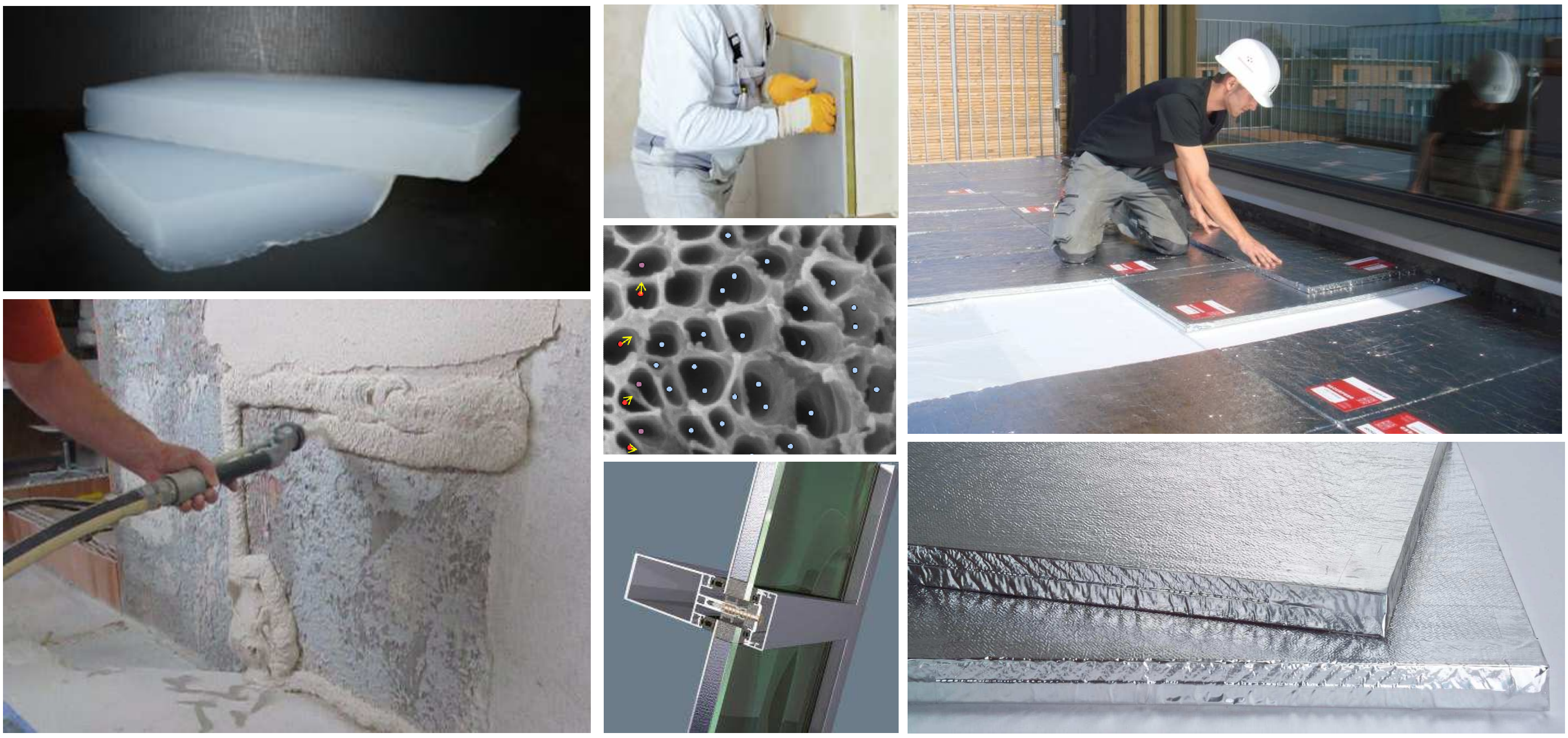
International symposium
Brussels, April 26, 2012

Superinsulating Materials



Present Applications and Ongoing Research

An initiative of INIVE EEIG

edited by G. Flamant (BBRI), A. Janssens (UGent) and M. Zimmerman (EMPA)

International symposium on

Superinsulating Materials

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The symposium and the publication of this book received financial support from the following Belgian Energy administrations :

- Flemish Energy Agency (VEA)
- Belgian Federal Public Services for Energy
- Public Service of Wallonia - DGO4 General Directorate for Spatial Planning, Housing, Heritage and Energy

A financial support has been also received from:

- EURIMA (European Insulation Manufacturers Association)
- Microtherm

Reference to papers:
Author, title. 2012. Superinsulating Materials (G. Flamant, A. Janssens, M. Zimmerman, ed.), ISBN 2-930471-33-6, INIVE, Belgium.

ISBN 2-930471-33-6
EAN 9782930471334

Number of copies printed: 400
Printed by University Press, Zelzate, Belgium, September 2012

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PREFACE

The energy and environmental challenges ahead of us are tremendous; a reduction of the heat flow through opaque building elements remains a top priority. This is not only the case for new buildings but even more for existing buildings. Whereas in the past insulation layers in the building envelope yielded rarely more than 100 mm of thickness, the tightening of the requirements and targets will lead to substantially thicker layers with classical insulation materials. Especially for renovation, the thickness of internal or external insulation layers becomes a major issue of concern. Within these boundary conditions, there is a growing interest in the so-called superinsulating materials. This is highlighted by substantial investments in the EU 7th framework programme. One part of the challenge is to develop materials with very high insulating values, the other part is the development of appropriate applications and installation methods. Durability of performances is a complementary aspect for study.

This publication contains papers related to the presentations made at the international symposium on superinsulating materials, held on April 26 2012 in Brussels (Belgium).

The papers in this publication aim to present an extensive overview of the state of the art in superinsulation, of new developments and of remaining challenges, addressing an audience interested in both the materials and the applications.

The symposium and this publication are an initiative by INIVE EEIG (International network for Information on Ventilation and Energy Performance) and its members.

The symposium and this publication were possible thanks to very important support by Mark Zimmermann and Karim Ghazi Wakili from EMPA, Gilles Flamant and Stéphane Degauquier from BBRI and Arnold Janssens from University Ghent.

We like to thank the following organisations for their support to the symposium and this publication, i.e. the Belgian Federal Public Services for Energy, Public Service of Wallonia (DGO4 General Directorate for Spatial Planning, Housing, Heritage and Energy), the Flemish Energy Agency, EURIMA and Microtherm.

This international symposium was the start of a process aiming at a new and broad international collaboration on superinsulating materials and applications for the next decade.

We wish you a nice reading

Peter Wouters

Manager INIVE EEIG

About INIVE EEIG

INIVE EEIG (**I**nternational **N**etwork for **I**nformation on **V**entilation and **E**nergy Performance) was created in 2001 as a so-called European Economic Interest Grouping. The main reason for founding INIVE was to set up a worldwide acting network of excellence in knowledge gathering and dissemination. At present, INIVE has 11 member organisations (BBRI, CETIAT, CIMNE, CSTB, ERG, ENTPE, IBP, SINTEF, NKUA, TMT US and TNO), and there is interest in joining among other organisations (*www.inive.org*).
The original reason for creating INIVE was the availability of a strong entity able to act as the Operating Agent for the IEA' Air Infiltration and Ventilation Centre (AIVC). AIVC is the IEA Information Centre that deals with the topic of energy efficient ventilation and air tightness of buildings. Since 2001, INIVE has been the Operating Agent for the AIVC (*www.aivc.org*). As a service provider to the European Commission and the European Agency for Competitiveness and Innovation, INIVE EEIG has been coordinating the European Buildings Platform since 2006 and, since 2009, BUILD UP, which is THE European portal on Energy Efficiency (*www.buildup.eu*). INIVE aims to stimulate and contribute to the creation of new knowledge in key areas of ventilation and energy efficiency. In the ASIEPI project (*www.asiepi.eu*), which finished in March 2010 and was coordinated by INIVE, several critical areas related to energy-efficiency policies were analysed, with a whole range of new findings as a result.
INIVE also wants to facilitate structured collaborations, which go beyond the duration of single projects. The best example of such collaboration is the DYNASTEE-PASLINK network (*www.dynastee.info*), which is the leading network of use and development of system identification techniques and related applications. The DYNASTEE-PASLINK network is a part of the INIVE Activities.

SUPERINSULATION - A NEW TREND

INTRODUCTION

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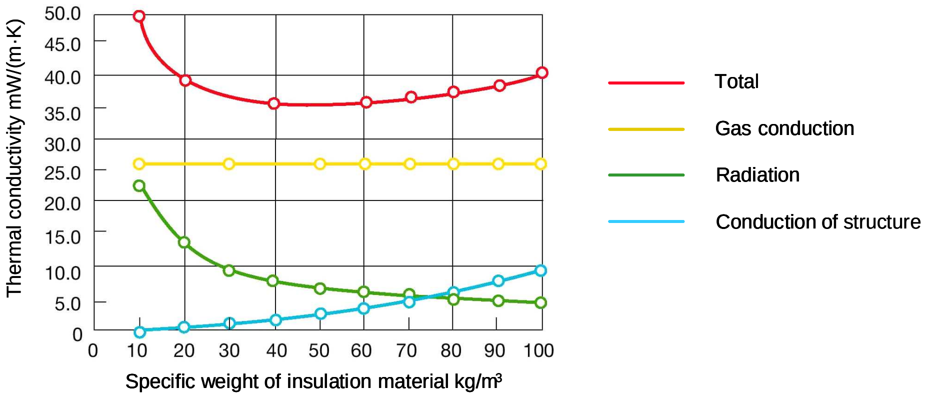
Building insulation is the most reliable measure for reducing the energy consumption of buildings. Insulation layers of 20 to 30 cm thickness have become daily practice in many European countries. They avoid excessive energy losses and provide a good thermal comfort. However, such buildings insulations are also space consuming and require often difficult and risky constructions.

All traditional building insulation materials were relying on air as insulator. Air offers with a thermal conductivity of 25 mW/m·K a reasonable good insulation if convection can be prevented. All good insulation materials use therefore a light structure to create little pores that prevent air movement. This is the reason, why most air based insulation materials have a similar insulation value, with a minimum limit of about 29 mW/m·K.

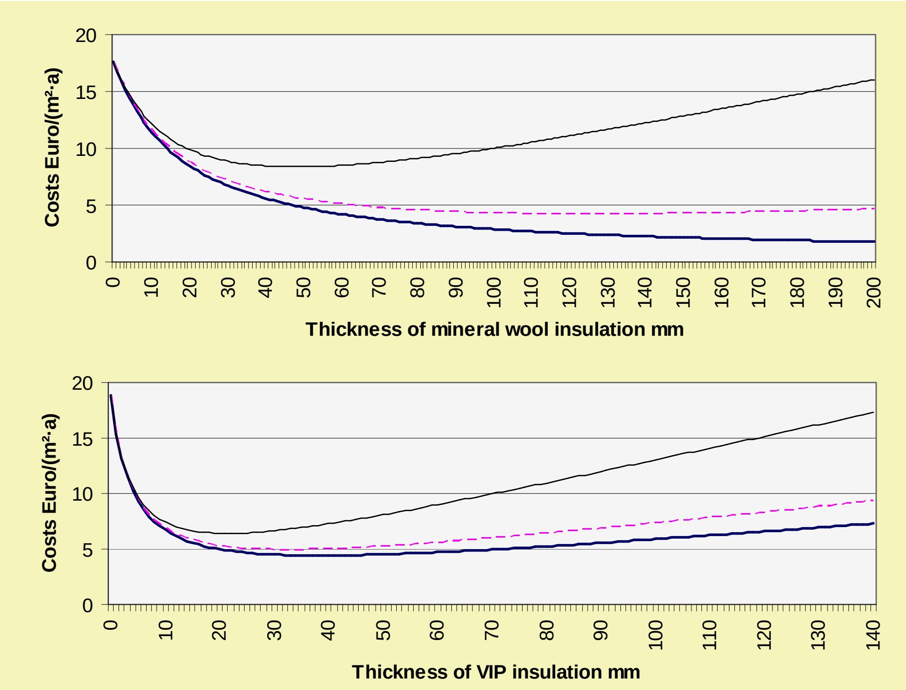


The heat transmission through a tradition insulation material is largely dominated by the conduction of air (yellow line) (IEA ECBCS Annex 39, 2005)

The first building components that reached values below that limit were organic foams which used gases with better insulation properties than air. However these gases were often harmful for the environment. A real progress was first made with low-e coated window systems. These glazings use low-e coatings to reduce radiative losses and argon or krypton to reduce gas conduction. Modern triple glazings reach within 36 mm a u-value of 0.4 W/(m²·K). This means that the equivalent thermal conductivity is as low as 16 mW/(m·K).

NEW GENERATION OF INSULATION MATERIALS

Only the development of the vacuum insulation started a new area of insulation technologies. Vacuum Insulation Panels (VIP) offer a new dimension for building insulation. The excellent declaration value of 7 mW/(m·K) is based on a nanoporous core structure (normally fumed silica) and a gas tight envelope of metal coated polyester film. But vacuum insulation is much more expensive than traditional materials. However, the overall cost for any insulation is much higher if besides the materials costs also the lost space is considered. Vacuum insulation is often economically the most attractive solution if the costs for saved building space are correctly calculated.



Optimal insulation thickness for mineral wool and VIP's considering insulation and energy costs only ——, insulation, energy, and land costs - - - -, insulation, energy, land, and building costs ——

Assumptions: Insulation on 15 cm brick wall, $\lambda_{mineral\ wool}$ = 0.036 W/(m·K), λ_{VIP} = 0.008 W/(m·K), service life for mineral wool 80 years, for VIP 50 years, degree days 3735, cost of mineral wool 100 €/m³, cost of VIP 4000 €/m³ + 60 €/m², energy costs 0.10 €/kWh, land cost 400 €/m² (maximum utilisation 0.4 m²/m²land), space renting costs 200 €/(m²·year), floor height 2.8 m, capital costs 4 % per year

The appearance of vacuum insulation for space saving constructions has caused a need for further improvement of other high performance insulation concepts. Especially alternative solutions that avoid the potential risk of loss or early degradation of the vacuum have been looked for.

Materials that overcome the performance barrier of air as insulator are considered as high performance insulation or superinsulating materials. They should have a thermal conductivity below 25 mW/(m·K) if air filled, below 20 mW/(m·K) if gas filled, or below 15 mW/(m·K) if evacuated.

There are presently three main concepts that allow such low thermal conductivity:

- Evacuation of the insulation: This method allows the best insulation values. It requires a very gas tight insulation envelope that maintains the vacuum and minimizes thermal bridges at the same time, an insulating core material that can withstand the air pressure from outside, does not outgas (mostly inorganic materials) and also avoids radiative heat transfer. Typical products on the building market are Vacuum Insulation Panels (VIP)

- Materials with nanoporous structure: The gaseous heat transfer is lowered if the pore sizes are smaller than the free path length of gas molecules (average path length of gas molecules before interacting with another gas molecule, approx. 70 nm). Aerogels are using this method and achieve a thermal conductivity of 12-14 mW/(m·K).

- Filling the pores with gas that has a lower thermal conductivity than air. For this purpose a closed pore structure and a low conductivity gas that is not harmful are needed. The sides of insulation boards are often covered with aluminium foil in order to further reduce gas loss. The best products on the market are micro-porous PU foams with a thermal conductivity around 20 mW/(m·K).

Comparison of thickness of VIP (right) and glass wool fibres (left) with similar thermal resistance.

Aerogel granulate has a low thermal conductivity due to its nanoporous structure.

Superinsulating materials are presently rapidly capturing the building insulation market. Today's insulation standards are often requiring space saving insulation technologies, especially for building refurbishment. New types of micro-foams, aerogel products and vacuum insulation panels have become attractive alternatives that allow a reduction of the insulation thickness by a factor 2 to 5.

However, superinsulating materials and systems are not only more expensive, they are also more risky. The additional costs have to be judged for each application. They may be well covered by added values and/or more simple constructions. The thermal performance has to be planned more carefully. Thermal bridges and moisture problems may have more severe effects. But also production and construction problems may reduce the insulation performance.

LONG TERM EXPERIENCE

Long term experience regarding the durability of superinsulating materials and systems is still lacking. Traditional materials and their long term performance are well known since many years. Superinsulation is only known since a few years and new products are introduced on the market. For these reasons, ***IEA Energy Conservation in Buildings and Community Systems Programme*** is planning a new collaborative research project that should investigate potential long term benefits and risks of such newly developed insulation materials and systems.

The aim of this research project is to understand potential degradation processes that could occur. All superinsulating materials have very fragile material structures that could be damaged by moisture, outgassing or aging processes.

Superinsulating materials and systems can offer big advantages; however potential drawback effects should be known and considered in the planning process in order to make optimal use of the extraordinary properties.

LITERATURE

IEA ECBCS Annex 39, Subtask A (2005), Simmler H., Brunner S., Heinemann U., Schwab Kumaran H., K., Mukhopadhyaya Ph., Quénard D., Sallée H., Noller K., Kücükpinar-Niarchos E., Stramm C., Tenpierik M.J., Cauberg J.J.M., Erb M., Vacuum Insulation Panels — Study on VIP-components and Panels for Service Life Prediction of VIP in Building Applications (Subtask A), IEA/ECBCS Annex 39 “HiPTI — High Performance Thermal Insulation” 2005.

SPACELOFT® INTRODUCTION

INTRODUCTION

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aspen aerogels™

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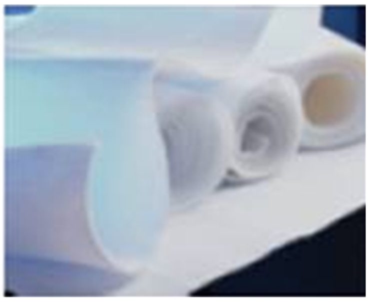
Aspen Aerogels, Incorporated has been producing and selling aerogel blanket insulation into a wide range of markets and applications since 2004. The Spaceloft® line of products is optimized for low thermal conductivity, water repellency/breathability, fire safety, and a long service life. In this presentation, we discuss how Spaceloft aerogel insulation performs, provide a few application examples and illustrate with a simple case study involving an insulation retrofit of an existing dwelling.

PRODUCT DESCRIPTION

Aerogels are made of over 90% air, making for extremely effective insulation. By integrating aerogel into a fibrous blanket, Aspen Aerogels has developed Spaceloft: a strong, durable, thin and flexible insulation material. Spaceloft provides an R-value of 10 per inch, 2 - 4 times traditional insulation.

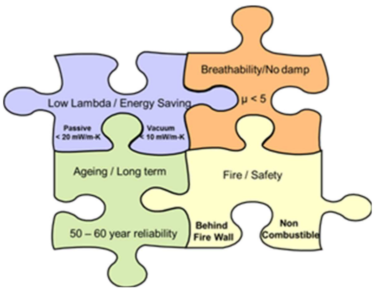
- Industry-leading R-Value
- Class-A Fire Rating
- Mold and Fungus Resistance
- Non-Absorbance and Non-Permeability to Liquids
- Industry-low Embodied Energy and CO_2
- Sustainable: Silver Cradle-to-Cradle Certified
- A revolutionary blanket thermal insulation

Spaceloft™ makes insulation retrofits on masonry buildings possible on a large scale. Spaceloft retrofits have overcome many traditional barriers through efficiency and design. Spaceloft retrofits can be done *cost effectively and quickly*, with *limited occupant disruption*, and with *minimal space loss*. Spaceloft retrofits typically have a payback period of 5 - 12 years, depending on building conditions, providing a better return than most furnace replacements and almost all windows.



Spaceloft's solution brings energy savings to under-insulated masonry buildings, a large sector that includes multi-family housing, university buildings, schools, office and municipal buildings. The value is even higher for masonry buildings built before 1970, which rarely were insulated. Many of these buildings would have no chance of being insulated short of a significant renovation project. With 16 million pre-1970 masonry units in housing alone, Spaceloft retrofits have the potential for substantive energy savings and job creation.

Product performances



The declared lambda value of Spaceloft® blanket insulation is 15 mW/m-K at 10°C. The water uptake for Spaceloft® blanket insulation according to ASTM C-1511 (full submersion) is nominally 1-2% by weight and far less than 1% by volume. On the other hand, the water vapour resistance behaviour of the product is excellent, with measured m < 5. This allows the system to both repel liquid water and maintain vapour permeability to prevent damp and mold formation. The Spaceloft® product exhibits a Euroclass C performance fire safety classification for interior use, while Spaceloft® A2 product exhibits an 18 mW/m-K performance with Euroclass A2 fire rating. The product can be applied in many ways and can be cut, sewn, laminated, adhered with various adhesives to structural boards and facing materials.

Applications

Insulating Masonry Buildings

Insulating walls has offered an important and cost-effective means to reduce energy consumption in most buildings. Unfortunately, traditional insulations are not cost-effective for masonry construction. Masonry construction accounts for 28% of housing in the United States, or 31 million units, and a significant portion of municipal, university, and residential buildings

Typical Barriers to Insulation

- *Time Consuming, Expensive Construction*: Without an existing wall cavity, insulating requires buildout of a new wall with significant plumbing and electrical work

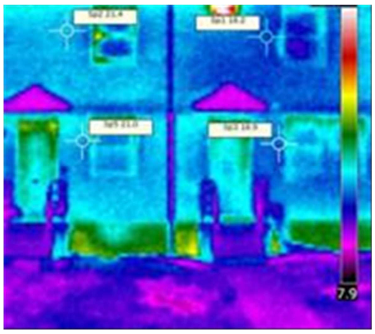
- *Disruptive to Occupants*: Process is cumbersome, frustrating occupants and causing expensive relocation

- *Space-Intensive Design*: Installation of thick cavity eliminates living space, requires additional electrical and plumbing work

Traditional insulation retrofits of a solid masonry wall require installing a new studded cavity to hold the insulation. Because of its thin profile, Spaceloft can be installed in a much simpler manner. A 10mm thick Spaceloft blanket is mounted directly to the interior wall surface, like wallpaper. Afterwards, drywall is applied over the Spaceloft and affixed to the existing wall, and then finished normally. An alternative is pre-lamination of Spaceloft to drywall, then direct installation onto the existing wall. Comparably, Spaceloft solutions are simpler, cheaper, less-disruptive, space-saving and require fewer contractor trades than traditional solutions.

Experiences

Since 2001, Aspen Aerogels has used case studies and third party testing to demonstrate Spaceloft's significant energy-efficiency potential. Spaceloft has been used in over 150 buildings in the Europe and the US, and has validated a 44% reduction in heat transfer (U-value), lowering energy use. Since initial demonstrations, a growing group of designers, contractors and building owners in the U.S. have begun including Spaceloft in their project plans, including several low-income housing complexes, the Pentagon and other public buildings, and universities.



Conclusions

<u>Spaceloft Retrofit Benefits Include:</u>

- *Simple, Quick Construction*: Spaceloft installation is a streamlined process, saving time and minimizing electrical, plumbing and trim work.

- *Minimal Disruption*: Since installation is simple, occupants do not need to move out. Work can be done within a matter of days.

- *Space-Saving Design*: With installed thickness of less than 1 inch, Spaceloft retrofits save space for occupants.

Typical MF Building	
Size (feet)	90'
	73'
	8'
Floors	4
Total Units	24
Rentable space	26280
Windows	4
Radiators	2
Electrical fixtures	4
Heating/cooling	$2,292
R-value, at start	2.5

•4 story
•24 Unit
•Electric Heat
•Solid Masonry Wall

Results, Summary	SpaceLoft
Total cost	$45,763
Tax Credits*	$13,729
Net Cost	$32,034
% savings, HVAC costs	23%
Annual savings, HVAC	$6,180
Payback period, years	5.2
Increase in interior wall thickness	0.9"
Lost space due to renovation	98sf

RELEVANT LITERATURE/REFERENCES

Please see our website: *http://www.aerogel.com/markets/building.html*

ROCKWOOL AEROWOOL®

INTRODUCTION

Institute/organisation:

FIRESAFE INSULATION

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The Rockwool Group is the world's leading supplier of innovative products and systems based on stone wool.

Turnover 2010 DKK 11,732 million.

More than 8,800 employees.

Sales points and factories in more than 30 countries.

The Rockwool Group has developed a low lambda composite board made of Stonewool, Aerogel and binder to be used in the GBI insulation market. The name of the new high insulating material is Aerowool® .

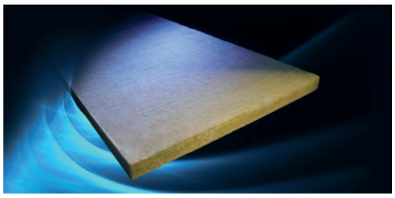
PRODUCT DESCRIPTION

Aerowool in 20 mm thickness is certified with ETA 11/0414 for internal use. It is a solid board with a non-woven veil on both sides. The product can be easily glued or mechanically fixed to the building construction.

The first application of Aerowool is a kit as internal wall insulation by combining it with a gypsum fibre board and a slight vapour barrier: Aerorock® ID.

It is very thin insulation kit for high efficient energy saving measures in ancient and/or listed buildings. As Aerowool itself is a vapour open material (MU: 4) the IWI kit has an integrated, slight vapour barrier. The vapour barrier reduces the moisture transport into the wall in winter time and enables the dry-out potential of the wall in summer time. Aerorock ID has been developed acc. WTA recommendations and can be installed under defined conditions without a hygrothermical calculation.

Product performances



Aerowool:

Solid board

Non-woven veil on both sides

Thickness: 20 mm (online)

CS(10/Y): 40 kPa acc. EN 826

Tri: 1 kPa acc. EN 1607

WS acc. EN 1609

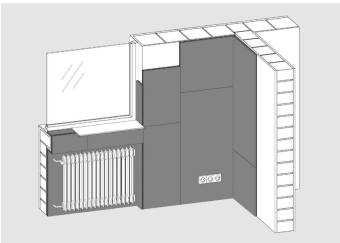
WL(P) acc. EN 12087

λ: 0,019 W/(m·K) acc. EN 12667

Reaction to fire class: B-s1,d0 acc. EN 13501

μ: 4 acc. EN 12086

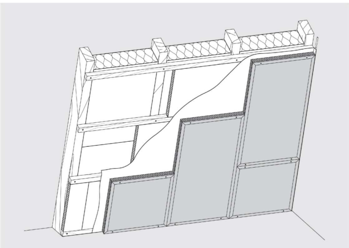
Applications



Internal application in GBI segment

First application:

IWI kit



Second application:

Under rafter and dormer insulation kit

Experiences

The former substation in Wilhelmshaven was converted into a modern restaurant in 2011. The former substation was built around 1890. For its conversion into a gastronomic establishment, it had to be redeveloped and made more energy-efficient whilst preserving the historic red-brick facade at all costs as a kind of ‘business card’ for the new restaurant. Since the beautiful old brick facade had to be preserved at all costs and as little space as possible could be wasted, it was decided to insulate the exterior wall using the extremely thin and highly energy-efficient Aerorock® ID internal wall insulation.

ThecConstruction company created the required space by using the high-insulation material Aerorock® ID from Rockwool. With thermal conductivity values of just λ = 0.019 W/(m·K), this 50-millimetre-thin composite panel provides outstanding thermal insulation in a particularly space-saving manner. Reliable insulation from heat loss which is simple and convenient to install: ‘We initially spackled the existing wall surfaces to level them out so that we could subsequently affix the Aerorock® ID panels across the entire area. By using a joint glue on the panel joints, the necessary diffusion breaking effect and air tightness was achieved with minimal effort. Since the composite panels have an integrated slight vapour barrier, the physical structure of the wall is perfectly insulated from floor to ceiling from the inside. All subsequent fittings and ducts are hermetically sealed.

Conclusions

The goal was to develop a low lambda board which can be easily installed under typical building sight conditions. Aerowool can be cut with a knife or saw, glued with cement based render or fixed with dowels as a standard mineralwool board. The installer does not have to perform a special training to be able to install Aerowool. The high compressive strength of Aerowool is beneficial for al internal applications and offers possibilities to create insulation kits as wall, floor or ceiling covering.

Relevant literature/references

More information available at *www.aerowolle.de*

IIFS - STOTHERM IN AEVERO

INTRODUCTION

With an ultra-low thermal conductivity of λ_{10} 0,016 W/(m*K) Sto presents an innovative Aerogel based composite board as part of its new high performance Interior Insulation Finishing System (IIFS). The super-effective IIFS called StoTherm In Aevero slims down either space requirements as well as costs for heating in new or existing buildings and houses.

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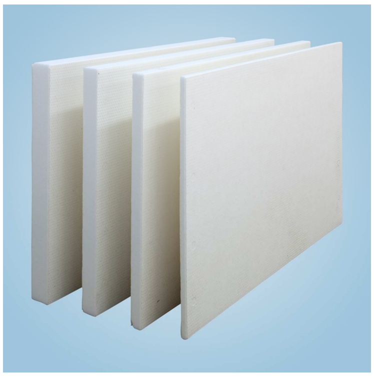
PRODUCT DESCRIPTION

The increasing need for saving the world's energy resources either from an environmental as well as a cost position require readily applicable, practical and effective solutions. Thus, reducing the heat energy demand of buildings and houses by means of insulation has moved worldwide into focus.

However, many existing buildings cannot be insulated at their exterior façade due to restrictions or local constraints. In such cases interior insulation has to be considered as an appropriate alternative for energy saving measurements. Although modern IIFS have overcome the challenges of construction physics loss of living space still remains. However, interior living space is extremely valuable and especially in city centres often at premium costs.

Due to its super-slim design StoTherm In Aevero reduces this problem to a minimum. With the new Aerogel based composite insulating board having an outstanding low heat conductivity of λ_{10} 0,016 W/(m*K) board thicknesses of not more than 40 mm are necessary with respect to the specific and individual wall constructions in order to fulfil most governmental regulations. Sto-Aevero Insulating Boards as thin as 10 or 15 mm may especially be of interest for use in areas where space is even more limited such as window reveals or behind radiators.



Pict.1 Sto-Aevero Interior Insulating Boards (580 mm x 390 mm), thickness 10, 15, 20, 30, 40 mm

Product performances

Sto-Aevero Interior Insulating Boards are available in the dimension 580 mm x 390 mm and thicknesses of 10, 15, 20, 30 and 40 mm (Pict.1). The ultra-insulating Aerogel core is protected with glass fibre facings for a more convenient handling. The functional facing surface is structured which enhances adhesion to the adhesive and reinforcing mortar. Cutting and tailoring of the boards to individual needs is done simply by using a knife without any special tools (Pict.2). Thicker boards (30, 40 mm) are first cut and then broken (Pict.3).

Pict.2 Cutting & tailoring simply with a knife without special tools

1. Adhesive (mortar)
2. Insulating material
3. Reinforcing mortar
4. Reinforcing mesh
5. Decorative finish

Pict.3 Breaking 30-40 mm boards

Pict.5 System setup StoTherm In Aevero IIFS

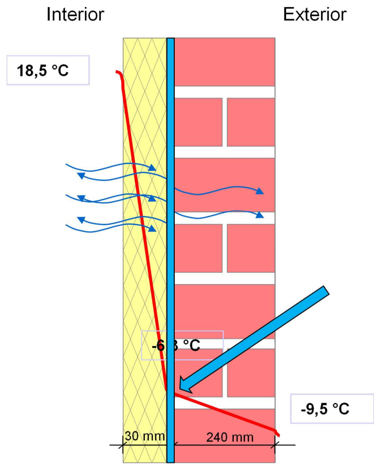
Pict.4 Applying & mounting

Special focus was set to construction physics and the system setup of StoTherm In Aevero as a fully diffusion open interior wall system avoiding the problematic use of a vapour barrier. Unlike other diffusion open systems where the so called capillary active insulating material has got the function of managing moisture and water the Sto-Aevero Insulating Board is likewise very diffusion open but not capillary active. Thus, in StoTherm In Aevero a specially designed capillary active adhesive and reinforcing mortar called StoLevell In Aevero takes on the crucial function of moisture management.

Pict.6 shows schematically an IIFS wall setup with moisture (blue waved arrows) penetrating from the interior side of a room through the diffusion open Sto-Aevero board (yellowish layer) being finally absorbed by the StoLevell In Aevero adhesive layer (blue layer). The adhesive layer is well designed having sufficient capacity for intermediate moisture storage until environmental conditions allow back-evaporation (blue waved arrows) either through the insulant or the wall.

This is a new construction physical principal for IIFS evaluated and confirmed independently by calculations and test rooms.

Pict. 5 illustrates the typical system setup consisting of StoLevell In Aevero as adhesive and reinforcing mortar (1./3.), the Sto-Aevero Interior Insulating Board (2.), a reinforcing mesh (4.) and a diffusion open decorative finish (5.) like Sto's interior Chalk or Silicate products.



Pict.6 Schematic IIFS wall setup with new construction physics

Applications

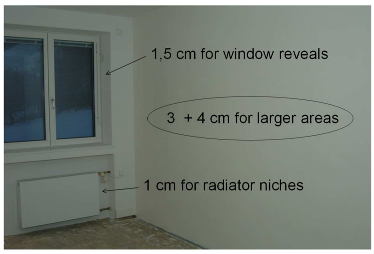
Pict. 7 and 8 illustrate a typical application of StoTherm in Aevero. In window reveals where space is extremely limited a 10 or 15 mm board may be used without pre-treating the reveal in order to increase mounting space.

For a full renovation 30 and 40 mm may be preferred for larger areas while the thin 10 and 15 mm boards may be used for the window and radiator details according to the individual situation.

Pict.7 Window reveal using a 10 mm Sto-Aevero board

Conclusions

StoTherm In Aevero combines the advantages of a high performance Aerogel based insulating board having an outstanding low heat conductivity of λ_{10} 0,016 W/(m*K) with a modern and diffusion open IIFS to allow ultra-slim wall setups without using the traditional but problematic vapour barrier approach.



Pict.8 Example of a renovated room with StoTherm In Aevero

Relevant literature/references

www.sto-aevero.de

AEROGEL-BASED RENDERING

INTRODUCTION

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Those undertaking the renovation of historical buildings are frequently faced with the challenge of how to improve the thermal insulation levels of old structures effectively yet elegantly. To date there has been no method available, which offers a technically satisfactory solution to this problem without noticeably changing the appearance of the historic building. Now, researchers from Empa's Building Science and Technology Lab are working on a solution for this problem in cooperation with Fixit and Kabe, two leading manufacturers of building materials. They have developed an aerogel-based high performance insulating render which will undergo field tests this year and is expected to be commercially available by 2013. Thanks to its mineral basis, the new render is both optically and in application very similar to the original historical building materials, and this makes it ideal for use on old buildings – on internal as well as on external surfaces.

PRODUCT DESCRIPTION

Traditional buildings should not become renovated with modern insulation technologies. The buildings would loose their historic character (picture AGI).

The developed high performance rendering has a thermal insulation value that is three-times better than that of conventional insulating renderings. It is also about 30% better than a compact façade insulation system with polystyrene foam.

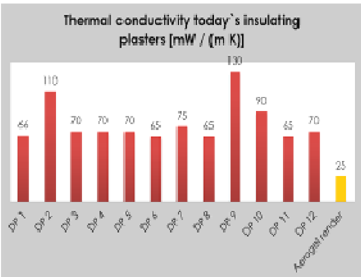
The new material offers an elegant method for renovating traditional buildings and to save energy without altering their appearances. Before, it had often to be decided between a thin layer of artificial looking compact insulation and a badly insulating but natural looking rendering layer. The aerogel rendering now offers both – natural look and high performance insulation.

The rendering system can be applied in layers of 20 to 60 mm thickness on façades and additionally as internal insulation. The rendering is relatively soft and has to be protected like all compact insulation systems by a reinforced protection rendering of about 8 mm thickness. The application can be done by hand, similar to traditional renderings or for larger areas by machine spraying.

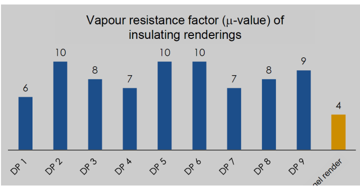
The purely mineral rendering is very open for vapour transmission. This allows fast drying if the construction contains water. On he other hand, the aerogel structure is hydrophobic and will reject rain water that could enter the construction.

The relatively soft insulation rendering will additionally be very tolerant against little cracks that may occur in the supporting structure.

Product performances



Comparison of the thermal conductivity of conventional insulating renderings and the new aerogel rendering (yellow)



Comparison of the vapour resistance of conventional insulating renderings and the new aerogel rendering (yellow)

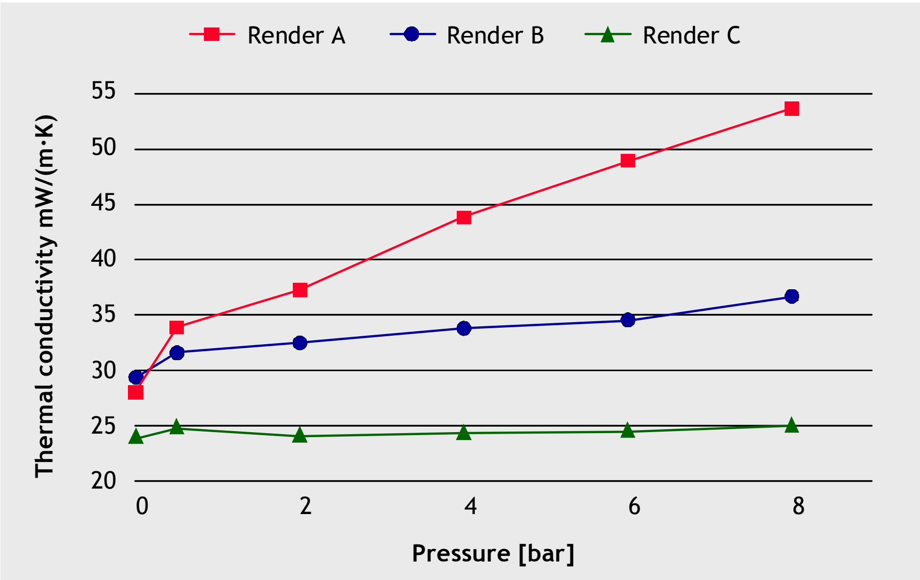
The «secret» behind the novel insulating render is a so-called aerogel. This silicate based material consists of about 90% air and has nanometer-sized pores. These minute pores make aerogels an excellent thermal insulation material. The pore sizes are smaller than the free path length of gas molecules and are therefore reducing the convective heat transport even at normal air pressure. The aerogel itself reaches a thermal conductivity as low as 14 mW/(m·K). A special mixture of aerogel granulate with mineral binders is creating an aerogel rendering with it a thermal conductivity value that is around 25 mW/(m·K). This is about three times better than that of insulation renderings with expanded polystyrene and therefore very competitive. Only pure and still air has about the same insulation value.

A further advantage of the new rendering is its property of being simultaneously water repellent and permeable to water vapour. The new product is significantly more breathable than conventional renderings, and yet its surface does not become easily wet. The porous structure of the aerogel makes the rendering permeable to water molecules, but the nano-pores are much to fine for macroscopic water droplets.

Applications

The first buildings will be rendered with the new high performance material on a trial basis beginning mid 2012.

The lab tests have been completed during 2011. A special challenge was to maintain the excellent performance also when applying machine spraying technologies. During the first test, the thermal conductivity was increased dramatically. This was due to the high pressures that are needed for pumping the aerogel mixture. The fragile aerogel structures were partially destroyed by cement water that was pressed into the aerogel pores. Further improvements of the rendering mixture and the mixing process itself have avoided this negative effect. Now, both the manually and the machine applied renderings achieve nearly the same insulation results.



Improvement of pressure independency of mixture A to mixture C (Stahl et al., 2012)

Spraying tests have been done in order to evaluate the practicability on site and the real thermal performance.

Presently, full size in situ tests of external and internal insulation systems are ongoing and measured. Test walls with a variety of different constructions are exposed in field tests. Additional investigations will be done in weathering chambers. The results will allow to simulate more precisely applications in different situations.

In parallel, about 5 smaller demonstration projects (each approx. 100-500 m²) are planned for 2012. The experience with these “real” applications and the ongoing tests should allow to bring this novel insulation system to market during 2013.

CONCLUSIONS

The available results are very promising and a wide range of applications can be expected throughout Europe especially if aerogel prices can be reduced. Additional testing is needed to evaluate the long term performance of the system. Special issues for closer investigations are:

- long term adhesive strength on masonry
- investigation of internal insulation condensation risks
- materials degradation, e.g. due to frost cycles
- reduction potential for mould and algae growth on exposed façades

RELEVANT LITERATURE/REFERENCES

Stahl, Th., Brunner, S., Zimmermann, M., and Ghazi Wakili, K. (2012), Thermo-hygric properties of a newly developed aerogel based insulation rendering for both exterior and interior applications, Energy and Buildings 44 114–117

BUILDING INSULATION WITH VIP

INTRODUCTION

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Porextherm - Advanced thermal insulation

Porextherm is one of the world-wide leading suppliers of micro porous high performance insulation materials with huge, ISO 9001 and ISO 14001 certified, production facilities in Kempten, Germany.
The fumed silica based Vacuum Insulation Panels (VIP), brand-named Vacupor® or Vacuspeed® are state-of-the-art insulation materials in the temperature range of -50 °C to 80 °C.

Vacuum insulation panels are receiving increasing attention in a wide variety of application areas. In the fields of appliances, construction and the temperature-controlled packaging industries, Vacupor® VIPs are already firmly established. The insulation properties exceed the achievable values of conventional, meaning non-evacuated insulation, by far.
Thus, very good insulation with comparatively thin structures can be achieved. Application-oriented specially-designed versions of our Vacupor® vacuum insulation panels allow easy and secure installation of the VIPs. Furthermore rapid-building-systems such as Vacuspeed® are available from stock on a short-term basis and will be supplied in construction-site-customized packaging.

After supplying the building & construction Industry in Europe with VIPs for more than 13 years, most of the barriers for a wider commercialization were overcome.

A lot of customers/users are convinced by the outperforming qualities of Vacuum Insulation Panels and their capability to solve very complex and demanding applications.

Also obstacles such as legal approvals of the building authorities (Fig. 1) or missing Environment Product Declaration (EPD) (Fig. 2) are overcome.

Several VIP suppliers do have products available that can be used in a lot of internal and external applications based on reasonably low rated values for thermal conductivity.

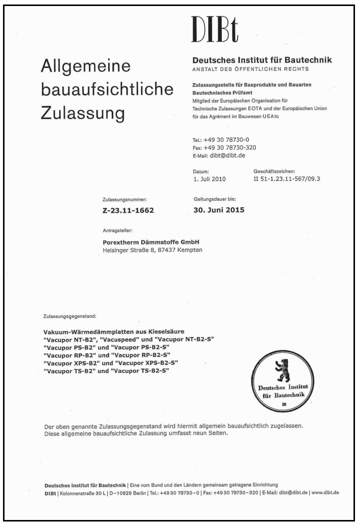


Fig. 1) DIBT approval

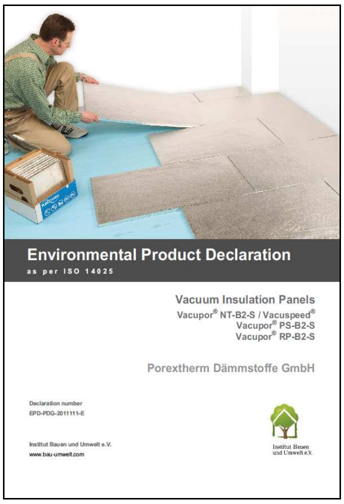


Fig. 1) DIBT approval

Even quality issues are sufficiently managed by external quality controls and quality labels in place, such as Ü-label (Fig. 3) and GSH quality label (Fig. 4)

Fig. 3) Ü-label. External

Fig. 4) GSH VIP quality label

PRODUCT DESCRIPTION

Vacupor® is a microporous insulation material with an extremely low coefficient of thermal conductivity.

Vacupor® consists of inorganic oxides. The main constituent is fumed silica, the other components are opacifiers for minimizing infrared radiation, and small amounts of reeinforcing filaments

Vacupor® is heat sealed in a multi layer, metallized, plastic barrier film under vacuum.

Under the certification number Z-23.11-1662 the German Institut for civil engineering (DIBT) granted an approval for various Vacupor® types.
The approval is valid for construction applications DAD, DAA, DZ, DI, DEO, WAB, WAA, WH, WTR and WI according to standard DIN 4108-10, table 1 and for prefabricated façade panels with insulated glass character (Fig. 5).

The approved versions conform to Baustoffklasse B2.
The test of behaviour in case of fire according DIN 4102-1, May 1998, Baustoffklasse B2; Testcertificate No. H.3-145/07 and H.3-146/07, was issued by the Forschungsinstitut für Wärmeschutz e.V. München

Fig. 5) Approved building applications

The core material od Vacupor® is not flammable and is classified A1 according to DIN ISO EN 13501-1.

According to particular insulation requirements, the Vacupor® VIPs can be supplied in various shapes, sizes and coverings with different functional protection layers.

Basically 5 different versions are available:

- Vacupor® NT-B2-S
  Standard B&C VIP, unprotected (Fig. 6)
- Vacupor® RP-B2-S
  protected with rubber granule mat (Fig. 7), mainly floor applications
- Vacupor® PS-B2-S
  protected with EPS sheet (Fig. 8), mainly wall applications
- Vacupor® XPS-B2-S
  protected with XPS sheet (Fig. 9), mainly window reveals, roller shutter boxes
- Vacupor® TS-B2-S
  protected with sound insulation sheet (Fig. 10), mainly floor- and ceiling applications

Fig. 6) Vacupor® NT-B2-S

Fig. 7) Vacupor® PP-B2-S

Fig. 8) Vacupor® PS-B2-S

Fig. 9) Vacupor® XPS-B2-S

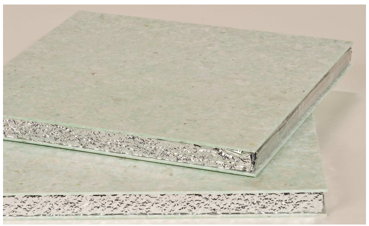


Fig. 10) Vacupor® TS-B2-S

PRODUCT PERFORMANCES

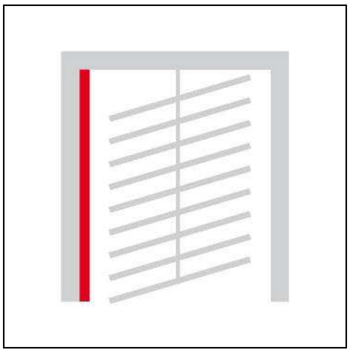
Vacupor® combines the properties of a micro porous insulation material with the advantages of vacuum insulation technology.
In this way, an extremely low thermal conductivity of ≤ 0,005 W/m*K can be achieved.

The rated values, according to DIBT approval number Z-23.11-1662 are as following:

- Vacupor® NT-B2-S: 0,007 W / (m×K)
- Vacupor® RP-B2-S: 0,007 W / (m×K)
- Vacupor® PS-B2-S: 0,007 W / (m×K)
- Vacupor® XPS-B2-S: 0,007 W / (m×K)
- Vacupor® TS-B2-S: 0,007 W / (m×K)
- Vacuspeed®: 0,008 W / (m×K)

Due to the extremely low permeation rates of the used barrier film and the very good sorption behaviour of the fumed silica core, very long lifetimes can be achieved.

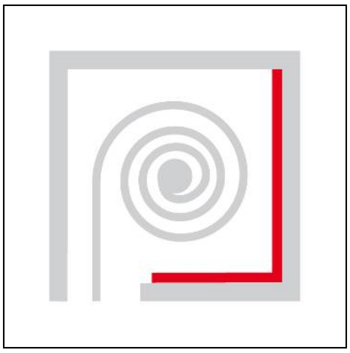
APPLICATIONS



As mentioned Vacupor® VIPs are approved for construction applications such as DAD, DAA, DZ, DI, DEO, WAB, WAA, WH, WTR and WI according to standard DIN 4108-10, table 1 and for prefabricated façade panels with insulated glass character.

The abbreviations stand for:

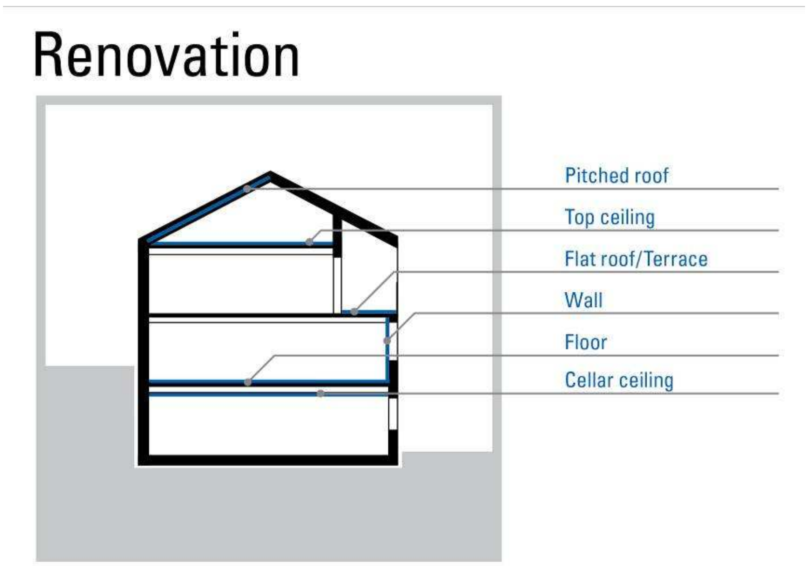
DAD - outside insulation, roof or ceiling, under coverage
DAA - outside insulation, roof or ceiling, under seal
DZ - common rafter insulation
DI - inside insulation of the ceiling or roof
DEO - inside insulation of the ceiling or ground slab
WAB - outside wall insulation behind sheathing
WAA - outside wall insulation behind seal
WH - insulation of wood frame and wood panel construction
WTR - insulation of space separation walls
WI - inside wall insulation
WH - insulation of wood frame and wood panel construction

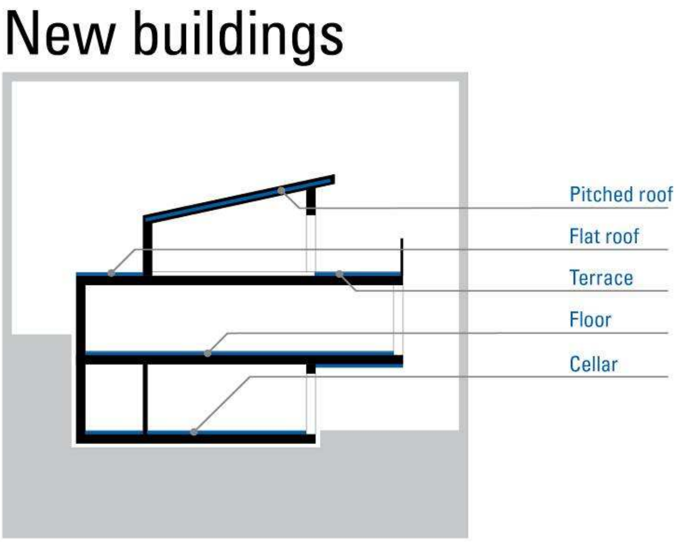


In consequence various interior and exterior insulation applications can be managed.
Due to the availibility of VIP in various shapes, such as triangles, trapeziod etc., a lot of designs/geometries can be followed. Even bended panels, to form a radius are possible.

Fig. 11) Vacuum insulation panels in roller shutter casings and lamellar -blind-boxes

The following scetches show the most common applications in new buildings and renovation.





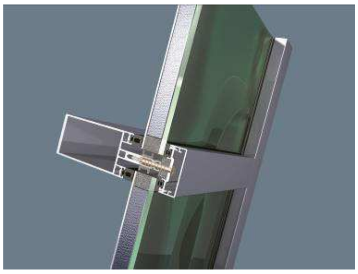


Fig. 12) Vacuum insulation panels in façade elements
Source: Schueco

Besides this, the use in systems, such as façade elements (Fig. 12), roller shutter boxes (Fig. 11), ETICS like wall insulations and various sandwich systems for inside and outside use are quite popular.

EXPERIENCES

The experiences with vacuum insulation panels in building applications go back for almost 13 years now.
In this time several thousands of projects/objects have been successfully solved.

One of the latest realized projects, where VIPs could show their benefits, is the renovation of the secondary school of Freilassing/Germany.

After the renovation, passive house standard was achieved.
Vacupor® RP-B2 had a substantial contribution towards that aim. Given the lack of space for insulation, the low height of Vacupor® was decisive.

The ambitious aim was fixed since the beginning of the project: after renovation the building has to fulfill all technical aspects of a passive house. Appointed by the city of Freilassing architects team Fred Meier and Bernhard Putzhammer designed an ingenious concept. The reinforced concrete construction of 1972 got covered with a building shell on passive house standards. Additionally to that the whole floor insulation was made with Vacupor® vacuum insulation panels.

Floor insulation with Vacupor® RP-B2 on sealing membrane

Vacupor® RP-B2 covered with flooring membrane

Screed floor

Potter room
Source: Meier and Putzhammer

Secondary school of Freilassing/Germany
Source: Meier and Putzhammer

High insulation - low thickness

The limited space for insulation plays always an important role in renovating aspects of building. Solutions become particularly tricky, as soon as there are no alternative solutions e.g. for the heights of a room. To achieve targets of high thermal insulation rates without loosing too much room heights, architects like to hark back to the extreme thin Vacupor® high performance vacuum insulation panels. “For that object Vacupor® was the smartest solution, to fulfill the requirements of thermal insulation without loosing heights of the rooms” (Dipl.-Ing. Architect Bernhard Putzhammer of the architects team: Meier and Putzhammer). For this object, Vacupor® RP-B2 with a double sided rubber protection layer against mechanical damaging was used. Due to an early and close cooperation between planning- and consulting office Meuvo Ökotechnik GmbH and the manufacturer Porextherm Dämmstoffe GmbH in Kempten a smooth running of the project was guaranteed.

Fitting of Vacupor® by experts

Additionally to an exact measurement and a comprehensive planning in advance, the laying of the Vacupor® panels is a further very important aspect. Initially for all spaces of the several rooms, a floor plan and panel list were generated with a special data processing Vacupor® planning program.
It is to get automatically the optimized quantities of standard and special size panels.

The team of Meuvo Ökotechnik showed its years of experiences of handling with Vacupor® vacuum insulation panels and guaranteed a professional and smooth operation during the fitting of the panels.

Because of using the version Vacupor® RP-B2 with its double sided rubber protection layer, not even one panel got damaged at the building site.

CONCLUSIONS

Vacuum Insulation Panels offer outperforming thermal insulation values compared to conventional system.

In cases of limited available space, advanced requirements on energy consumption or demanding requirements on the aesthetics of a building, VIPs are a premium solution even in comparison of cost.

The state-of-the-art provides suitable products and systems, that allow to use VIPs in a wide range of building & construction applications.

QASA VACUUM INSULATION PANELS FOR A SAFE APPLICATION

INTRODUCTION

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Variotec is a middle-sized company with currently about 100 employees.

All products are manufactured and developed as passive house suitable components for the energy-efficient market. The product lines comprise the fabrication of windows, doors and vacuum insulation.

Apart from the high quality standard of the product that we assure as the single manufacturer the developments are based on practical experience and consultancy in close collaboration with the HYBRID BUILDING 2050 consulting firm for building concepts ltd., the planning competence of the world's first fully vacuum insulated zero energy house built in Voggenthal from 2000 to 2004.

The QASA vacuum insulation products are manufactured since 2004 in our plant and comprise the complete system range of the internal and external insulation according to DIN 4108 – part 10.

PRODUCT DESCRIPTION

The QASA vacuum insulation panels manufactured at VARIOTEC are exclusively developed against the background of the safe application on site at the interior as well as at the exterior of the building shell according to DIN 4108 – part 10, the quality of the elements and the long-life cycle assured by high quality criteria and test standards as well as the quality in the detail solution.

The product name QASA is deducted from Q (heat) and casa (house, building).

The product QASA comprises vacuum insulation element solutions that are manufactured with protective covering layers and edge solutions adapted to each particular application area. Each QASA system presents the necessary mounting solution.

PRODUCT PERFORMANCES

Due to the approval Lambda value of λ 0,007 W/(m K) the QASA vacuum insulation has a more than 5 times better insulation performance in comparison to conventional insulation systems. The resulting slim component solutions enable innovative constructions in the field of refurbishment and new buildings and achieve high area gains by slim cross sections of the external wall from 20 cm in passive house standard. In this way projects with vacuum insulation become highly realizable from the economic point of view. Legally relevant reductions of the building height respectively the utilization of useful cubatures as well as legal requirements of the spacing arrangements can also be realized with a high insulation effect. Furthermore the QASA vacuum insulation provides slim contemporary and energy-efficient architectural solutions.

By the application areas in new buildings (facades, flat roof, steep roof, blinds) or refurbishment (internal insulation, floor, wall, ceiling, facades, blinds) the vacuum insulation offers problem solving and economic advantages in the holistic use or in punctual areas.

The prefabrication of complete slim building solutions in the field of new buildings enables the economic integration of the vacuum insulation. Furthermore it provides in addition to transport and installation simplification the solution for building concepts according to the requirements of the CO_2 reduction and the legal requirements.

Slim insulation constructions on facades facilitate the solar gains by reducing the window areas due to the reduction of the reveal depths.

Applications

QASA vacuum insulation products are applicable according to DIN 4108 – 10 and comprise the following areas:

DAD	External roof insulation
DAA	Flat roof insulation
DZ	Common rafter insulation
DI	Internal ceiling insulation
DEO	Internal ceiling or floor insulation
WI	Internal wall insulation
WAB	External wall insulation behind cladding
WZ	Insulation of double-shell walls or core insulation
WH	Insulation of wooden frames and timber panels constructions
WAP	External wall insulation under plaster

The application of the QASA vacuum insulation elements is possible due to 14 different protective materials for the covering layers according to the general technical approval from the DIBt.

Since 2012 there is the possibility to use QASA vacuum insulation elements in the range B1 (hardly inflammable) that is feasible by developed materials for the covering layers with general technical approval as well as thermal bridge optimized hardly inflammable edgings.

EXPERIENCES

The research building in Voggenthal that has been developed from 2000 to 2004 is the base of all QASA vacuum insulation solutions developed since 2004. For the first time worldwide vacuum insulation has been applied as core insulation in irreversible prefabricated concrete and wooden components for exterior walls, flat roof and under the floor slab.

A monitoring of several years carried out by the Fraunhofer Institute for solar energy Freiburg ISE gave important evaluation results from over 150 measurement points in the building. Furthermore the aim of the project as a research building was to develop indoor climatic data as well as passive applications for climate cooling systems.

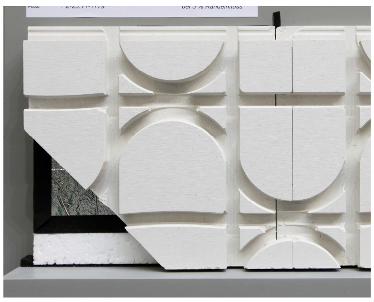
Since 2004 numerous applications in the field of new buildings and refurbishment were the basis of further product developments for QASA internal and external insulation. In 2010/2011 a HYBRID building in a wood and concrete mixed construction with ventilated vacuum insulated facades has been erected in Freiburg.

Project realizations with QASA in the field of internal insulation provide product safety in the application with highest requirements for the building physics.

Innovative solutions for facades are currently realised with QASA in the field of glass facades.

CONCLUSIONS

QASA vacuum insulation is a very important product for all building concepts of the present and the near future (EU directive 2019/2021). The requirements for future energetic project solutions that are increasing to a great extent can already be realised in a safe way.



RELEVANT LITERATURE/REFERENCES

Publications and reports in leading professional magazines as e.g.: GFF, Denkmalsanierung, ausbau + fassade, bba, BDB, Dämmen + Dichten, dach + holzbau.

VIP FLAT ROOF INSULATION

INTRODUCTION

A big variety of VIP application has been developed during the pioneering phase 2000 to 2004. However, the flat roof application covers now more than 95% of the market share of VIPs used in buildings in Switzerland. Over 25.000 m^2 VIPs are used to allow a flat access from apartments to insulated terraces.

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LABORATORY BASED ACCELERATED AGING

Empa addressed in 2004/2005 the durability issues with laboratory based aging tests (Simmler et al 2005). Laboratory based accelerated aging test confirmed, that permeation rates of gas are mainly depending on ambient temperature and humidity. over the permeation rate is depending on the temperature, and can be fitted with the Arrhenius law for both for pressure increase as well as for water uptake. The testing condition selected had been high relative humidity of about 80% r.h. at changing temperatures. Such high humidity does occur in flat roof constructions, where the VIP's are sealed by bituminous layers.

Some of the laboratory based accelerated aging tests had been performed during a longer period in order to accentuate failures related to damages in the metallised barrier (Brunner et al 2008). Of course, there are many failure types possible. One that occurred in a house build in the pioneer phase in 2004 was related to the alkaline condition, which attacked the aluminium of the metallized barrier (Heinemann and Kastner 2011).

Flat roof terraces with heated rooms beneath are the most common application of VIP's in Switzerland with more than 25.000 m²/year and a market share of over 90%. (Photo: Sunnywatt buildings by 'kämpfen für architektur AG' 2009)

Insulation work for a flat roof terrace with double layered VIPs. Photo from SunnyWatt construction site (Source: www.vacuspeed.ch/referenz)

Likely the oldest flat roof is the Hanging Gardens of Babylon about 2600 years ago.

Source of image: *http://www.baunetzwissen.de/standardartikel/Flachdach-Geschichte-des-Flachdachs_155933.html*

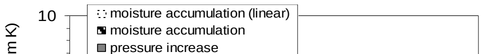
SERVICE LIFE TIME OF VIPS

The service life time of VIPs for building application was evaluated by Empa and other institutes within the IEA ECBCS Annex 39 project. Based on these measurements a service life time of 30 to 50 years can be expected. This is comparable to the 40 to 60 years of service life that are assumed for flat roofs with conventional insulation (Kasser and Klingler 2011).

Most data published refer to a 25 years value, because this is the standard aging time to be declared for thermal insulation products used in building applications (EN 13162 to EN 13171). However, this value does not represent the expected service life time, which can be 50 years for dry conditions and about 30 years for humid conditions.

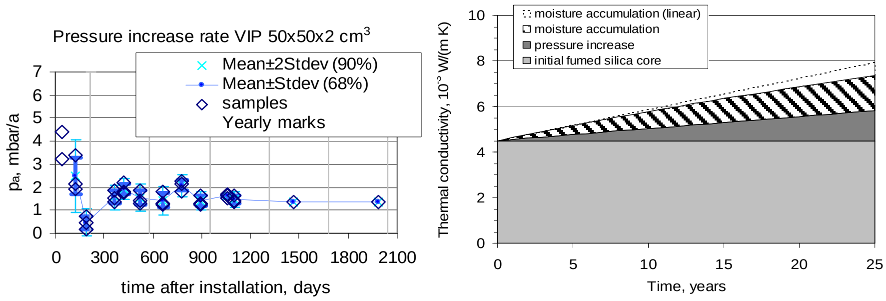
MONITORED TEST ROOF

Empa is monitoring a VIP insulated roof since 2004. First results have been published in Brunner and Simmler (2008). Several samples of VIP roof insulation were regularly removed from a roof and measured in the laboratory. The internal gas pressure and the moisture related weight change



was measured. The two parameters pressure increase and moisture uptake have been compared with a laboratory based prediction model simulation that considered the measured temperature profile on the roof. The simulated pressure increase fits well to the measured data. This allows to assume, that laboratory ageing under steady condition can be used to predict the real pressure increase. However, the accuracy of a forecast is depending on the accuracy of predicted temperature profile.

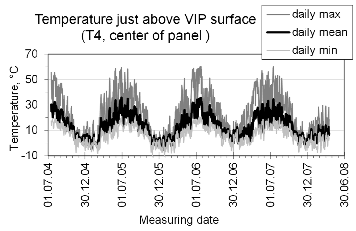
Test area 1 was reopened several times.



Test area 1 was reopened about 4 times per year. The data show the pressure increase divided by time (left). Predicted thermal conductivity (right) as published for the flat roof (Source: Brunner and Simmler 2008)

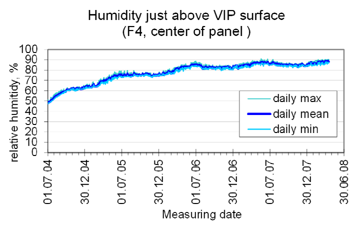
Test area 2 sealed and subsequently covered with gravel.

MICROSCOPY OF VIP LAMINATES



Temperature above the VIP on test area 2

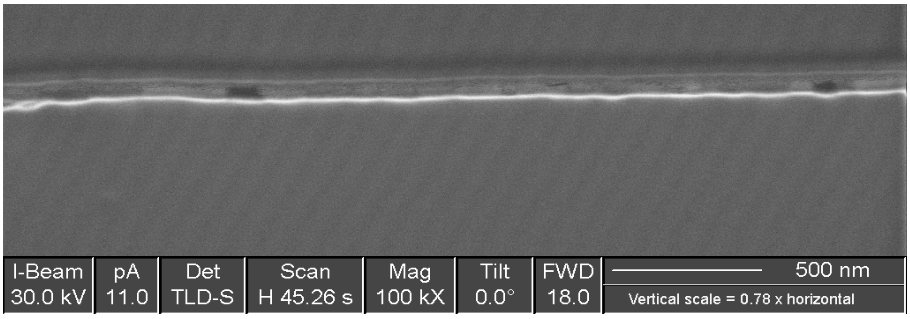
An important question in common service life prediction approaches is, whether other ageing effects (or degradation/deterioration) might occur. High temperatures and high humidity might accelerate hydrolysis of the adhesive used in the laminated VIP envelope. Also the aluminium layer may suffer from corrosion depending on the environmental conditions. Preferable are applications with low humidity, but many applications have periods with condensation on parts of the VIP surface.



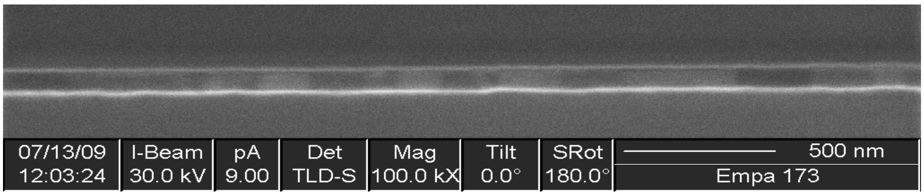
Humidity above the VIP on test area 2

A 5 years old sample of the test roof was not installed any more but used to investigate potential early degradation of the barrier layer. The VIP envelope consists of a multi-layered laminate with 4 films as common for building application. In this case 3 PET (Polyethyleneterephtalate) layers with a metallization of 100 nm of aluminium are laminated together with a polyethylene film of 50 μm thickness.

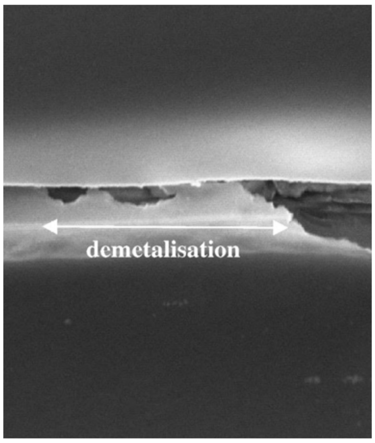
No sign of change has been observed in the barrier layer of the laminate L1 that was exposed for 5 years in the roof, whereas the accelerated aging under rigorous conditions of 16.000 hours at 65%C and 75% r.h. destroyed the layer of laminate L2-type. Another reason for degradation could be the hydrolysis that attacks the PU adhesive between the layers of the laminate.



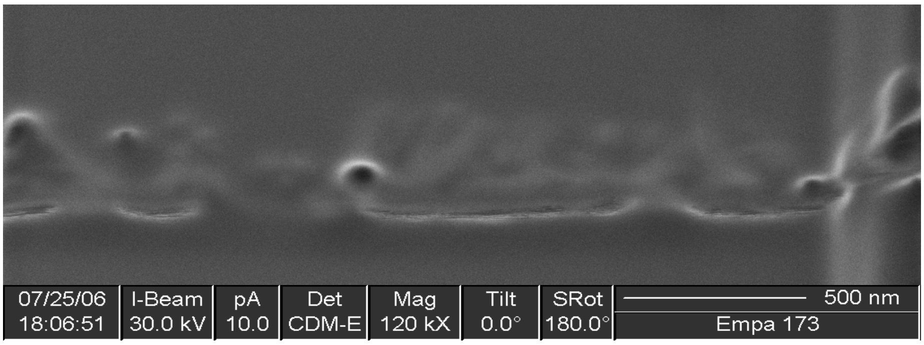
Microscopic cross-section through a new (as produced) metallized barrier layer of 100 nm (Laminate L1-Type in Brunner et al 2008). Image done with Focused Ion Beam (FIB) cross-sectioning.



The most exposed aluminium layer was imaged with Focused Ion Beam microscopy. The aluminium layer of Laminate L1-type after 5 years service in the roof without any visible change. This sample has a temperature history of 15 hours T> 60°C, 450 hours T> 50°C and 1900 hours T> 40°C simultaneously with high humidity.



Besides chemical attack also demetalisation and delamination defects could be identified by accelerated ageing. TEM image (E-beam) of laminate L1. Details in (Brunner et al 2008)



Aluminium layer of Laminate L2-type of 60 nm thicknesses after 16.000 hours accelerated aging at 65°C and 75% r.h. The barrier layer is clearly damaged and corroded (Details see Brunner et al 2008).

CONCLUSIONS

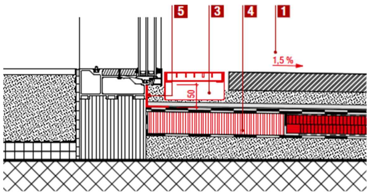
The application of VIPs for flat roof insulation is in Switzerland normally done with “unprotected” VIPs. This application is often commented to be more risky, but allows a more direct quality control. Vented VIPs can be detected and the construction process can profit from a faster learning curve.

The practical approach seen in Switzerland is the change more and more to double layered VIP applications, where the thermal bridge effect gets further reduced by the staggered arrangement and where the few potentially damaged VIPs are hardly at the same place. This double layered VIP construction got possible by the market demand of 40 to 60 mm thick vacuum insulation that requires double layers. It also facilitates the use of standard sized VIPs combined with foam pieces, which can cut to the actual needs on the building site. The standardisation of VIPs has improved the availability of VIPs and reduced the delivery time. This has led to a market grow in Switzerland.

Regarding VIP use in general, the statistics in the VIP-Prove project of Heinemann and Kastner (2010), show that a 95% reliability of VIP or better can be expected for future market applications. There, in the context of a façade, the use of alkaline mortar is mentioned as very critical. In the meantime also secondary literature (ZAE VIP Lehrmittel 2009, Brockmann and Herr 2011, both in German) documented that alkaline conditions have to be avoided.

Flat roof insulated using VIP:

Equal level access to the terrace.



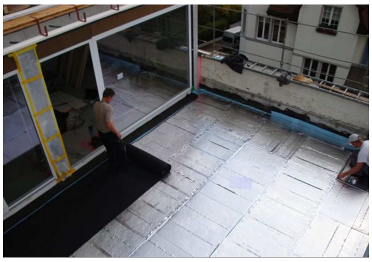
Detail for equal level access to a terrace

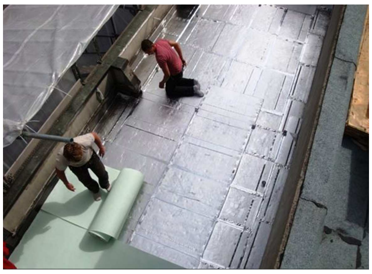
View to a barrier free access to a terrace constructed with natural stone plates.

(Source of images: www.vacuspeed.ch/de/content/brosch-re)

LITERATURE

Buildings of another distributor of VIPs:





Source of images:
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VACUUM INSULATION PANEL APPLICATIONS IN CONSTRUCTION

MICROTHERM

Microtherm, a world leader in high and low temperature thermal insulation solutions, is known for its ever-growing portfolio of microporous insulation and for its creative design advice, the result of a relentless commitment to R&D and innovation.

The end-uses of the microporous nanotechnology-based insulation materials developed by Microtherm include high temperature applications such as storage heaters, insulation for petrochemical installations, in the steel and glass industry, in aerospace and other transportation industries and more recently in fuel cells.
Vacuum insulation panels based on microporous cores also constitute superior performing insulation materials in the lower temperature range, especially when energy savings are to be considered in applications such as cold storage and in the building industry.

The main components of Microtherm® include microporous amorphous silica reinforced with filaments and formulated with opacifiers. The microporous structure has been designed to minimize heat transfer in a wide range of temperatures, either high or low. Furthermore these light weight products also provide superior passive fire protection.

Today Microtherm is actively involved in the development and optimization of vacuum insulation panels to be used in cold storage and building applications. The main goals of these efforts are geared to include other functionalities in the existing products, e.g. improved long term behavior and the development of concepts to include VIP in building systems.

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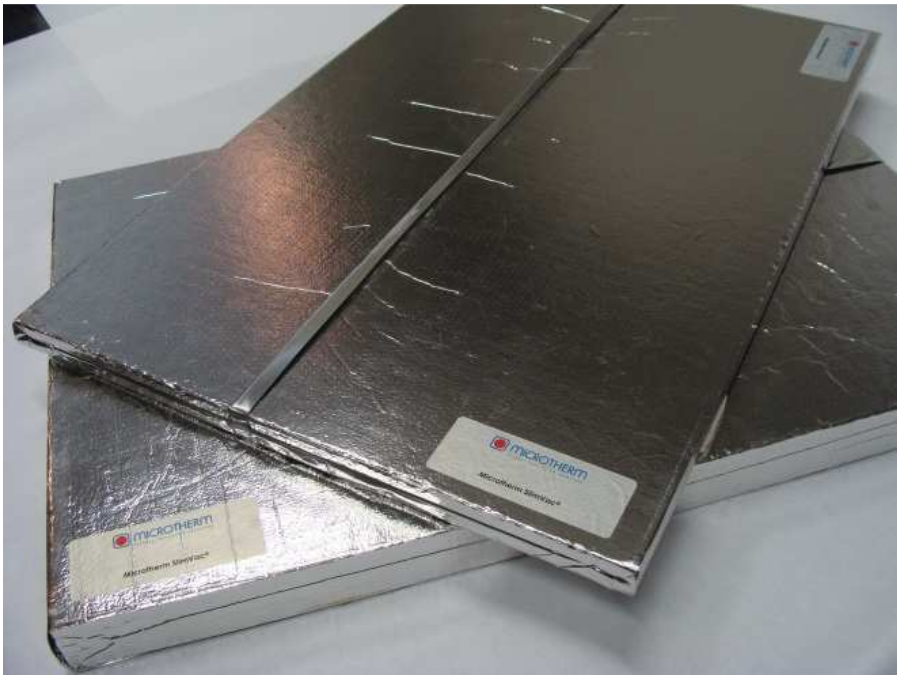


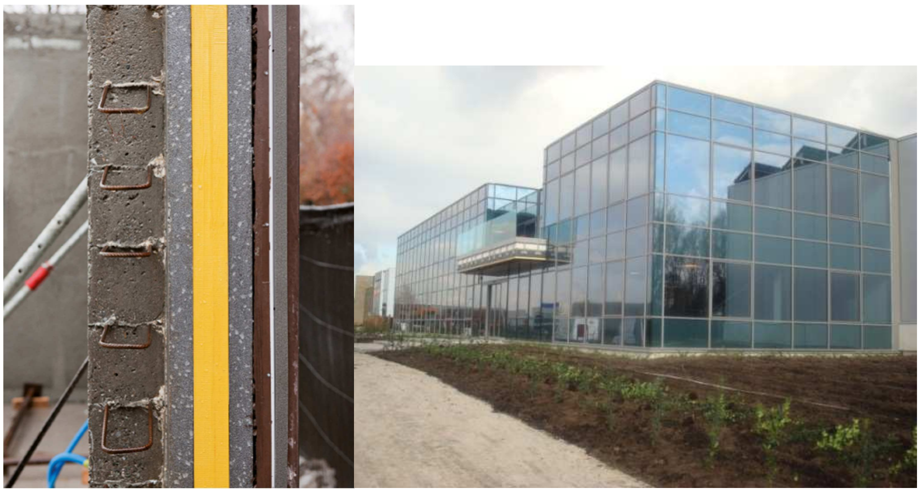
Since the takeover by Promat International, itself part of the Etex Group, the synergy between the various groups within the company is strongly emphasized. The expertise in insulation and passive fire protection of Microtherm and Promat is now linked into the product portfolio of the more recently acquired Lafarge Gypsum Division (now named Siniat) and the building materials marketed by Etex.

Current market trends highlight stricter environmental regulations, the existence of an aging building inventory and rapidly evolving construction modes. The vision of Etex is to become a worldwide recognized leader in solutions for energy saving and comfort, offering sustainable products and services based on products enabling affordable housing.

VIP IN BUILDING APPLICATIONS

Different applications for vacuum insulation panels in building systems have been developed the last several years in close collaboration with industrial and academic partners. The main driver in the choice of these applications is the key attribute of vacuum insulation panels, i.e. the savings in space when utilizing this newer type of insulation vs. traditional insulation materials. In light of its the geometry it is advisable and often necessary to provide a protecting envelope around the vacuum insulation panel when installed in the particular building system. This is illustrated in the following examples in the application portfolio of Microtherm, including :

- Concrete wall elements, where the VIP panels are encapsulated between layers of EPS before this composite is affixed to the concrete slabs which will eventually complete the structure to be installed on the outside of a newly erected building.



- Glass curtain walls constitute a great potential for the use of vacuum insulation panels as the limited thickness of the VIP panels offer many possibilities to the designers of this type of façade.

- Ventilated facades where again the VIP panels are protected by other traditional insulation materials to be included in the larger structure. It is worth noting that such a project requires a lot of initial planning in order to optimize the number of maximum size VIP panels to be used. Due to the presence of doors and windows it is always necessary to include a number of smaller, less thermally efficient panels.

- Terraces or balconies which need to be insulated due to the presence of an inhabited space underneath whereby it is very appealing to avoid a level difference between living quarters and terrace or balcony.

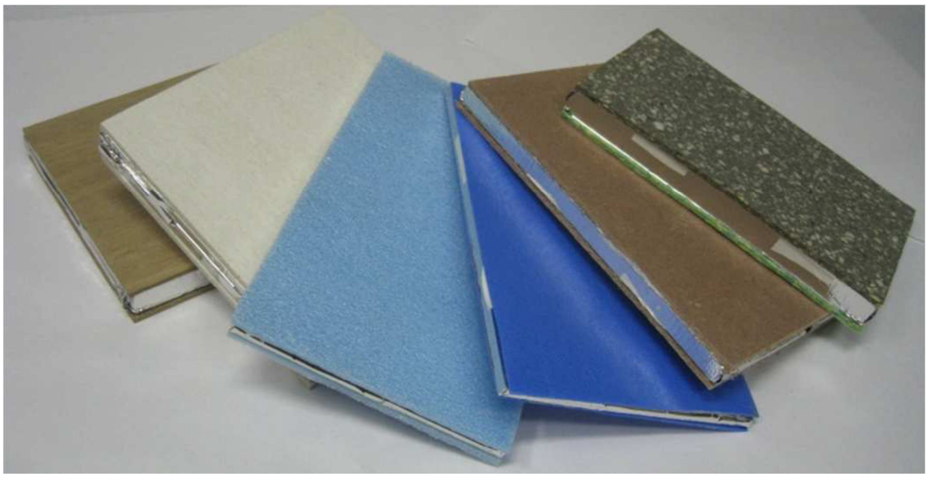
- Insulation of doors in order to convert current housing to a lower energy level appears to be another attractive application area for VIP. Producing large quantities of standard size doors and thus large, standard size VIP will make this application very appealing from a cost point of view.

- Modular building systems where a vastly improved thermal efficiency can lead to increased comfort at a much lower price, also keeping in mind the space limitations in this particular application.

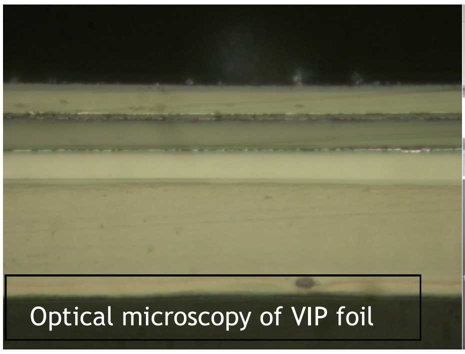
Functional requirements

As indicated earlier it is desirable to provide a protective cover to vacuum insulation panels to limit possible damage to the VIP during handling, installation and working life. Many different materials such as PU, EPS, rubber mats, … are tried out and proposed today.

Furthermore it is clear that the use of vacuum insulation panels in building applications requires the development of new concepts and systems to overcome some of the handling issues when installing VIP, and to optimize the key attributes of this material. The use of VIP goes beyond the simple replacement of the traditional insulation materials by a more thermally efficient alternative ; thus the development of composite structures is also of great interest.

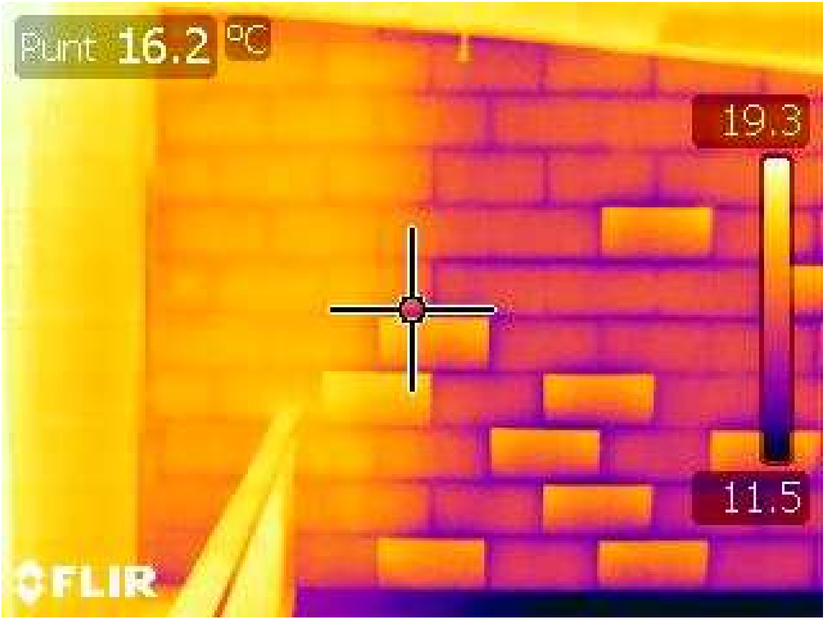


In the building applications the life time of the materials used remains a key issue. Therefore it is very important to study the long term behavior of the VIP and its components. At Microtherm the evaluation of the properties of the barrier foils constitutes a major research activity in collaboration with industrial and academic partners. Of particular interest also is the behavior of the films at higher temperature and relative humidity, as well as under thermal cycling so that the most suitable film can be recommended for a particular application ; this can be studied in climate chamber under controlled conditions of temperature and moisture as well as in in small scale mock-ups where the properties of the VIP panel can be monitored as a result of varying environmental loading conditions.



Optical microscopy of VIP foil

An additional powerful tool for determining the performance of vacuum insulation panels once they have been installed is the use of thermography, whereby the effect of the insulation material becomes visible. At the same time the performance over time can be monitored very easily.



CONCLUSION

As part of the Etex Group Microtherm develops building concepts and systems for VIP with its sister companies and is dedicated to providing high performance solutions to the building industry based on the use of vacuum insulation panels.

Using the experience and expertise acquired with a number of initial building applications the company strives to expand its portfolio of solutions in those cases where the VIP provide a clear technical and thermal advantage.

In addition Microtherm recognizes the need for further study and investigation in order to come up with suitable answers with regard to the specific functional requirements when using VIP in building applications ; this effort will also be pursued in collaboration with external partners.

EMBEDDED VIP ON THE FACADES

INTRODUCTION

Insulation of the building envelope is by far the most important action for reducing the energy needs of the built environment. Meeting the 20-20-20 target of the EU will need very performing solutions, both for new built as well as for existing buildings.

The higher the desired heat resistance, the thicker the insulation layer gets. Traditional insulation materials need 30 cm and more to meet the passive house or zero energy standards. Especially for the post-insulation of walls and floors in existing buildings, this space is often not available. [1]

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PRODUCT DESCRIPTION

Intelligent ETICS* with VIPs

/* External thermal insulation composite systems

The new LockPlate system requires less than 10 cm thickness to realise U-value of less 0.15 W/m²K, whereas most traditional insulation materials would require 30 cm or more. The system is especially interesting for low energy retrofitting of existing buildings, but can also be used for new constructions. [2]

The smart way? VIP inside of ETICS!

The LockPlate system is an innovative ETICS based on VIPs embedded in EPS in its core. The EPS envelope serves as a mechanical protection for every VIPs. *Fig. 1*. To reduce the thermal bridge effect on VIP edges in their joints (each VIP is wrapped up in an aluminium foil bag to seal the vacuum) the base VIP's are overlapped with another plate, also with embedded VIP. *Fig. 2*. And more, because of the EPS frame around VIP, the panels can be fixed to the wall with fasteners without having to perforate the VIP. [3] *Fig. 7*.

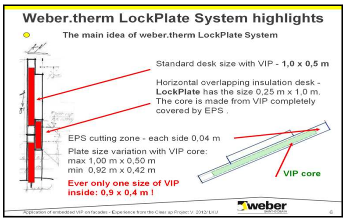

Figure 1. The main idea of LockPlate system

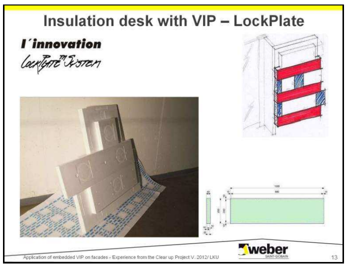

Figure 2. LockPlate composition

Figure 3. Window frame – horizontal overlapping

Figure 4. Window sill insulation

Figure 5. Construction connection

Product performances

What does VIP stand for?

Vacuum Insulation Panel (VIP) has rated thermal conductivity (lambda value) of around 0.007 W/mK [4], which makes them 5 to 6 times thinner than traditional insulation materials. The core material usually exists in shape of an open cell materials or fumed silica, e.g. VIPs are covered with a multi-layer barrier film to eliminate gas and moisture permeation. VIPs are typically evacuated at inside pressure below 5 mbar. Heat transfer by conduction, convection and radiation is dramatically reduced thanks to the very small pore sizes of the core material, the vacuum and added opacifiers. However, the very thin barrier film is very sensitive. Consequently, the VIP is quite fragile.

Applications

What has especially been targeted?

- Maximizing mechanical VIP protection during transportation and at the building site to avoid any damage. Fig. 2.
- Minimizing heat flux transfer in the VIP joints - so called edge effect. Fig. 1.
- VIP size adjustment directly at the building site with no plate size limitation.
- Optional mechanical anchoring by fasteners, which is useful even at retrofitting. Fig. 7.
- Minimizing the number of VIP size typologies. Fig. 2.
- LockPlate System is ETICS in combination with VIP designed as one layer system with overlapping plate. Fig. 2

EXPERIENCES

LockPlate System in the building practice

The LockPlate system components are produced in a limited number of standard sizes (0,5x1m and 0,5x0,5m for the base layer ("Panel") and 0,25x1m for the second layer ("Lock"). *Fig. 2.* This enables fast production and prompt delivery. The choice of three plate types has been made for the reason of covering every possible shape of façade. This fact is made easier because every plate has on its perimeter a cutting zone that enables easy plate size modification directly on site. *Fig. 1.* A software tool LockPlate Planner [5] is available for a tailor made lay-out of the panels on the facade. *Fig. 4.* The resulting output is a layout list for every facade, as well as a printout of plates required for production. Thus, possible errors in counting plates for the facade are being minimized. Those areas of the façade that cannot be covered by the base plates can still be overlapped by LockPlate in second layer. *Fig. 5.* This way, basically almost all shapes of facade can be properly insulated with this system. The whole LockPlate system must be applied by licensed contractors.

Figure 6. Mechanical fixation by fasteners

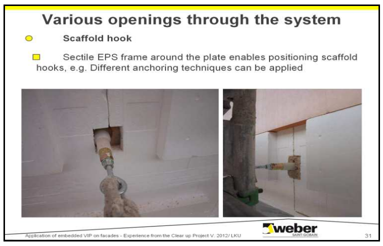

Figure 7. Scaffolding fixation in the system

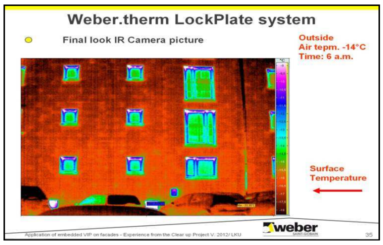

Figure 8. IR camera picture

CONCLUSIONS

LockPlate at a glance…

- Relatively thin system with very high insulating performance
- Intelligent combination of two materials and entire VIP protection by EPS
- Smart prefabrication and design software tool
- Easy plate size modification on site
- Mechanical fixation of ETICS components as usual
- Sharp thermal bridge effect reduction on VIP edges
- Verified solution from building practice
- Applicable for retrofitting and also for new building

The LockPlate System combines current applications of ETICS at building sites with the only difference that it contains embedded VIP.

This fact is a guideline of further treatment ETICS with integrated VIP because the VIP itself must be protected from mechanical perforation and because the use of VIP requires a balance about its positioning on the facades. As already mentioned, LockPlate System offers the solution of above stated problems.

Released intention is meeting requirements for passive houses by taking in account suggestions coming from not only designers but mainly from investors and housekeepers.

The reason is that replacing thick standard ETICS by the thin LockPlate System offers the possibility to create more inside room [6].

The LockPlate System itself has been tested at different sites where we were focussed on meeting the following targets [7, 8, and 9]. *Fig. 8.*

- Planning LockPlate System on the wall
- Mass production of LockPlate elements and sustainably keeping their quality
- Simple application at the site while utilisation all technological steps incl. mechanical anchoring
- Appropriating the best way of communication with not only architects but also with other professions at the site

RELEVANT LITERATURE/REFERENCES

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[9] Kubina, L.: Experience from building site Munich, 2010

AEROCOINS EU FP7 PROJECT

INTRODUCTION

Buildings in Europe account for approximately 40% of the total global energy demand and hence come with a CO_2 footprint of a similar magnitude. The International Energy Agency (IEA) proposes a 77% reduction of CO_2 emissions by 2050. In order to support IEA targets, the energy consumption in buildings must be cut by 60% by 2050.

Improving the energy efficiency of buildings is indeed one of the most promising ways to save substantial amounts of energy. The AEROCOINS project proposes to significantly enhance the thermal performance of the insulation layer in the building envelope for a given layer thickness. Novel materials based on organic-inorganic hybrid aerogels will be designed and developed combining nanotechnology and sol-gel chemistry techniques.

Silica aerogels are the most widely studied and class of aerogel materials and are nowadays commercially used in building insulation. They are mesoporous, nanostructured solids with extremely high specific surface area (up to > $900 m^2 g^{-1}$) and the lowest thermal conductivity known to man for solids (λ < $0.015 Wm^{-1}K^{-1}$ at ambient conditions). However, aside from the high production cost, they are mechanically weak and tend to dust formation.

The AEROCOINS project aims to create a new class of strong, super-insulating aerogel composite hybrid materials by overcoming the two major obstacles which have endured for so long and have prevented a more wide-spread use of silica-based aerogels insulation components in the building industry:

- **Strengthening of silica aerogels by coupling with cellulosic polymers and/or incorporation of cellulose-based nanomaterials.**
- **Lowering the production cost of these composite hybrid aerogel materials via ambient pressure drying and "continuous" production technology.**

Acting on these two significant material & process incentives, brand new superinsulating aerogel-like materials with improved thermo-mechanical properties will be synthesized at the laboratory scale, and later on developed at the pilot scale. Finally an elaboration concept for cost effective mass production will be laid out for further pre-industrial development.

AERO COINS

Partners:

TECNALIA RESEARCH & INNOVATION

ARMINES/MINES ParisTech

EMPA

VTT

POLITECHNIKA LODZKA

ZAE BAYERN

PCAS

SEPAREX

ACCIONA INFRAESTRUCTURAS

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Key facts:

Start date: JUNE 2011

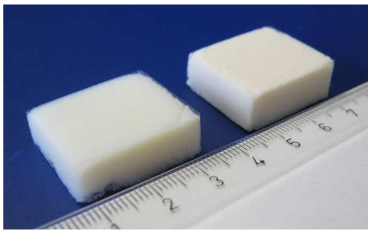
Duration: 48 Months

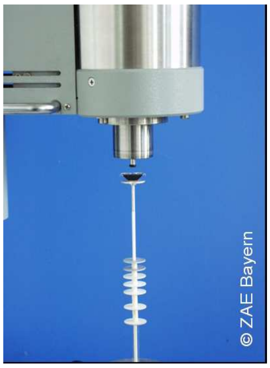
Project Cost: 4.3 million euro

Project Funding: 3 million euro

SEVENTH FRAMEWORK PROGRAMME


SiO_2 Aerogel ARMINES/MINES ParisTech


SiO_2 Aerogel with modified microfibrillated cellulose (MFC) fibers, EMPA.



THERMAL Analysis – Experimental Equipment - ZAE Bayern: Sample holder of differential scanning

OBJECTIVES

Within this frame, the main goal of the AEROCOINS project is to develop a brand new composite/hybrid organic-inorganic aerogel material to improve the insulating performance of existing buildings aiming at reducing their energy demands.

Hence, the main objectives are:

- To synthesize and elaborate novel, mechanically strong and superinsulating aerogel-based materials based on coupling of silica and cellulose via “green” technology approach.
- To develop “cheaper” aerogels via subcritical ambient pressure drying.
- To design and fabricate a highly efficient and robust building component for implementation in the external envelope of already existing buildings.
- To demonstrate a significant cost reduction of the commercial production of this type of superinsulating aerogel-like material and the component.

METHODOLOGY

To accomplish its objectives, the AEROCOINS project contains five workpackages which address specific technical objectives plus one devoted to dissemination and exploitation and one to management activities.

- **WP1: Synthesis of reinforced superinsulating aerogels** is focused on the design and synthesis of novel superinsulating silica-based aerogels.
- **WP2: Drying and thermal conductivity optimization** deals with the development of a robust and efficient drying process for the preparation of superinsulating aerogel boards.
- **WP3: Pilot scale material fabrication** is focused on the upscaling of the fabrication of superinsulating aerogel boards.
- **WP4: Aerogel-based component manufacturing** deals with the fabrication of new superinsulating building components for retrofitting installations.
- **WP5:Building integration and validation** deals with the integration of the component in a demonstrator building to validate its performance (thermal, mechanical) under real conditions

EXPECTED DELIVERABLES

The main expected deliverables from the AEROCOINS project are the following:

- **To obtain a reinforced aerogel-based thermally superinsulating material:** improvement of mechanical properties while maintaining a low thermal conductivity by cross-linking or by compounding with cellulosic matter to form hybrid materials. *(by month 30)*
- **To develop an ambient pressure drying process:** minimize evaporation-induced shrinkage by optimized fine-coupling between materials and process parameters. *(by month 30)*
- To design and fabricate a **novel building component prototype** based on the developed aerogel-like material, compatible with conventional construction installations. *(by month 36)*
- **To design a cost-effective continuous industrial-level process for the production of the aerogel-like material boards** *(by month 36)*
- To demonstrate **the thermal, structural and mechanical performance** of the highly insulating component under real conditions. *(by month 45)*


Industrial facilities at PCAS


Industrial facilities at SEPAREX

CONCLUSIONS

The successful completion of all **AEROCOINS** objectives is expected to:

- Provide new high-performance solutions to the insulation industry with the ultimate goal to contribute to a reduction of the energy demand/consumption in buildings.
- Impact favorably on the European insulating materials sector with the development of a new class of insulation component offering a tremendous economic potential for the worlds fast growing aerogel insulating business.
- Impact also the construction and building sector. Falling aerogel prices are going to propel their use and at that point in time, the saved space will be able to largely compensate for the extra cost.


Kubik by TECNALIA

RELEVANT LITERATURE/REFERENCES

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H-P. Ebert, "Thermal Properties of Aerogels", Chapter 23 - "Aerogels Handbook", *Springer*, ISBN 978-1-4419-7477-8 (2011).

ACKNOWLEDGEMENTS

The AEROCOINS Consortium would like to acknowledge the financial support of the European Commission under the Seventh Framework Program, Grant N° 2690141.

HIPIN, the development of a high performance insulation material based on aerogels using a high silicon content precursor

INTRODUCTION

Industrial adoption of higher technology insulation solutions, such as vacuum insulated panels and nanotechnology based options have remained at a very low level, not least because of their very high cost for the volume market. This is despite the fact that in the last five years, the global market for aerogels has tripled to \$83 M in 2008 and is expected to reach up to \$646 M by 2013 (Cagliardi, 2009).

Comparison of thermal performance data shows that the use of aerogels is very favorable from the insulating performance point of view. This is because aerogel's thermal conductivity and density are respectively 0.004-0.03 W/mK and 10-300 kg/m^3 by comparison the respective values for concrete are 0.20-1.01 W/mK and 600-2000 kg/m^3 respectively, and for mineral wool 0.04-0.05 W/mK and 11-100 kg/m^3 respectively. However, the current high cost and low strength of aerogels prohibit their volume use. These properties are related to the high pore volume of aerogels, figure 1.

In this context a cheaper way of manufacturing aerogels is being investigated to make these materials more accessible to the construction sector.

Partners:

TWI

Envipark

Orient Research

Thomas Swan

Airglass

Vimark

AkzoNobel

Arup

Methodo

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Key facts:

Start date: November 2011
Duration: 36 Months

Figure 2: Silica aerogel with 30-35% solid content is a strong material. By increasing the solid content up to 60% the strength will be improved.

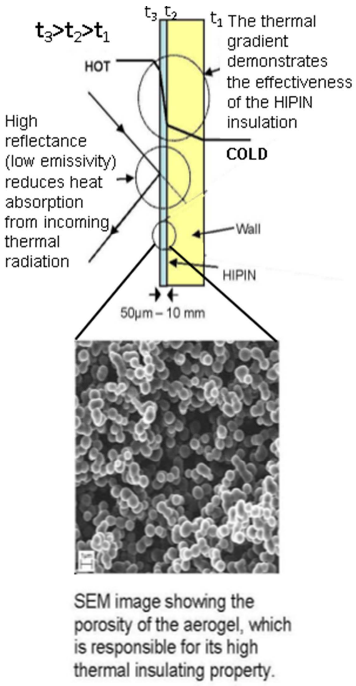

Figure 3: Sketch of the HIPIN system.

Today, the typical silica content of the precursor is around 30%. Higher silica content precursors are expected to lead to stronger aerogels and solve some of the manufacturing process problems thereby reducing cost. That is why an aerogel based on a pre-hydrolysed precursor with a solid silica content of at least 50% will be made in the HIPIN project.

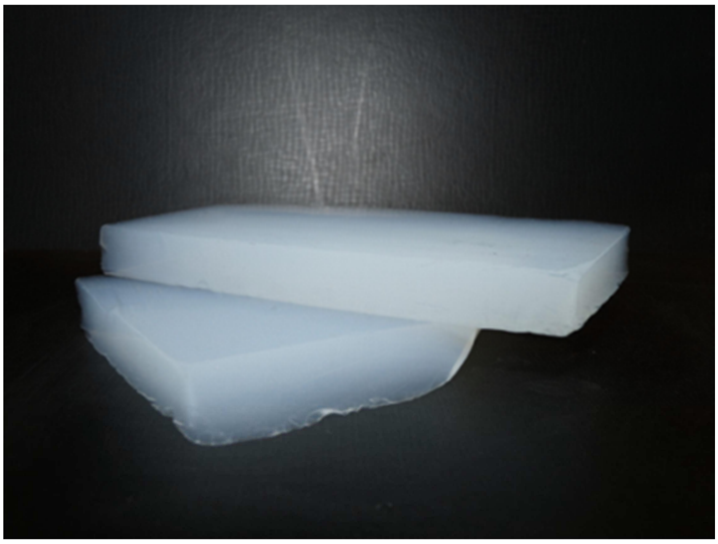

***Figure 1**: Pictures of silica aerogel.*

OBJECTIVES

Five main targets have been identified.

- To **increase the silica content** of the precursor from around 30% up to 60%. It is expected that this change will create much stronger aerogels ***(Figure 2)***, which can be manufactured at less cost and can be applied to new build or retrofit, at modest coating thicknesses (from less than 1mm to 10mm).

- To **reduce the process's costs** of production. A faster and energy efficient method (comparing with the supercritical drying) where carbon dioxide is substituted for alcohol (Duer, and Svendsen, 1998) has achieved promising results. The manufacturing costs can still be further reduced.

- To have new nano-materials **which are more efficient and effective** than conventional construction and insulation materials currently used. The objective of the HIPIN paint/coating system ***(Figure 3)*** will be to ensure that, if applied to existing typical buildings, the additional thermal performance that will be generated will allow the heating or cooling requirement to be reduced on average by 20%. HIPIN material will be low emissivity (below 0.7 compared to 0.9 for a conventional material as concrete) and the thermal conductivity will be at least 10 times lower than commonly used construction insulation materials. The reflected heat will be radiated towards the building.

- To **maximise long term performance** from the system by giving some multifunctionality to the aerogel (eg. self-cleaning) through the use of chemically bonded appropriate groups. The self-cleaning property will be beneficial to maintain thermal performance of the insulating coating stable as the emissivity value will increase following deposition of pollutants onto the exterior surface (*Figure 4*).

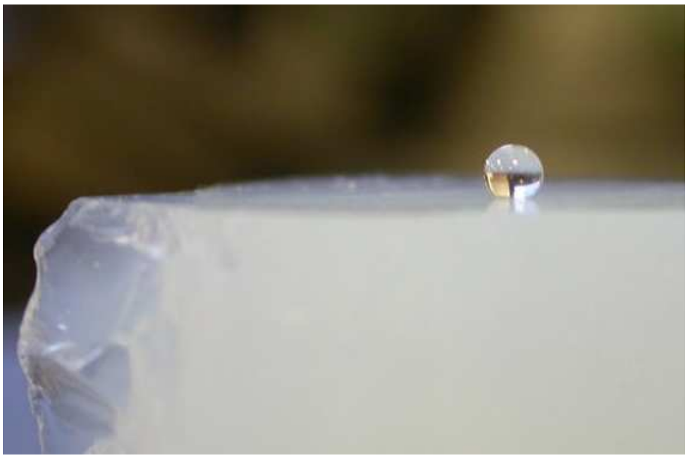

Figure 4: *Picture of a water droplet on a hydrophobic aerogel*

- To **mix the aerogels into the paint or coating systems *(Figure 5)*** to make new affordable technology, and apply the system to buildings. Today's high volume manufacturing processes apply shear forces that are likely to damage the aerogels, despite their enhanced robustness. This objective includes developing suitable technology to ensure that the paint/coatings can be manufactured and applied with reliability and ease by the applicator.

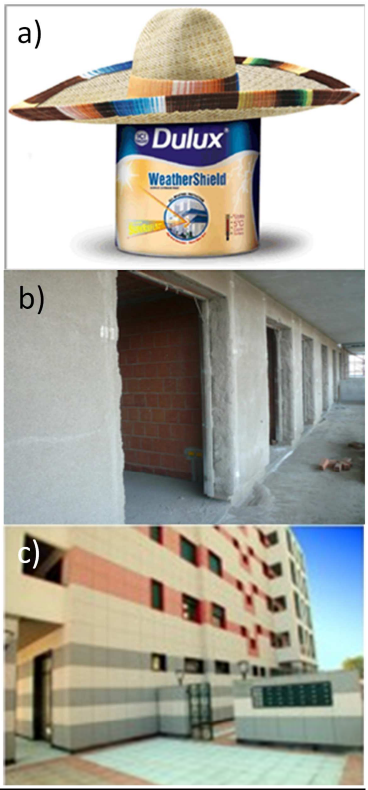

Figure 5: Incorporation of aerogels into a suitable vehicle that can be applied as a) thick paint layers, b) as plaster or c) incorporated into sandwich panels.

Figure 6: TEOS 50% precursor.

METHODOLOGY

A work package (WP) approach will be adopted to delineate the stages of the project. Five of them directly concern research and development (WP 1 to WP 5); the sixth is devoted to demonstration in the construction sector. The two last one are respectively dedicated to management and exploitation & dissemination.

WP 1: Finalisation of the HIPIN Specification

WP 2: Design and formulation of nanostructured aerogel material

WP 3: Design and synthesis of the complete nanocomposite system

WP 4: Testing and optimization of technology for applying to buildings

WP 5: Modeling and building physics analysis

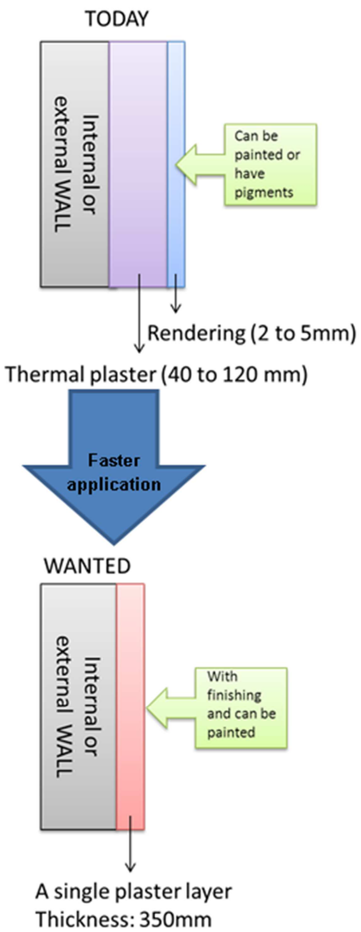

Figure 7: Schematic of the application of Vimark Plaster, Hipin's partner.

EXPECTED DELIVERABLES

The expected deliverables for the HIPIN project are the following:

- To have an aerogel whose thermal conductivity is between 0.01 and 0.03 W/mK, or below. The aerogel must be robust, water resistant, have a high compressive strength (> 20 N/cm^2) and be cheaper than the current product.

- To incorporate aerogels into thick paint layers or coatings. The uses include thermal-insulating paint for interior and exterior application to reduce heat transfer. The final paint should remain stable (2 years when in liquid state and 5 years when dry) and no stress should be observed. The color and gloss of the cured coating compound should stay stable over time.

- To integrate aerogel into a plaster. The insulation plaster will be deposed directly on the internal or external wall without the need of a top coat. The modification will involve the replacement of the polystyrene spheres by aerogel in order to obtain a thermal conductivity close to 0.07 W/mK. By improving the insulation by 10%, HIPIN is expecting reducing the thickness of the plaster and obtain a 35 mm thickness.

- To make insulating panel which is part from the overall thermal and transpiration performance of ventilated façade system made from Aerogel sandwiches panels, and has the largest impact on the HIPIN Project.

The currently adopted insulating blanket (e.g. graphite-added expanded polystyrene BASF product Neodur 0,031) has a thickness of about 9 cm, being its thermal conductivity equal to 0.031 W/mK. To decrease this value the thicknesses of the insulating blanket will become more excessive. The ideal thickness for the insulating blanket is of course the lowest possible, but a very good thickness for common applications can be about 3 cm.

The insulating blanket must allow water transpiration while, at the same time, it must not degrade when exposed to a significant amount of moisture. Vapour transpiration is also important, in general, to eliminate moisture generated inside the building as well (Künzel 1995).

- To maximise long term performance from the system by adding functions (e.g. Self-cleaning, sound insulation and fire retardant properties). The sound insulation (related to the high porosity) and the fire retardant (inherent to silica-based composition) are intrinsic properties of an aerogel, but the self-cleaning property needs to be more investigated. Concerning the fire retardant, attention may need to be given to other components of the paint/coating system; particularly to the binder components as aerogel is already used for fire retardant material (it can withstand temperatures up to 650°C).

Figure 7 - Silica aerogel has excellent thermal properties. The fire retardant (inherent to silica-based composition) are intrinsic properties of an aerogel

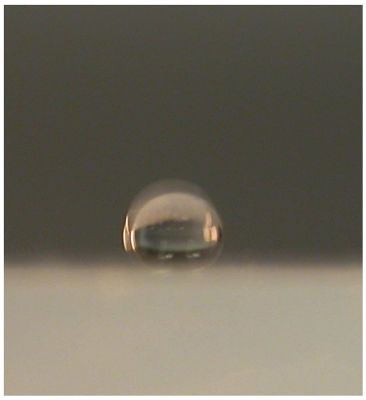

Figure 8 - The hydrophobicity properties of TEOS based silica aerogels an be obtain by a surface chemical modification

CONCLUSIONS

The goal of this paper was to put in place the objectives which lead to a new process to fabricate a robust aerogel. A solid content of at least 50%, a poor thermal conductivity, a good robustness and small thickness are the key of success for such a material. As a consequence the cost of the aerogel production and final product price can be reduced and aerogels introduced in the construction market for instance as paint, coatings, in plaster or insulating blanket.

Relevant literature/references

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NANOFOAM

NEW NANO-TECHNOLOGY-BASED HIGH PERFORMANCE INSULATION FOAM SYSTEMS FOR ENERGY EFFICIENCY IN BUILDINGS

INTRODUCTION

The NANOFOAM project consortium is formed by leading and experienced players in the sector of manufacturing innovative chemical products, engineering nanostructured foams and materials, energy efficiency for the Construction sector, Materials Science and advanced modelling and characterization of material properties and thermo-physical processes.

The expected results of the NANOFOAM project have the potential to drastically reduce energy consumption and to decrease CO2 emissions for both new buildings and the renovation of existing assets.

Partners:

- Dow Europe GmbH
- ZAE-Bayern
- CSTB
- Caba-Blind GmbH

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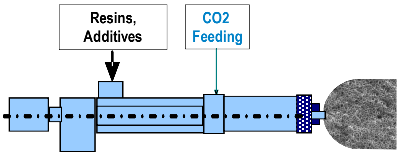
OBJECTIVES

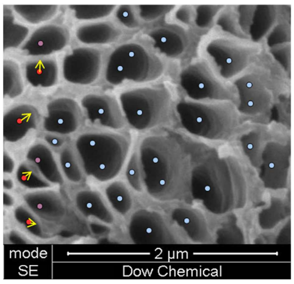
1. Develop an innovative nano-structured polymeric foam, employing a low GWP BA CO2 and having a lower thermal conductivity and superior properties (mechanical, fire resistance, moisture resistance).
2. Design this technology to be in compliance with European standards and environmental, health and safety regulations.
3. Assess gaps between technical, economic and environmental product performance versus commercial needs for new buildings and for retrofitting.

Key facts:

Start date:	1/1/2012
Duration:	36 months
Total budget:	3.3 MM€

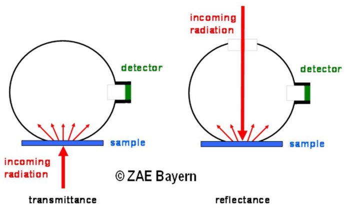
METHODOLOGY

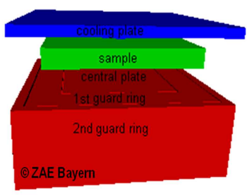




1. Engineer nanostructured foams through development of foaming process with CO_2 as main foaming agent with some selected thermoplastic chemistry.
2. Modelling, characterize and validate physical properties, such as λ value, mechanical performance and durability.
3. Application design and Building Science modelling of thermal envelop and LCA determination.

EXPECTED DELIVERABLES





- Validation of Proof of Concept and at the Mini Plant testing
    - Nanostructured polymeric foams with pore size of 100nm and porosity > 80%
    - λ-value of the Nanofoam would be 18 mW/m.K or less
    - Thermal conductivity and mechanical property modelling of nanostructure material
- Engineering and building a novel semi-industrial line for producing Nanofoam for demonstration testing at mock-up/climate chambers
    - Assessment of technical performance and EH-S of up-scaling the chemistry and process
    - Assessment of economics and market introduction plan
- IPR protection of developed technologies
- Dissemination, clustering and exploitation.

CONCLUSIONS

Progress to date

- Initial identification of polymer chemistry and nucleating systems
- Initial development of transport properties modelling
- Initial development of a foaming process
- Initial development for mechanical property modelling
- Initial development for thermal conductivity modelling
- Initial development for thermal conductivity measurement and radiative properties characterization

Project added value

- Industrial Expertise and Commitment
- Innovative building solutions with high energy efficiency
- Fundamentals of physics, chemistry, building science and material science
- Large scale industrialization through customer oriented business plan
- Research and Building Practice expertise

THE NANOINSULATE FP7 PROJECT

Development of Nanotechnology-based High performance Opaque & Transparent Insulation Systems for Energy-efficient Buildings

INTRODUCTION

The goal of this short article is to provide brief description of the European VIP project NanoInsulate. The NanoInsulate project is an IP EU project in the frame of the FP7 program. It is a 4 year long project started on July 2010. The project deals with new types of vacuum insulation panels for building applications.

OBJECTIVES

- **Develop high performance and cost effective thermal insulation solutions for buildings based on VIPs.**
- Develop Industrial production processes for complete solutions to be used in buildings.
- Develop new generations of high barrier envelopes for 60+-year service lifetime of the VIPs in buildings
- Develop transparent VIPs based on silica Aerogel
- Develop PU open cells (Nanofoam) to be used as core material
- Develop much more reliable techniques for evaluation of the VIPs performance
- Comprehensive evaluation and assessment activities

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Malcolm Rochefort – Kingspan, UK

Contact person:

Dr Yoash Carmi
Hanita Coatings, Kibbutz Hanita, Israel
Tel: +972-525-739186
e-mail Yoash@hanitacoatings.com

Partners:

No.	Beneficiary	Country	Activity in project
1	Kingspan	IE	Project co-ordination. Design of large VIP, pilot plant development and end user
2	Pera	UK	Process manufacture/pilot scale up Project management and administration
3	Hanita	IL	Barrier films and VIP production
4	Va-Q-Tec	DE	Materials, design of VIP prototype and process development
5	Fraunhofer	DE	Transparent and opaque barrier films, characterisation and development, VIP production, simulation and modelling of the building envelope and VIPs
6	Koç	TR	Development of aerogels and aerogel-polymer composites
7	Airglass	SE	Aerogel-polymer composite manufacturer: production of aerogel-polymer composite panels, up-scaling, cost reduction
8	BASF	DE	Nanofoam development and process up-scaling
9	Gaiker	ES	Lifecycle assessment, cost analysis, safety assessment, and end-of-life studies
10	Acciona	ES	Component assessment and demonstration in building applications

METHODOLOGY

Fig 1 External Insulation for Walls

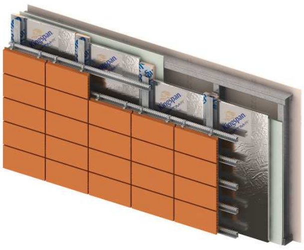


Fig 2:Insulation for Rainscreen Cladding System

Fig 3: Transparent VIP with Silica Aerogel core

In this part of the article four running activities out of many more will be described.

1st running activity –2 examples of possible applications where VIPs are used for buildings insulation (proposed by Kingspan): Fig 1 & Fig 2

2nd running activity - Development of translucent VIP.

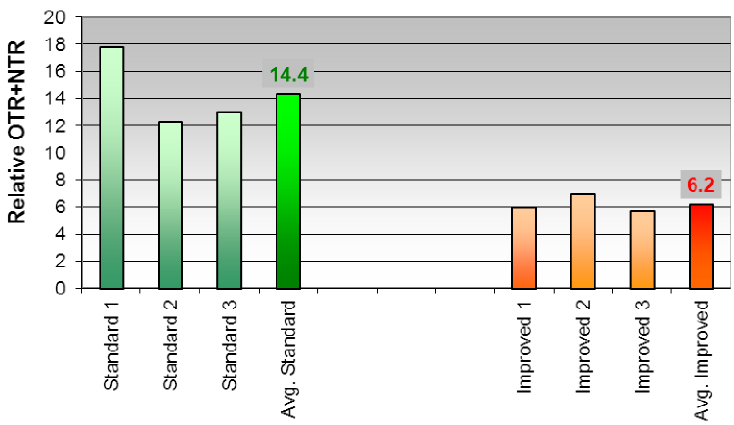
Vacuum panels made with translucent silica based Aerogel blocks and transparent high barrier laminates based on deposition of oxide layers: Fig 3

3rd running activity – Developing new laminates (opaque) with much higher barrier properties.

Up to now about 10 different new types of laminate have been developed. Their performance was evaluated by producing glassfiber core panels and measuring the increased rate of the thermal conductivity at ambient conditions. This data was used to calculate the pressure increase rate and the air permeability (nitrogen and oxygen) of the films.

Graph A below shows the permeability of 3 standard tri-laminates with average permeability of 14.4 milibarliter/m^{2}year, compared to that of 3 newly developed laminates with average permeability 6.2 milibar liter/m^{2}year.

The new laminate allows 2.3 times slower permeation with expected pressure build up during 60 years of only 18.6mbar for 20mm thick panel.



Graph A - Comparison of relative OTR+ NTR

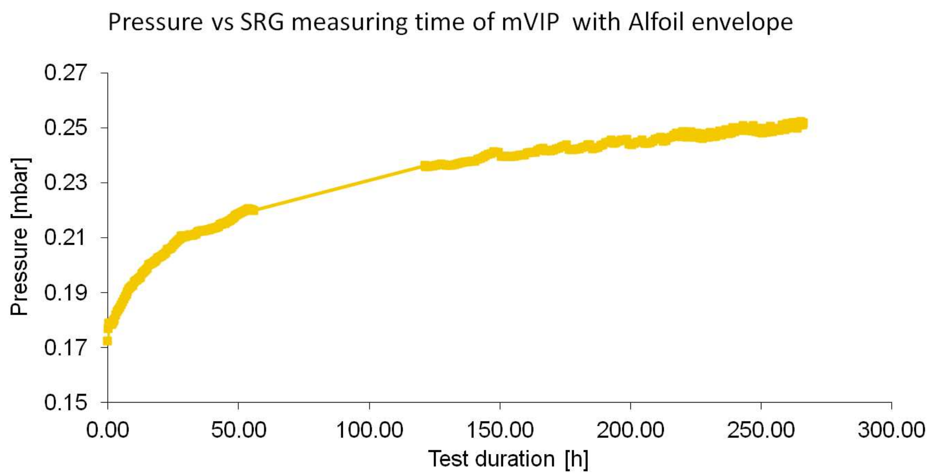
Another newly developed laminate with sandwich structure
PETMET/lacquer/Al/Adhesive/LDPE
showed very low level of MVTR<0.01g/m^{2}day at 38^{0}C and 100% RH

4th Running activity – The mVIP – ultra sensitive system for measuring air permeation.

The gas permeation level of the high barrier VIP laminates is well below the detection level of any existing commercial OTR monitors. In the frame of the NanoInsulate project, Hanita has developed a new permeation monitoring system that is sensitive enough to measure the permeation through laminates even when they contain Al foil. The new system is based on vacuum panels with metallic plate replacing the porous core material and spinning rotor pressure gauge connected permanently by o-ring vacuum tight connection to the envelope. The metallic core leaves very small internal open space to ensure much higher pressure increase rate and the smart O-ring based connection allows very easy samples preparation with almost zero leaks.

Fig 4: mVIP system

Fig 4 shows the mVIP system, whilst Graph B below describes the pressure increase due to permeation through Alfoil based VIP laminate. The pressure increase rate in this case was dP/dT = 1X10^{-4} mbar/hour , which corresponds to an annual pressure build up in 20mm thick porous VIP of 0.64mbar/year.



Graph B : Pressure vs SRG measuring time (hours)

EXPECTED DELIVERABLES

- NanoInsulate will develop integrated highly energy-efficient opaque and transparent VIPs using novel low-cost high-volume sustainable processes, thereby addressing the zero-carbon drivers of the EU construction and modern Buildings sector, a key economic innovation.

- The innovative manufacturing solutions developed in Nanoinsulate will reduce the current high level of capital and operating costs for the wide-scale exploitation of the VIP technology. Moreover, it will increase the use of highly functional nanomaterials within the sector through sustainable pilot scale manufacturing of derived nanosolutions.

- These new durable lightweight thin-panel systems will exhibit thermal and mechanical properties far exceeding those presently on the market (*e.g.* at least four times more energy efficient), thereby reducing heat losses and increasing indoor comfort.

- Significant reductions in EU energy consumption and GHG in the construction, retrofit and modern building sector giving clean affordable and societal benefits to EU citizens, a key environmental innovation.

CONCLUSION

The results achieved in the first 20 months of the 4 years NanoInsulate project look very promising. Especially in the efforts related to improving the properties of the opaque high barrier laminates, developing new permeation measurement systems with much better detection level and designing new production lines for VIP insulation units for building. Interesting results were also achieved with translucent VIPs and open cells PU Nanofoams but in these field much more work has to be done before reaching the stage of pilot production.

ACKNOWLEDGMENT

THE RESEARCH LEADING TO THESE RESULTS HAS RECEIVED FUNDING FROM THE EUROPEAN UNION SEVENTH FRAMEWORK PROGRAMME (FP7/2007 – 2013) UNDER GRANT AGREEMENT NO. NMP4-SL-2010-260086.

SUPERINSULATION RESEARCH IN FRANCE

Introduction

The purpose of this short paper is to synthesis the oral presentation made in the name of the French community on super insulation research and giving an overview of their studies. The scope is limited to research rather than development, to materials (or component) rather than products and to the activities of members of the group “GEsSI”.

Organisation

The research in France on super insulation is split as everywhere in two sectors: academic and industrial but show two specificities. The first one is the strong and continuous support since twelve years of the French Environment and Energy Management Agency (ADEME).

The second one is an Exchange Group on Super Insulation (GEsSI) whose mission (Article 1 of the charter of GEsSI) is to contribute to the emergence on the French market of solutions in the building based on super insulation. "super insulation" is of course the first key word, and “Building” is the second. The group don’t deal with other applications.

This is a free, French speaking and open to Europe group. It act for:

- Identification of strategic (public policy, vision of the issues by companies)
- Preparation of associative research programs (nearly all the programs presented hereafter have at least a large part coming from the exchange between members of GEsSI)
- Construction of the French position (Procedures, rules, assessment, certification)
- Finding of partners: Institutional, Industrial and University
- Communication and training activities in the scientific, technical and large public areas. He organise the symposium "Super insulation materials".

Institute/organisation:

Electricité de France

Contact person:

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Thanks to:

Samira KHERROUF
ADEME

Patrick ACHARD
Arnaud RIGACCI
MINES-PARISTECH

Daniel QUENARD
CSTB

BRI (daily management team)

The actors of the research on super insulation in France are listed in the Table 1. As we can see, there is a wide range of actors member of GEsSI, where all the jobs from upstream research to real building applications are represented. It's a great strength of the group. For the other actors, we have to note that half of them are linked to some GEsSI members through a national project.

Table 1: Actors of the research on super insulation in France second line: members of GEsSI third line: other actors

Institutionals and energy companies	Universities	Design offices	Upstream industrials (material)	Downstream industrials (building)
ADEME CSTB EDF	MINES-PARISTECH INSA LYON U. TOULOUSE	TBC POUGET Cons.	MICROTHERM REXOR TORAY DUPONT DOW-CORNING PCAS	ARCELORMITTAL SWISSPOR LAFARGE ISOLPRODUCTS ROCKWOOL
CEA	U. NANCY U. MONTPELLIER LEPMI/LMOPS IS2M MULHOUSE	EC2MS NEOTIM	ST GOBAIN RES SEPAREX.	ISOVER PROMAT

PROJECTS

This paragraph is split between the projects about Vacuum Insulation Panel (VIP) and Super Insulation at Atmospheric Pressure (SIAP). Only the main and public projects with several partners are quoted. Of course there is a lot of bipartite others works and also a few building achievements not mentioned here.

VIP

Table 2 summarizes the projects about VIP. As we know the subject is worked long, the technology is of course quite mature as shown by projects dealing with evaluation and building system development. But as we can see on this table, in spite of the large number of projects that dealt partially with ageing, this subject is still relevant and under studies as the improvement of the barrier complex.

If we look more closely to the current projects, we can list their objectives. The first axis is to increase the life and three ways to reach this goal are under studies:

- Increase the barrier performance
- Increase their resistance to higher temperature and humidity
- Increase the tolerance of the silica to aging

The second axis is to improve the forecast of durability in real climate. And the two last ones are to prepare the scaling up of the production capacity and some specific systems for building retrofitting.

The common point of these objectives is their contribution at the end to lower the overall costs. Not directly but through mastery of performance margins and life duration. This is consistent with the maturity of the technology.

<table>
<tr><th rowspan="2">Project</th><th colspan="2">VIP</th><th colspan="3">Use</th></tr>
<tr><th>Core</th><th>Barrier</th><th>Durability</th><th>Evaluation</th><th>Building system</th></tr>
<tr><td>Ageing of silica</td><td>✖</td><td></td><td>✖</td><td></td><td></td></tr>
<tr><td>VISP - Ageing</td><td></td><td>✖</td><td>✖</td><td></td><td></td></tr>
<tr><td>VIP - Procedures</td><td colspan="2">✖</td><td>✖</td><td>✖</td><td>✖</td></tr>
<tr><td>ECOSIL</td><td>✖</td><td></td><td>x</td><td></td><td></td></tr>
<tr><td>BARISOL</td><td></td><td>✖</td><td>✖</td><td>x</td><td></td></tr>
<tr><td>MACHA</td><td></td><td>✖</td><td>✖</td><td></td><td></td></tr>
<tr><td>SSIR</td><td colspan="2">✖</td><td></td><td></td><td>✖</td></tr>
<tr><td>ITI - VIP</td><td>✖</td><td>✖</td><td>✖</td><td>x</td><td>x</td></tr>
<tr><td>EMMA - VIP</td><td></td><td>✖</td><td>✖</td><td></td><td></td></tr>
</table>

Table 2: VIP projects (past ones are written in italics)

SIPA

The following table is the equivalent table for SIAP. It reveals that the technology is more exploratory:

- No project in the past dealing with use properties;
- Although the synthesis of silica aerogels is controlled, their use as component of a complex material is quite new as the development of organic aerogels;
- Their durability starts asking questions;
- As the costs which have to be dramatically reduced.

Beside the main goal of reaching the thermal performance on industrially viable materials, we also find:

- The problem of cost which are now very far from the target market;
- Some attempts to greener materials (partially bio sourced for example) with only exploratory researches;
- The development of specific characterization techniques which are necessary to understand and optimize the mixed materials;
- The problem of durability linked to the thermo-hydric ageing behaviour.

The scientific challenges are very sharp and a large part of them deal with the process or the chemical synthesis point of view.

Table 3: SIAP projects (past ones are written in italics)

Project	SIAP				Use		
	Aerogel SiO2	Organic aerogel	Mixed	Hybrid	Durability	Evalua-tion	Building system
HILIT & HILIT+	✖						x
AEROCELL		✖					
Aerogels I & II	✖						
ISOGEL	✖						
NANOBAT		✖					
ISOCOMP	✖						
NANO-PU		✖					
NANOCEL		✖	✖		✖		
SIPA-BAT	x		✖		x	x	x
SIPAMONT			✖		x		

Skills

The skills of actors of the above projects are summarized in Table 4 and Table 5. For the VIP, the main skills are about the core material, the complex barrier, ageing and modelling. For the SIAP, they are about the synthesis of the different materials or raw materials, the development of composite materials, the structural characterization, the ageing and modelling.

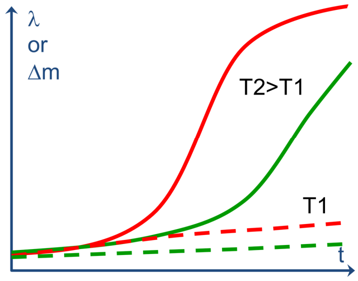


Figure 1: Regular and accelerated ageing of VIP [BARISOL project]

STRIKING EXAMPLES

VIP ageing

Based on wide experimentations, two types of VIP ageing depending on temperature and humidity was demonstrated (Figure 1). At low temperature for example, a regular ageing occur, which can be slow or also fast but regular, with no ageing of the barrier complex itself. At higher temperature, an accelerated ageing of the VIP occur, due to an ageing of the barrier complex itself which can be affected by two different mechanisms (Figure 2):

- Delaminating of the films mainly related to high temperature;
- Aluminium corrosion related to high humidity and hydrolyse of the polymers.

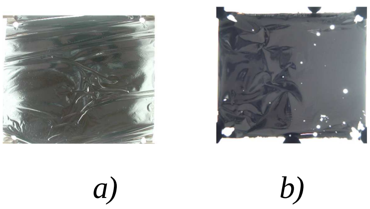


Figure 2: Ageing of the barrier complex; a) delaminating, b) Al corrosion [BARISOL project]

The conditions of switching between the two ageing modes, regular or accelerated, depend of the products but also of the batch.

Table 4: VIP, Skills of actors

	Core material behaviour	Core ageing	Develop. Of barrier complex	Permeance & physical characterization of complex	Complex ageing	VIP ageing	Use evaluation & thermal measurements	Modelling of VIP behaviour	Thermal modelling of materials
MICROTHERM	✖					x			
REXOR			✖						
CSTB	✖	x				x	✖		
EDF	✖	✖	✖	✖	✖	✖	x	✖	
INSA Lyon								x	✖
Univ. Savoie				✖	✖				
Univ. Toulouse							x		x
CEA									✖

Table 5: SIAP, Skills of actors

	Synthesis of silica aerogel	Synthesis of organic aerogel	Develop. Of mixed mat. (blankets)	Develop. Of mixed mat. (panels)	Hybrid materials	Structural characterization	Durability, hydric behaviour	Use evaluation & thermal measurements	Thermal modelling of materials
MINES Paristech	✖	✖	✖		x	x			
PCAS-ENERSENS	✖		✖						
CSTB								✖	
EDF				✖		x	✖	x	
INSA Lyon				✖					✖
EC2MS									✖
NEOTIM								✖	
CEA		x							
SEPAREX	x	x							
U. Montpellier						✖			
U. Nancy		x						✖	
U. Mulhouse		x							
U. Toulouse								x	✖

The modelling of VIP ageing is a very important challenge with different topics, from the multilayer and his defects, to the coupling of water vapour and dry air in real climates, and to the influence of hydric behaviour and ageing the silica core. These modelling studies are based on sophisticated experiments designed to determine the diffusion and solubility coefficients as well as their dependence on temperature and moisture and the validity of the assumptions behind the simple laws usually used.

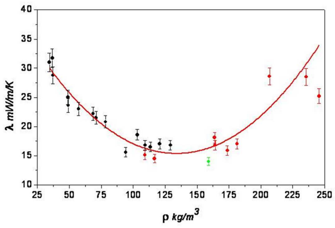


Figure 3: Conductivity of blankets made by simple evaporation [ISOCOMP project]

Hydrophobic silica xerogels

On SIAP, the first example is the development of silica aerogels prepared by simple evaporation thanks to the silylation of silica walls. This has led to granular and blanket type hydrophobic super insulating materials with good conductivities (Figure 3). More recently this as also led to composite material based on granular silica xerogels with incredible conductivity of 15 mw/(m.K).

Cost isn't the only serious problem for SIAP: some works find that ageing occur on hydrophobic silica aerogels. This ageing can be severe with strong degradations observed of several physical or use properties: conductivity, specific area, pores size distribution, water uptake. The different aerogels have clearly not the same behaviour.

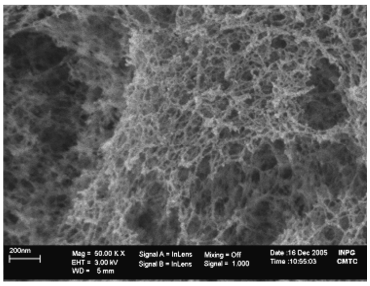


Figure 4: SEM examination of a cellulose acetate-based aerogel [NANOCEL project]

Cellulose acetate-based aerogels

The last examples are about researches on organic aerogels. Some laboratory samples of cellulose acetate-based aerogels coming from polyurethane technology are promising: the best thermal conductivity obtained from these aerogels is measured by flash method at 20 mW/(m.K). Of course, some challenges remain on drying, ageing and on final microstructure to remove the residual macro pores (Figure 4).

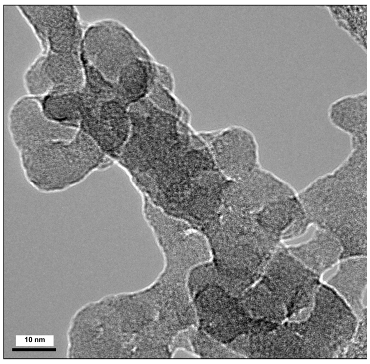


Figure 5: TEM examination of a aged silica [Morel thesis]

CONCLUSION

To conclude I come back to the highlights of French researches on super insulating materials. They are: complex barrier for VIP and durability of VIP, synthesis and development of silica aerogels based materials, hygrothermal aging of nanoporous materials, and exploration of "greener" organic aerogels tracks.

None is completed; all are being with two kinds of research on the way: some classical one around the chemical synthesis and some others driven by the need and precise building specifications.

The cross-cutting theme of the two families of super insulating materials is their ageing (Figure 5); this is a strategic field of studies.

MICROPOROUS POLYURETHANE FOAMS FOR THERMAL INSULATION

Introduction

Polyurethane foams as insulation material make a substantial contribution to save energy and cut CO_2 emissions. Microporous polyurethane foams are a step-change innovation project to increase the efficiency of insulation materials, thus saving energy and enable designers to use a thinner insulation.

Objectives

Polyurethane foams with micropores have excellent insulation properties as the cell size is in the range of the mean free path of the gas molecules (Knudsen-Effect). The reduction of the cell size is realized by the expansion of a microemulsion containing the blowing agent in nanometer sized droplets (POSME= Principle Of Supercritical Microemulsion Expansion).

The Principle Of Supercritical Microemulsion Expansion offers the possibility to use close to state-of-the-art processing technologies for the manufacturing of foams with the unique insulating properties of a microstructured material.

Partners:

Coordinator name
Bayer MaterialScience AG

Name of other partners
Prof. Dr. Strey, University of Cologne, Germany

Contact person:

Dr. Stefan Lindner
e-mail: stefan.lindner@bayer.com

METHODOLOGY

In cooperation with Prof. Strey (University of Cologne) microemulsions of polyurethane systems with special designed surfactants and carbon dioxide as a supercritical blowing agent were developed. As supercritical conditions are used no nucleation step is necessary and therefore every micelle can lead to a pore. In a technical pilot plant microporous polyurethane foams could be prepared with these microemulsions.

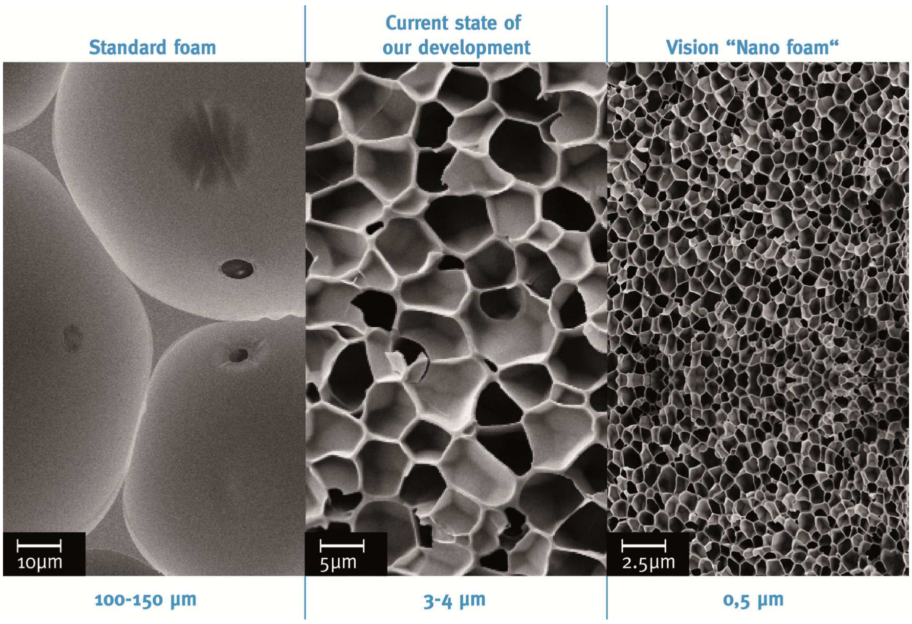
The next steps will be the transfer of these initial results to a continuous production process.

CONCLUSIONS

Today, polyurethane foams as insulation material make a substantial contribution to save energy and cut CO_2 emissions. Thereby they conserve natural resources and protect the climate.

With this disruptive technology we have the possibility to further increase these achievements. It could be shown that polyurethane foams with significantly reduced cell size can be prepared.

Microporous PUR foams offer an unique opportunity to use the insulating properties of microstructured materials with the efficient process of preparing polyurethane foams.



FRAMEWORKS FOR FORMAL ASSESSMENT OF QUALITY

Super insulating products are necessary to meet the construction sector's ambitions. Especially when being faced with space restrictions, super insulation products may contribute substantially.

However, stakeholders need to be convinced that products are fit for the intended use, specifiers and contractors need to be informed how these products should be designed and installed and manufacturers need to demonstrate that products meet the claimed performances.

UEAtc, the European network of institutes that are engaged in the issue of technical approvals for innovative construction products or systems, may be an attractive partner in getting the construction sector to accept super insulating products as a trustworthy alternative to the more traditional products.

European Union for technical Approval in construction (UEAtc)

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MEETING ENERGY EFFICIENCY CHALLENGES

If the European Union is to meet its high energy efficiency policy, introducing more stringent minimum requirements for new buildings and high renovation rates of existing buildings, leading to an overall decrease in direct CO_2 emissions by 45% through energy efficiency measures such as thermal insulation by 2050, innovative products and techniques will be required.

Developing innovative super insulating products is insufficient. A roadmap needs to be developed to create conditions for the construction sector to embrace these innovations such as Vacuum Insulation Panels, Gas-Filled Panels, Aerogels and Phase Change Materials.

Given the energy-use reduction challenges we face, we cannot afford to allow the market to grow steadily.

CONVINCING THE STAKEHOLDERS

Super insulating products offer a variety of potential benefits, but their use also introduces questions. Users need to be convinced that they can rely on claimed product performances and that super insulating products are fit for their intended use. Questions over the degradation of insulation capacity over time (air and moisture penetration), the performances at panel edges, dimensional stability and overall durability need to be addressed. Given their specificities, design requires attention (robustness, thermal bridges due to studs) and may need to be adapted to the market circumstances. Installation requires due care, so that problems due to incompatibilities, fragility or need for mechanical protection against puncturing, limited dimensional flexibility (cutting to size) and panel layout do not lead to reduced confidence in the products' abilities and their use. Specifiers and installers need to be informed and may need to be trained.

INTELLECTUAL PROPERTY RIGHTS

To benefit optimally development efforts, protection of the intellectual property rights of innovative super insulating products by means of patents can be considered. Also knowledge about existing patents is valuable when developing new products.

Patlib is a European network of patent information centres. These PATLIB centres provide advice in searching patents or in using patent information and may perform patent searches for their clients. Depending on the national system for intellectual property rights, PATLIB centres may also provide information on other intellectual property rights like trademarks, design and models. Some Patlib centres are specialized in the construction sector, such as the BBRI's patent unit (*patent@bbri.be*) in Belgium.

CONDITIONS FOR THE SECTOR TO EMBRACE SUPER INSULATING PRODUCTS

In the European Union, CE marking is an important instrument for manufacturers to place products on the market without individual member states each requiring their individual evaluation. Performances for regulated characteristics are determined making use of European evaluation means (testing, calculation, …) and expressed in a harmonized technical language. In the absence of harmonized product standards for VIPs, European technical approvals may be applied for. A common conformity assessment system ensures market access.

However, market access does not necessarily lead to market acceptance. It is important that all economic operators in the construction sector are convinced about the suitability of super insulating products for the works they are involved in.

In other words, manufacturers of super insulating products need to instil confidence in product ability, installation conditions and methods and conformity of performance of products placed on the market. This may be done by:

- Demonstrating that products placed on the market and in use achieve claimed performances
- Product users need to be convinced about products' performances and fitness for use
- Dissemination of information taking into account particular markets' conditions (regulations, state-of-the-art, climate, uses and traditions, …)
- Communication reaching relevant stakeholders
- Training of designers and installers

For industry, it is important, to prevent repetition, that evaluation methods are harmonized (criteria may depend on markets).

SETTING THE STANDARD: STANDARDS AND TECHNICAL FITNESS FOR PURPOSE DECLARATIONS

Standardization is a voluntary, consensus driven activity, carried out by and for the interested parties themselves, based on openness and transparency, within independent and recognized standardization institutes, leading to the adoption of standards, compliance with which is, in most cases, voluntary.

Standards should be based on sound scientific research, be updated regularly, and be performance-based where possible and relevant. These documents, established by consensus and approved by standardization institutes, provide, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context[1]. What is all too easily forgotten, is that, in accordance with ISO/IEC Guide 2:2004, standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits.

Taking into account the required service life of construction works and the corresponding risks if the intended service life is not met or if parts of the works fail during use, the state-of-the-art in the construction sector develops relatively slowly. Innovations require time to demonstrate fitness for use in construction works, before being accepted as state-of-the-art.

Product standards are developed for products available on the market. Requirements, evaluation methods and criteria address only those aspects that are known to be of relevance for the products found on the market at the time when standards are being developed.

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[1] ISO/IEC Guide 2:2004, definition 3.2

Consequently, in the construction sector, product standards have always been complemented by technical fitness for purpose declarations [2]. These declarations are independent favourable judgements of a product, kit or system, taking into account the use(s) for which the manufacturer places the product onto the market. Whereas in general (national) product standards cover products for which codes of practice [3] exist, technical fitness for purpose declarations usually cover installation guidance, limiting conditions, possibly related to the climate and geography, or requirements, as set by codes of practice or (national) regulations on works.

Technical fitness for purpose declarations are issued by independent organizations, taking into account the needs and concerns of all stakeholders in the construction sector.

The approval institutes serve the public interest. As such, these institutes work in collaboration with the whole spectrum of stakeholders making up the construction industry, i.e. architects, building control inspectors, consultants, contractors, developers, engineers, insurance providers, manufacturers, promoters, public authorities, quantity surveyors, regulators, service providers, specifiers, other conformity assessment bodies (certification bodies, inspection bodies, laboratories), works' occupants and owners, … As the institutes are impartial, no stakeholder group is favoured before another and every manufacturer, large or small, is treated equally.

CERTIFICATION

Not all approval institutes offer product certification, but in many cases, they do monitor products for which fitness for purpose declarations have been issued. Certification, especially when being offered by accredited certification bodies, represents an important added value for users and enhances the reputation of the issued declaration and the fitness for purpose declaration in general, by increasing confidence that products on the market comply with the declaration.

[2] Fitness for purpose declarations are generally referred to as Approvals, but these may also be referred to by terms such as Agrément certificates, Avis Techniques, Zülassungen, Documento de Idoneidad Tecnica, Technical Approval, Agrément Techniques etc.

[3] Specification comprising recommendations for accepted good practice as followed by competent and conscientious practitioners in the construction sector, and which brings together the results of practical experience and acquired knowledge for ease of access and use of the information. Examples are Documents Techniques Unifiés (DTU) in France, Note d'Information Technique (NIT) in Belgium.

UEAtc

In 1960, a number of bodies from different countries granting fitness for purpose declarations agreed to cooperate, trying to reduce the burden for manufacturers seeking such declarations in several countries. Over time, other such bodies joined the organization to arrive at the European Approval Union (UEAtc) that we know today, comprising eighteen member institutes from and in the vicinity of Europe.

Approvals issued by UEAtc members continue to be different in order to meet the specific needs of the markets and the stakeholders they are aimed at, but the basis for issuing them may be substantially similar.

UEAtc aims at:

- Bringing together expertise from various fields (research, standardization, certification, …) and many countries
- Development of common assessment methods
- Indirect access to all relevant stakeholders
- Distribution of technical information in many countries

At international level, approval institutes join forces through the World Federation of Technical Assessment Organisations (WFTAO).

DYNASTEE

DYNASTEE

DYNASTEE is an informal grouping of organisations involved in research and application of tools and methodologies for DYNamic Simulation, Testing and Analysis of Energy and Environmental performances of buildings. DYNASTEE provides a multidisciplinary environment for a cohesive approach to the research work related to the energy performance assessment of buildings in relation to the Energy Performance for Buildings Directive (EPBD).

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- Renewable Energy Unit

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Belgian Building Research Institute

The DYNASTEE Network

DYNASTEE stands for: "**DYN**amic **A**nalysis, **S**imulation and **T**esting applied to the **E**nergy and **E**nvironmental performance of buildings".
DYNASTEE is an informal grouping of organizations actively involved in the application of tools and methodologies relative to this field. DYNASTEE functions under the auspices of the INIVE EEIG and constitutes a sustainable informal networking mechanism, which is intended for those who are involved in research and applications for the assessment of energy performance of buildings in relation to the Energy Performance for Buildings Directive (EPBD).

DYNASTEE, being a network of competence in the field of outdoor testing, dynamic analysis and simulation, has over 25 years of experience through a series of EU research projects. DYNASTEE is an open platform for sharing knowledge with industry, decision makers and researchers.
DYNASTEE has the expertise needed to support the developments and design of Nearly-Zero Energy Buildings as required by the EPBD. Specific outdoor experimental work needs knowledge of the analysis process in order to optimise the dynamic information in the measurement data. Simulation requires results from analysis in order to be able to scale and replicate the results from analysis and testing to real buildings in different climates.
DYNASTEE functions under the auspices of the INIVE EEIG. For more information visit the DYNASTEE web-site at www.dynastee.info

WHAT ARE DYNAMIC METHODS?

Dynamic analysis methods are techniques to analyse dynamic processes and to identify typical parameters of physical processes like energy flows in buildings. Dynamic methods take into account the aspect of time whereas a static analysis method in general does not. Dynamic analysis, simulation and testing remains an area of high scientific interest.

The application of system identification techniques to the energy performance assessment of buildings and building components requires a high level of knowledge of statistics, physical and mathematical models. This factor, combined with the quality of the data, the description of the monitoring procedure and test environment, together with the experience of the user of the analysis software itself, can produce varying results from different users when applying different models and software packages.

The developed dynamical methods will enable new methods for providing guidelines for improving buildings with the purpose of obtaining energy savings and optimising efficient use of energy. Dynamic tools will indicate the most beneficial actions for improvement, as e.g. further insulation of the walls, roof and floors, tightening the envelope, changing windows and shading, and will be able to assess the effects of thermal mass of the building.

It is expected that buildings will play an active role in the integration of renewable energies in the energy system. Smart and intelligent meters are one of the big energy saving hopes by reducing the energy used in residential houses and public buildings, lowering the energy bill and carbon emissions. Dynamic methods are essential for NZEB and imply that smart meters can be used for automatic generation of reliable energy labels for buildings.

Regular trainings organised by DYNASTEE, take place in the form of workshops or Summer School and deal with the application of dynamic methods for outdoor testing, related analysis and modelling techniques. In general it is targeted to energy researchers, engineers, building designers and energy system managers.

APPLICATION OF DYNAMIC CALCULATION TECHNIQUES

By dynamic evaluation techniques (parameter identification) dynamic effects due to accumulation of heat in the equipment, test room envelope and test specimen are properly taken into account. Parameter identification is needed to be able to derive the steady state properties from a short test with dynamic (e.g. fluctuating outdoor) conditions.

The capability to extract these parameters from a test carried out under dynamic conditions and real climate, using a relatively short test period, is one of the main features of this approach.

Several tools have been developed or used in the framework of the PASLINK grouping such as CTSM, LORD or the SIT in the MATLAB environment to analyse building component tests using test cells.

Although the step from test cell level to whole buildings level and other building systems is not trivial. New measurement devices and computer capabilities, together with background from previous work regarding experiment set up, quality of measurement, methods for dynamic analysis, etc., provide a very strong base to broaden the scope of application as mentioned.

In the past steady-state or averaging methods were widely applied. These methods usually require a very long period of testing. In some cases, this is because high thermal inertia leads to a long period of integration. In other cases, in components with less thermal inertia, effects such as wind speed, long wave radiation, or solar irradiance in sunny weather, may become important and non-negligible. It makes it necessary to use multi-linear regressions in which the increase of the number of inputs leads to longer test periods in order for there to be enough degrees of freedom for regression. Dynamic methods are very useful for overcoming some of these problems. Traditionally, these methods have taken into consideration linear models with linear and time invariant parameters. Recent studies have shown the flexibility and usefulness of dynamic nonlinear models in several applications such as the modelling of ventilated photovoltaic modules, solar chimneys and also for dealing with problems related to warm sunny weather taking the boundary conditions in a test cell into account. Models including time-dependent parameters also present very interesting potential applicability in this field.

The DYNASTEE Network's experience

At a glance, the DYNASTEE network has long term experience with:

Testing under outdoor conditions

- Use of standardised PASLINK test cells (generation of high quality data series)
- PASSYS test cells and similar test cells
- Test houses (energy systems performance assessment)
- Real building testing (occupancy behaviour)

Analysis applying dynamic methods for analysis and forecasting

- LORD (lumped model analysis tool)
- CTSM (Continuous Time Stochastic Modelling)
- Matlab – System Identification Toolbox
- Others (including regression techniques)

Modelling (based on technical specifications; design phase)

- TRNSYS
- ESP-r

Up to date Technology

Dynamic mathematical and statistical technologies are recognised as crucial in optimisation of energy efficiency.
Integration of renewable energy technologies in our society is rapidly evolving, giving another perspective to the use of available energy resources. The recast of the Energy Performance for Buildings Directive, the Energy Service Directive and the Construction Product Regulation require energy standards for calculation methods, certification, etc. New buildings will consume and produce energy for space heating while electricity consumption for systems and appliances is increasing.

Innovative applications in the energy sector for dynamic methods:

- Energy labeling for buildings (certification)
- In-situ measurements and analysis (new CEN – WG)
- Energy performance assessment of buildings (EPBD)
- Integration of solar and wind power in the grid (2020 targets)
- District heating (optimising CHP)
- Intelligent metering techniques

The developments of Nearly-Zero Energy Buildings will be to a large extent based on dynamic characterization and methodology. Besides dynamic evaluation and modelling, dynamic testing under real climate conditions is an essential part.

The DYNASTEE network of Outdoor Test Facilities

PASLINK original test-cell

The strength of the DYNASTEE network lays in its multi-disciplinary nature of academic and research teams. In addition the availability of high quality outdoor test facilities at several member organisations offers a direct interaction between realistic experimental testing and dynamic evaluation and simulation.
For more information please visit the DYNASTEE web site www.dynastee.info.

New design of PASLINK testcell in Florence

IEA ECBCS Annex 58

During 2011 the DYNASTEE network organised two workshops that resulted in the successful submission of the IEA ECBCS Annex 58 proposal on the topic of "Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements".

International Energy Agency
Energy Conservation in Buildings and Community Systems Programme

Major aim of the Annex 58 project is collaboration in the ECBCS-context to:

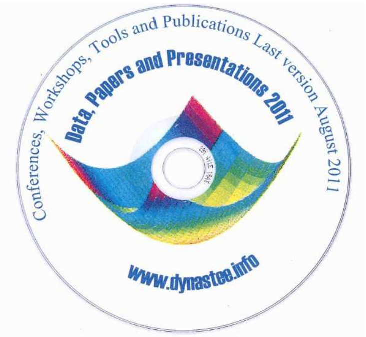
- Develop the necessary knowledge and tools to achieve reliable in-situ dynamic testing and data analysis methods that can be used to characterize and label the effective energy performance of building components and whole buildings.
- Develop procedures with the focus both on the test environment and experimental setup as well as on the data analysis and performance prediction.

Organisations or people interested in receiving more information about this Annex 58 can be found at the Annex 58 website.

MORE ABOUT DYNASTEE

The Network of Excellence

The DYNASTEE network is developing a Network of Excellence for the Annex 58 project. It plays a co-ordinating role between actual partners in the Annex 58 research, other members of the DYNASTEE network, other industrial networks and partners. In addition it will facilitate the transfer of knowledge and expertise by organising conferences, workshops and training events.



Publications

During the last ten years a number of workshops, conferences and training events have been organised by the DYNASTEE network. The outcome of these events in the form of papers and presentations has been collected on a CD together with data and tools for self-training. The CD can be obtained for free upon request. Visit the DYNASTEE web-site www.dynastee.info for further details.

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ISBN 2-930471-33-6
EAN 9782930471334