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CHAP. 1 *Energy efficiency: thermal insulation according to current international norms*

Introduction

Thermal insulation systems are made of those simple and complex materials and operations that allow reducing the transfer of heat between two environments at different temperatures. The partial or total thermal insulation that is produced, allows realizing energy savings in the process of indoor heating and cooling. In the building industry, insulation systems are therefore one of the ways to contribute to the global energy saving, not only to preserve existing energy sources on our planet, but also to safeguard human health, thanks to reduced emissions of CO2 and other combustion products coming from house heating. What is the real impact of these combustion products on the climate change cannot be exactly quantified; however, widespread scientific evaluations suggest that the impact of global warming on the climate is certainly significant, although in an extensive period of time.
Given the global nature of the problem, international regulations have greatly anticipated the individual national ones that have been gradually put in place reflecting to a large extent the existing international standards.
Today, the national standards are nothing more than the transposition of the European ones with some adaptation to different local climates. Thermal insulation works in buildings are regulated by the provisions of the European Union that designers and applicators must follow. It is therefore necessary to get full information about such requirements both as consumers or designers and manufacturers of insulating systems.
Docchem decided to build a product technical file that includes a summary of the existing regulations in order to make clear what are the responsibilities of each individual provider of products and services in the construction industry chain. To the supplier of insulating paints does not compete to establish the energy class obtainable from the application of its product, but to offer a complete set of chemical and physical data that allow the technician and the designer to evaluate the positive impact of using Thermorasante on the final result. This is not due just to the different professional skills, but as well to the different provisions of law for the various climatic zones. On one hand the producer can take advantage of the existence of the European guidelines in order to develop a product that can be marketed internationally, on the other hand he cannot take action in the technical calculation, but only in developing the properties of its product.

EPBD - Directive on the energy performance of buildings

The "parent" directive 2002/91/EC was repealed on 1 February 2012 and replaced by the European Directive 2010/31/EC on energy performance of buildings, published in the Official Journal of the European Union on 18 June 2010 (L 153).
The new Directive originates from the request made in its resolution of 31 January 2008 by the European Parliament, which has called for strengthening the provisions of the EPBD on several occasions, most recently with its resolution of 3 February 2009 on the second strategic review of energy policy, asking to make legally binding **the goal of improving energy efficiency by 20% by 2020**.

The Directive promotes the improvement of the energy performance of buildings, taking into account the local outdoor climatic conditions as well as the provisions relating to indoor climate and cost effectiveness.

Docchem, acting as a formulator and manufacturer of insulating systems, has decided to focus on the development of innovative technologies suitable to be applied on the inside of the building, with special regard to energy efficiency.

The Directive in a nutshell

The directive defines the common general framework for a methodology for calculating the energy performance of buildings and building units, which the European Member States are required to apply in accordance with the terms specified in the Directive. This methodology of calculation shall take into account **the type of building** (dwellings, offices, hospitals, restaurants, etc...), **the thermal characteristics of the building** and its internal divisions, **its heating, hot water production, conditioning** and ventilation, **lighting**, position and orientation, **passive solar systems** and solar radiation protection.

The minimum energy performance

Member States shall take the measures necessary to ensure **that minimum requirements - reviewed at regular intervals not exceeding five years**, and if necessary updated to reflect technical progress in the construction industry – **are set for energy efficiency** of buildings or building units in order to achieve optimal levels in relation to costs.

Calculation of the optimum levels

With the Delegated Regulation n. 244/2012 of 16 January 2012 (published in the EU Official Journal L 81 of 21 March 2012); the Commission established a comparative methodology framework for calculating the optimal levels of minimum requirements for the energy performance of buildings and building elements in relation to costs. Member States shall calculate the optimum levels using this framework and compare the results of this calculation to the minimum energy performance requirements currently in force. By 30 June 2012, Member States have provided the Commission with the first report describing the results. If the minimum requirements in force are significantly lower than the optimal level, Member States will have to justify this difference in a written document to the Commission and to act to reduce the gap.

New buildings and existing ones

For new buildings, the States must ensure that is evaluated the technical, environmental and economic feasibility of alternative high-efficiency systems, including: decentralized energy supply based on renewable energy, cogeneration, district heating and cooling, heat pumps.

When existing buildings undergo a major renovation, their energy performance must be improved in order to meet the minimum requirements.

Technical systems for the construction industry

In order to optimize consumption, Member States shall establish minimum requirements for technical systems for buildings (heating and domestic hot water systems, air-conditioning, large ventilation systems). In addition, they shall promote the introduction of active control systems in buildings under construction or major renovation. Therefore any intervention on the internal wall structure will have not just to meet the law requirements in terms of energy efficiency, but also to be compatible with the installation of such technical systems in terms of ensuring breathability, anti-mould and anti-condensation properties, and possibility of local repair interventions without impairment of the building energy efficiency.

Nearly zero-energy buildings

Member States shall ensure that by 31 December 2020, all new buildings are "nearly zero energy buildings", i.e. with a high energy performance, where the energy demand is very low or almost zero covered to a very significant extent by energy from renewable sources. The public buildings of new construction shall be nearly-zero-energy ones from 31 December 2018.

Energy performance certificate

Member States shall establish a system of energy certification of buildings. The certificate will include the energy performance of the building and reference values such as minimum energy performance requirements, in order to allow owners or tenants to compare and assess the energy performance.

The certificate - valid for 10 years - if not already available in accordance with Directive 2002/91/EC, shall be issued for buildings constructed, sold or rented in which an area of over 500 m2 is occupied by public authorities and attended by the public. As of July 9, 2015 the threshold is lowered from 500 to 250 m2.

With regards to working on the wall structure, it becomes essential to have the opportunity to work on the inside of the building without risking damages to any existing decoration on the outside (with special reference to public buildings of artistic or historical value) and at the same time to make it possible to choose solutions of different nature and cost for those parts of the building that may not be in need of the same strict law compliance (non-residential / used for storing)

The new Directive provides also for periodic inspections of heating and air-conditioning systems by qualified independent experts.

CHAP.2 *From the general terms to the local Italian and European implementations*

Italy

The current legislative decree, DL 63/2013 transposing the European Directive 2010/31 / EU introduces a new methodology for calculation and the minimum standards of energy performance of buildings. **The new buildings belonging to the Public Administration must be "nearly zero energy" from 31 December 2018, while the private ones from 2021.**

The Italian national methodology of calculation involves **the division of the territory in climatic regions** for which the **requirements are set in local regional resolutions** that can be different but conforming to the three cornerstones in energy efficiency and energy certification of buildings:

A. the definition of minimum requirements of energy performance, **which can vary according to the type of construction project**, regarding the **building shell**, the installations, and the complete set of building-and-technical systems;
B. the enhancement of the role of the energy certification of buildings as a tool to improve transparency in the real estate market and **to promote the improvement of energy efficiency of buildings, both new constructions or subjects of restructuring**;
C. the establishment of an energy register of buildings that, thanks to the data from certifications recorded in the information system, can help the Regional authorities and other public agencies in promoting policies aimed at improving living comfort, health and energy conservation in civil constructions.

This technical file is built in order to facilitate the certifier in preparing the energy performance certificate (APE) and provides information on technical and regulation matters, as well as the values of the chemical and thermo- physical properties needed for the determination of thermal transmittance and insulating power.

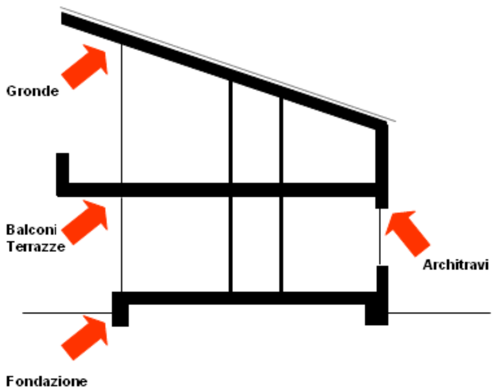


Fig.1: thermal discrepancy points

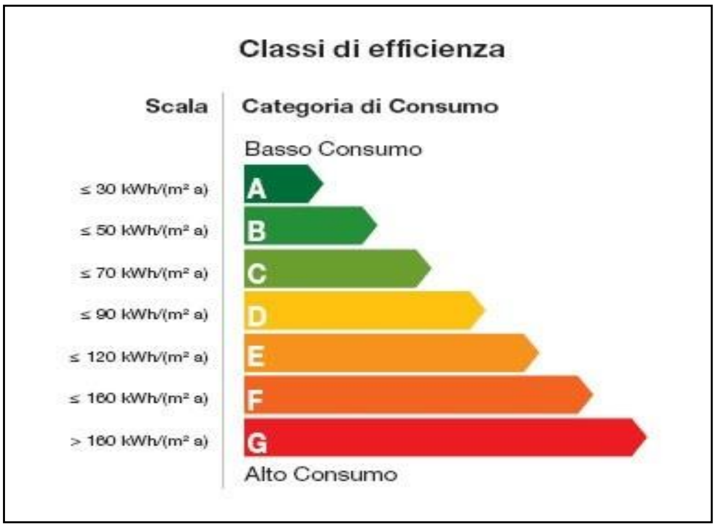
The definition of climatic zones in Italy

The climatic zones of the Italian territory and the distribution of the municipalities to the various zones of each region, as well as the limits for the annual period and daily time of operation of heating systems have been defined depending on the DD (Degree Day). For each climatic zone have been defined the thermal transmittance values in accordance with the European Directive guidelines.

Climatic zone	Vertical matt structures	Horizontal /oblique matt structures		Windows or similar
		Ceiling	Floor	
A	0,54	0,32	0,60	3,7
B	0,41	0,32	0,46	2,4
C	0,34	0,32	0,40	2,1
D	0,29	0,26	0,34	2,0
E	0,27	0,24	0,30	1,8
F	0,26	0,23	0,28	1,6

Tab.1:Limit values of thermal transmittance U for the structures of a building shell, expressed in W/m^2K, in force in Italy since March 14, 2010

Energy efficiency classes according to the European norm



Tab 2

Other European Countries

Docchem, for the purposes of international certification of its products, shows in this file a summary of the legislative provisions on energy efficiency in some of the major European countries, which put Thermorasante at the forefront in terms of specific performance.

France

The French energy policy is managed by the central government and only some specific responsibilities in energy management have been devolved to the Regions in 1982.

The legislative instruments relating to the construction of buildings are:

- the construction and housing code (CCH), general;
- the thermal regulation (RT) linked directly to the limitation of energy consumption in buildings.

The transposition of the European Directive 2002/91/EC was made with the Law 1343/04 of 9 December 2004, subsequently updated with the decree 655/05 and the law 872/06 of 13 July 2006.

They were later adopted numerous decrees designed to specify the implementation of the certification, called the Diagnostic de Performance Énergétique (DPE). As regards the energy performance certificate, in implementation of the European Directive has been set the obligation of energy certification for the new buildings and for the existing ones when subject to purchase or lease. For public buildings and private buildings for public use with a floor area larger than 1000 m2, it is also established the obligation to display the energy certificate at the entrance or at a reception point. To new buildings are also imposed some prescriptive requirements, additional to the certification process:

a) a specific annual energy consumption;

b) the indoor temperature in summer, for buildings without forced air cooling;

c) the thermal characteristics of building elements;

d) the performance of mechanical systems.

As for existing buildings: for individual units made prior to January 1, 1948, the energy consumption cannot be calculated with the conventional method, but it must be based on the actual average consumption over the last three years prior to the diagnosis (operational rating)

France: heat transmission limits for building elements

Structural elements of the building shell	Heat transmission W/m^2K
Side walls facing outwards or towards the ground	0,45
Side walls facing unheated rooms	0,45/b*
Lower floors facing outward or open parking areas	0,36
Lower floors facing a ventilated crawl space or an unheated room	0,40
Concrete or cement roof slab and pitched roofs covered with metal plates	0,34
Flat roofs covered with metal plates	0,41
Other roof slabs	0,28
Windows and French windows facing outwards	2,60
Curtain walls	2,60
Shutter box	3,00

Tab 3: *Temperature correction factor for the different types of unheated rooms (as defined in the Regulation Th-U)

Germany: heat transmission limits for building elements

Type of building		Limit value U [W/m²K]
Isolated building	S ≤ 350 m²	0.40
	S > 350 m²	0.50
Building connected to others on one side only		0.45
All other buildings		0.65
Extensions		0.65

Tab 4. Limit values for residential buildings [W/m2K]

Where U is the specific value, related to the useful floor area, of the coefficient of transmission dispersion for the building shell Ht [W / K]

Building shell element	Average Heat transmission Average value U [W/m²K]	
	Rooms with $T_{ind} \geq 19°C$	Rooms with $12 < T_{ind} < 19°C$
Opaque elements	0.35	0.50
Transparent elements	1.9	2.8
Curtain walls	1.9	3.0
Large glass and roof elements	3.1	3.1

Tab 5: Limit values for non-residential building shell

Austria: heat transmission limits for building elements

Structural Elements	Heat transmission W/m²K
Side walls	0.35
Side wall sections that do not exceed 2% of side walls total	0.70
Partition walls between units or between rooms with different use	0.90
Walls facing unheated rooms (excluding attics)	0.60
Walls facing unheated or not habitable attics	0.35
Walls facing other buildings	0.50
Floors and walls facing the ground	0.40
Windows, French windows , doors and transparent vertical elements facing unheated rooms	2.50
Outwards windows and French windows , in residential buildings	1.40
Outwards windows, French windows , doors and transparent vertical elements	1.70
Skylights	1.70
Outwards horizontal or inclined transparent elements	2.00
Flat roofs, pitched roofs and floors of not insulated or ventilated attics	0.20
Floors facing unheated rooms	0.40
Floors facing other units or rooms with a different use	0.90

Tab.6

CLASS	Requirement [kWh/m²a]
A++	HWB ≤ 10
A+	HWB ≤ 15
A	HWB ≤ 25
B	HWB ≤ 50
C	HWB ≤ 100
D	HWB ≤ 150
E	HWB ≤ 200
F	HWB ≤ 250
G	HWB > 100

Tab.7 Energy classification in AUSTRIA

CHAP. 3 THERMORASANTE insulation system: the material’s composition and properties with regard to environmental impact

The quality of an insulating material must be judged with respect to the performance that is required to ensure, which is not limited to the insulating power, but includes also its mechanical properties, its behaviour within the operating temperature range, its resistance to fire and water, etc.
Each material has specific properties that make it preferable to others according to the application, being understood that it owns the chemical and physical characteristics to ensure the insulating effect.
The way of applying the product it’s a critical issue, especially in the field of energy efficiency of buildings; its nature (simple or complex) can make a real difference in the calculation of the total cost of the work, both in economic and environmental terms, and becomes itself a determining factor in the choice of the solution to be adopted.

Properties of the product

Thermorasante is in effect a SMART system as it is based on technology that offers hyper-performing highly integrated solutions with a low environmental impact, easy to use although consisting of complex active materials. A thin layer, applied directly to the wall, manually or mechanically, provides a significant barrier that makes it a professional insulating material in both cooling and heating of housing in private and public buildings. The simplicity of the formulation structure ensures an effective process control and the respect of the technical parameters certified by the manufacturer for more than 90% of the volume produced in accordance with the DPR 846/93, concerning the approval of construction products.
The chemical nature of the product guarantees the eco-sustainability according to the guidelines defined by the CEPE’s "sustainability chart".

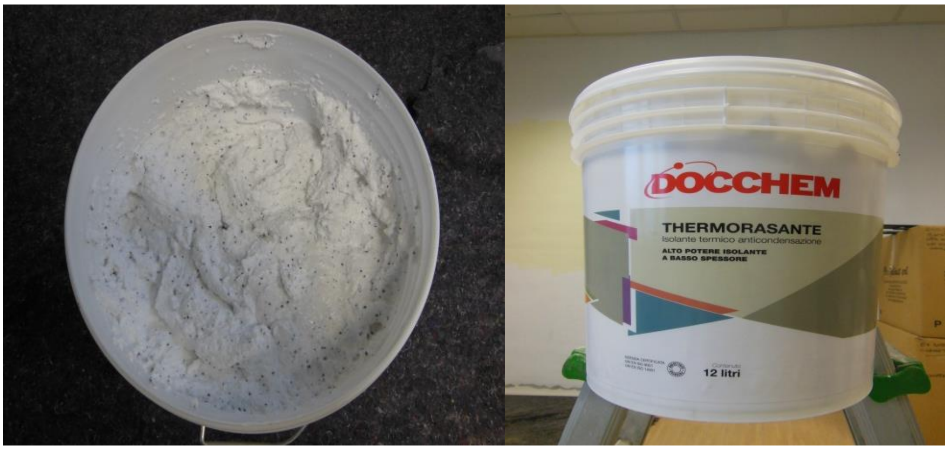


Fig.2

The cost of materials, design and laying, in the economics of a work to improve the energy efficiency of a residential building

Let us consider the installation of an insulating system and, given the nature of Thermorasante, let us focus on its application method that, unlike most of the insulation systems based on panels, allows a manual or mechanical laying operation typical of smoothing products, thus generating clear savings through reduction, simplification and optimization of:

- Costs related to planning the works and getting the necessary authorizations
- Restrictions on buildings protected for artistic or historic reasons
- Scaffolding (type, number, assembling and disassembling time, rental fees, transportation, use of specialized workers, safety systems required for workers)
- Complexity of paperwork required for condominium works compared to those for single owners
- Possibility of application in individual units without affecting the external structure of the building facade, whether historical or special in any way such as in a mountain environment, or when the materials of the outer surfaces do not allow the use of other known methods of insulation for aesthetic or technical reasons
- Number of components and materials necessary for the creation of an effective wafer, including the related logistics
- Duration of the works and related cost of personnel

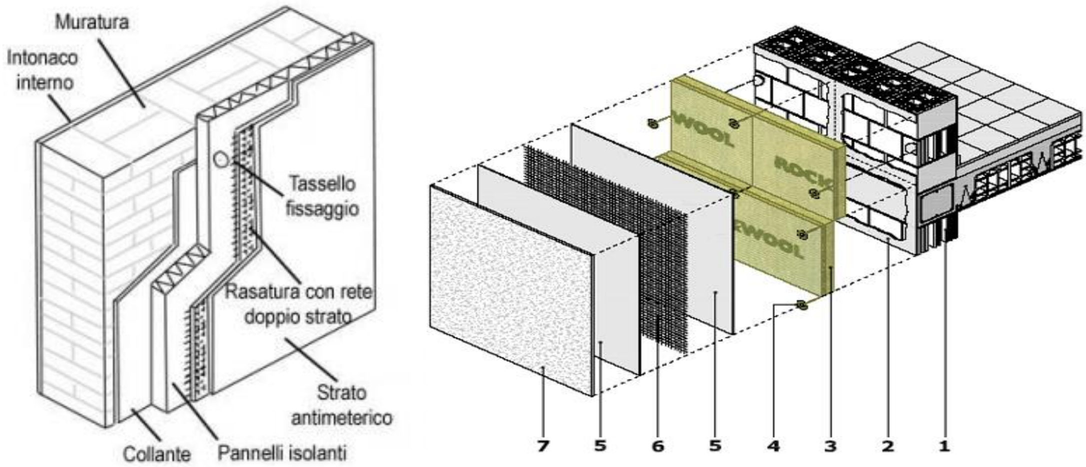


Fig. 3: Example of a solution using a multi-coat on the external wall (7 layers wafer)

Fig.4 : Example of application of Thermorasante (single layer)

Fig.5 :Example of one step of the works required to improve the energy efficiency of an existing building acting on the external vertical surfaces

These factors, that can be quantified in terms of economic and eco-sustainability value, are key elements in the overall calculation of the cost of operations in the field of energy efficiency and justify the adoption of new solutions versus the traditional systems available on the market.

Application areas

Fig.7: Type 1 : residential housing in an historic building

Fig. 8 Type 2: multi-material residential housing, not be covered externally

Fig.9: Type 3: Individual residential housing with many thermal bridges and relevant exposure to thermal gradients

Fig. 10: Type 4: residential units in buildings with non-masonry external walls

Fig.11: Type 5: residential buildings with multiple external structures

CHAP. 4 *Testing of Docchem THERMORASANTE and methodologies used*

CPD – Construction products directive: when does it apply?

The Construction Products Directive (CPD) 89/106/EEC, implemented in Italy by DPR 846/93, has the aim of ensuring the free movement of goods within the European Union AND allowing their performance evaluation on the basis of harmonized technical standards.
The CE marking is not a quality mark and therefore does not require the product to achieve a certain standard performance value. It is, however, an important guarantee for the consumer as the manufacturer, responsible for affixing the CE marking, is committed to complying with a protocol of product testing, to using only accredited laboratories for external testing, to verifying that the stated performances are achieved by 90% of the production, at least.
The CPD considers suitable for use those products that allow the buildings in which they are incorporated to meet six necessary requirements:

- Mechanical resistance and stability
- Safety in case of fire
- Hygiene, health and environment
- Safety in use
- Protection against noise
- Energy saving and thermal insulation

Each Member State is free to define what requirements should be met by individual products and to set minimum thresholds of performance. The products compliance with the criteria of the Directive shall be stated on an appropriate declaration and by the CE marking on the product or packaging.
Currently, the insulating materials for which it is available a harmonized technical standard, are subject to CE marking and according to the DM 5/3/2007 manufacturers are required to declare on the label the following features:

- Fire resistance
- Water permeability
- Heat resistance
- Water vapour permeability.

For all other characteristics, the manufacturer is free to declare their value or to use the words NPD (No Performance Declared).

The following materials, as defined by the harmonized technical standards UNI EN shown below, are in fact subject to the CE marking:

A. Manufactured mineral wool products UNI EN 13162
B. Manufactured polystyrene foam products UNI EN 13163
C. Manufactured extruded polystyrene foam products UNI EN 13164
D. Manufactured rigid polyurethane foam products UNI EN 13165
E. Manufactured phenolic resin products UNI EN 13166
F. Manufactured cellular glass products UNI EN 13167
G. Manufactured wood wool products UNI EN 13168
H. Manufactured expanded perlite products UNI EN 13169
I. Manufactured expanded cork products UNI EN 13170:
J. Manufactured wood fibre products UNI EN 13171

Up to now, the products made from silica aerogel (like Thermorasante) are not included among the insulating materials subject to the CE marking; however, Docchem has decided to put on the label the technical properties listed below, communicating and certifying their values in order to allow a correct evaluation of the product's effectiveness in thermal insulation of a building's shell, in accordance with the **EPBD - DIRECTIVE ON THE ENERGY PERFORMANCE OF BUILDINGS.**

THERMORASANTE: Declared technical properties

- Fire resistance
- Water permeability
- Thermal resistance
- Water vapour permeability.
- Specific heat
- Grip strength
- Compression

ETA – EOTA 01/07/2013 "The European Technical Assessment"

The directive is clear: **if a construction product is not completely or partially covered by a harmonized standard**, it is necessary for the manufacturer to provide a statement of performance (DOP). An ETA certificate can be issued only by an institution (TAB) recognized as belonging to EOTA.
As defined in Article 2, paragraph 1, a "construction product" is "any product or kit of products that is produced and put on the market for incorporation in a permanent way in a construction work or in parts of it and whose performance affects the performance of the construction work in relation to the basic requirements of such a work"*.
With regard to insulation materials a guideline exists solely for outside insulating materials with a complex structure (coat system) : the European Assessment Document - Guideline 004.
There is no European guideline for a single layer insulating material. The DOP (Declaration of Performance) in this case is the manufacturer's self-certification on the basis of the result of the tests made according to international standard procedures (ASTM, EN, ISO) by a certified laboratory, as told in the general directive concerning the definition of construction products subject to the CE marking.

THERMORASANTE: Declared technical properties
Docchem decided to certify all the technical parameters of Thermorasante in accordance with the guidelines for the ETA certificate, that is using an external certified laboratory and according to the rules and methods required for approval. Thermorasante is certified with respect to :

- *Fire resistance*
- *Water vapour permeability*
- *Water permeability*
- *Thermal Resistance*
- *Grip strength*
- *Compression*
- *Specific Heat*

CHAP. 5 *THERMORASANTE's physic-chemical properties and their effects on insulation applications*

Fire resistance according to UNI EN 13501 -1

A comparative evaluation of the fire resistance of different materials must be based on the following factors: flashpoint, harmful effect of flue gas, formation of droplets and formation of dense smoke. Building materials are divided and classified according to their reaction to fire in 7 European classes, in accordance with the EN 13501 -1 standard

A1 A2	An intense fire cannot be started - non-flammable material
B	An intense fire cannot be started, but there may be a substantial contribution to the fire
C	An intense fire can be started in a period of time of 10 to 20 minutes
D	An intense fire can be started in a period of time of 2 to 10 minutes
E	An intense fire can be started in a period of time of 2 minutes
F	Does not follow any fire resistance norm and the material, after the test, has no function in protection from fire

Tab.8

Thermorasante: Determination of fire resistance (EN 13501-1 standard)
Average loss of mass: 17%
Fire resistance class: A2

Fire Resistance Classes – Traditional materials	
Polystyrene	Classe E
Fiberglass	Classe A1
Rockwool	Classe A1
Wood fiber	Classe E
Cork	Classe E

Water vapour permeability according to the UNI EN ISO 7783

The heating of living spaces during the cold season provides a continuous supply of moisture, raising the water content of indoor air to a much greater level than the outdoor one. The partial pressure of water vapour is therefore greater indoor than outdoor. This pressure difference causes a migration (diffusion) of water vapour through the external structural elements. During such a migration of water vapour it can occur a condensation, which is formation of water within the structural element. If the temperature of the inner surface of the structural element is low enough, the condensation can occur already on the inner surface, with the consequent formation of mold. The exact level of the dew point, i.e. where in the structural element the water formation will take place, and the amount of water involved can be calculated with reasonable precision. For the most common wall structures there is a sufficient number of empirical values, while for the special ones a specific calculation must be done, such as for external walls with an inside insulation, that is much more susceptible to the condensation of water than an outer insulation.

Today there are also insulating materials for inner side application with a high capillary absorbency, which can be used without a specific calculation up to a thickness of 5 cm. Depending on the material and its thickness, the diffusion of water vapour inside the structural element is opposed by a resistance called diffusion resistance. The diffusion resistance of a material is measured by the coefficient μ, which corresponds to the thickness in m of the layer of air which opposes the same vapour diffusion resistance as 1 m of that material. As insulating materials oppose the heat-flow, others - the so-called vapour brakes or vapour barriers – are able to stem the flow of water vapour. These brakes or barriers must always be applied before the dew point area, to make it difficult for the water vapour to get there. In general, the diffusion resistance of the structural elements should be very strong till the dew point area and very slight beyond it. The water that it might form in the wintertime must be able to get out easily during the summertime and dry out completely the structural element in order to avoid permanent damages to it.

Diffusion resistance coefficient μ	**Classification**
Up to 10	High diffusion
From 10 to 50	Medium diffusion
From 50 to 500	Moderate diffusion
Infinite	Vapour barrier

Tab.9

Equivalent air layer S_d	**Classification**
$S_d < 0.1$ m	Highly breathable membranes
0.1m $< S_d <$ 0.3 m	Breathable membranes
2m $< S_d <$ 20 m	Vapour brake blankets
$S_d >$ 100 m	Vapour barrier blankets

Tab.9 bis

Thermorasante: Measurement of water vapour permeability (Norma UNI EN ISO 7783) .

	Thermorasante			**AVERAGE VALUES**
	1	**2**	**3**	
V(g/m^{2}d)	**6.134E02**	**6.421E02**	**5.780E02**	
S_d (m)	**0.039**	**0.037**	**0.041**	**0.039**
μ	**12.5**	**14.1**	**13.8**	**13.4**

Tab.10

The product is **highly breathable,** with **diffusion values between high and medium, tending toward high**.

In this regard it should be emphasized that the evacuation of air moisture present indoor and generated by activities such as cooking, washing, showering, as well as that coming from people living in the room, must be carried out mainly by means of adequate ventilation. This means that the behaviour of the users, especially in spaces used for living and personal care, plays a significant role.

The permeability to liquid water according to UNI EN 1062-3

The water permeability is measured in [kg] of water passing through 1 [sqm] in 1 [hour], where low values correspond to low absorption thus indicate high water resistance, while higher values indicate a water permeability (very different from vapour permeability) that in the context of functional coatings for the construction industry means a poor protection of the overall wall structure from infiltration. This means that when applied to a masonry work exposed to water and moisture, a painting or coating product, both aesthetic or functional (insulating), must be able to protect it by regulating the transit of water and steam in a way most suitable to the environmental conditions and to the nature of the surface, **slowing down the water inflow and facilitating, when necessary, the outflow of vapour .**

The standard says:

Class	**Liquid water permeability [(Kg /(m^2√h)]**
Absorbing	W > 0.5
Partly absorbing	$0.1 < W \le 0.5$
Water-repellent or waterproof	$W \le 0.1$

Tab.11

Thermorasante: Measurement of liquid water permeability (Norma UNI EN ISO 1062-3)

Change in mass of the sample Δm t_{24h}(kg)	**Coefficient W of liquid water permeability [(Kg /(m^2√h)]**
0.0155	**0.13**

Tab.11 bis

Thermorasante **is a water-repellent product with a significant waterproofing power**

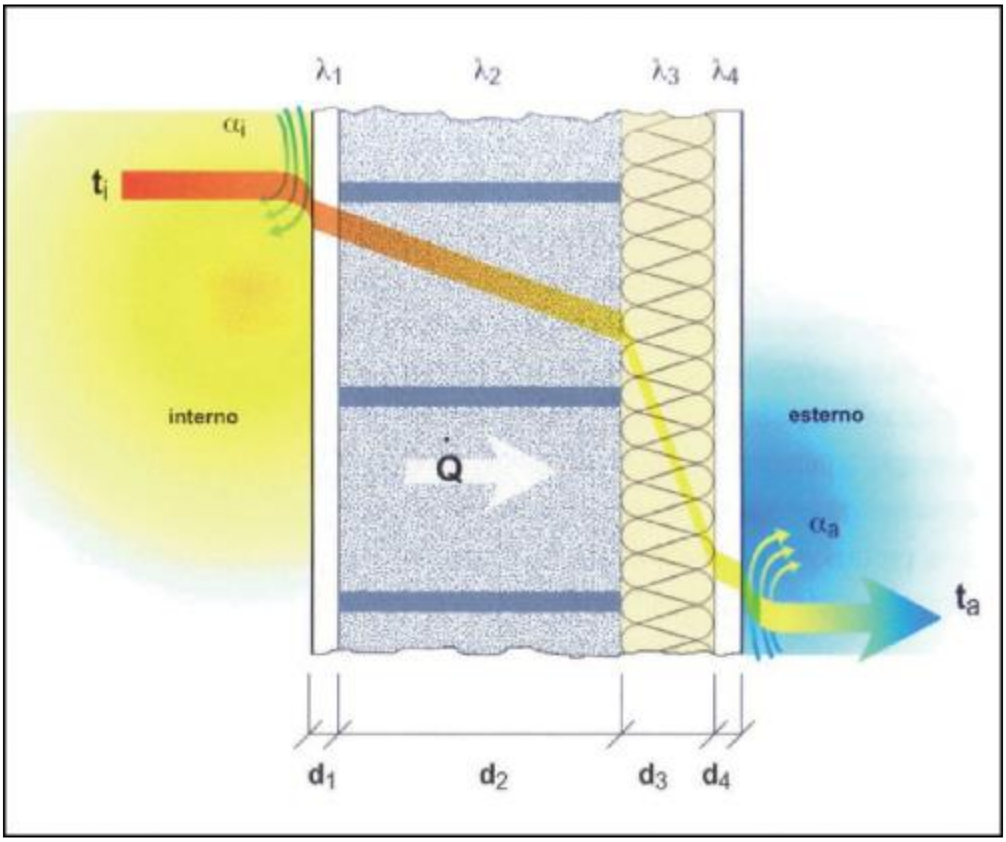
Thermal conductivity according to UNI EN 12667

Summarizing what already reported in Chapter 1, the ability of a building material to conduct heat is quantified on the basis of its specific thermal conductivity λ (lambda). **Materials with a λ coefficient (lambda coefficient) smaller than 0.1 W / mK can be considered insulating ones.** The λ coefficient

indicates the amount of heat that flows per second through 1 m2 of a building material with a thickness of 1 m and with 1K (= 1 ° C) temperature difference between inside and outside
- Sign: λ
- Unit of measure: W / mK

The following rule applies: the lower the λ coefficient, the better the insulating capacity of the material.
In addition, the measurement of the heat transmission through a structural element with reference to a stationary state represents the overall heat transmission coefficient or, in short, the U coefficient, that shows the heat transferred from the inside to the outside through a surface of 1m2 and with a temperature difference of 1K.
- Sign: U
- Unit of measure: W/m2K

Fig. 12 Heat transfer through an insulated external wall



The heat transfer through a given structural element of a building depends on the natural thermal convection of indoor air (αi), the thermal conductivity (λ), the thickness (d) of the materials which it is made of and the natural thermal convection of outdoor air (αa). The following rule applies: the lower the U-value of the structural element, the smaller its heat loss. The choice of an insulating system and the calculation of its cost effectiveness are strongly dependent on the relationship between the energy efficiency obtainable with a given thickness, i.e. the quantity of product needed at a given purchasing price, and the installation cost, which depends on the characteristics of the chosen system. That can be easily represented on a diagram based on energy performance as independent variable.

Thermorasante : Determination of thermal conductivity (UNI EN 12667)

λ certified experimental value for Thermorasante **= 0.020 ± 0.001 W/mK**
λ certified value for silica aerogel **= 0.014 ± 0.001 W/mK**

From a careful analysis of the thermal conductivity values of insulation materials available on the market, it is evident the clear superiority of silica aerogel when it comes to this parameter. That material is the main component of Docchem's Thermorasante.

MATERIAL	CONDUCTIVITY λ [W/mK]	PRODUCTS
Fiberglass		**RIGID AND SEMI-RIGID BOARDS**
Resin mats	0,053-0,046	
Semi-rigid boards	0,046-0,038	
Rigid boards	0,038	
Cellular glass	0,055-0,066	
Mineral fibres from feldspar or basalt rocks	0.038-0.048	**PLATES**
Wood		**BOARDS**
Expanded cork	0,043-0,052	
Wood-wool board with inorganic binders	0,085-0,11	
Wood chipboard with inorganic binders	0,12-0,15	
Wood chipboards, pressed or extruded	0,10-0,17	
Natural wood, hard or extra-hard	0,14-0,18	
Magnesite	0.09-0.075	
Polystyrene foam		**BOARDS**
Extruded, with skin	0,035	
Extruded, without skin	0,041-0,034	
Sintered	0,040-0,034	
Hot pressed	0,040-0,039	
Polyurethane plates	0.034 – 0.032	**PLATES**
Silica aerogel	0.014	
Thermorasante	0.020±0.001	**PRE-MIXED SMOOTHING PASTE**

Fig.13

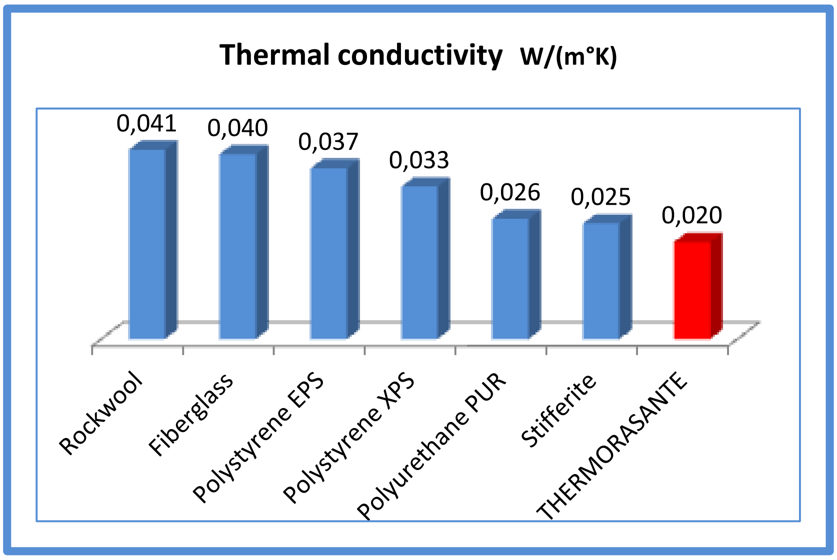


Fig.14

Thermal conductivity, thermal transmittance and heat build-up: the thermal wave time-lag and the energy efficiency according to UNI EN 13786

In a building, heat build-up has the task of contributing to energy savings and avoiding overheating during the summertime.
However, the effect of the storing mass on energy consumption for heating in countries with a central-European climate, it is often overestimated. In the summertime a storing mass inside the building can absorb the excess heat and then discharge it at night by means of proper ventilation.
In general it is known that in presence of large windows facing south and west, a storing mass alone cannot solve the problem of overheating. In this case it is essential to provide external shading. For rooms facing south with large windows it is useful to provide a sunshade efficiently coupled with a storing mass, but this is not true for rooms rarely used as guest rooms, or houses occupied only on weekends. The lower the storing mass to be heated, the lower the time required to reach the heating regime. In light buildings and roofs for protection from the summer heat must be taken into account the so-called time-lag: this term refers to the time required for a heat wave to go through a structural element from the outside to the inside. A sufficiently long time-lag (> 10 hours) delays the passage of the thermal wave to the extent that the highest daytime temperature manages to get inside when you can counter it with the cool night air.
Experimental evidence of energy efficiency results obtained both on heating and cooling with the application of a 5mm thick layer of Thermorasante on the inside of perimeter masonry structures of a residential building is shown on the time-lag diagram here below.

Thermorasante performs much better than standard insulating products on the market.
The diagram can be drawn for higher thickness depending on the required class of energy certification.

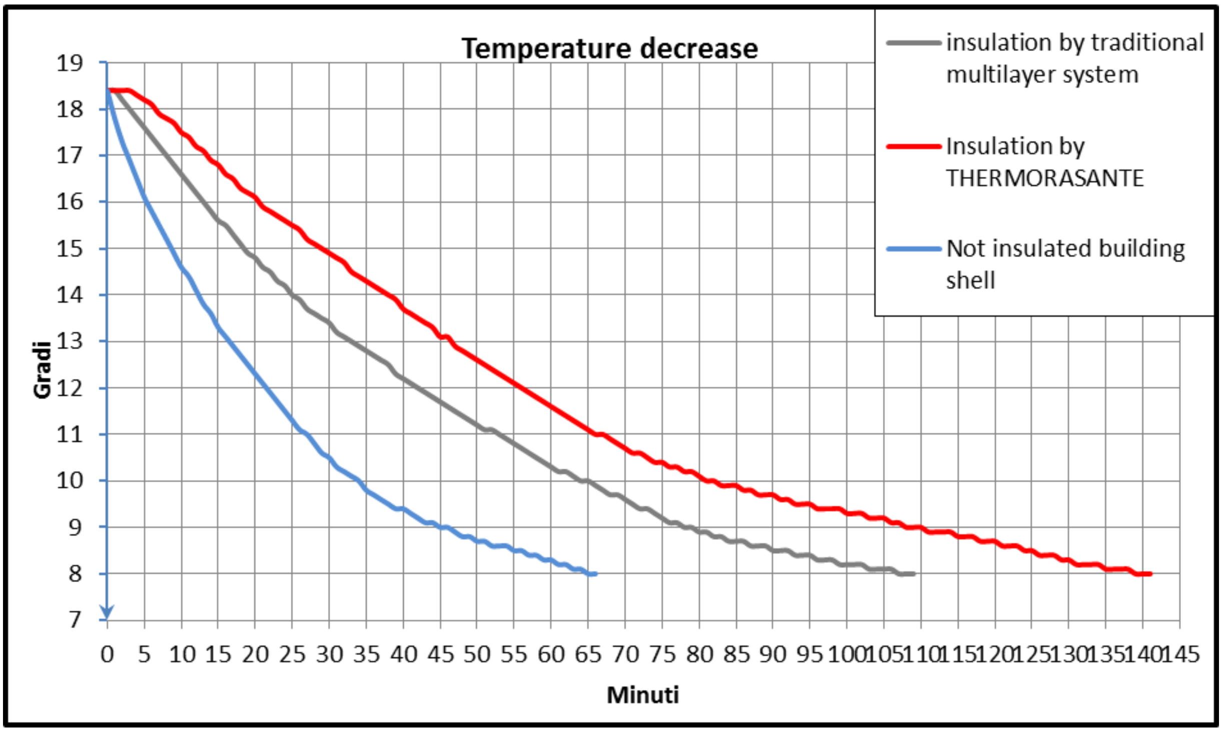


Fig.15: Temperature decrease in grades centigrades vs time in minutes

Not Treated	
Minuti	Tc (°C)
0	18,4
10	14,6
20	12,3
30	10,5
40	9,4
50	8,7
60	8,3
70	8

Standard Insulation Multilayer System	
Minuti	Tc (°C)
0	18,4
10	16,6
20	14,8
30	13,4
40	12,2
50	11,2
60	10,3
70	9,6
80	8,9
90	8,5
100	8,2
110	8

THERMORASANTE	
Minuti	Tc (°C)
0	18,4
10	17,5
20	16,1
30	14,9
40	13,7
50	12,6
60	11,6
70	10,7
80	10,1
90	9,7
100	9,3
110	9
120	8,7
130	8,3
140	8

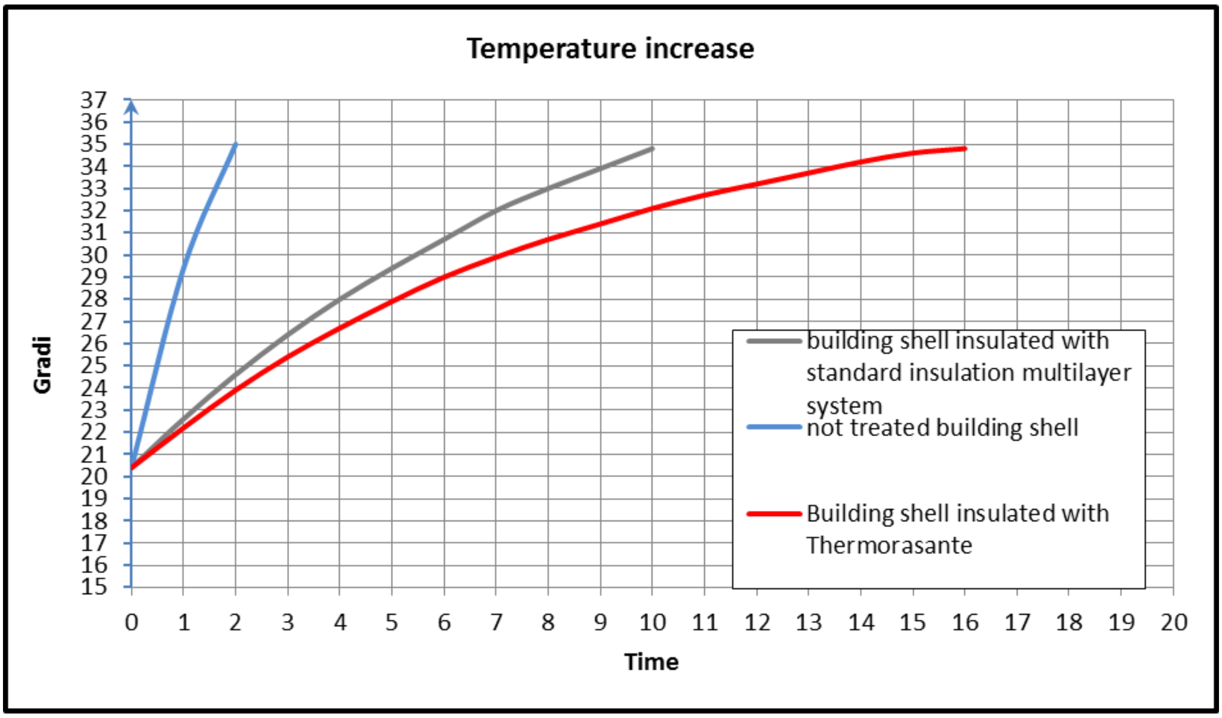


Fig.16: Temperature increase in grades centrigrades vs time in hours

Not Treated	
Ore	Tc (°C)
0	20,4
1	29,4
2	35

Standard Insulation Multilayer System	
Ore	Tc (°C)
0	20,4
1	22,6
2	24,6
3	26,4
4	28
5	29,4
6	30,7
7	32
8	33
9	33,9
10	34,8

THERMORASANTE	
Ore	Tc (°C)
0	20,4
1	22,2
2	23,9
3	25,4
4	26,7
5	27,9
6	29
7	29,9
8	30,7
9	31,4
10	32,1
11	32,7
12	33,2
13	33,7
14	34,2
15	34,6
16	34,8

Grip strength according to UNI EN 1542

The test allows measuring the grip strength, or strength of adherence, of a Thermorasante layer applied to a concrete substrate. It is carried out in order to allow its use for the smoothing of the inside walls of a building. Standard values of grip strength of thermal insulating products are of the order of 10^{-1} -10^{-2} N/mm2

Thermorasante: Determination of the average grip strength "fh" (UNI EN 1542)

The value, based on the tests made, is stated to be 0.05 N/mm2 with a type B breakage, where the fracture occurs within the layer of Thermorasante.

The grip strength test proves that the detachment occurs within the layer of Thermorasante and not at the interface Thermorasante /base support. Equally, there is no detachment at the interface Thermorasante - Evolution S (finishing product). This test shows an excellent behaviour of the whole package: Thermorasante and Evolution S interact with each other, forming a compact thermo - insulating layer perfectly fixed to the support.

Compression strength according to UNI EN 826

The compression strength is the stress that a material can withstand when it is subjected to a compressing force. This value is needed to evaluate the possibility of using a material in the floor foundation screeds. When thinking about the choice of an insulating material to be positioned under the floor, it is essential to check that its compression strength allows it to carry the existing load. The CE marking provides for an indication of the compression strength value, measured at 10% deformation, in the product data sheet.
In this case, it was decided to perform the test in order to evaluate the suitability of Thermorasante for use on dull vertical walls, not subject to floor load but rather to normal conditions for vertical indoor walls of a residential building. Furthermore, Thermorasante represents just one of the two components of the complete package, as it is then coated with a mineral plaster finishing for aesthetic purposes.
Thermorasante, because of its physical characteristics, shows an extremely low rigidity, thus reaching very low values of resistance to compression with a 10% deformation. **If you consider instead the ultimate compression strength of the Thermorasante - Evolution S package, without reference to deformation, you can reach extremely high ultimate compression loads, of the order of 50 tons (500 kN).**
In conclusion, it is confirmed that the Thermorasante - Evolution S package **is not suitable as a thermal barrier in correspondence of floor screeds,** due to too low values of resistance to compression with 10% deformation. In some cases, a floor for civil use can achieve, and easily overcome values of 4.6 ± 2 kPa.
Furthermore, a compression load on Thermorasante, even a relatively low one, it can cause the "breaking" of its silica aerogel spheres, thereby altering the thermal performance of the material.
The package instead is suitable for the treatment of vertical matt perimer walls of a housing building.

Thermorasante: Determination of compression strength (UNI EN 826)

From experiments carried out, were obtained an average compression strength value of 4.6 ± 2 kPa.
The material, as occurred in the course of the tests, can withstand loads up to values of 500 KN without any failure.

Specific Heat of Silica Aerogel

The specific heat, measured in [Joule / kg. ° K], is the amount of heat required to change of 1°C the temperature of 1kg of the considered material. It indicates the capacity of a material to store heat.
The ability of a material to act in the summertime as an insulating barrier to the heat wave, is given by the thermal diffusivity parameter:

$\alpha = \lambda / (\rho . Cp)$ [m^2 / s]

where:

λ = thermal conductivity of the material [W / m. ° K]

ρ = density of the material [kg/m3]

cp = specific heat of the material [Joule / kg. ° K]

The ability of an insulating material to give a good contribution to thermal insulation in the summer can be estimated by calculating its thermal diffusivity. The smaller its diffusivity value, the better its performance.

Determination of Thermorasante's specific heat: Cp = 1040 J / Kg °K

CHAP.6 *Comparative representation of the state of the art of insulating materials according to application*

Thermal conductivity and insulating power

The following materials must be applied with the thickness shown below in order to obtain the same result in terms of energy performance. The analysis refers exclusively to the thermal performance and does not accounts for the differences between installation systems required by different materials, which however must be included in a correct calculation of the cost of insulating a building, that must start from costs of architectural and structural engineering and, especially in the case of outdoor works, consider the means of application and the complexity of application cycles, especially in the case of wafer materials.

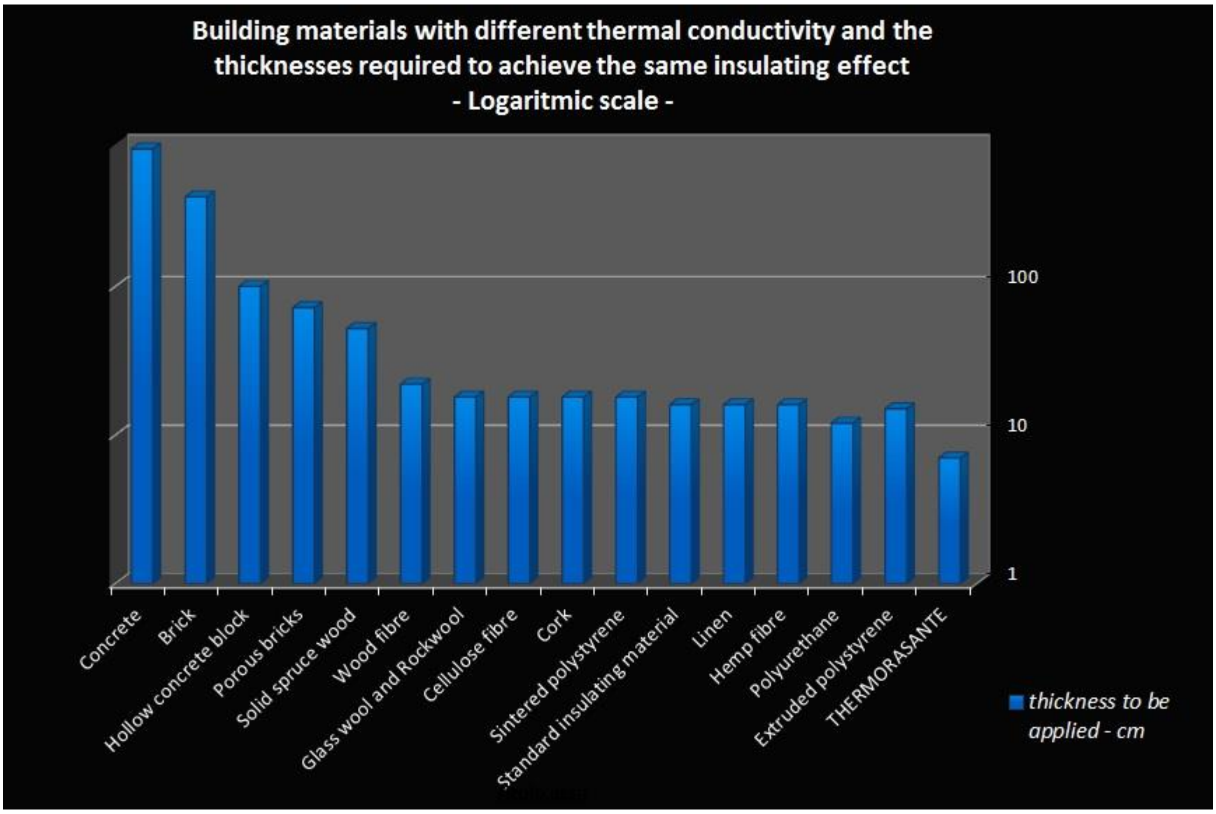


Fig.17

Building materials with different thermal conductivity	Thickness (cm) to be applied to get the same energy performance
Concrete	840
Bricks	400
Hollow concrete block (Parpaing creux béton)	100
Porous bricks	72
Solid spruce wood	52
Wood fibre	22
Glass wool and Rockwool	18
Cellulose fibre	18
Cork	18
Sintered polystyrene	18
Standard insulating material	16
Linen	16
Hemp fibre	16
Polyurethane	12
Extruded polystyrene	15
THERMORASANTE	7

Tab 12

Comparison of insulating materials' thicknesses that are necessary to achieve the same thermal transmittance value and/or energy saving.

The table below compares various insulating materials used in energy efficiency applications for the purposes of an evaluation of the material costs in a case where the goal is to obtain a **Transmittance value of U = 0, 20 W/m²K.** As can be seen in the table, the available data refer only to the materials, without taking into account all the additional operational costs that must still be computed by designers and technicians.

Material	Thermal conductivity λ	Thickness mm
Thermorasante	0,020	100
Stiferite foam Polyiso waterproof	0,023	115
Stiferite foam Polyiso permeable ≥ 120 mm	0,025	125
Polystyrene foam with graphite	0,031	155
Polystyrene foam	0,035	175
Extruded polystyrene	0,036	180
Rockwool or glass wool	0,038	190
Cork	0,043	215
Wood wool	0,047	235

Comparison between materials with different thermal conductivity and installation systems.

As regards to the way various insulating materials available on the market are installed, consider the table below as a relevant example of the different methods of application

MATERIAL	CONDUCTIVITY λ [W/mK]	FINAL PRODUCT
Fiberglass		RIGID AND SEMI-RIGID BOARDS
Resin mats	0,053-0,046	
Semi-rigid boards	0,046-0,038	
Rigid boards	0,038	
Cellular glass	0,055-0,066	
Mineral fibres from feldspar or basalt rocks	0.038-0.048	PLATES
Wood		BOARDS
Expanded cork	0,043-0,052	
Wood-wool board with inorganic binders	0,085-0,11	
Wood chipboard with inorganic binders	0,12-0,15	
Wood chipboards, pressed or extruded	0,10-0,17	
Natural wood, hard or extra-hard	0,14-0,18	
Polystyrene foam		BOARDS
Extruded, with skin	0,035	
Extruded, without skin	0,041-0,034	
Sintered	0,040-0,034	
Hot pressed	0,040-0,039	
Polyurethane plates	0.034 – 0.032	PLATES
Thermorasante	0.019-0.021	SMOOTHING PASTE

Tab 13

Comparison of insulating materials according to their resistance to compression according to the UNI EN 826: comparison among same class products

- *Extruded polystyrene* - Compression strength at 10% deformation ≈ 200 kPa

- *Rockwool* - Compression strength at 10% deformation ≈ 50 kPa

- *Wood wool* - Compression strength at 10% deformation > 200 KPa

- *Thermorasante*: Compression strength at 10% deformation ≈ 5 KPa

-*Thermorasante+ Evolution S:* Load capacity of 50 KN

Comparison of insulating materials according to their value of specific heat

The ability of an insulating material to give a good contribution to thermal insulation in the summer can be estimated by calculating its thermal diffusivity. The smaller its diffusivity value, the better its performance.

Glass wool / Rockwool
- Specific heat = 900 [Joules / kg. ° K]
- Density = 55 [kg/m3]
- Thermal conductivity = 0.045 [W / m ° K]

Expanded polystyrene
- Specific heat = 1450 [Joule / kg. ° K]
- Density = 30 [kg/m3]
- Thermal conductivity = 0.035 [W / m ° K]

Polyurethane foam
- Specific heat = 1400 [Joule / kg. ° K]
- Density = 35 [kg/m3]
- Thermal conductivity = 0.032 [W / m ° K]

Expanded Cork
- Specific heat = 1600 [Joule / kg. ° K]
- Density = 120 [kg/m3]
- Thermal conductivity = 0.045 [W / m ° K]

Panel of pressed wood-fibre
- Specific heat = 2100 [Joule / kg. ° K]
- Density = 265 [kg/m3]
- Thermal conductivity = 0.048 [W / m ° K]

THERMORASANTE
- Specific heat = 1040 [Joule / kg. ° K]
- Density = 125 [kg/m3]
- Thermal conductivity = 0.020 [W / m ° K]

Examples of complex masonry structures used in energy efficiency applications with and without THERMORASANTE: theoretical studies of construction operations

Energy saving THERMORASANTE

Silica Aerogel based product - λ = 0,020 W/(m°K)

Masonry work n°1 - Double layer of semi-solid bricks				
LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m²°K)	RESISTANCE (m²°K) / W
Lime plastering	0,015	0,70	/	0,021
Semi-solid bricks	0,12	/	4,16	0,240
Semi-solid bricks	0,12	/	4,16	0,240
Gypsum plastering	0,015	0,45	/	0,033
Internal transfer coeff.		8,13	W / (m²°K)	0,123
External transfer coeff.		23,25	W / (m²°K)	0,043
			TOTAL	0,702
	Wall thermal transmittance			***U* = *1,43* *W / (m²°K)***
LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m²°K)	RESISTANCE (m²°K) / W
THERMORASANTE 4mm	0,004	0,020	/	0,200
			TOTAL	0,902
	Wall thermal transmittance			***U* = *1,11* *W / (m²°K)***
	Reduction of wall thermal transmittance		**22.18 %**	

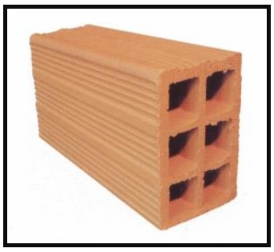


Fig. 17

Masonry work n°2 - Hollow clay tiles				
LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m²°K)	RESISTANCE (m²°K) / W
Lime plastering	0,015	0,70	/	0,021
Hollow clay tiles	0,37	/	0,94	1,064
Gypsum plastering	0,015	0,45	/	0,033
Internal transfer coeff.		8,13	W / (m²°K)	0,123
External transfer coeff.		23,25	W / (m²°K)	0,043
			TOTAL	1,285
	Wall thermal transmittance		**U = 0,78**	**W / (m²°K)**
LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m²°K)	RESISTANCE (m²°K) / W
THERMORASANTE 4mm	0,004	0,020	/	0,200
			TOTAL	1,485
	Wall thermal transmittance		**U = 0,67**	**W / (m²°K)**
	Reduction of wall thermal transmittance		**13,47 %**	

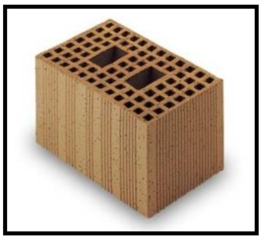


Fig. 18

Masonry work n°3 - Semi-solid bricks & air cavity				
LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m²°K)	RESISTANCE (m²°K) / W
Lime plastering	0,015	0,70	/	0,021
Semi-solid bricks	0,12	/	4,16	0,240
Air cavity	0,06	/	6,40	0,156
Clay bricks	0,08	0,25	/	0,320
Gypsum plastering	0,015	0,45	/	0,033
Internal transfer coeff.		8,13	W / (m²°K)	0,123
External transfer coeff.		23,25	W / (m²°K)	0,043
			TOTAL	0,937
	Wall thermal transmittance		***U = 1,07***	***W / (m²°K)***

LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m²°K)	RESISTANCE (m²°K) / W
THERMORASANTE 4mm	0,004	0,020	/	0,200
			TOTAL	1,204
	Wall thermal transmittance		***U = 0,88***	***W / (m²°K)***
	Reduction of wall thermal transmittance		**17,58**	**%**

Fig. 20

Masonry work n°4 - Reinforced concrete

LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m^2°K)	RESISTANCE (m^2°K) / W
Lime plastering	0,015	0,70	/	0,021
Reinforced concrete	0,30	2,1	/	0,143
Gypsum plastering	0,015	0,45	/	0,033
Internal transfer coeff.		8,13	W / (m^2°K)	0,123
External transfer coeff.		23,25	W / (m^2°K)	0,043
			TOTAL	0,364

Wall thermal transmittance ***U = 2,75 W / (m^2°K)***

LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m^2°K)	RESISTANCE (m^2°K) / W
THERMORASANTE 4mm	0,004	0,020	/	0,200
			TOTAL	0,564

Wall thermal transmittance ***U = 1,77 W / (m^2°K)***

Reduction of wall thermal transmittance	35,48	%

Fig.21

Comparison of wall thermal transmittance

Masonry work n°1 - Insulation made with 4 mm thick POLYSTYRENE				
LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m²°K)	RESISTANCE (m²°K) / W
Lime plastering	0,015	0,70	/	0,021
Semi-solid bricks	0,12	/	4,16	0,240
Semi-solid bricks	0,12	/	4,16	0,240
POLYSTYRENE insulation	0,004	0,036	/	0,111
Gypsum plastering	0,015	0,45	/	0,033
Internal transfer coeff.		8,13	W / (m²°K)	0,123
External transfer coeff.		23,25	W / (m²°K)	0,043
			TOTAL	0,813
Wall thermal transmittance		***U = 1,23***	***W / (m²°K)***	

Fig.22

Masonry work n°1 - Insulation made with 4 mm thick ROCK WOOL				
LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m²°K)	RESISTANCE (m²°K) / W
Lime plastering	0,015	0,70	/	0,021
Semi-solid bricks	0,12	/	4,16	0,240
Semi-solid bricks	0,12	/	4,16	0,240
ROCK WOOL insulation	0,004	0,041	/	0,098
Gypsum plastering	0,015	0,45	/	0,033
Internal transfer coeff.		8,13	W / (m²°K)	0,123
External transfer coeff.		23,25	W / (m²°K)	0,043
			TOTAL	0,799
Wall thermal transmittance		***U = 1,25***	***W / (m²°K)***	

Fig.23

Masonry work n°1 - Insulation made with 4 mm thick THERMORASANTE				
LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m^2°K)	RESISTANCE (m^2°K) / W
Lime plastering	0,015	0,70	/	0,021
Semi-solid bricks	0,12	/	4,16	0,240
Semi-solid bricks	0,12	/	4,16	0,240
THERMORASANTE insulation	0,004	0,020	/	0,200
Gypsum plastering	0,015	0,45	/	0,033
Internal transfer coeff.		8,13	W / (m^2°K)	0,123
External transfer coeff.		23,25	W / (m^2°K)	0,043
			TOTAL	0,902
Wall thermal transmittance	***U = 1,11***	***W / (m^2°K)***		

Fig 24

Masonry work n°1 - THERMORASANTE *Silica Aerogel product - λ = 0,020 W/(m°K)*				
LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m^2°K)	RESISTANCE (m^2°K) / W
Lime plastering	0,015	0,70	/	0,021
Semi-solid bricks	0,12	/	4,16	0,240
Semi-solid bricks	0,12	/	4,16	0,240
THERMORASANTE 4 mm	0,004	0,020	/	0,200
EVOLUTION S 1 mm	0,001	0,20	/	0,005
Internal transfer coeff.		8,13	W / (m^2°K)	0,123
External transfer coeff.		23,25	W / (m^2°K)	0,043
			TOTAL	0,873
	Wall thermal transmittance		***U = 1,1***	***W / (m^2°K)***

The total thickness of the insulation package is equal to 5mm : 4mm of THERMORASANTE insulating material and 1mm of EVOLUTION S surface finishing.

Fig.25

Masonry work No. 1 - TRADITIONAL

Thermal insulation performed using a metallic frame fixed to the wall and plaster boards fixed to it, with insulating material, in this case rock wool, in between.

LAYER DESCRIPTION	THICKNESS m	CONDUCTIVITY W / (m°K)	CONDUCTANCE W / (m²°K)	RESISTANCE (m²°K) / W
Lime plastering	0,015	0,70	/	0,021
Semi-solid bricks	0,12	/	4,16	0,240
Semi-solid bricks	0,12	/	4,16	0,240
Metallic frame 3,00 cm *ROCK WOOL 1,00 cm* *Plaster board 1,25 cm*	0,01	0,041	/	0,244
Internal transfer coeff.		8,13	W / (m²°K)	0,123
External transfer coeff.		23,25	W / (m²°K)	0,043
			TOTAL	0,912

Wall thermal transmittance ***U = 1,1 W / (m²°K)***

The TOTAL thickness of the insulation package is equal to 4.25 cm : 3cm metal structure - with 1cm of ROCK WOOL insulating material inside - and 1.25 cm plaster board

Fig.26

CHAP.7 *Description of the execution of some applications*

Treatment of a residential unit housed inside an industrial building and erected with prefabricated modules and reinforced concrete. The variety of building materials here coexisting shows the flexibility of Thermorasante, especially in existing buildings where it is not possible or cost-effective to operate on the outside surface.

1) Pre-treatment of an internal residential unit with multiple structure, window frames, fan heaters, plasterboard covered pillars, panelled ceiling, and wood flooring

2) Special pre-treatment of thermal bridges

3) Detail of the pre-treatment work

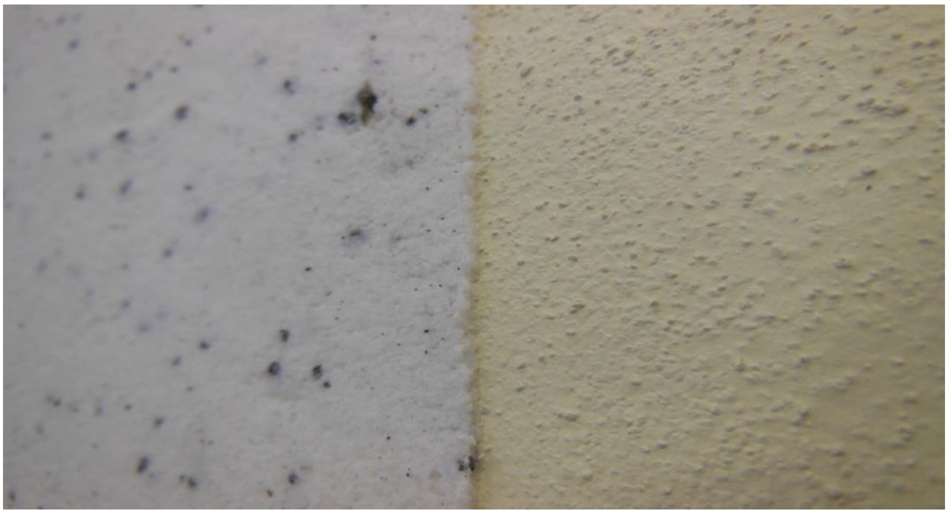
4) Detail of the pre-treatment work

5) Pre-treatment of wall surface portions affected by formation of mold and uplifting of the pre-existing wall covering due to condensation build up-

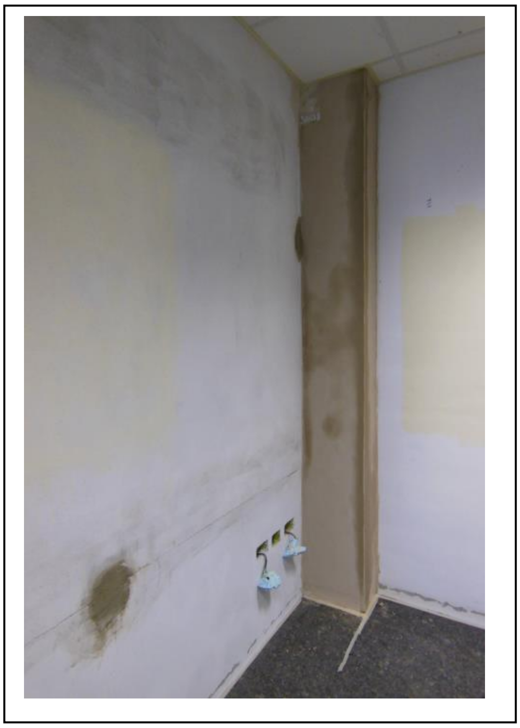
6) Restoration of the wall structure by puttying vertical and horizontal damaged parts

7) Surface prepared for the insulation treatment

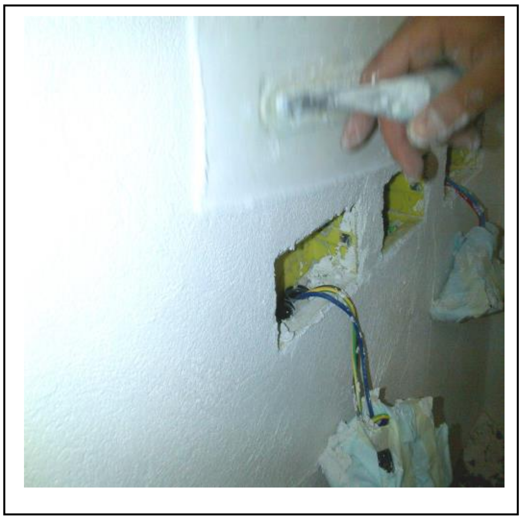
8) Adhesion test on substrates differently treated

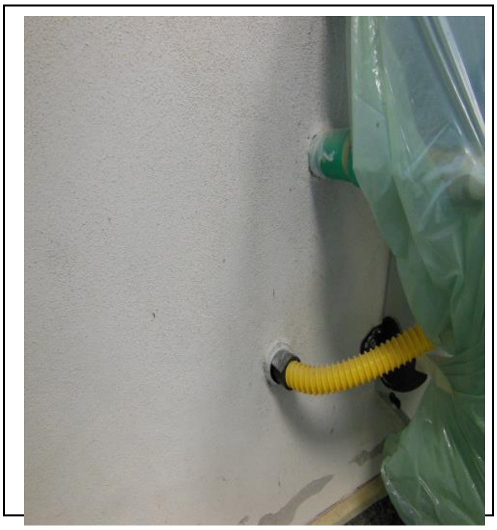


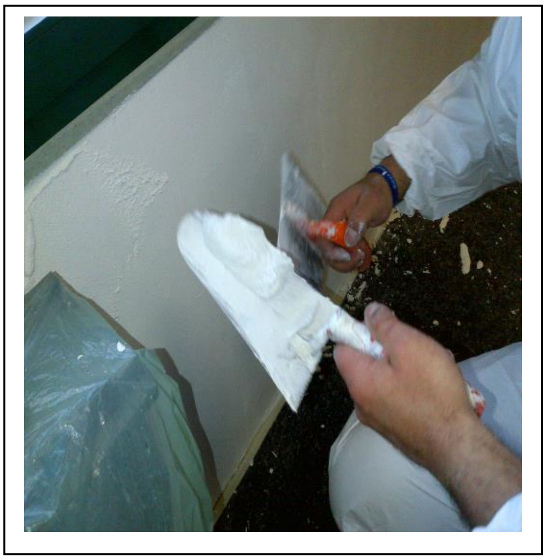
9) Work of technical importance: the sequence of steps in the treatment of a pillar close to a thermal bridge, within the insulation work of a residential housing carried out with Thermorasante and Evolution S



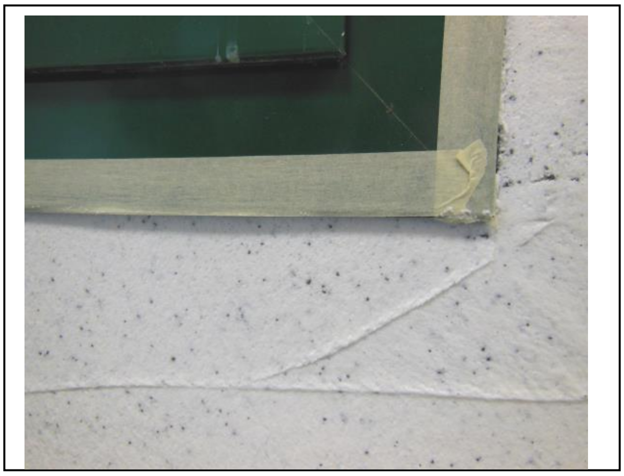
10) Detail of application in close proximity to discontinuities on inside walls

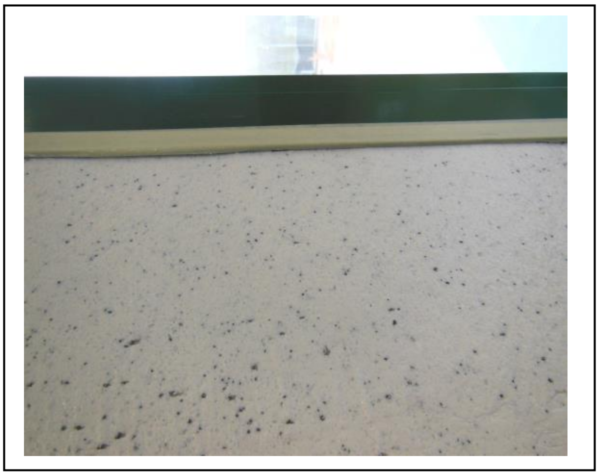






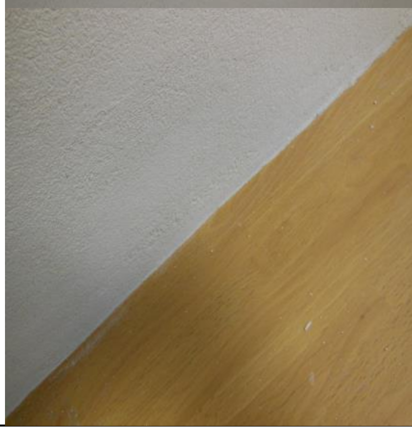
11) Application close to window frames





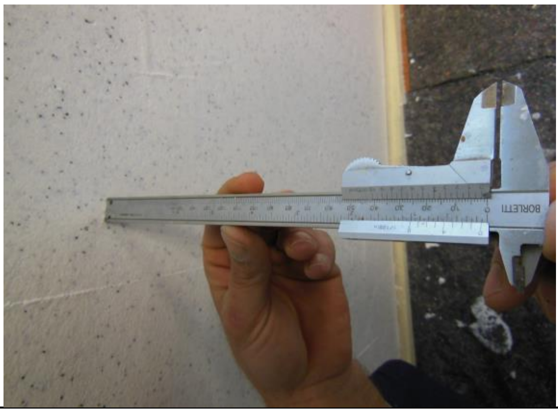
12) Treatment of generic matt walls inside the housing unit

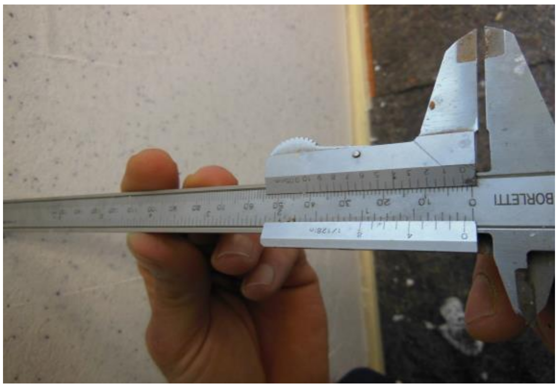

DOCCHEM



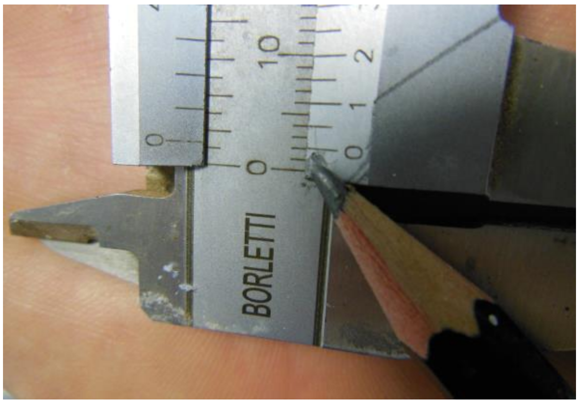
13) calibrated measuring of the thickness applied

14) checking the thickness





15) gage shows 2.5 mm



CHAP.8 *THERMORASANTE – The technical file*

1. Product Description

Premixed smoothing paste for effective insulation of a building's shell by application on the inside surfaces of the walls. Its high insulating performance reduces heat losses allowing significant energy saving that can be actually measured using the certified chemical and physical parameters that are provided.
It proves to be effective for both wintertime heating and summertime conditioning.

2. Fields of application

The smoothing paste, ready to use, is suitable for use on concrete, cement, plaster and wood.
Thermorasante can be slightly diluted, depending on the state of the surface to be treated.
Its use is recommended inside houses, public buildings, schools, hospitals, as well as historic buildings and structures with a complex front that cannot be treated on the outside.

3. Features

The product proves to have an excellent thermal resistance in low thickness applications as shown by the value of thermal conductivity and thermal transmittance of the material, calculated according to UNI EN 12667: 2002 and ASTM E1530: 2006 and reported in the product technical file.

The experimental evidence of its effectiveness in thermal insulation is also confirmed from the diagrams of thermometric shift over time comparing different thicknesses of Thermorasante Docchem with both the untreated support and the traditional systems of thermal barrier.

The product characteristics and method of use do not require special actions in the vicinity of thermal bridges, ensuring the continuity of the barrier effect on junctions and eliminating the problem of mold formation on vertical walls, while ensuring the permeability to moisture.

The values of compression strength and surface hardness of the product, make it necessary a finishing with a plaster (recommended Evolution S) to get the right hardness of the wall surface and also to get the desired look.

The product technical specifications are shown in Table 1.

TABLE 1 – TECHNICAL SPECIFICATIONS

Physical state	**Homogeneous premixed paste**
Active component	**Silica Aerogel**
pH	**Neutral**
Specific Weight / Average Mass	**125 ± 0.3 Kg/m^3**
Thermal conductivity (UNI EN 12667)	**$\lambda_{10/dry}$ =0.020 ± 0.001 W/mK** **$\lambda_{silica\ aerogel}$ = 0.014 ± 0.001 W/mK**
Fire resistance (Norm EN 1305-1 2002-02)	**Average loss of mass: 17%** **Fire resistance class: A2**
Specific Heat	**Cp= 1040 J/KgK**
Coefficient of permeability to water vapour (UNI EN ISO 7783)	**S_d (m)=0.040** **μ= 13.4** The product is **highly breathable** with a **high value of diffusion.**
Permeability to liquid water (UNI EN 1062-3)	**W= 0.13 [(Kg /(m^2√h)]** **Water resistant** with a significant **waterproofing** power
Grip strength (UNI EN 1542)	**5 x 10^{-2} N/mm^2**
Compression strength (UNI EN 826)	**4,6 ± 2 KPa** The material, ensures **a load capacity** without failure up to values of **50 KN.**
Storage	**At least 12 months at temperature between 5 and 40 ° C in a well closed can (sealed)**
Application rate	**2.3 l /m^2 for an applied thickness of 2,5 mm**

4. Application cycle

The application cycle has 1 to 3 steps on concrete, old reinforced concrete, new reinforced concrete or plaster, according to the type of finish and compression strength (hardness) to be obtained.

1. **Monophasic cycle**:
   A) Thermorasante (medium-smooth finishing with low compression strength)

2. **Biphasic cycle**:
   A) Thermorasante
   B) Finishing plaster (smooth finishing with excellent resistance to compression).

3. **Three-phase cycle:**
   A) Thermorasante
   B) Finishing plaster
   C) Wall painting (smooth painted finishing and excellent compression strength); after finishing use COLORDOC® or other decorative paintings

5. Application

5.1 Preparation of the substrate:

It must always be applied on a clean, dry and cohesive substrate

In case there is an old paint flaking off, eliminate it with BIADOC NEW (see Technical Data Sheet).

If there is any mould, first eliminate it by performing a wash with NEUDOC (see Technical Data) and let it dry before applying the ANTIFOULING product (see Technical Data Sheet)

If the substrate is not cohesive, it is advisable to apply first a consolidating product based on acrylic resins like CERAMIDOC (see Technical Data Sheet)

5.2 Treatment with Thermorasante:

Once the substrate is completely dry, proceed to the application of THERMORASANTE in the following way: the product can be applied with a plastic or stainless spatula; apply the product as it is, directly on the prepared surface until you get the desired thickness of about 2-3 mm, making a slight dilution with water in the event that it is too dry. In this case mix with an electric whip for 5 minutes at low speed (WARNING: too much water could cause the detachment from the substrate and / or create a web-like effect)

5.3 Application steps

STEP I: the application of Thermorasante must always be done on a clean, dry, non-dusty and cohesive surface in order to avoid possible detachments at a later time. The treatment of thermal bridges is performed following the same application method, taking care of forming a continuous film of uniform thickness at all concave and convex edges.

STEP II: in order to increase compression strength and surface hardness, it is suggested to complete the cycle by applying a surface smoothing like plaster or a fine spatula product or a thick decorative product based on lime, gypsum or mica.

STEP III: just for aesthetic purposes, it is suggested that the cycle is completed with wall painting, according to the architectural project

5.4 Drying Times

Allow to dry for 24/48 [h] at every step and then continue with the finishing.
In case you have to apply additional Thermorasante, follow the directions for time and thickness.

5.5 Maintenance of equipment

The cleaning of the equipment should be carried out with running water

6. Colours and compatibility

The product, light grey to white, opaque even at low thickness, cannot be painted directly. It is compatible with finishing products based on gypsum, cement and lime.

7. Packaging and storage

8. Safety Tips

Operate at temperatures > 5 ° C., in thoroughly ventilated areas. Avoid contact with food. During the application is necessary to protect the surrounding surfaces to prevent damages to the materials with which the product could come in contact. We recommend using gloves for personal protection during application and handling of the product.

This product is not classified as dangerous; a safety data sheet prepared according to law requirements is available on request.

All the technical data here included shall be considered as approximate ones. For more information, please refer to the safety data sheet or contact our technical service.

ATTACHMENT I

Financial evaluation

In the following pages we aim to show the economic advantage deriving from the application of **THERMORASANTE**’s technology in the realization of a complete thermal insulation system.
To the scope, here below a complete whole comparison in getting an interior complete insulating system both by a traditional methodology (back drywall based) and the innovative system proposed by Docchem.

<u>Insulating material</u>:

THERMORASANTE → ***3 mm***

Traditional insulating → ***10 mm***

THERMORASANTE’s thermal conductivity allows the usage of a small thickness , in the range of millimeters**.**

1. *THERMORASANTE: costs analysis*

1.1 Total Materials Costs:

- Thermorasante → thickness 3 mm

  <u>Cost of material</u>

  12,00 € / mm / sqm

  12,00 X 3 mm = 36,00 € / sqm

- Fine Si based plaster Evolution S → thickness 2 mm

  <u>Cost of material</u>

  4,00 € / sqm

  *4,00 * 2 mm = 8,00 € /sqm*

- Decorative paint Evolution (white color) → n°2 layers

  <u>Cost of material</u>

  2,20 € / sqm

  *2,20 * n°2 layers = 4,40 € / sqm*

TOTAL Material cost: 48,40 € / mq

1.2 Labour costs:

- Thermorasante's Application → n°1 layer

  Labour costs
  Pubblic works official price lists (Regione Lombardia 2011) – B15017

  9,70 € / sqm

- Application of the fine plaster Evolution S → n°2 layers

  Labour costs
  Pubblic works official price lists (Regione Lombardia 2011) – B15007

  6,30 € / sqm

  *6,30 * n°2 layers = 12,60 € / sqm*

- Decorative paint's application Evolution (white color) → n°2 layers

  Labour costs
  Pubblic works official price lists (Regione Lombardia 2011) – B55017

  1,80 € / sqm

  *1,80 * n°2 layers = 3,60 € / sqm*

TOTAL Labour Costs: 25,90 € / mq

1.3 Total Costs' estimation THERMORASANTE:

- Material costs: 48,40 € / sqm
- Labour costs: 25,90 € / sqm

TOTAL: 74,30 € /sqm

2. TRADITIONAL METHOD: costs analysis

Pubblic works official price lists (Regione Lombardia 2011)

ACCOMPLISHED WORKS – according to B75039

"Plasterboard backwalls, 12,50mm thickness, fixed into 0.6 mm Zn treated steel sheets by 0.6 mm wires, interfaced to 600mm struts and to pavement and ceilings by tracks in a way to include

rough edges, reinforced or bulging, lacquered and sealed to the ceiling with vynil based adhesive,in presence of metal based joiners, windows and doors"

(b): with plasterboards → 34,85 € / sqm

(c): extracharge to add glass fiber boards (1cm) → 2,05 € / sqm

TOTALE cost for TRADITIONAL Method: 36,90 € / sqm

3. Comparative analysis

Hypothesis: Internal thermal insulation for the living space reported in Figure A.

- ✓ Internal walls height 2,70 m;

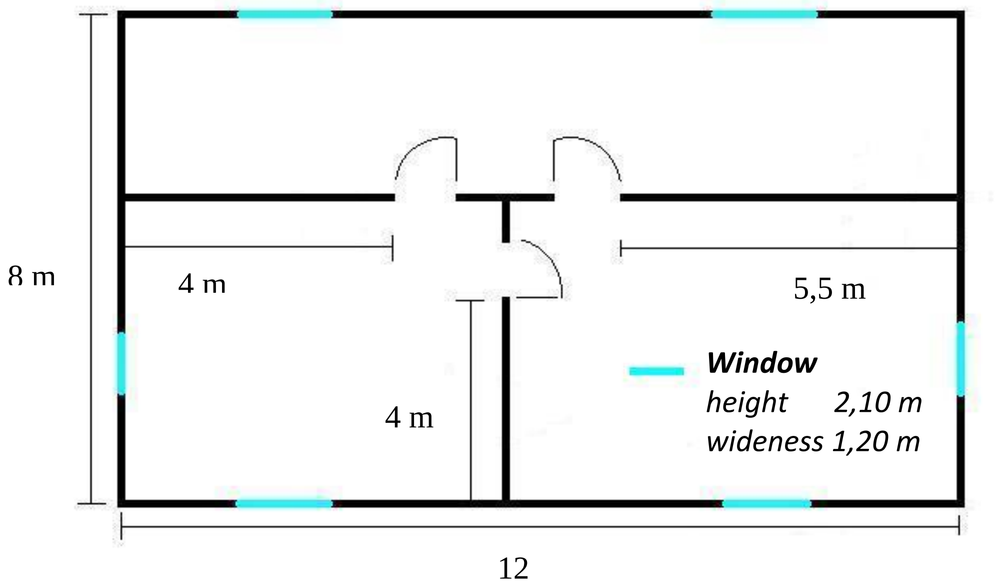


Figure A – living space map

3.1 Method: THERMORASANTE

3.1.1 Perimetral walls' wideness calculation for insulating

- ml. (8 + 8 + 12 + 12) * ml. 2,70 = 108 sqm
- windows surface areas ml. (2,10 * 1,20) = 2,52 sqm

  n°6 windows : 2,52 * 6 = 15,12 sqm

TOTAL SURFACE of the perimetral walls:

sqm 108 – sqm 15,12 = ***93 sqm***

3.1.2 Mathematical evaluation of the internal walls to be insulated

In order to well insulate a living space it is necessary to avoid thermal bridges between the internal partitions and the perimetral walls. By using THERMORASANTE technology it is enough to apply 40 cm length of product towards the interior parts as shown in Figure B, red segments.

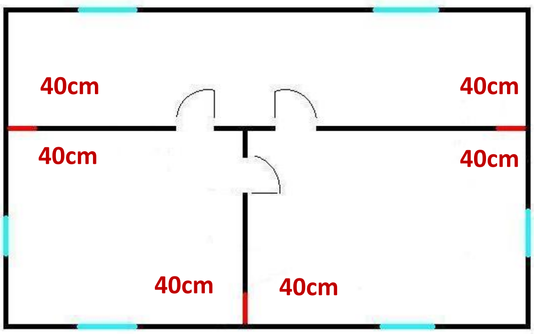


Figura B

Internal partitions surfaces to be treated:

ml. (0,4 * 6) = 2,40 ml.

ml. 2,40 * ml. 2,70 = ***6,48 sqm***

3.1.3 Mathematical evaluation of the TOTAL surface to be insulated

- Perimetral walls 93,00 sqm
- Internal partition walls 6,48 sqm

TOTAL 99,50 sqm

3.1.4 Mathematical evaluation of the complete thermal insulation work's cost

Material cost + labour cost for THERMORASANTE methodology: 74,30 € / sqm

Surface to be insulated: 99,50 sqm

Total Cost: 74,30 * 99,50 = 7.393,00 €

3.2 Method: TRADITIONAL

3.2.1 Mathematical evaluation of the internal walls to be insulated

- ml. (8 + 8 + 12 + 12) * ml. 2,70 = 108 sqm
- Windows surface areas ml. (2,10 * 1,20) = 2,52 sqm

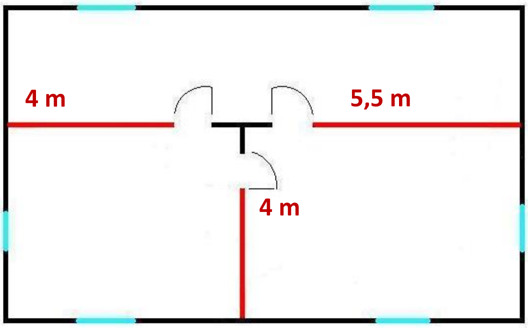
  n°6 windows 2,52 * 6 = 15,12 sqm

TOTAL perimetral walls surface to be treated:

sqm 108 – sqm 15,12 = ***93 sqm***

3.2.2 *Mathematical evaluation of the internal partitions to be insulated*

In order to well insulate a living space it is necessary to avoid thermal bridges between the internal partitions and the perimetral walls. By using THE TRADITIONAL technology it is necessary to inslutae all the internal partitions , as shown in Figure C, red segments.



Internal partitions' surface

ml. (4 + 4) + ml. (5,5 + 5,5) + ml. (4 + 4)

ml. (8 + 11 + 8) * ml. 2,70 = ***72,90 sqm***

3.2.3 *Mathematical evaluation of the TOTAL surface to be insulated*

- Perimetral walls 93,00 sqm
- Internal partitions 72,90 sqm

TOTAL 165,90 sqm

3.1.4 *Mathematical evaluation of the complete thermal insulation work's cost*

Materials Cost + Labour cost method TRADITIONAL: 36,90 € / sqm

Surface to be insulated: 165,90 sqm

TOTAL Cost: 36,90 * 160,50 = 6.121,71 €

3.3 *Structural modifications*

The usual additional costs due to the structural modifications necessary during the insulation work in proximity of windows, doors, covers, heaters proximity areas, aerating systems, electricity plugs, light points , have not to be considered in the case of THERMORASANTE , thanks to the limited thickness necessary to get the desired insulation. Those costs being considearble and significant on the total financial evaluation by using the TRADITIONAL systems.

In addition these costs are enhanced by the fact that expert professional profiles have to be involved in the labour costs to perform this kind of modifications

Labour cost for electrician

Pubblic works official price lists *(Regione Lombardia 2011)*

M0 1005: 31,27 € / hour → 8 working hours = 250,16 €

Labour cost for a plumber

Pubblic works official price lists *(Regione Lombardia 2011)*

M0 1005: 31,27 € / hour → 16 working hours = 500,32 €

Labour cost for a construction worker

Pubblic works official price lists *(Regione Lombardia 2011)*

M0 1001: 37,07 € / hour → 16 working hours = 593,12 €

TOTAL 1.343 €

THERMORASANTE METHOD	
Completion work cost	*7.393,00 €*
Structural modifications costs	**/**
TOTAL COSTS	***7.393,00 €***

TRADITIONAL METHOD	
Completion work cost	*6.121,71 €*
Structural modifications costs	*1.343,00 €*
TOTAL COSTS	***7.464,71 €***

As a first impression it seems that it is not worthy to apply the innovative technology by Docchem in comparison to the traditional systems, especially by considering the cost of materials and the labour costs to perfom the insluation work. On the contrary, based on the above performed costs' evaluation we can adfirm that using the THERMORASANTE no additional structuring costs are needed, bringing at the end to even a slight saving vs the traditional systems application:

THERMORASANTE is more economic than the traditional systems used in the construction segment

ECONOMIC GAIN   - 72 €

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