

A1

INTRODUCTION

TYPES

The insulating panels produced by Isopan S.p.A. are monolithic, self-supporting sandwich panels, consisting of a layer of insulation between two facing skins. In terms of the diverse nature of the materials used for these elements, these products can be divided into two principal families:

A1.1 THERMO-INSULATING POLYURETHANE PANELS:

THERMO-INSULATING POLYURETHANE PANELS FOR ROOFS

- Isocop – S 1000
- Isoduplex 1000
- Isotego 1000

THERMO-INSULATING POLYURETHANE PANELS FOR WALLS

- Isotego 1000
- Isopiano 1000; Isopiano 1155
- Isorighe 1000
- New Isoparete 1000
- New flat Isoparete 1000

SINGLE-SKIN THERMO-INSULATING POLYURETHANE PANELS

- Isogrecata 1000
- Isodeck 40 1000
- Isodoga 1000

The types of panel listed differ in respect of the external profiles of the facings, their static behaviour, the shape of the connecting joints and the uses for which they are designed. What they have in common is the nature of the raw materials used: in particular, all the panels mentioned use an insulating layer consisting of expanded polyurethane foam. When correctly mixed and controlled during the continuous production process, this confers on the product the property of outstanding thermo-insulating power which is the distinguishing characteristic of this family of products.

A1.2 MINERAL WOOL INSULATING PANELS:

MINERAL WOOL PANELS FOR ROOFS

- Isofire Roof 1000
- Isofire Roof 1000 - Fono

MINERAL WOOL PANELS FOR WALLS

- Isofire Wall 1000
- Isofire Wall 1000 - Fono



The panels in these last categories are of the sandwich type, monolithic and self-supporting, consisting of two metal skins, in steel (or on request, aluminium, stainless or copper), connected by an insulating layer in biosoluble high-density rock wool ($100 - 110 \text{ kg/m}^3$), with fibres oriented at right angles to the bearing surfaces. This type of panel is being used increasingly frequently in the construction of roofs and panelling for industrial and public buildings, where there is a requirement not only for good thermal insulation properties but also for a high level of fire resistance, to comply with strict fire safety regulations. Isofire 1000 panels have certified characteristics for reaction to fire and resistance to fire which are such as to make the product virtually incombustible (Class 0 for the outer skin and Class 1 for the internal insulation and fire resistance ratings of R.E.I. 30 - 60 - 120). The panels are also available in the sound-absorbing version, with micro-perforated facing, certified for its level of sound insulation and sound absorption.

A1.3 DIMENSIONAL STANDARDS

The panels offered by Isopan S.p.A. are produced with a standard modular width of 1000 mm, or in the case of Isopiano, 1155 mm as well. The length, on the other hand, depends on the individual design requirements of the customer. Please bear in mind, however, that the maximum length transportable by articulated lorry is approximately 13.5 m, and this therefore represents in practice a dimensional limit, barring transport by special carriers. The thicknesses in production normally vary from 25 mm to 150 mm and even 200 mm, according to the type, the nature of the bearing surfaces and the intended use.

A2

RAW MATERIALS

A2.1 PRINCIPAL CHARACTERISTICS OF THE METAL FACINGS:

Our panels use only top quality metal facings, with the following basic characteristics:

- Steel, hot-dip galvanised by the SENDZIMIR process (UNI-EN 10147); no guarantees of resistance to oxidation or corrosion are offered beyond what is provided by the UNI standards or by the corresponding European standards with regard to the gram weight per square metre of zinc deposited.

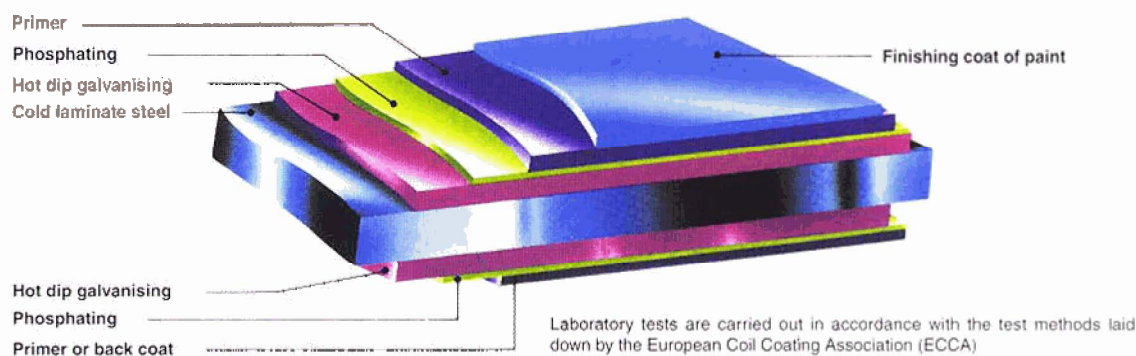
Steel, galvanised and prepainted on continuous lines with cycles applying polyester resin, siliconised polyester and PVDF (polyvinylidene fluoride), on the outer side. On the inner side of the panel a primer is applied.

- 3103 aluminium alloy with natural finish, embossed and prepainted with the cycles mentioned in the previous paragraph. The natural aluminium facings are supplied with a primer applied to the inner side.

- Stainless steel AISI 304 (designation X5CrNi1810) to standard EN 10088-1.

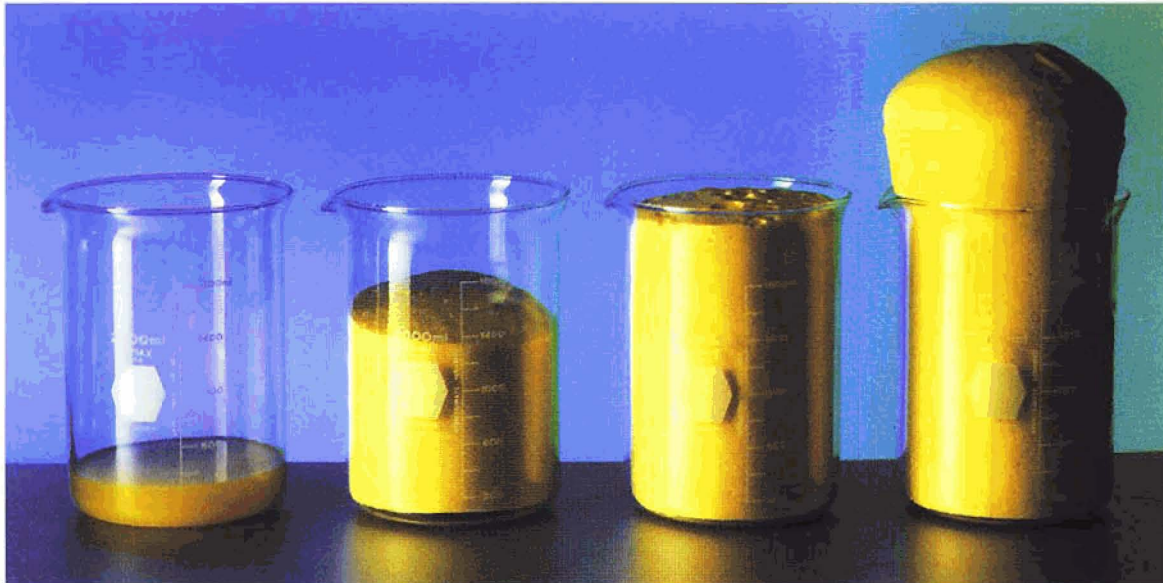
Copper (for the ribbed side).

Especially in the use of facings in copper and aluminium, we recommend paying attention at the design stage to the environmental conditions to which the product will be exposed, particularly direct exposure to the sun and maximum temperatures reached, taking into account the characteristics of the material: in this regard, the Isopan Technical Office will be able to provide useful information to anyone who requests it.



The choice of organic coating to go with the metal facing depends on the environment in which the product will be installed. For explanation, please see the table below, which identifies the best coating in relation to the environmental exposure. Isopan metal facings are required to comply with the strictest European standards:

- for Steel: UNI EN 10143, UNI EN 10147
for Stainless Steel: EN 10088-1, EN 10088-2
- for Aluminium: UNI EN 485-4
- for Copper: UNI 9329



component A = polyol mixture/polyol
 component B = isocyanate

a) COMPONENT A - polyol

In addition to polyols, the polyol mixture is made up of catalysts, intermediaries to the reaction and expanding agents.

Polyols: these are particular chemical compounds characterised by the presence in their molecule of so-called hydroxide groups (-OH groups). These are oligomers with variable molecular weights and structures. They are the product of the reaction between propylene and ethylene oxides and polyalcohols or sugars such as saccherose and sorbitol.

Catalysts: substances which act as promoters of the polymerisation and/or expansion reaction according to their composition. Generally these consist of aliphatic amines which are present in the formulation in relatively small quantities compared to the polyol.

Stabilisers: they are generally called silicones and their function is to regulate the cell-structure as it forms, in order to obtain minimal and constant cell diameters.

Fire retardants: halogenated and/or phosphorated compounds which act as flame retardants and therefore regulate the reaction to fire of the expanded material when it is subjected to the action of flame or a source of intense radiant heat.

Expanding agents: expanders in their turn may be divided into two families according to whether the expansion involves a chemical reaction or a simple transformation of a liquid into a gas. We will therefore speak of chemical expanders and physical expanders.

b) COMPONENT B - isocyanate

Component B is an isocyanate which normally belongs to the family of the so-called MDI polymers. An isocyanate is distinguished by the presence in its molecule of isocyanic functional groups (NCO groups) and MDIs (diphenyl methane diisocyanates). These consist of 4,4' diphenyl methane diisocyanate and its higher oligomers.

A2.5 EXPANSION

Expansion is a process which occurs at the same time as the formation of the polymer matrix and is caused by a gas being given off during the course of the reaction. The evolution of the gas can occur either as a result of a chemical reaction, or because of a change of state in a liquid with low boiling-point. We will therefore speak respectively of chemical expanders or physical expanders. It is the latter which concerns us.

The physical expander is represented by a liquid with a boiling-point normally below 50°C. The polymerisation reaction is exothermic, and causes an increase in temperature in the reacting mass and the low-boiling expander dispersed in it.

Until a few years ago, the physical expander universally used was CFC 11, because of its convenient boiling-point, its low toxicity, its reasonable price, its non-flammability and above all its excellent insulating properties. Unfortunately, it was discovered that it bears a considerable responsibility for the destruction of the ozone in the upper reaches of the atmosphere, where it accumulates, precisely because of its stability, and in conjunction with ultra-violet radiation, tends to destroy the ozone molecules. The discovery of this negative effect on the environment led to a process of replacing it with a substitute, under the control of strict regulations on the protection of the ozone layer.

The process has now been completed, and CFC 11 and HCFC have been replaced by expanding agents whose molecular structure no longer contains chlorine, which is responsible for the interaction with the ozone. The use of pentane and its isomers represents the best compromise in the direction of full respect for the environment. The problems relating to flammability have been satisfactorily resolved. The costs have been high, but sustainable.

A3 CHARACTERISTICS OF THE POLYURETHANE INSULATION

A3.1 DENSITY

When considering the finished product, and also when considering free expansion, it is important to distinguish between total density and density at the core.

'Total density' refers to the total volume of expanded material including the skin. In the case of a sandwich panel, it is obtained by subtracting the weight of the facings from the weight of the complete panel and dividing the value obtained by the volume of the foam alone. The core density, on the other hand, is obtained by eliminating the skin or high-density area of the foam from the calculation. The density is a very important parameter because it has a direct influence on most of the physical and mechanical characteristics of the foam.

A3.2 CELL-STRUCTURE

The features of the cell-structure are the diameter of the cells, their shape and their uniformity. Talking about a rigid foam implies a structure which is predominantly closed-cell.

The cell diameter can be estimated roughly by visual comparison with a standard sample, and assessed exactly by means of microscope images and subsequent computerised analysis. In the majority of cases, when shape and uniformity are within normal limits, the cell diameter is between 200 and 300 microns. Thermal conductivity is linked with cell diameter, but with variations which are relatively unimportant.

The shape and uniformity of the cells are also characteristics which must be taken into account, as they can be responsible for appreciable deficiencies in performance of the finished product. They are also an unequivocal index of the quality of the production process and of the correctness of the formulation.

Briefly, we can say that a good cell structure is characterised by:

- a uniform appearance
- absence of zones of discontinuity easily visible to the naked eye (bands of different colours)
- absence of highly elongated or "stretched" cells, as they are known.

A3.3 RESISTANCE TO COMPRESSION

The application of an external force deforms the cell-structure until it collapses completely. Normally, the resistance of a rigid foam to compression is calculated on the basis of the force necessary to induce a deformation of 10% and is expressed in kg/cm² or in dimensionally equivalent units.

In practice a test-piece of standard dimensions, generally 50x50x50 mm, is subjected to compression between two flat surfaces, connected to a dynamometer, which move at a preset speed. A graph is then drawn up in which the curve plots the deformation against the force applied. Compression resistance is affected by the following factors:

- characteristics inherent in the formulation
- the density of the foam
- the orientation of the cells
- the quality of the cell-structure.

Resistance to compression is a very important characteristic because it is directly linked to the dimensional stability of the foam when subjected to particular operating conditions.

Accumulated experience tells us that for a sandwich panel we need to be sure of a minimum compression resistance of 1 kg/cm².

A3.4 DIMENSIONAL STABILITY

By 'dimensional stability' we mean the capacity of the foam to maintain its dimensions unchanged over time and in actual conditions of use. Several factors, including temperature differences, diffusion of the gas contained in the cells, permeability to air, and operating conditions, give rise to forces acting in three dimensions which, if not adequately opposed, can lead to irreversible deformation. Generally, dimensional stability is measured by accelerated tests where samples of known dimensions are subjected to high temperatures (70-80°C, sometimes associated with high relative humidity in the air) and low temperatures (-25/-30°C) for a period of time (24-48 hours or more) and the variations which the foam undergoes in the three dimensions and in total volume are recorded, expressed as percentages of the original dimensions.

A3.5 REACTION TO FIRE

'Reaction to fire' is defined as the behaviour of the foam when exposed to the action of a flame or of radiant heat. Reaction to fire is assessed on the basis of tests which simulate exposure to fire and radiant heat, carried out on samples of fixed shape and dimensions, in accordance with strict rules, though these unfortunately vary from country to country. The reaction is then observed by measurement of:

- speed of propagation and maximum height of the flame
- time required for extinguishing it
- area damaged
- occurrence of dripping.

Reaction to fire is controlled by making changes at the formulation level, with suitable additives, and at the level of design and manufacture of the finished product. The results of the tests, which are specific to the individual country, are used to assign products to classes of fire resistance. It must always be specified whether the tests concerned just the foam or the finished product.

A3.6 WATER ABSORPTION

This is a measure of the quantity of water that the foam can absorb by direct immersion in water. Since we are dealing with a material with predominantly closed cells, this value is always very small (<1%). It can be easily verified that the only cells involved are the ones cut in the process of preparing the sample.

A3.7 THERMAL CONDUCTIVITY

The thermal conductivity of a material is its capacity to transport heat from one surface to another. It is expressed in terms of the variable λ (lambda), with W/mK as the unit of measurement. The thermal conductivity of a foam is principally linked to the composition of the gas contained in the cells, and to their size, and also to some extent linked to the nature of the polymeric matrix. In every case, the composition of the gas contained in the cells is the determining factor, and we can state positively that, next after a vacuum, pentane is actually among the best insulators (7.4 mW/mK). CO₂ (15.3 mW/mK) and air (25 mW/mK) turn out to be among the worst.

MATERIAL	d kg/mc	ρ_m w(m-k)	M %	λ w(m-k)
Polyurethane in panels with metal facings, UNIPLAST 517	35-40	0,020	10	0,022
Polyurethane in panels with semi-permeable facings, UNIPLAST 9051	30-40	0,020	40	0,028
Polyurethane in slabs cut from blocks	32	0,023	40	0,032
Polyurethanes in slabs cut from blocks	40-50	0,022	45	0,032
Polyisocyanurates in slabs cut from blocks	40	0,022	45	0,032
Extruded expanded polystyrene, with skin	35	0,030	15	0,035
In situ expanded polystyrene	37	0,023	50	0,035
Extruded expanded polystyrene, with skin	30	0,031	15	0,036
Glass fibre – rigid panels	100	0,035	10	0,038
Mineral fibres from feldspathic rocks – rigid panels	100-125	0,034	10	0,038
Glass fibre – semi-rigid panels	30	0,036	10	0,040
Mineral fibres from feldspathic rocks – semi-rigid panels	55	0,036	10	0,040
Sintered expanded polystyrene, in slabs cut from blocks, UNI 7819	25-30	0,036	10	0,040
Expanded polystyrene in slabs moulded by thermocompression	20	0,036	10	0,041
Extruded expanded polystyrene, without skin	30	0,037	10	0,041
Phenolic resins in slabs	35	0,034	20	0,041
Sintered expanded polystyrene, in slabs cut from blocks	30	0,038	10	0,042
Cork – expanded with binders	90	0,039	10	0,043
Mineral fibres from basaltic rocks – felts on metal mesh	60-80	0,037	20	0,044
Sintered expanded polystyrene, in slabs cut from blocks	20	0,040	10	0,044
Phenolic resins in slabs	60	0,037	20	0,044
Pure expanded cork and cork expanded with binders	130	0,041	10	0,045
Sintered expanded polystyrene, in slabs cut from blocks	15	0,043	10	0,047
Glass fibre – resinated felts	14	0,044	10	0,048
Ureic resins expanded in situ	30	0,032	50	0,048
Expanded cellular glass	130	0,050	10	0,055
Low-volume loose materials – cellulose fibre	32	0,040	45	0,058
Slabs composed of expanded perlite, fibre and bituminous binders	190	0,059	20	0,071
Low-volume loose materials – expanded vermiculite in granules from 0.1 mm to 12 mm	80	0,064	20	0,077

Thermal conductivity of the most important insulating materials

A3.8 MIXING OF THE COMPONENTS

Polyurethane systems for continuous panel manufacture are generally supplied as a multi-component system. It is essential to be able to adjust the expansion and catalysis to suit working conditions and the type of panel being produced: for relatively thin panels (30-40 mm) we will have a high catalyst and expander content, while for thick panels (120-200 mm) we will have a lower content of catalyst and expander.

A polyurethane system normally consists of the following components:

- polyol (polyols + stabilisers + fire retardant)
- one or more catalysts
- one or more expanders
isocyanate.

The polyol is first premixed with the expander and the catalyst. This mixture and the isocyanate are then suitably measured out and transferred to the distribution location. It is here that the process of high-pressure mixing takes place. The temperature of the components has a considerable influence on the viscosity, and can therefore affect the quality of the mix, so it must be kept under constant control. A poor quality mix is indicated by the presence of brown streaks, a coarse cell-structure and a 'glassy' look to the foam.



A3.9 ENVIRONMENT

The environmental impact of the products at the present time is of large and growing importance, in a society conscious of the need to safeguard its natural resources. The manufactured products of Isopan S.p.A. have for some time been compliant with the strictest standards and legislative requirements which have been enacted in this field.

As regards the polyurethane foams used, we emphasise the following characteristics:

- They are self-extinguishing in terms of standard ISO 3582 (formerly ASTM 1692).
- Ozone: in compliance with the limits for safeguarding the stratospheric ozone agreed by the signatory countries to the Montreal Protocol and European regulation 3093/94.
- Classified in Group 3 of the I.A.R.C. (Lyon Institute for Cancer Research) This means that the polyurethanes come under the heading of NON-CLASSIFIABLE AGENTS as regards their capacity for causing cancer in man and animals. ("This classification reflects the fact that the numerous tests carried out to date have not indicated any carcinogenic or mutagenic effects on man or animals deriving even from prolonged physical contact with polyurethane foams.")

In the case of sandwich panels with a core of rock wool, we have the following characteristics:

- Biosoluble inorganic material, free of asbestos, crystalline silica and CFCs and HFCs.
- Material classified in Group 3 of the I.A.R.C. (Lyon Institute for Cancer Research).

Finally, as regards the external bearing surfaces such as the metal components, we have the following characteristics:

- Prepainting in conformity with current Italian regulations on the contact of materials with foodstuffs (Ministerial Decree 21/03/1973 and subsequent amendments on hygienic discipline regarding packaging, containers and utensils intended to come into contact with foodstuffs or substances for personal use). This certification relates to colours Grey White, White 21, plain white similar to Ral 9010 and Top Class PVC coating.

Waste disposal:

in terms of current Italian legislation (Legislative Decree 22/97; Ministerial Decree 5/2/98 and updates and amendments), the "Residues of insulating materials in C.E.R. 170604 panels" have been certified as "special non-hazardous waste" intended for recycling (R4, R13) or, here this is impossible, suitable for waste disposal in the normal way. The Safety Data Sheet for the insulating panels is available on request, but this is purely of an informative nature, since the product is not considered "hazardous" and does not come within the scope of Ministerial Decree 28/01/92 (Official Gazette no. 50 of 29/02/92, supplement no. 46).

A4 PRODUCT TECHNICAL SPECIFICATIONS

The following are the Technical Product Specifications of Isopan panels.

A4.1 TYPES AND INTENDED USES

There are the following categories:

Insulated metal roofing panels for industrial and civil buildings (category: roofing panels)

- Insulated metal panels for infill, walls and suspended ceilings of industrial and civil buildings (category: wall panels)
- Single-skin insulated metal panels (category: single-skin panels)

The latter category has very specific intended uses, summarised here:

- a) ISOGRECATA 1000. Single-skin insulated metal panel for pitched roofs on industrial and civil buildings, with the lower skin in aluminium foil.
- b) ISODECK 40 1000. Single-skin insulated metal panel for pitched or flat roofs with outer facing in bituminised paper, for covering with an outer layer of bituminous membrane.
- c) ISODOGA 1000. Single-skin insulated metal panel for suspended ceilings and infill panels, with the upper skin in aluminium foil.

A4.2 DIMENSIONAL CHARACTERISTICS

Roofing panels:

- Length: as requested by customer up to the maximum transportable
- Useful width/spacing: 1000 mm
- Thickness outside ribs: 30, 40, 50, 60, 80, 100, 120 mm
- Height of ribs: 40 mm
- Spacing of ribs: 250 mm (500 mm for Isotego 1000)
- Lower bearing surface: micro-ribbed.

Wall panels:

- Length: as requested by customer up to the maximum transportable
- Useful width/spacing: 1000 mm
- Thickness: 30, 40, 50, 60, 80, 100, 120, 150 - 200 mm
- Bearing surfaces smooth or micro-ribbed

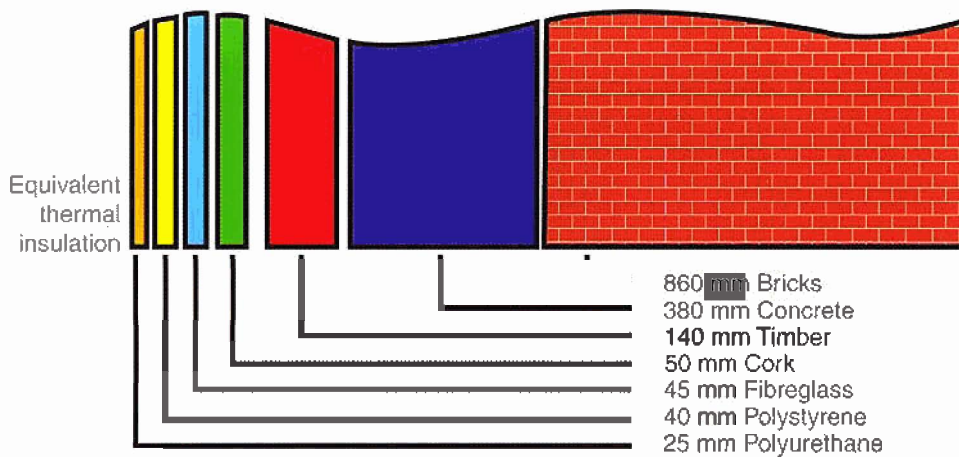
Single-skin panels:

- Length: as requested by customer up to the maximum transportable
- Useful width/spacing: 1000 mm
- Thickness outside ribs (excluding Isodoga 1000): 30, 40, 50, 60, 80 mm
- Height of ribs (excluding Isodoga 1000): 40 mm
- Spacing of ribs (excluding Isodoga 1000): 250 mm
- Lower bearing surface: aluminium foil (excluding Isodeck 1000), thickness 0.07 mm
- Upper bearing surface (Isodeck 1000 only): bituminised paper 350 g/m².

A4.3 INSULATION

- Composed of rigid polyurethane foam, self-extinguishing in accordance with current European standards

COMPARATIVE TABLE OF INSULATING MATERIALS



Reaction to fire Class B2 or B3 in terms of DIN standard 4102 part 1

- Average density $40 \text{ kg/m}^3 \pm 10\%$
- Compression resistance $\geq 11 \text{ N/cm}^2$ (at 10% deformation)
- Resistance to stretching $\geq 1 \text{ N/cm}^2$
- Resistance to cutting $\geq 1 \text{ N/cm}^2$
- Coefficient of thermal conductivity $\lambda=0.022 \text{ Kcal/m.h.}^\circ\text{C}$
- Non-hygroscopic because made up of over 95% closed cells

Coefficient of heat transmission:

For single- and double-skinned roofing panels

Thickness (mm)	30	40	50	60	80	100	120
Coeff. K ($\text{W/m}^2\cdot^\circ\text{C}$)	0,55	0,44	0,36	0,31	0,25	0,20	0,16
Coeff. K ($\text{kcal/h}\cdot\text{m}^2\cdot^\circ\text{C}$)	0,48	0,38	0,32	0,27	0,22	0,17	0,13

For single- and double-faced walling panels

Thickness (mm)	30	40	50	60	80	100	120	150
Coeff. K ($\text{W/m}^2\cdot^\circ\text{C}$)	0,64	0,50	0,40	0,34	0,26	0,21	0,18	0,14
Coeff. K ($\text{kcal/h}\cdot\text{m}^2\cdot^\circ\text{C}$)	0,57	0,44	0,35	0,30	0,23	0,18	0,15	0,12

A4.4 LOAD-BEARING CAPACITY

This depends on the type of metal bearing surface, its thickness and the thickness of the layer of thermal insulation, as stated in the tables in the specific product catalogues. Load-bearing capacities refer to the

panel fitted horizontally and under the action of a distributed load.

If, in view of the climatic conditions in the place of installation, the designer thinks a detailed check is desirable into the stresses caused by thermal action in the long term, he can refer to the ISOPAN Technical Office. It remains the responsibility of the designer to check the adequacy of the fixing system, with regard to the number and arrangement of the fixing points.

A4.5 TOLERANCES

- Thickness of the facings: in accordance with the reference norms for the products used
- Thickness of the panel: ± 2 mm
- Length: ± 5 mm
1000 mm module: ± 2 mm
- Out-of-square: max 3 mm
- Flatness: L= distance between the extremes of measurement, s= deviation
With L = 300 mm, s = 1%. With L > 300 mm, s = 3 mm max.