KNOW-HOW

Quality characteristics of technical insulation materials:

Costs over the entire service life are key

armacell
MAKING A DIFFERENCE AROUND THE WORLD

The product price is just the visible tip of the iceberg. Maintenance, repair, replacement and consequential costs due to damage to the building lie hidden below the surface and are often not taken into account when investment decisions are made.

MAKING SOUND INVESTMENT DECISIONS

When specifying equipment insulation, the technical performance and reliability of the installation must always be the deciding factor. Taking only the price into consideration can be expensive both for those involved in the construction and for the operators of the building. If unsuitable building materials are specified and used, maintenance, repair and possible consequential costs, such as damage to the building or production losses due to plant downtime, can soon exceed the supposed savings many times over.

Insulation makes a crucial contribution to the operational reliability of domestic and industrial equipment: it increases energy efficiency, prevents condensation processes, supports corrosion protection, reduces noise emissions and keeps industrial processes running. Elastomeric insulation materials ensure higher performance, a longer service life and the efficiency of the equipment in buildings and industry. Yet insulation accounts for only a negligible share of the total installed costs of the technical equipment – often just 1 %. Anyone making false economies here is likely to pay more in the long term.

Technical performance is decisive

As we have shown in this series of articles, the thermal conductivity (λ-value) of a material is a key technical property when it comes to selecting insulation, but it should not be the sole one. Condensation on the surface of the pipe and a rise in thermal conductivity over the service life will only be prevented if the material is protected against moisture absorption. On the one hand, moisture occurs due to condensation on the surface of pipes whose line temperature is below the ambient temperature. On the other hand, water vapour can diffuse into the insulation because of the difference in vapour pressure and soak the material. The resistance to water vapour diffusion (μ-value) indicates how many times greater the resistance to transmission of a layer of building material is compared to a static layer of air of the same thickness and temperature.

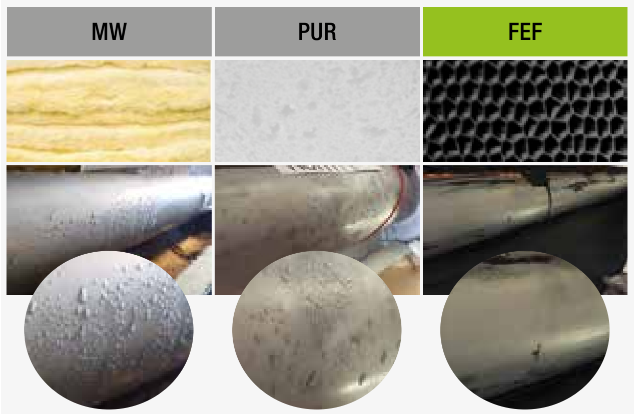
Moisture penetration must be prevented

Water has a much higher thermal conductivity than typical insulation materials. Therefore the absorption of moisture always leads to a rise in the thermal conductivity of the insulation material and a reduction in its insulation capacity. With every vol.-% of moisture content, the thermal conductivity increases and the insulation effect deteriorates. The consequences are not only higher energy losses, but also a drop in the surface temperature. If this falls below the dew-point temperature, condensation occurs on the surface of the pipe. Only if the thermal conductivity of the insulation material does not increase significantly as a result of moisture penetration is it possible to guarantee that the surface temperature will remain above the dew point even after many years of operation. The insidious thing about moisture ingress is that the processes are not visible. Condensation occurs under the insulation on the surface of the pipe. It often only becomes apparent that the insulation material has failed when water drips from the suspended ceiling or ice forms on the pipe.

CONDENSATION – THE DEADLY ENEMY OF INSULATION

Therefore, when selecting an insulation material the key question is how well it is protected against moisture absorption. As an investigation carried out by the Fraunhofer Institute for Building Physics (Stuttgart, Germany) shows, Armaflex insulation materials are very well protected against moisture absorption. Even during the relatively short test period, considerable amounts of moisture had accumulated under both the PUR and mineral wool insulation. Despite the moderate test conditions, the vapour barrier of the PUR and mineral wool could not prevent the absorption of water vapour. In contrast, no moisture diffused into the elastomeric insulation material and the surface of the pipe remained dry. While the pipe insulated with FEF showed no signs of condensation even after 33 days, the mineral-fibre insulation failed right at the beginning of the test.

Surfaces of the pipes after removing the insulation (condensation)



Long-term consequences of moisture penetration

To investigate the long-term effects of moisture absorption, the Fraunhofer Institute simulated how the insulation materials behave over an assumed period of ten years. While the thermal conductivity of the FEF only rose by around 15 % after ten years, the λ-value of the mineral wool increased by 77 % and that of the PUR insulation by 150 %.

Condensation on the surface of the pipe and a rise in thermal conductivity over the service life can only be prevented if the material is protected against moisture absorption. The thermal conductivity stated by manufacturers must be understood as being the initial thermal conductivity or 'dry λ-value'. It may only decide on the choice of material in combination with the resistance to water-vapour diffusion. In other words: an insulation material with an excellent 'dry λ-value' but low resistance to water vapour diffusion is a poor choice.

If the insulation material is completely soaked, the increase in energy consumption is often the least of the problems. Mould, structural damage, corrosion under the insulation (CUI) or disruption to industrial processes due to maintenance work and downtime can result in huge costs.

More information
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CUI – THE TRILLION-DOLLAR PROBLEM

Corrosion under insulation (CUI) is insidious: the processes occur hidden beneath the insulation and are often only discovered when extensive damage has already taken place. CUI usually occurs on pipes with line temperatures between 0 °C and 175 °C, temperatures above 50 °C are particularly critical. The risk also increases on equipment which is operated discontinuously or at dual temperatures. If the temperature fluctuates, condensation can form in the insulation material and reach the surface of the pipes. In the oil, gas and petrochemical industry alone, this leads to damage amounting to around 1 trillion US dollars annually. According to a study by the US American ExxonMobil Chemical Company, 40 to 60 % of maintenance costs for pipework are due to CUI.

Insulation alone cannot safeguard plant components against corrosion, but appropriate insulation systems can support corrosion protection effectively. The choice of material decides whether the insulation minimizes the risk of corrosion or favours corrosion processes.

Corrosion protection ratings
To what extent can various insulation systems mitigate the risk of CUI? This was the question which Armacell looked into in a further investigation. The test was carried out by InnCoa an institute based in Neustadt/Donau (Germany), which is specialized in corrosion testing.
The two FEF insulation systems performed best in the test: the elastomeric foam with all-over adhesion (system B) even attained the top rating, R_P 10. No signs of corrosion were found anywhere on the surface of the pipe. All-over adhesion of the insulation materials further increased the already high corrosion protection of FEFs. The glass-fibre insulation system, on the other hand, only had an R_P of 4 to 5 and the polyurethane system achieved an R_P of 5. The greatest corrosion damage was observed on the stone wool specimen. The surface area of defects was between 5 and 10 % of the total pipe surface, resulting in an R_P of 3.

The test demonstrated impressively that closed-cell flexible elastomeric foams which have an 'integrated vapour barrier' are more tolerant towards small defects in the covering and insulation than other insulation systems. If moisture penetrates the other insulation systems and reaches the surface of the pipe, it usually leads to CUI.

RELIABILITY OF THE INSTALLATION

The results of the investigations by independent, external institutes confirm the excellent experiences that have been made with FEF insulation materials throughout the world for decades. The closed-cell insulation material with low thermal conductivity and high resistance to water-vapour diffusion provides plant components with long-term protection against condensation and energy losses and minimizes the risk of corrosion. As is often noticed during maintenance work, equipment insulated with Armaflex displays no sign of corrosion even decades after its installation. Internal and external tests have shown that even after it has been installed for well over 25 years Armaflex still has the values guaranteed at the time of manufacture. To ensure that the insulation system works reliably for many years, it is not only essential that the insulation thickness is calculated correctly and system-compatible accessories are used, but also that the materials are installed professionally following the manufacturer's instructions.

Professional application is key

The technical performance of an insulation material plays a decisive role when choosing a product. But only if the materials can be applied reliably even under difficult conditions on the building site can the long-term function of the equipment be ensured. To investigate how easily various technical insulation materials can be installed, Armacell carried out practical tests with four typical insulation systems provided for cold applications. The materials examined were an elastomeric insulation material (FEF), cellular glass (CG), PUR and an aluminium-covered mineral wool system for cold applications (MW).

FEFs and cellular glass are closed-cell insulation materials with a very high resistance to water-vapour diffusion. Unlike mineral wool and PUR, neither product requires an additional vapour barrier, which is always a weak point in the insulation concept. Both during the installation and in the course of maintenance work later on, the delicate aluminium foil can easily be damaged, allowing water vapour to penetrate the insulation system. Whereas tears can be seen quite easily on the smooth aluminium foil covering of a PUR product, they are often not noticed on the aluminium grid foil on the soft mineral wool. As the application video of a well-known manufacturer shows, even the careful, specially trained insulator in this advertising film damaged the delicate vapour barrier without noticing it while he was fabricating a component.

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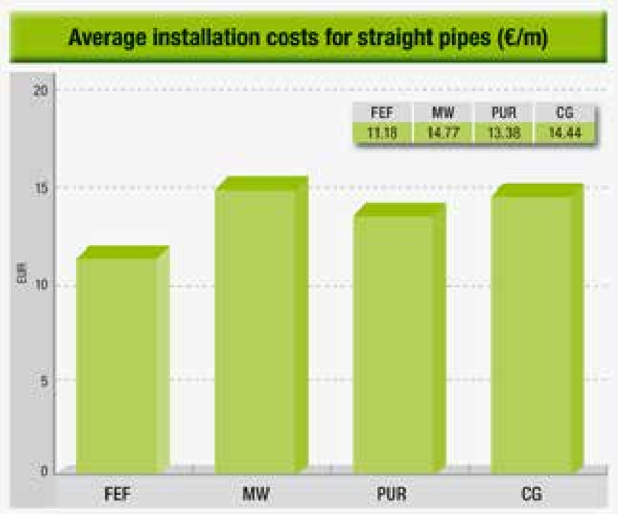
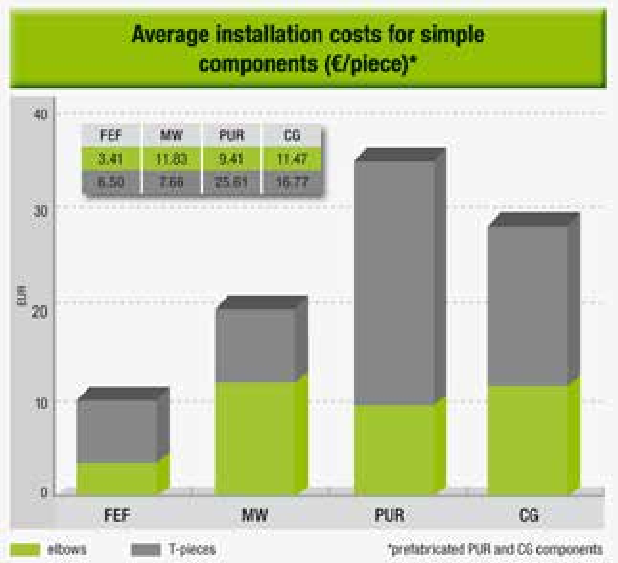
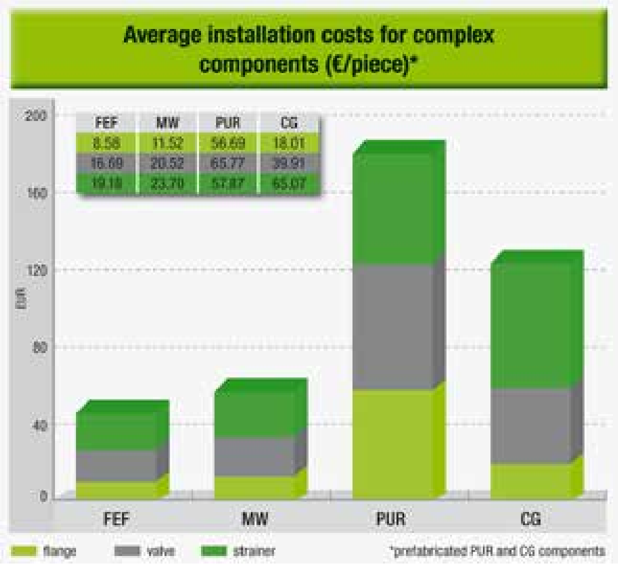
In some European countries, the use of mineral wool in cold applications is severely restricted. In Germany, DIN 4140 stipulates that it is only allowed if a double jacket is installed. In Belgium, according to Typebestek/105, mineral wool may only be used on pipes with a minimum temperature of 13 °C. By using open-cell insulation materials in cold applications specifiers and installers are taking an incalculable risk, which can cost them dearly. Manufacturers of mineral-fibre products currently advertise that their insulation materials can also be used in cold applications. Even if these systems are explicitly marketed as cold insulation materials, they are open-cell mineral-fibre products with an aluminium foil.

TOTAL INSTALLED COSTS







The application time is a decisive factor for the total installed costs of a project. Armacell investigated the installation speed of the various technical insulation materials in application tests. All in all, each material was installed in 20 different situations and the average installation time was determined. The figures on the left show the average costs (material and installation costs) incurred for the different insulation materials. Due to the comparatively high material price and consumption for mineral wool pipe sections and aluminium tape, this system is the most expensive on straight pipes.

The differences become even more obvious when simple components are fabricated: the costs for mineral wool are almost twice as high as those for the elastomeric material. Using prefabricated PUR or cellular glass elbows and T-pieces even increases the costs by up to 200 per cent! The situation is very similar with complex components. Here too, the costs multiply when PUR and cellular glass are used. Compared to the FEF components fabricated by the insulator himself, the prefabricated cellular glass components are almost three times more expensive and those made of PUR cost more than four times as much.

Case study: Comparison of the costs for insulation work

To show the impact these cost differences have on an actual construction project, Armacell went a step further and carried out a case study on the basis of these calculations. The starting point was a typical invitation to tender for cold insulation work. The project is an extension to a US American chemical company's production facility in Baden-Württemberg (Germany). A total of 30 million US dollars were invested in the new construction, which creates additional production, warehousing, laboratory and office facilities on a total area of 11,500 m^2.

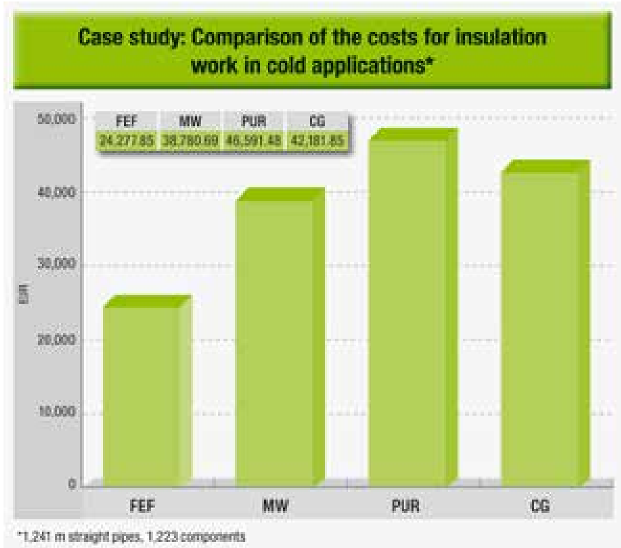
The invitation to tender for the cold insulation work covered the insulation of 1,241 m of straight pipes (DN 15 – DN 200) and 1,223 components. The various pipe diameters and installation heights were considered in the calculation and assigned to the test results described above. Depending on their complexity, the components to be insulated (e.g. valves, ball valves, heat exchanges etc.) were assigned to those tested. In addition to the material costs, labour costs were also included at an hourly rate of 60 euros. All items and accessories needed were considered and calculated separately for each insulation material.

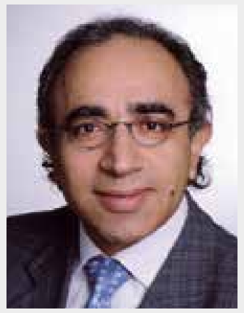
As the figure below shows, the use of FEF insulation materials allows significant cost savings: carrying out the project with a mineral-wool system for cold applications would have been almost 60 % more expensive. Had cellular glass been used, the costs would have risen by 70 %. The PUR system would have cost almost twice as much as the elastomeric insulation material.

Focus on costs during the total service life

When it comes to technical insulation, those who focus only on the lowest material price will lose out in the end. The total installed costs, i.e. material price and labour costs, must always be compared. Many investment decisions are made solely on the basis of the purchase price. Yet the costs during operation often exceed the investment costs many times over. They are difficult to calculate, often overlooked or underestimated. The total cost of ownership (TCO) approach considers all costs associated with the procurement and use of goods. Here, not only the purchase price is taken into account, but all the costs incurred are estimated in advance. This allows hidden costs to be identified before an investment decision is taken. In the case of technical insulation materials, these include not only investment costs but also maintenance, repair, replacement and possible consequential costs that may result from operational downtime or damage to the building.

A fact that is often not taken into account when planning equipment is that although insulation materials cost money, they save considerably more money in the course of their service life. If the aim is to meet only the minimum requirements and keep the purchase price as low as possible, the enormous savings potential of technical insulation over many decades of operation is not fully utilized. Higher insulation levels – i.e. insulation thicknesses that exceed those needed to prevent condensation – require slightly higher investment costs, but these often pay off many times over during their service life and allow considerable financial savings after just a few years.





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As the inventors of flexible foam for equipment insulation and a leading provider of engineered foams, Armacell develops innovative and safe thermal, acoustic and mechanical solutions that create sustainable value for its customers. Armacell's products significantly contribute to global energy efficiency making a difference around the world every day. With 3,000 employees and 25 production plants in 16 countries, the company operates two main businesses, Advanced Insulation and Engineered Foams. Armacell focuses on insulation materials for technical equipment, high-performance foams for high-tech and lightweight applications and next generation aerogel blanket technology. For more information, please visit: www.armacell.com. For product information, please visit: www.armacell.eu.

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