Poland – Spektral, Yawal, Metalplast, Turkey – Asas, Fenis, Saray. Greece – Alumil, Etem, Balkan, Finland – Purso, Nokian profiles.

Those companies can be divided into three parts by prices. The first part is profiles with low price. Aluminum systems from Poland, Turkey and Greece can be attended to this group. Their price is quite low but bigger than Russian analogs. The second group is profiles from Italy. They have the middle quality and the middle price. The third group is a category of elite profiles from Western Europe (Germany, Belgium and Finland). The price is mostly much bigger but the quality very good. Perfect reputation is also important.

The standards are improved everywhere. That is why the right way is to provide people with high quality systems. In this case the most interesting group of sellers is the third one (Schuco, Reynaers, Purso). The characteristic of each company is presented shortly below.

Schuco (Schüco, Schueco) was founded in 1951. They started to produce facade and stair-glass systems. The company entered to the international market already in 1971. They have their own logistic center Schüco International KG in Bielefeld (Germany). In 2004 Manager magazin marked

Schuco the company with the best reputation in building industry. The investigation were based on interviews of 2500 directors and authorities. Schuco was one of the first foreign companies in the Russian market of aluminum systems also. They do not have their own manufacturing in Russia but the company has two official departments in Moscow and Novosibirsk. Schuco cooperate with several Russian companies (for example Estel factory in Tatarstan and Aluminum Constructions company in Moscow region). Schuco provides the processing equipment to those companies and orders aluminum profiles from Russian extrusion plants. Schuco chooses plants with the best quality of manufacturing because this is the main principle of the company. The total control of manufacturing from German authorities is taken place always. In this case the plants which can be chosen are Realit, Tatprof and Agrisovgaz.

Reynaers was founded in 1965 in Duffele (Belgium). This is an engineering company which develops and sells aluminum profile systems. There are about 1000 people working in this company in the world. Reynaers has one head department in Moscow and six small representative offices countrywide.

Purso Oy is a Finnish company which was founded in 1959. They have their own extrusion plant in Siuro (Finland). Now they are working as an international company with a staff of 250 people. Purso realized its aluminum systems through cooperation with private Russian companies (Be-Group in Moscow, Mikon in Saint-Petersburg). At the same time the company does not have any official departments or extrusion factories in Russia.

All of those systems have an excellent quality. In this case other relevant factors should be taken into account such as price and service. Profiles with similar quality and lower price can be very competitive. Especially in Russia people at first look at the price and right after that quality and reputation. Service and speed of execution ordering are also important. Therefore the opening of manufacturing in Russia would save time to process the order and save money (no customs taxes). In this case the best is Schuco's way. But it can be improved by lower prices mostly.

7 SUMMARY

Study showed the developing process of new aluminum profile system with thermal breaks. This system is followed present European standards of energy savings² and it will be also followed the new European norms. Those norms are going to come in 2012.

Good results of thermal insulation are achieved by using special heat-insulating inserts. These inserts fit perfectly in the design of the new system. They have unified form which again saves on their production. Final insulation tests had not been conducted and are in the process of expectations, but are estimated as positive.

The evaluation work for assessment of the possibility of applying the newly developed system in the Russian market was done. Competitive ability is evaluated as good. In compare to foreign manufacturers that produce. The quality of R72 TERMO comparable with the best systems (Schuco, Reynaers), but has lower price and more attractive design.

8 REFERENCES

wikipedia.org

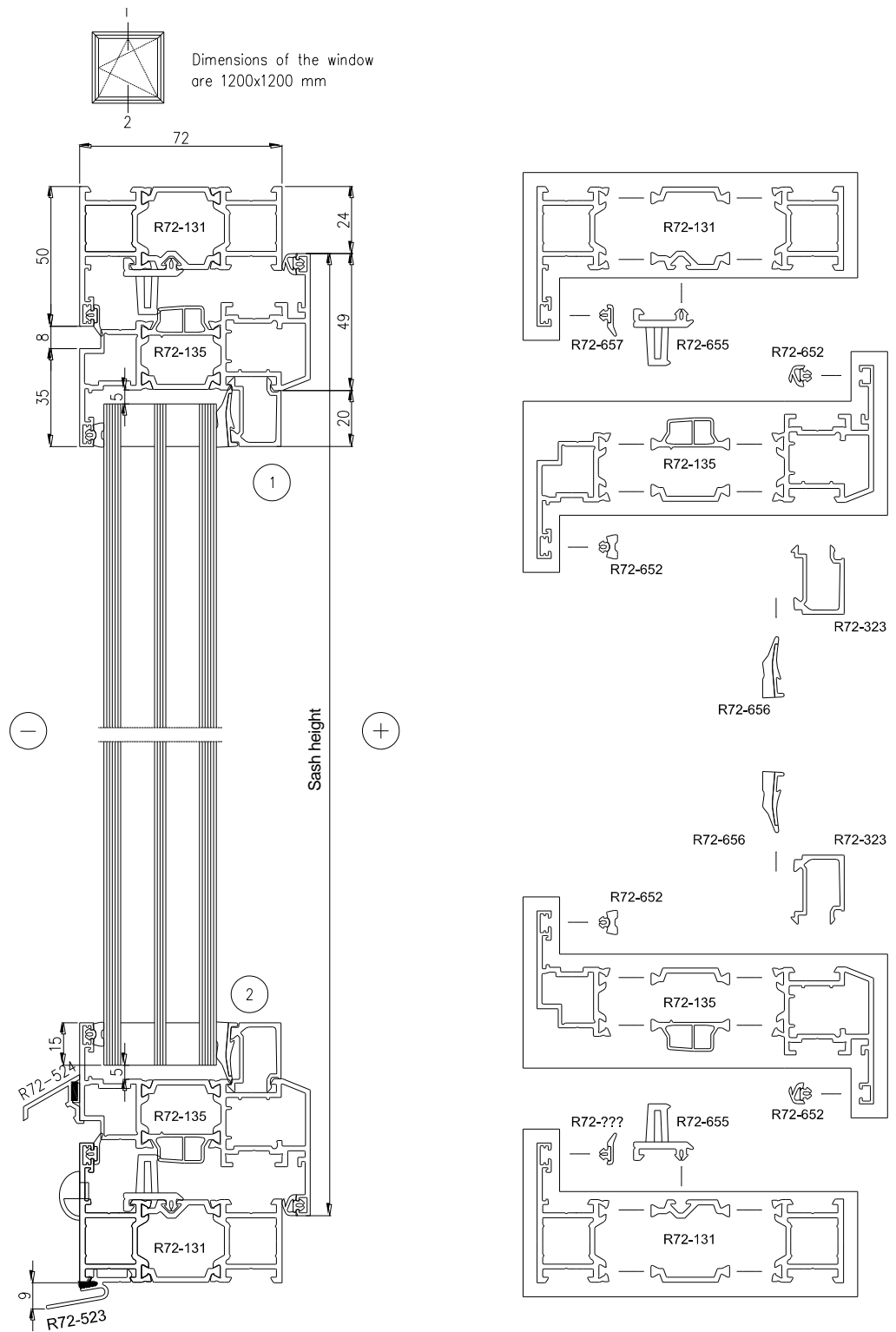
C3 SUOMEN RAKENTAMISM ÄÄRÄYSKOKOELMA
YMPÄRISTÖMINISTERIÖ, Rakenneyun ympäristön osasto

Nordic Aluminium Catalogues

Brook Hunt. UC RusAl

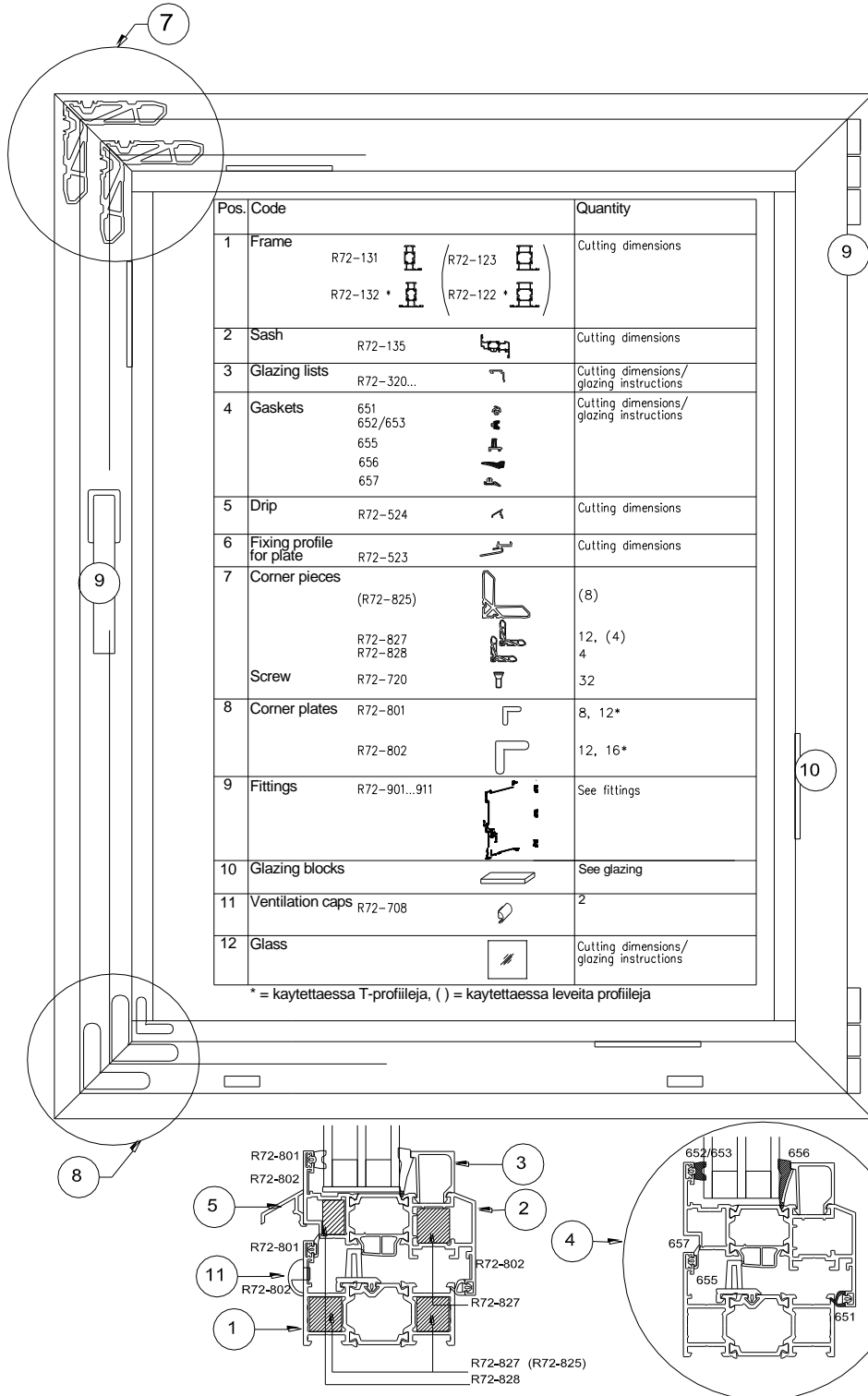
APPENDIX 1

The cross section of R72 TERMO window



APPENDIX 2

Extra parts of the R72 TERMO window (Source: Nordic Aluminium Catalogues)



APPENDIX 3

U-value calculation (Source: C3 SUOMEN RAKENTAMISM ÄÄRÄYSKOKOELMA YMPÄRISTÖMINISTERIÖ, Rakenneyun ympäristön osasto)

The window 1200x1200 mm was chosen. The glass type is 3K with $U=1,0$ W/m^2K

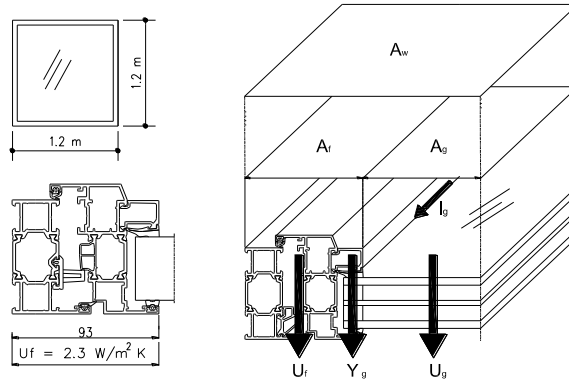


Figure 11 The scheme for calculation

Formula for U-value calculation:

$$U_w = \frac{A_g U_g + A_f U_f + l_g \Psi_g}{A_g + A_f} \quad (\text{Formula 1})$$

A_g – light opening area ($1,03 \text{ m}^2$)

A_f – area of the frame ($0,41 \text{ m}^2$)

$A_w = A_g + A_f$ ($1,44 \text{ m}^2$)

l_g – length of the heat bridge forming on the edge of the light opening ($4,06 \text{ m}$)

U_g – thermal transmittance of the light opening ($1,0 \text{ W}/(\text{m}^2 \cdot \text{K})$)

U_f – thermal transmittance of the frame ($2,3 \text{ W}/(\text{m}^2 \cdot \text{K})$)

$\Psi_g = 0.08$, 2K/3K with selective coating

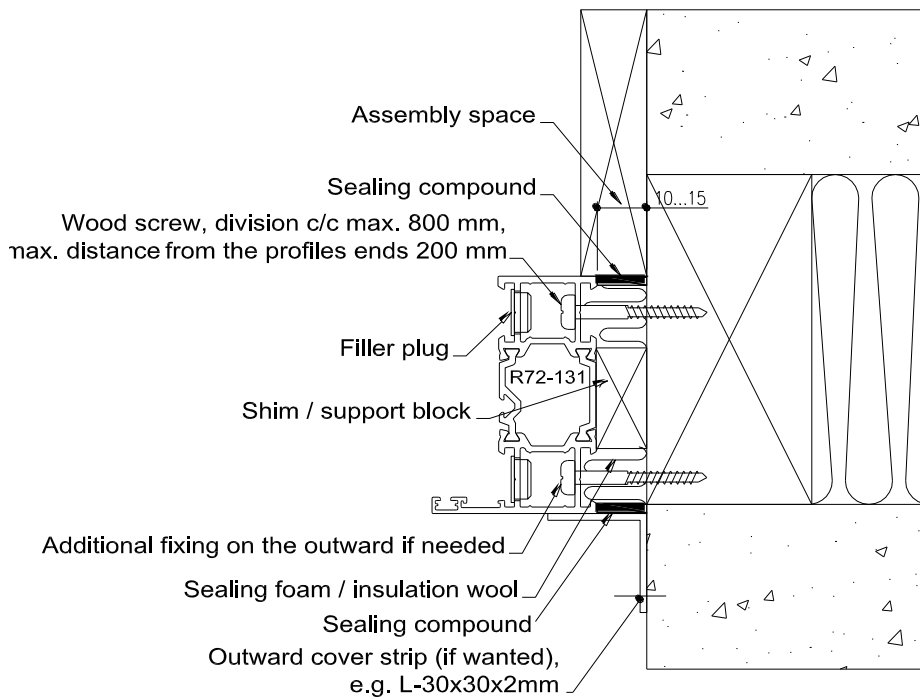
According Formula 1:

$$U_w = \frac{1,03 \times 1,0 + 0,41 \times 2,3 + 4,06 \times 0,08}{1,44} = 1,6 \text{ W}/(\text{m}^2 \cdot \text{K})$$

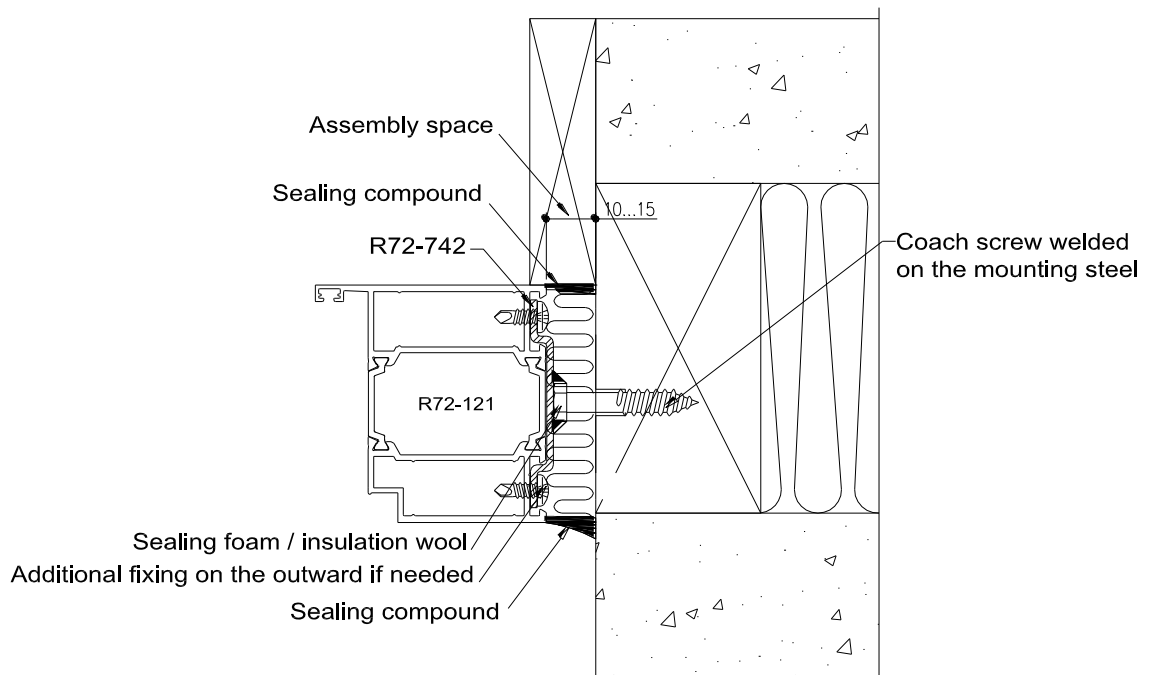
APPENDIX 4

Joining with screws (Source: Nordic Aluminium Catalogues)

ALTERNATIVE 1 / WOOD SCREW:

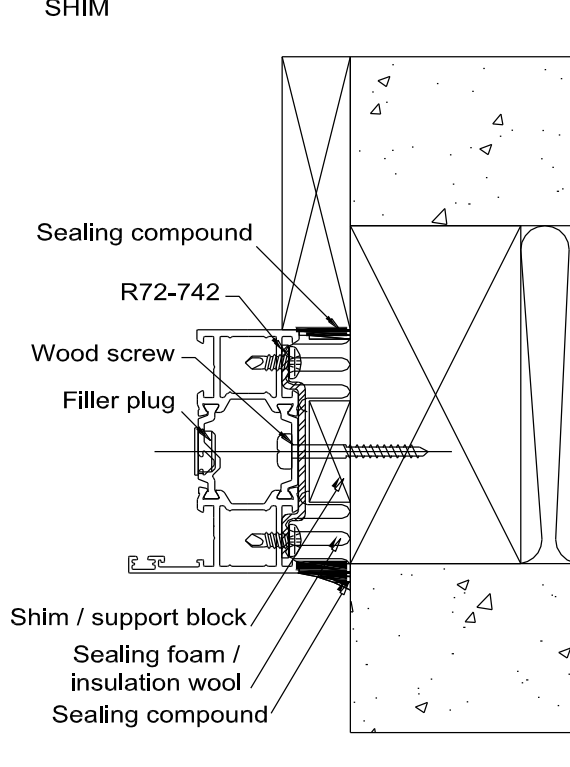


ALTERNATIVE 2 / COACH SCREW + WELDING:

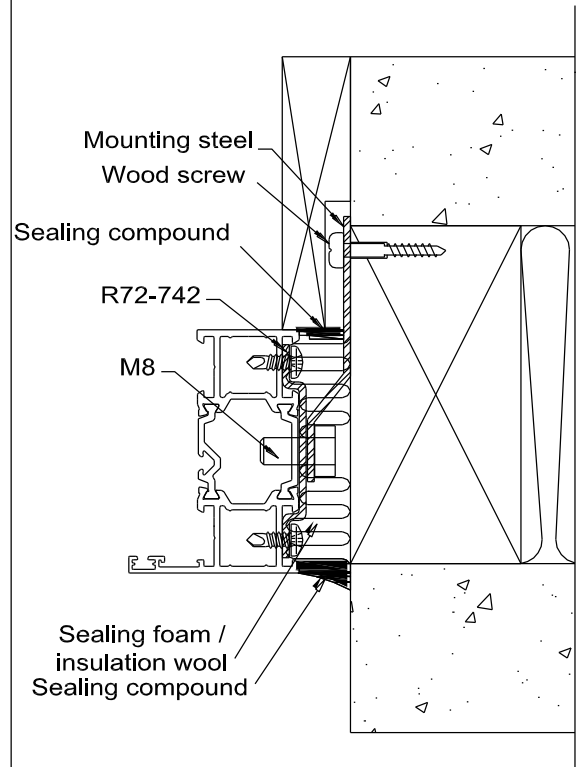


Joining with mounting steel (Source: Nordic Aluminium Catalogues)

ALTERNATIVE 1: MOUNTING STEEL + SHIM



ALTERNATIVE 2: MOUNTING STEEL



ALTERNATIVE 3: MOUNTING STEEL, ADJUSTER BOLT + WELDING

