KNOW-HOW – PART V

# Fast and reliable installation

Professional application is paramount in cold insulation. So installation properties play a decisive role when choosing a product. In addition to reliability and ease of application, the installation time is also extremely important. Because together with the price of the material it is the labour expenses which determine the total cost of a project.

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# TIME IS MONEY

**Professional application is all-important in cold insulation. So installation properties play a decisive role when choosing a product. After all, what use is a technically superior insulation material if it cannot be installed securely, cleanly and quickly? In addition to reliability and ease of application, the installation time is also extremely important. Because together with the price of the material it is the labour expenses which determine the total cost of a project.**


## AUTHOR

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The physical and technical properties of a material are decisive when evaluating and selecting technical insulation, but installation aspects are at least as important. Depending on the area of application, the destination and the complexity of the equipment to be insulated, different demands are made of the insulation. The highest maxim should be: it must be possible to carry out the insulation under difficult building site conditions without risking any weak points in the entire construction. Alongside the reliability, the ease of installation is one of the core criteria. This includes not only the speed at which the materials are installed, but also factors such as the preparation needed, cleanliness, space requirements and ultimately the cost-effectiveness of the systems.

The installation speed has a significant influence on the total installed costs of a project. Nevertheless, one cannot simply say ‘the quicker, the cheaper’. Fast installation of unsuitable insulation materials involves risks for the operation of the equipment. Condensation, increased energy losses or corrosion damage can lead to consequential costs which exceed the supposed savings many times over.

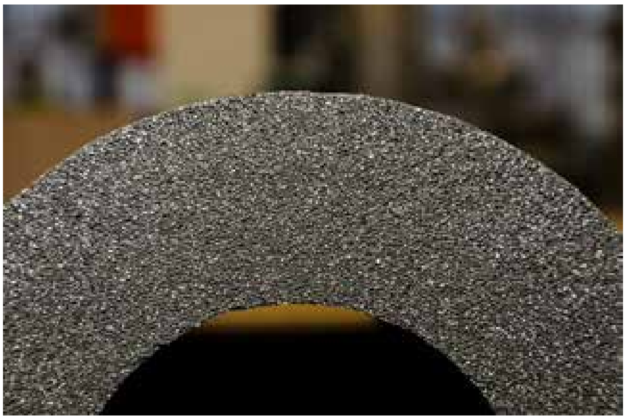
# INSULATION MATERIALS TESTED

To examine the installation effort and speed of various technical insulation materials, Armacell carried out tests reflecting typical application conditions. The focus was on four common insulation systems provided for cold applications.

The materials investigated were:
- cellular glass,
- PUR/PIR,
- an aluminium-covered mineral wool system for cold applications and
- an elastomeric insulation material.

## Cellular glass (CG)

Cellular glass is a thermal insulation material made of foamed glass. The raw materials used to manufacture cellular glass are all mineral. The energy-intensive preliminary manufacturing stage with quartz sand as the main raw material has now been largely replaced by the use of recycled flat glass. The material is manufactured in blocks out of which the sections, sheets and component pieces are later milled. Cellular glass has a completely closed-cell material structure and an infinitely high resistance to water-vapour transmission. Of the insulation materials examined, cellular glass has the highest thermal conductivity, which lies between 0.037 and 0.042 W/ (m·K) at 0 °C mean temperature. Cellular glass is not hygroscopic and does not absorb moisture from the environment. A weight change occurs only when the surface is moistened at the location of the cut cells. Furthermore, cellular glass is virtually vapour-tight and vapour diffusion processes can therefore be prevented permanently. Due to its brittleness, cellular glass cannot take point loads and o it must lie flat on the equipment which is to be insulated. In addition to pipe sections, prefabricated products are available for insulating elbows, T-pieces and caps for valves, flanges, etc. When the material is cut, small amounts of hydrogen sulphide are released, causing an unpleasant odour. The material is glued using a two-component reaction adhesive based on a polymer-modified bitumen emulsion and a powder that is mixed in at a ratio of 1:3. Only the amount of adhesive that can be used within the pot life (time during which it can be applied) may be mixed. In the case of pipes with diameters of DN 80 and larger, the pipe sections are additionally secured at intervals of 300 to 600 mm with installation tape (fabric, aluminium or filament tape) or metal straps with a buckle.



Cellular glass is virtually vapour tight, but because it is brittle it cannot take point loads.

Cellular glass is installed with a two-component adhesive and then additionally secured with installation tape or metal straps.

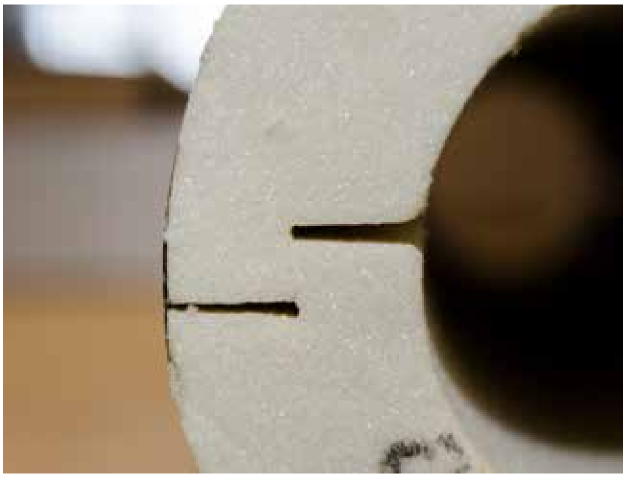
## PUR/PIR

Insulation materials made of rigid polyurethane foam are produced by the chemical reaction of liquid raw materials – the basic material is usually crude oil – with the addition of low-boiling blowing agents. In the block foaming process, the reaction mixture flows from a mixing head into a block mould or onto a continuous block band. After foaming and settling, the blocks are then processed accordingly.

Insulation materials made of rigid PUR foam are hard foams which are at least 90 % closed cell. Of the insulation materials examined, polyurethane has the lowest thermal conductivity. At a mean temperature of 0 °C, it lies between 0.025 W/ (m·K) and 0.033 W/ (m·K). PUR/PIR rigid foams are not hygroscopic and therefore do not absorb moisture from the ambient air.

However, with μ-values between 40 and 250, PUR has only a low resistance to water-vapour transmission. When used as cold insulation this results in increased moisture penetration over the long term due to differences in water-vapour partial pressure. Therefore, an effective vapour barrier is required if these materials are installed on refrigeration lines.

Pipe sections and other shaped parts are milled from discontinuously or continuously produced blocks. Pipe sections are offered with and without an aluminium or a PVC covering. They are cut using saws. The products are bonded with a two-component adhesive – a paste is mixed with a hardener (catalyst). Then an aluminium adhesive tape must be applied on all longitudinal and circumferential seams to create a diffusion-tight bond.



Rigid PUR/PIR foam has a low resistance to water-vapour transmission and therefore needs an effective vapour barrier

PUR is also glued using a two-component adhesive. Then an aluminium adhesive tape must be applied on all longitudinal and circumferential seams to create a diffusion-tight seal.

Because it is an open-cell insulation material, mineral wool is not protected against moisture penetration and, therefore, should not be installed on refrigeration pipes.

Mineral wool pipe sections are fastened with an overlapping self-adhesive strip and the join is then smoothed using a spatula. For additional security, aluminium tape is wrapped around the pipe sections at least every 600 mm.

## Mineral wool (MW)

Man-made mineral fibres are produced by melting the mineral raw material and then centrifuging, blowing or drawing it. The raw materials used for making glass wool are waste glass or glass raw materials such as quartz sand. Rock wool is manufactured from basalt or diabase rock. Mineral fibre insulation is manufactured in continuous processes. These are open-cell materials with a resistance to water-vapour transmission (μ) of 1 - 2. Mineral wool is open to diffusion and the insulation properties can be greatly reduced by moisture. An aluminium covering acts as a vapour barrier.

The system tested here which was developed for use in refrigeration and air-conditioning applications is offered as pipe sections, lamella mats and matching pipe supports. The pipe sections are sealed with the overlapping adhesive strips and then the join is smoothed with a spatula. For additional security, the pipe sections are wrapped with an aluminium tape at least every 600 mm. A flexible sealing tape is applied at penetration points, e. g. pipe suspensions or measuring and control devices.

At this point it should be pointed out that in some European countries, the use of mineral wool on refrigeration pipes 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. Manufacturers of mineral fibre products currently advertise that their insulation materials can also be used in cold applications. Although these systems are expressly marketed as cold insulation materials, they are still open-cell mineral fibre products with an aluminium covering!

Nevertheless, in order to examine the installation properties of these systems, they were deliberately included in the tests.

Elastomeric insulation materials have a closed-cell structure and a high resistance to water-vapour transmission, so they do not need a separate vapour barrier and can be installed easily, quickly and reliably.

Elastomeric insulation materials are available as standard and self-adhesive products. After applying adhesive or removing the protective foil the edges are simply pressed together section by section. No further measures are needed to secure the seam.

## Elastomeric insulation materials (FEF)

Elastomeric foams are highly flexible insulation materials based on synthetic rubber. The raw sheets produced by compounding and rolling processes are fed through an extruder and formed into tubes and sheets. Heat is then added and the tubes and sheets are 'baked' with the aid of a blowing agent in a continuous process.

Like cellular glass, elastomeric insulation materials have a completely closed-cell material structure. The material is not hygroscopic. Depending on the type of rubber, the resistance to water-vapour transmission is between μ = 2,000 and 10,000, but usually much higher. In individual cases, values of up to μ = 20,000 are achieved. In FEFs, the vapour barrier is not limited to a thin film or covering, but is built up over the entire insulation thickness. There is no need for a separate vapour barrier.

In addition to tubes and sheets in standard and self-adhesive versions, self-adhesive tapes, pipe supports tailored to the insulation material range and highly flexible fire protection barriers are also offered. Self-adhesive tubes are closed by pressing the seam firmly together section by section after removing the protective strip. The tangential cut ensures a larger bonding surface and better adhesion. Today, a wide range of adhesives is available, including thixotropic, non-dripping contact adhesives and solvent-free products.

# WHICH MATERIAL MAKES THE RUNNING?

**Test set-ups and series of measurements**
The various insulation systems were installed by professional insulators following the manufacturers' application guidelines and heeding the appropriate standards. All in all, each material was installed in 20 different situations and the average installation time was determined. Ideal application conditions were chosen: a room temperature of 23 °C and 50 % relative humidity.

**Scenario A: straight pipes**
Here a 3-metre-long steel pipe with diameters of DN 20 und DN 80 was insulated at heights of 1.20 m and 2.30 m. At each end, the insulation was bonded to the pipe support.

**Scenario B: complex pipe system #1**
To simulate a more complex pipe system, a 90° elbow and a T-piece were added to the pipes. The tests were again carried out for the diameters DN 20 and DN 80 and at heights of 1.20 m and 2.30 m.

**Scenario C: complex pipe system #2**
In a further step, a pipe system with a flange, valve and strainer was insulated. Here, too, components had to be fabricated for the fittings with diameters of DN 20 and DN 80 and installed at heights of 1.20 m and 2.30 m.

A stop-watch was used to take the installation times. For documentation purposes, all application tests were videoed and archived. Afterwards the costs for the application were determined. Both the material and labour costs were estimated. The latter based on an hourly rate of 60 euros.

**Test results**
**Reliability of the installation**
FEFs and cellular glass are closed-cell insulation materials with a very high resistance to water-vapour transmission. 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 later maintenance work the vapour barrier (e.g. aluminium foil) can easily be damaged, allowing water vapour to penetrate the insulation system. The aluminium covering on the new cold insulation system tested is more robust than that on traditional mineral wool products, however it is still hardly possible to avoid damage during the installation work. This fact is clearly shown in the manufacturer's application video: the insulator – who was presumably working especially carefully in this advertising film – still damaged the delicate vapour barrier while fabricating a component. The manufacturer provides a flexible sealing tape for penetrations. This increases the reliability of the insulation system, but it also means that more installation effort and material are required. The seams of FEF insulation, on the other

The manufacturer's application video shows just how easy it is to damage the vapour barrier: while cutting out a piece for a component, the insulator pierces the mat underneath without noticing it. Even such small defects are enough to prevent the vapour barrier working effectively.

hand, do not need to be additionally secured and penetration seals can also be carried out much more easily. An advantage of elastomeric insulation materials compared to rigid foams is their high flexibility. If subjected to mechanical impact with blunt instruments, the material is not damaged and it recovers immediately from blows.

## Cleanliness of the installation

As far as the cleanliness of the installation is concerned, FEF insulation materials are the clear winner in the tests. The flexible material can be cut easily and cleanly and has very good bonding properties. All other materials generate considerable amounts of dust and dirt when they are cut. PUR and cellular glass are installed with a two-component adhesive, which first needs to be mixed. When cellular glass is installed there is also an extremely unpleasant odour. In both cases, the work area should be protected with a tarpaulin. Mineral wool products can also generate considerable amounts of dust. Full-length, long-sleeved clothing and protective gloves should be worn when working with mineral wool. If the fibres come into contact with the skin, they can cause mechanical irritation, leading to extremely unpleasant itching.

## Space efficiency

Mineral wool products and FEFs require little space on the building site. All pieces for bends, branches, fittings and vessels can be made out of tubes and sheets or pipe sections and mats. A work surface measuring 2 to 3 m² is sufficient for fabricating FEF components. If necessary, the preparatory work can also be carried out on a cut-open cardboard box on the floor. Fabricating one's own components out of PUR or foam glass is extremely time-consuming, even for bends and T-pieces, and it is almost impossible for complex shapes such as valves or strainers. Here, installers have to use factory-made products. These must be measured up for, ordered and assigned to the corresponding fittings when they are delivered. This requires not only patience, but also a great deal of space and very good organization. If mistakes are made when measuring up or the wrong products are delivered, it is necessary to reorder. Foam glass is very easily damaged in transit. In spite of the relatively small quantities needed for the tests, two damaged products were delivered.

When installing PUR and cellular glass, considerable amounts of dust occur and the working area must always be covered with a tarpaulin.


Not really space-saving: when using cellular glass enough storage space must be provided on the building site

## Installation speed and costs

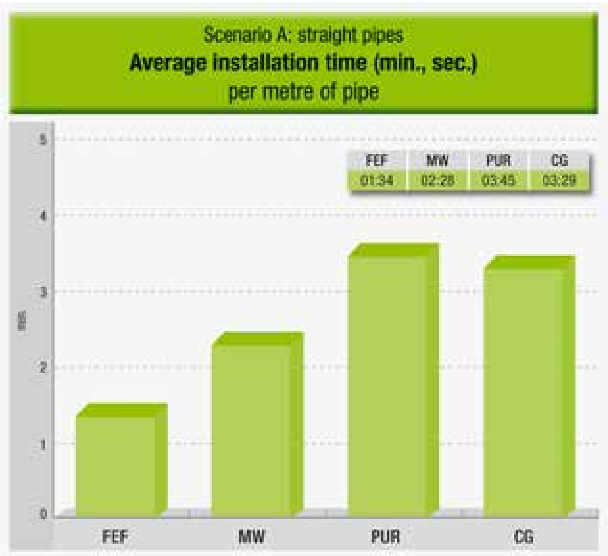
Elastomeric insulation materials make the running in terms of speed, too. Self-adhesive products are particularly quick to install.

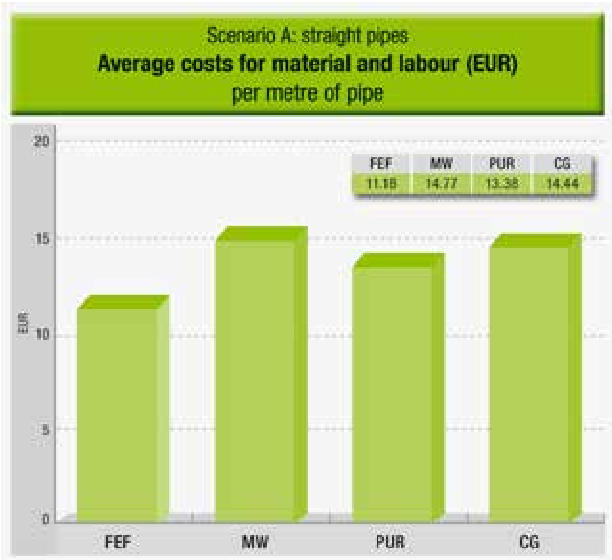
## Scenario A: straight pipes

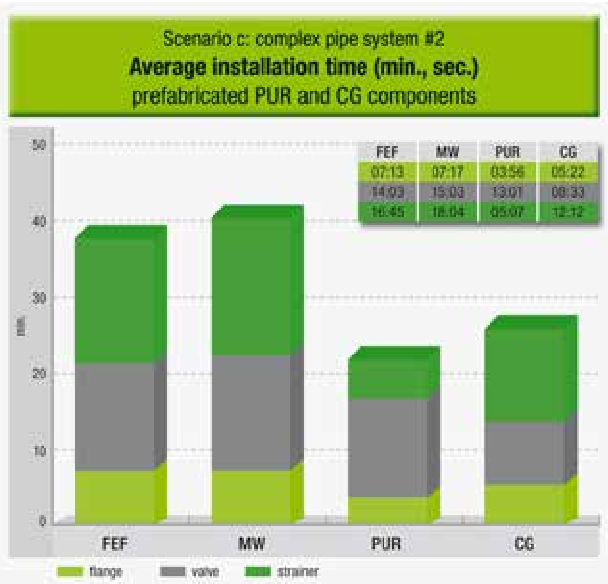
On straight pipes, the FEF installation takes on average only 1:54 minutes per metre. Almost one minute longer is needed for mineral wool and more than twice the time is needed for PUR. Because the material price and consumption are comparatively high for mineral wool pipe sections and aluminium tape, the mineral wool system is the most expensive on straight pipes.

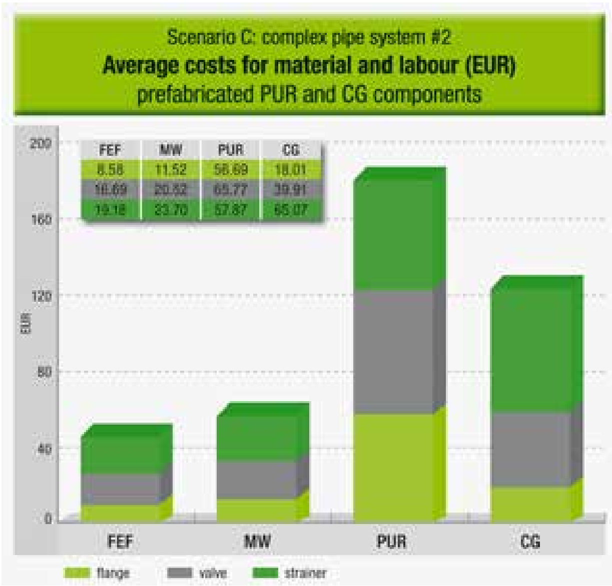
## Scenario B: complex pipe system #1

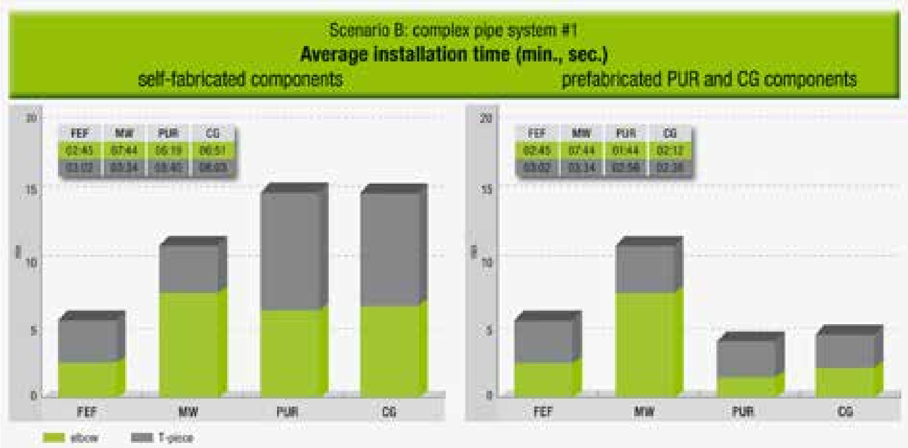
The differences become even more obvious when it comes to fabricating components. Almost twice as much time is needed to fabricate elbows and T-pieces out of mineral wool as out of elastomeric insulation materials. And using PUR and cellular glass takes three times as long. Ordering prefabricated products for PUR and cellular glass reduces the installation time significantly, but this is not the way to save money. Quite the opposite: using prefabricated PUR elbows and T-pieces increases the costs by 70 per cent!

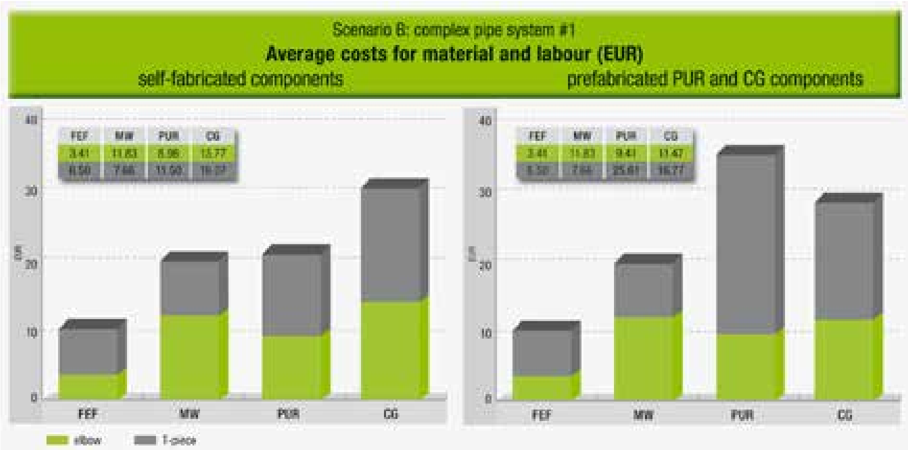





## Scenario C: complex pipe system #2

It is almost impossible for the installer to fabricate more complex components for flanges, valves and strainers out of PUR and cellular glass. Therefore prefabricated products were used here. This reduced the installation times considerably (see Figure 17), but the costs were multiplied. Compared to the FEF components made by the insulator himself, the prefabricated cellular glass products are almost three times more expensive and those made of PUR cost more than four times as much.

## Conclusion

The installation properties of technical insulation materials are a decisive factor for the performance of the products. Only if the materials can be installed reliably even under more difficult conditions on the building site can the long-term function of the equipment be ensured.
Flexible and soft insulation materials can be installed faster than rigid foams. On complex pipe systems, the installation time for rigid foams can be significantly reduced by using prefabricated components, but the costs then increase many times over. Elastomeric insulation materials were convincing in all categories. No other insulation material can be installed as reliably, cleanly and quickly.

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