SPECIFICATION GUIDE #4

THERMAL INSULATION OF STORAGE TANKS

OWENS CORNING® PAROC®

TABLE OF CONTENTS

EXTENT OF THIS SPECIFICATION

1.1 This specification covers the insulation of industrial flat bottom storage tanks, installed above-ground, both in the open air or under cover and focuses on the available insulation systems for tank sidewalls and tank roofs

1.2 Standard geometries for the walls are cylindrical or flat. Tank roofs are either flat, conical or domed.

1.3 The covered service temperature range extends from ambient up to 700 °C.

1.4 Product Data Sheets of the applicable product types, as referred to in Attachment B, explicitly show all relevant details with respect to product properties and application limitations and have to be fully complied with.

1.5 Any additional system requirements such as fire protection are described in separate specifications and have to be read and conformed to in combination with this specification.

1.6 Any deviation from this specification should be submitted to PAROC Technical Representative by written request and authorized by PAROC Technical Representative.

PRELIMINARY CONSIDERATIONS

2.1 Insulation products and all accessory materials must be transported, stored and handled with appropriate care. Products to be installed must be protected from the elements at all time. Direct contact with soil, humidity and contaminating agents must be avoided.

2.2 Prior to starting the insulation application, all surfaces to be insulated should be properly checked in order to verify that they are clean, dry, and free from oil, grease, dust, rust, scales and loose particles from any past or present activities or processes.

2.3 In the case of metal objects, it is strongly recommended that the surfaces are properly protected against corrosion by means of a suitable corrosion protective coating. This coating should be compatible with the object's material, its maximum operating temperature and with the specified insulation system.

2.4 Any damage or surface imperfection should be repaired, derusted, cleaned and re coated with the same or an equivalent corrosion protective coating. If remaining risks are detected, Owner and Engineer should be informed and works have to be paused until an appropriate solution is convened and necessary measures are carried out.

2.5 For particular situations, alternative measures for corrosion prevention can be specified. As an example: the use of aluminium foil wrapping to protect austenitic steel surfaces against stress corrosion cracking could be an option.

2.6 As in the long term, due to aging, damages, unsatisfactory maintenance and so on, performance of the cladding cannot be fully guaranteed, it is important that the design of the insulation system as well as of all connected piping details, is carried out in such a way that the risk of water ingress and moisture accumulation within the system is minimized.

Mineral wool with very low water absorption under partial immersion test EN 1609 / EN 13472 is preferred. E.g.: PAROC Pro WR products offer superior water repellence at elevated temperatures and perform significantly better than the requirements of EN 1609 / EN 13472.

2.7 All mechanical works, assembly activities and acceptance testing should be completed before the start of the insulation application.

2.8 Surfaces and insulation materials should be kept dry prior to and during the application, until the final cladding is completed. This means that, when works have to be interrupted, for example by the end of a working day, already installed insulation without completed cladding must be covered by means of temporary weather protection.

2.9 Insulation system, including cladding, should be specified with appropriate securing, reinforcing and supporting provisions. These details should be determined at an early design stage, considering geometry, size, type, weight… and further relevant details of all concerned components.

When installing securing, reinforcing and supporting structures, any damages to objects and protective coatings must be strictly avoided.

2.10 In order to achieve the best possible thermal performance of the installed insulation system, it is important to achieve a close fit between the separate insulation components as well as between the insulation and the insulated object.

For some very specific applications though, for example the non-contact system for CUI avoidance purposes, a close fit between object and insulation may not be preferred. In these cases one should realize that the plain thermal performance could be possibly reduced.

DESIGN PARAMETERS AND SYSTEM REQUIREMENTS

3.1 For hot service applications, insulation systems will most frequently be designed aiming to:

- **a** Limit the outer surface temperature in order to provide personnel protection. In this case a maximum surface temperature of 60 °C under all circumstances is commonly considered to be an acceptable figure (although in some regions / markets a lower value may be recommended, such as 55 °C or 50 °C).
- **b** Limit heat losses for process control. Facility Owner and/or Process Engineer will be able to specify the exactly determined figures. Various national and international standards also describe maximum allowed energy losses and/or energy efficiency classes, and these may be adopted.
- **c** Limit heat losses even more, in order to optimize energy savings and minimize total costs.
- **d** Provide freeze protection. For example to prevent frost damage for a specified period of time under extreme ambient conditions, with or without a heat tracing system.
- **e** Maintain a certain minimum process temperature. For example to avoid coagulation of a medium for a specified period of time under extreme ambient conditions, with or without a heating and/or cooling system.
- **f** Prevent unacceptable overheating of the stored substance by solar irradiation

3.2 If additional requirements with respect to CUI avoidance and/or fire protection have to be covered, a specific design of the insulation system would have to be carried out. Such a combined design often requires a specific build-up of the system, eventually with the implementation of additional layers and specific supporting and cladding details.

3.3 Insulation thicknesses will be calculated in compliance with International Standard ISO 12241:2022. This calculation method takes into account all related product properties, system particularities, environmental conditions and process details. PAROC Calculus is a free and easy-to-use calculation tool, which is kept updated with the latest ISO 12241 standard. This is widely used to check compliance with requirements (https://calculus.paroc.com/paroc-calculus/?utm_medium=specification+tanks#/).

3.4 Insulation works shall be carried out in accordance to the respective operating temperature and insulation class, and in compliance with all communicated P&ID documents, equipment arrangement drawings, equipment list, equipment vendor drawings, and insulation thickness tables.

3.5 For practical reasons, it is common for layer thicknesses to be limited to 100 mm. Thicknesses exceeding 100 mm are hence carried out in a double-layer (or multiple-layer for thicknesses > 200 mm) configuration.

However, for certain applications and if required, most PAROC Pro Slabs are available in standard thicknesses up to 200 mm.

A double/multi-layer configuration is also recommended for operating temperatures exceeding 100 °C, whatever the specified total thickness.

APPLICABLE PRODUCT TYPES

4.1 Storage tanks represent essential components in industrial processes. Whether in power plants or process industries, well-designed and efficiently insulated storage tanks are among the prerequisites for properly functioning operations and low maintenance costs.

For industrial applications, PAROC offers a wide range of storage tank insulation solutions, designed for various requirements and consisting of industrially manufactured, compatible insulation components for all kinds of shapes, sizes and operating temperature ranges.

4.2 PAROC storage tank insulation solutions, primarily represented by PAROC Pro Slab (WR) and PAROC Pro Wired Mat (WR) products, are dimensionally accurate and compatible with other PAROC products such as straight pipe sections and pre-fabricated elbow and bend solutions. Installation is straight-forward and results in a technically superior thermal performance.

4.3 The best possible insulation product for a specific application should be selected in order to ensure that the object performs efficiently and sustains a longer life. PAROC wired mat and slab insulation options provide all needed flexibility and quality required for different dimensions and shapes of storage tanks.

Due to the presence of various curvatures, nozzles, attachments..., small diameter tanks and tank components are often best served with flexible wired mat insulation. This insulation is generally more appropriate for small and irregular surfaces, ensuring that all different shapes and geometrical transitions are adequately filled without leaving any voids or air gaps

4.4 Insulation products should be chosen according to the prevailing operating temperature. This temperature will determine as well the choice for a certain product type (high-density products for elevated temperatures...) as the insulation system design (single-layer, double-layer...).

4.5 Often, single-layer solutions are suitable, but for more demanding requirements, double- or even multiple-layer applications should be considered.

A double-layer configuration is recommended for operating temperatures exceeding 100 °C and for thicknesses exceeding 100 mm.

4.6 A further essential consideration to be taken into account when determining the applicable insulation products for a given situation is the relationship between operating temperature and insulation density: for applications with operating temperatures exceeding 350 °C, special attention should be given to the thermal performance, air flow resistivity and maximum service temperature of the insulation product used.

4.7 By installing a better performing first layer, coping with a > 350 °C service temperature, the interface temperature between both layers drops sufficiently to allow for a lower density second layer.

Use the PAROC Calculus tool to perform specific calculations (https://calculus.paroc.com/paroc-calculus/?utm_medium=specification+tanks#/).

4.8 As far as the effect of internal convection in the case of vertical insulation layers is concerned: Standard EN ISO 23993 describes how this effect has to be taken into account by implementing a specific conversion factor “fc” when determining the design thermal conductivity value for thermal calculations.

This conversion factor (≥ 1.00) depends on:

- The total insulation thickness
- The average temperature within the insulation
- The thermal conductivity value for this temperature
- The temperature difference between the limiting surfaces of the system
- The vertical height of the insulation layer

According to the above Standard, the internal convection effect can be disregarded if the airflow resistivity of the fibrous insulation, measured according to EN ISO 9053, is > 50 kPa.s/m²

Practical solutions in order to cope with this phenomenon for elevated operating temperatures and significant wall heights are:

- Implementation of products with higher airflow resistivity values (hence higher densities)
- Implementing convection barriers in the insulation system in order to limit the free heights within the resulting compartmentations.

Consequently, for vertical walls operating at temperatures above 100 °C, applied stone wool mats, wired mats or slabs should have a nominal density of ≥ 80 kg/m³, should contain an air-tight foil facing on the exterior surface and should be installed directly on the object surface, i.e. without air gap at the hot side.

4.9 List with recommended insulation products for storage tank insulation:

Brand name	Nominal density (kg/m^3)	Max. service temp. (°C)
PAROC Pro Slab (WR) 350 (AluCoat)	40	350
PAROC Pro Slab (WR) 450 (AluCoat)	60	450
PAROC Pro Slab (WR) 640 (AluCoat)	80	640
PAROC Pro Slab (WR) 660 (AluCoat)	100	660
PAROC Pro Slab (WR) 680 (AluCoat)	120	680
PAROC Pro Slab (WR) 700 (AluCoat)	150	700
PAROC Pro Roof Slab (WR) 20 kPa	90	300
PAROC Pro Roof Slab (WR) 50 kPa	150	700
PAROC Pro Roof Slab 80 kPa	180	660
PAROC Pro Wired Mat (WR) 550	65	550
PAROC Pro Wired Mat (WR) 660	80	660
PAROC Pro Wired Mat (WR) 680	100	680
PAROC Pro Wired Mat (WR) 700 TH1	130	700
PAROC Pro Lamella Mat AluCoat	50	500
PAROC Pro Lamella Mat Clad	50	500
PAROC Pro Lamella Mat 80 AluCoat	80	500

For the Wired Mats, a series of optional versions is available. These deviations are indicated by a suffix added to the brand name:

- W1: black iron mesh instead of the standard galvanized mesh
- W2: stainless steel mesh and stainless steel sewing wire (1), (2), (3)
- SW2: standard galvanized mesh and stainless steel sewing wire (1)
- AL1: aluminium facing
- AluCoat: alu foil facing

(1) stainless steel sewing wire is needed for operating temperatures exceeding 300 °C

(2) stainless steel mesh is needed if the mesh is expected to be exposed to temperatures > 300 °C, for example as first layer in a multi-layer system or for fire protection purposes

(3) Stainless steel mesh and sewing wire are needed in order to avoid galvanic corrosion in case stainless steel cladding material is used as mechanical protection.

4.10 Recommended storage tank insulation solutions for specific objects, service temperatures and design requirements:

4.10.1 Moderate temperature storage tank walls

When selecting the appropriate insulation materials for storage tank walls, the most important characteristics to be looked at are low thermal conductivity values and outstanding water repellent properties.

Resilience, being a combination of pressure resistance and flexibility, is also a valuable property when insulating vertical walls.

Depending on the tank diameter, either flexible stone wool slabs, such as PAROC Pro Slab 350 WR, or semi-rigid slabs, such as PAROC Pro Slab 450 WR, should be used. For large diameter storage tank walls, and if the operating temperature justfies the use of higher density stone wool, rigid slabs, such as PAROC Pro Slab 660 WR are recommended. All of the above-mentioned products fulfil the complete range of requirements.

In this respect, one should always pay attention to the correlation between the insulation slab rigidity and the object curvature: any type of slab will require (likewise depending on the layer thickness) a certain minimum radius of the covered object.

Two benchmark dimensions need to be checked in order to verify acceptability:

- maximum distance between the inner face of the insulation slab and the surface of the curved object (radial divergence)
- maximum opening of the vertical joint at the outside of the insulation layer (longitudinal joint aperture)

Both values should be kept at a value less than 2 mm at all places, after fixation of the slabs, by means of either self-locking washers on welded pins, or metal straps. If these limits cannot be guaranteed without causing unacceptable crushing of the slabs, an alternative solution needs to be decided.

Depending on the specific situation, this solution could be one of the following substitutions:

- apply lower layer thicknesses, hence more layers (this will reduce the longitudinal joint aperture)
- apply a less rigid, more flexible slab type
- replace slabs by wired mats

Special attention should be addressed to the lower part of the tank wall. In order to limit the consequences of mechanical damage, to avoid accidental ingress of dirt or contaminated moisture into the insulation and to facilitate inspection of the critical welded seam between tank wall and tank base plate, the lower insulation support ring should be installed at a certain height above grade level. This height should be convened with Owner and Engineer and will usually be fixed at a figure between 30 cm and 50 cm.

In some cases, Owner prefers to leave this remaining plinth uninsulated over a height of for example 10 cm. It should be recommended though to install separate insulation and finishing over a height of 30 cm à 50 cm, which is removable without compromising the further tank wall insulation and cladding.

Of course, the detailing of this plinth insulation system should be designed in such a way that the insulation itself is not absorbing any liquids, and that the finishing is protecting against any ingress of water, moisture, eventual leakages…

For more details with respect to the design and application of spacer rings and supporting structures see paragraph 5.11.

4.10.2 Elevated temperature storage tank walls (> 100 °C)

For storage tanks, containing stored liquids at more elevated temperatures, some specific extra considerations need to be taken into account.

For storage temperatures exceeding 100 °C, a double-layer insulation is recommended.

Due to temperature differences between the insulation and cladding, the “chimney effect”, where air flows upwards, occurs in high tank walls. Because of this, we strongly recommend to use insulation slabs which are sufficiently dense, to prevent air movement inside the insulation, and minimize heat convection.

The right product with the appropriate density according to local requirements or insulation specifications should be selected. See paragraph 4.8 for more information.

Storage tanks typically tend to expand/contract due to changes in temperature and when the stored liquid is filled or discharged, the so-called “bulging phenomenon” can appear.

To avoid damage to the cladding, necessary precautions should to be taken in order to deal with expansion/contraction movements.

For elevated storage temperatures, the application of profiled sheeting is a necessary element within the scope of expansion relaxation measures.

4.10.3 Storage tank roofs

It is important to realize that tank roofs should be insulated, even in the case of rather low operating temperatures. Indeed, the thermal resistance of the air layer between the liquid level and the tank roof cannot be considered as sufficient when the storage temperature exceeds 20 °C above the ambient temperature.

The temperature difference between the stored liquid and the insulated tank roof results in heat losses by radiation between the 2 surfaces and by convection of the air in between. Particularly during periods of rainfall, the resulting heat losses can be quite substantial.

For storage temperatures exceeding 100 °C, a double-layer insulation is recommended.

In order to cope with possible foot traffic, tank roofs can be insulated with rigid, pressure-resistant slabs, type PAROC Pro Roof Slab. These insulation slabs for walkable roofs, or roof sectors, are available in different densities, each characterized by a specified compression resistance. This enables Owner, Engineer and insulation contractor to fulfil specific requirements according to specifications.

A typical solution is the use of PAROC Pro Roof Slab (WR) 50 kPa for the entire roof surface and for all layers. This product limits the deformation to maximum 10% under a 50 kPa load.

Alternatively, a relatively thin top layer (20 mm minimum) of PAROC Pro Roof Slab 80 kPa could be applied over one or more underlying layers of PAROC Pro Roof Slab (WR) 20 kPa.

The slabs themselves do not need any fixing, but the cladding should be anchored to the tank roof through the insulation layer. When, due to geometrical reasons (if too small radiuses are involved), the application of rigid slabs is not possible, semi-rigid slabs (for example PAROC Pro Slab 450) or flexible slabs (for example PAROC Pro Slab 350) or PAROC wired mats need to be used instead. To ensure foot traffic in those cases, supporting structures need to be implemented. These supporting structures can vary according to different specifications and standards.

If the tank roof surface needs to be made fit for foot traffic only partially, distinction can be made between parts with a pressure-resistant insulation system, and other, not readily treadable, surfaces. In that case, the actual walkways need to be clearly indicated.

Three-dimensionally shaped tank roofs, either domed or conical, should be finished by means of proper cladding, made of flat metal sheeting. Generally this will be aluminium, but galvanized steel, aluminized steel, alu-zinc coated steel, austenitic stainless steel, pre-painted steel... can also be used, according to specific needs or local preferences.

INSULATION APPLICATION DETAILS

5.1 All PAROC Pro Mat, PAROC Pro Wired Mat, PAROC Pro Lamella Mat and PAROC Pro Slab products are delivered with a specific design, shape and size in order to facilitate convenient handling and easy installation on any kind of storage tank wall, tank roof tank component.

5.2 As a general rule, on tank walls, Mats, Lamella Mats and Wired Mats should be applied in horizontal bands, Slabs are positioned vertically. Vertical joints should be staggered by at least 150 mm.

5.3 Installed insulation components should ensure a perfect fit to the object surface as well as to each other, to avoid convective air movement and resulting heat losses. Adjacent insulation components should be carefully pressed together in order to avoid thermal bridges due to open joints.

5.4 In some cases a double-layer application may be needed. This could be the case when:

- **a** The calculated insulated thickness exceeds 100 mm
- **b** The service temperature exceeds 100 °C
- **c** Specific layering with intermediate foils is specified
- **d** Specific engineering obligations should be met, for example to facilitate the implementation of “soft” heat tracing, which is installed in between 2 separate insulation layers

5.5 When installing double- or multiple layer insulation, layering and staggering of the insulation should be perfectly aligned and all joining insulation components should be neatly pressed together in order to avoid thermal bridges.

Assembly and securement of all layers should be applied in the same way as in the previous paragraphs.

5.6 Securement of the outer insulation layer should be accomplished by means of galvanized or stainless steel bands with minimum dimensions 19 mm x 0.5 mm. For the securement of underlying insulation layers, steel bands with minimum dimensions of 16 mm x 0.5 mm should be applied. Interspacing is recommended not to exceed 300 mm.

5.7 Wired mats option: all joints should be tied together by means of 10 blanket hooks per meter, or sewn with galvanized or stainless steel tie wire, 0.7 mm diameter, and then be secured by means of the above-mentioned steel bands.

5.8 Lamella mats option: all joints should be taped together by means of selfadhesive tape and then be secured by means of the above-mentioned steel bands.

5.9 If welding to the object's surface is permitted, the securement with the steel bands can be replaced by an alternative fixation of the insulation by means of welded pins and self-locking washers. In this case, approximately 6 welded pins per m² are recommended. For suspended insulation, a minimum of 10 pins per m² is recommended.

5.10 In the case of tank roofs, domed roofs as well as conically sloped roofs, securement of the insulation can be achieved by means of bands, connecting the fixed supporting ring at the tangent line with a floating ring located at the head centre. Spacing between the bands at the supporting ring should not exceed 150 mm.

5.11 Specific considerations with respect to the integration of spacers and supporting structures within the storage tank insulation system.

5.11.1 Spacers: definition and construction details.
Spacers keep the insulation cladding at the intended distance from the insulated object when the installed insulation material itself is not capable of maintaining this function. These rings exclusively deal with forces which are effective perpendicularly to the insulated object.

Following recommendations should be taken into consideration:

- A minimum of 3 spacers (distancers) per ring for steel spacers, a minimum of 4 pieces for ceramic spacers
- A maximum interspace between 2 spacers (distancers) of 400 mm for steel spacers, 250 mm for ceramic spacers

5.11.2 Supporting structures: definition and construction details.
Supporting structures deal with forces exercised by the insulation and cladding loads and other forces effective on the insulation system. These loads are transferred to the insulated objects by means of mounting supports (brackets) which are welded on the object's surface or by direct welding of the structures. In some cases, screwed or clamped constructions can be used if they can be securely anchored by already present tank components or attachments.

5.11.3 Need for spacers and supporting structures.
As explained above, the application of spacers and supporting structures is essential and should be considered very carefully before starting any insulation job.

Mounting provisions, to which the needed supporting structures can be fitted during the further insulation and cladding assembly, have to be installed before starting any storage tank insulation application. This can be accomplished by welding, screwing, clamping…

Specific types, location, dimensions and further details thereof, have to be determined according to the considered design loads, in compliance with the relevant norms and guidelines as listed under paragraph 10.

Parameters to be considered:

- Mass of the insulation system, including cladding and all accessories
- Type of the insulation material, specifically its longtime stability and further mechanical properties at the designed service temperature
- Geometry, positioning (vertical, horizontal, sloped…), dimensions, external loads, vibrations…

Depending on the actual geometry and dimensions of the insulated object and on the type of the applied insulation and cladding, supporting structures can, in parallel, assume the function of spacer provisions. In such cases, separate spacers are not needed.

Typically, support rings have to be installed at the base of the tank wall insulation as well as just underneath the wall-roof edge. Extra rings are necessary for tank wall heights exceeding 3 m. The maximum interspacing between support rings depends on the cladding type and should be determined before the start of the insulation application. Maximum interspacing between two support rings should preferably not exceed 3 m.

NOTES ON INSULATION SYSTEM FINISHING OPTIONS

6.1 Several parameters should be considered when selecting a finishing material for a given situation. Some of most crucial parameters to be looked at before a final choice can be decided on are for example:

- Indoor or outdoor situation
- Climatological conditions: temperature, rain, ice, wind force, airborne particles, direct sunlight, ozone…
- Resistance to mechanical damage
- Resistance to moisture, vapours, chemical substances in the surrounding atmosphere
- Resistance to spillage of corrosive or flammable liquids
- Reaction to fire classification (Euroclass)
- Fire resistance of the insulation system
- Appearance, resistance to mould growth, ease to clean
- Influence on the thermal performance of the system and/or on the finish surface temperature for reasons of condensation control or personal protection

6.2 The latter parameter is important with respect to the thermal efficiency and personnel safety and it reflects on the insulation thickness calculation.

In general terms, typically clean metallic surfaces have low emissivity (ε) values and are lower the more polished the surface. Other surface materials, e.g. cloths and plastics will typically have higher ε values.

For any particular combination of geometry, dimensions, operating temperature & ambient conditions, a low emissivity surface will result in a higher surface temperature than if a high emissivity covering was used. This difference in surface temperature can be significant. On the other hand, the difference in the actual heat loss is not so dependent on the surface emissivity. It can be slightly reduced when a low emissivity surface is used but the heat loss itself is much more dependent on the thermal resistance of the insulating layer.

6.3 Generally, the cladding of storage tanks protects the insulation against the impact of mechanical and climatological influences. In most cases, storage tank insulation will be jacketed by means of metallic cladding, which is prepared in specialized sheetmetal shops, on site or at the premises of a specialized insulation contractor.

A wide range of different types of metal sheets is available on the market and a proper choice has to be made, based on all of the considerations as listed under the above paragraph 6.1, and in line with reasoned preferences from Owner, Engineer…

Frequently used material types for flat metal sheets are: aluminium (various alloys and hardness numbers), galvanized steel, alu-zinc coated steel, aluminized steel, stainless steel (various alloys), prepainted steel… All of these are commonly available in thicknesses varying from approximately 0.4 mm up to 1.2 mm.

Flat sheets are primarily used for the tank roofs, which can be flat (sloped), conical or domed, as well as for small and medium diameter tank walls.

Whenever possible, metal cladding on large diameter tank walls should consist of corrugated or profiled sheeting. Among the advantages, besides the relatively easy application and hence a substantial reduction of manhours needed for the installation, are: the structural rigidity, the built-in possibilities to cope with transversal thermal expansion, improved rain shedding behaviour and a reduction of needed supporting structures, hence a reduction of thermal bridges.

An important disadvantage of the use of profiled cladding are the complexities met when adjusting the sheeting around all kinds of protrusions and interruptions. Specific expertise is needed to nicely and professionally finish these details.

The conclusion is that the use profiled sheets is preferred for large diameter tank walls, but only when the number of protrusions is limited.

NOTES ON INSULATION SYSTEM FINISHING OPTIONS

6.4 PAROC offers the possibility to specify factory pre-fitted cladding, already applied on the insulation outer surface, e.g.: the PAROC Pro Clad system - with a relatively high emissivity and hence able to reduce the required thickness in the case of applications where surface temperature control for reason of condensation control or personal protection is aimed at.

PAROC Pro Lamella Mat Clad is made of non-combustible stone wool insulation and is provided with an aluminium coated glass fibre cloth cladding with UV-protection.

This PAROC Pro Lamella Mat Clad product is mainly designed to be used in outdoor applications as a ready-finished insulation layer on various objects as: circular and rectangular ducts, flat surfaces of pipework and industry equipment, cylindrical vessel and drum bodies, containers… Together with the installation tape, PAROC Pro Clad products provide a solution against mechanical stress, e.g.: puncture resistance, and demanding weather conditions, e.g.: water ingress, without additional cladding.

This system can be very useful for the insulation of some smaller components, attached to the storage tanks, for example: heaters, steam manifolds, instruments. Also for the finishing around protrusions in the case of profiled metal cladding on tank walls, the PAROC Pro Lamella Mat Clad system proves to be a quite practical solution.

PAROC Clad Tape is a lasting water resistant butyl rubber tape with very high tack and very high ageing resistance. It is used amongst others for masking of Clad faced products. The butyl sealing tape can be used as moisture and diffusion barriers.

It is ideal for sealing the joints when using PAROC Clad products and it permanently seals facings of elbows and curved surfaces in pipes and ventilation ducts in heating, ventilation and air conditioning engineering. PAROC Clad Tape gives a great finish and safe installation.

PAROC Clad Alu Tape is a UV and weather resistance acrylic adhesive tape based on a special thermoplastic laminate compound with pure aluminium and PVC with excellent ageing resistance. It is used amongst others for masking of Clad faced products.

It is ideal for sealing the joints when using PAROC Clad faced elbows and it permanently seals facings of elbows and curved surfaces in pipes and ventilation duct in heating, ventilation and air conditioning engineering. PAROC Clad Alu Tape gives a great finish and safe installation.

A specially designed plastic spatula for supporting pressure and for optical smoothing of the tape is available.

MEASURES TO AVOID/MITIGATE CORROSION UNDER INSULATION

7.1 Description

Corrosion under insulation (CUI) is often referred to as one of the biggest challenges when it comes to insulation solutions for industrial applications.

CUI can dramatically reduce the lifetime of piping and equipment, and could increase the risk of leakages, shutdowns and potential injury to personnel in the area. A substantial part of maintenance costs on industrial installations can be caused by CUI.

Corrosion under insulation basically refers to the external deterioration of carbon and low alloy steel piping, vessels and industrial equipment that occurs beneath externally clad or jacketed insulation as a result of penetration of water or moisture. CUI can be an issue for both onshore and offshore operations, including petrochemical, refining and power sectors, among many others.

Properly planned and installed insulation solutions can provide many advantages such as decreased heat losses, improved process control, reduced emissions and maintenance, as well as prevention of corrosion under insulation.

On austenitic stainless steel surfaces, the combined influence of tensile stress and a corrosive environment may cause stress corrosion cracking (SCC).

In order to minimize the risk of SCC occurring under insulation, the insulation material should comply with a number of specific acceptance criteria:

- **AGI Q132:** content of leachable chloride-ions should be ≤ 10 mg/kg
- **ASTM C795:** contents of leachable chloride, fluoride, sodium and silicate ions should fit into a specific analysis acceptance diagram

7.2 Solutions

An excellent option to protect insulated metal surfaces from exposure to moisture and other harmful substances is to use highly water-repellent, non-hygroscopic, chemically robust and durable insulation material.

PAROC has been selling water repellent (WR) products for more than 20 years and has continuously invested in research and development to improve its product properties. Latest tests from independent test laboratories prove that PAROC's WR product range for industrial applications has outstanding properties for mineral wool insulation material – very low water absorption combined with a high temperature range. Additionally, PAROC has a broad product offering of WR products including pipe sections, wired mats, mats and slabs.

PAROC water-repellent stone wool insulation products maintain effective protection against CUI by providing outstanding water absorption properties. Third party tests prove that the properties of PAROC Pro Section WR 100 for example are better than the toughest known requirements on the market, when tested against compliance with EN13472.

Moreover, the insulation system itself should always be designed and installed in order to minimize the risk of water ingress into and accumulation within the system.

This includes:

- Water shedding cladding
- Welded sealing discs and covers
- Proper flashings and rain deflectors
- In some cases, non-metallic cladding material can be considered as an option, particularly when complex geometrical transitions and/or multiple protrusions are involved

As, in the long term, absolute avoidance of water ingress cannot be guaranteed, proper design and implementation of accumulated water evacuation solutions should be a prerequisite. The provision of drainage holes (and plugs) and the planning of preventive monitoring and maintenance should be part of the solution.

In this respect: the use of moisture-, water accumulation-, and corrosion-detection systems can be a great help to properly deal with the risks and manage the overall inspection and maintenance costs.

All of the above measures will also help to minimize the risk involved with the CUPS (Corrosion under Pipe Supports) phenomenon. CUPS might occur at support locations such as brackets and clamps which have an inherent tendency to act as entrapment areas for water and other harmful liquids that can lead to corrosion of the supported and insulated object.

Summarizing, proper CUI mitigation measures should include:

- Adequately engineered mechanical design
- The choice for a highly performing insulation material with very low water absorption, according to test methods EN 1609 / EN 13472
- Proper insulation system design and cladding details
- Integrated monitoring, systematic inspections and due maintenance

With respect to the use of PAROC mineral wool on austenitic stainless surfaces:

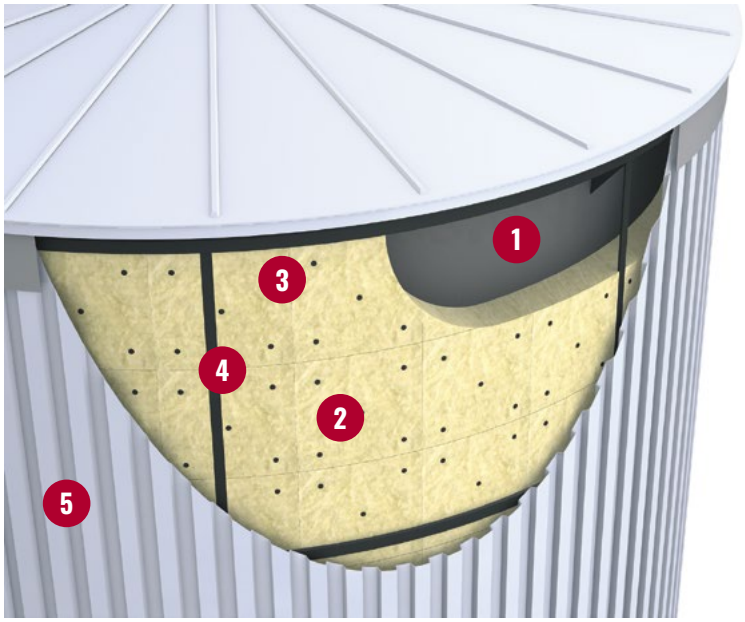
- The maximum content of water-soluble chloride ions (Cl-) of PAROC mineral wool does not exceed 10 ppm. PAROC mineral wool hence fulfils the requirement for the AS-quality designation according to AGI Q132
- Contents of leachable chloride, fluoride, sodium and silicate ions of PAROC mineral wool meet the specific acceptance diagram according to ASTM C795

ATTACHMENT A:
TECHNICAL DRAWINGS WITH INSTALLATION DETAILS

8.1 Tank wall, large diameter.

Typical design:

- PAROC Pro Slabs. Exact slab type, thickness and number of layers depending on design details and operating requirements. Secured by means of welded pins and self-locking washers.
- Supporting structure
- Profiled metal cladding

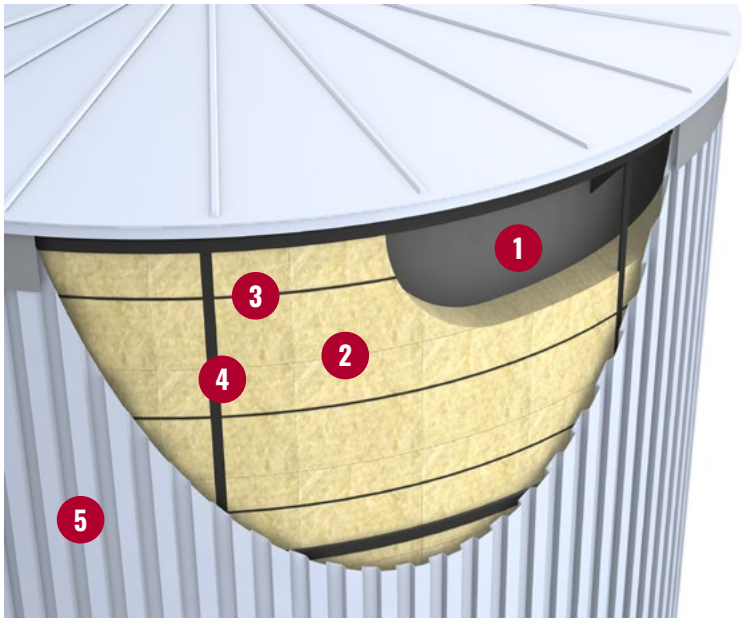


1. **Storage tank wall**
2. **PAROC Pro Slab**
3. **Welded pins and self-locking washers**
4. **Supporting structure**
5. **Profiled metal cladding**

8.2 Tank wall, large diameter, welding not allowed.

Typical design:

- PAROC Pro Slabs. Exact slab type, thickness and number of layers depending on design details and operating requirements. Secured by means of metal bands.
- Supporting structure
- Profiled metal cladding

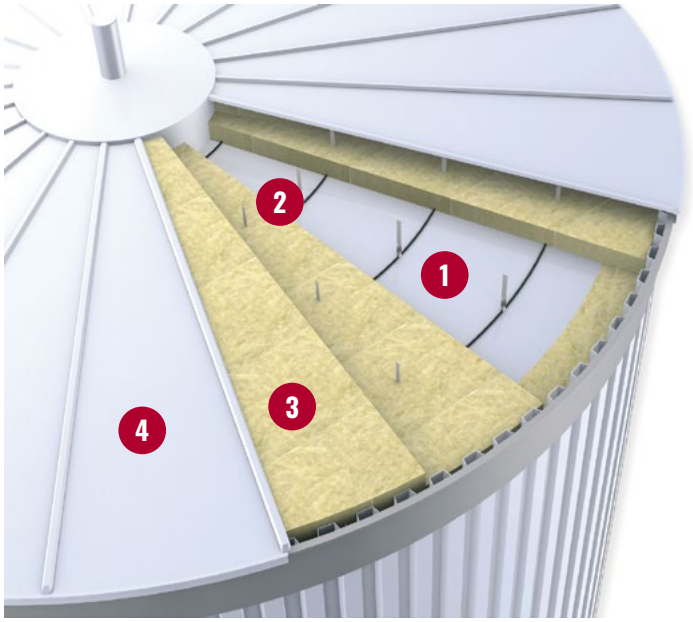


1. **Storage tank wall**
2. **PAROC Pro Slab**
3. **Metal bands**
4. **Supporting structure**
5. **Profiled metal cladding**

8.3 Tank roof, large diameter.

Typical design:

- PAROC Pro Roof Slabs, with high compression resistance. Exact type, thickness and number of layers depending on design details and operating requirements.
- Anchored by means of welded studs.
- Flat metal cladding



1. **Storage tank roof**
2. **Welded studs**
3. **PAROC Pro Roof Slab**
4. **Flat metal cladding**

Click on hyperlink to see detailed product data!

ATTACHMENT B: PRODUCT DATA SHEETS

ATTACHMENT C: APPLICABLE NORMS AND STANDARDS

10.1 International Standardization Organization (ISO)

10.1.1 **ISO 9001** Quality management systems: requirements

10.1.2 **ISO 9002** Quality systems, modelled for quality assurance in production, installation and servicing

10.1.3 **ISO 834** Fire resistance tests

10.2 European Standards (EN)

10.2.1 **EN 14303:2009+A1:2013** Thermal insulation products for building equipment and industrial installations. Factory made mineral wool (MW) products – Specification

10.2.2 **EN 822** Thermal insulating products for building applications - Determination of length and width

10.2.3 **EN 823** Thermal insulating products for building applications - Determination of thickness

10.2.4 **EN 824** Thermal insulating products for building applications - Determination of squareness

10.2.5 **EN 826** Thermal insulating products for building applications - Determination of compression behaviour

10.2.6 **EN 1604** Thermal insulating products for building applications - Determination of dimensional stability under specified temperature and humidity conditions

10.2.7 **EN 1609** Thermal insulating products for building applications - Determination of short term water absorption by partial immersion

10.2.8 **N 12086:2013** Thermal insulating products for building applications - Determination of water vapour transmission properties

10.2.9 **EN 12087:2013** Thermal insulating products for building applications - Determination of long term water absorption by immersion

10.2.10 **EN 12667** Thermal performance of building materials and products - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Products of high and medium thermal resistance

10.2.11 **EN 12939** Thermal performance of building materials and products - Determination of thermal resistance by means of guarded hot plate and heat flow meter methods - Thick products of high and medium thermal resistance

10.2.12 **EN 13162:2012+A1:2015** Thermal insulation products for buildings - Factory made mineral wool (MW) products – Specification

10.2.13 **EN 13172:2012** Thermal insulation products - Evaluation of conformity

10.2.14 **EN 13467** Thermal insulating products for building equipment and industrial installations - Determination of dimensions, squareness and linearity of preformed pipe insulation

10.2.15 **EN 13468** Thermal insulating products for building equipment and industrial installations - Determination of trace quantities of water soluble chloride, fluoride, silicate, sodium ions and pH

10.2.16 **EN 13469** Thermal insulating products for building equipment and industrial installations - Determination of water vapour transmission properties of preformed pipe insulation

10.2.17 **EN 13472** Thermal insulating products for building equipment and industrial installations - Determination of short term water absorption by partial immersion of preformed pipe insulation

10.2.18 **EN 13501-1:2007+A1:2009** Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests

10.2.19 **EN 13820** Thermal insulating materials for building applications - Determination of organic content

10.2.20 **EN 13823** Reaction to fire tests for building products — Building products excluding floorings exposed to the thermal attack by a single burning item

10.2.21 **EN 14706** Thermal insulating products for building equipment and industrial installations - Determination of maximum service temperature

10.2.22 **EN 14707** Thermal insulating products for building equipment and industrial installations - Determination of maximum service temperature for preformed pipe insulation

10.2.23 **EN 14477** Determination of puncture resistance – test methods

10.2.24 **EN 15715:2009** Thermal insulation products - Instructions for mounting and fixing for reaction to fire testing - Factory made products

10.2.25 **EN ISO 1182** Reaction to fire tests for products - Non-combustibility test (ISO 1182)

10.2.26 **EN ISO 1716** Reaction to fire tests for products - Determination of the gross heat of combustion (calorific value) (ISO 1716)

10.2.27 **EN ISO 8497** Thermal insulation - Determination of steady-state thermal transmission properties of thermal insulation for circular pipes (ISO 8497)

10.2.28 **EN ISO 9229:2007** Thermal insulation - Vocabulary (ISO 9229:2007)

10.2.29 **EN ISO 10456** Building materials and products - Hygrothermal properties -Tabulated design values and procedures for determining declared and design thermal values (ISO 10456)

10.2.30 **EN ISO 11925-2** Reaction to fire tests - Ignitability of products subjected to direct impingement of flame - Part 2: Single-flame source test (ISO 11925-2)

10.2.31 **EN ISO 13787** Thermal insulation products for building equipment and industrial installations - Determination of declared thermal conductivity (ISO 13787)

10.2.32 **EN ISO 12241:2022** Thermal insulation products for building equipment and industrial installations - Calculation rules (ISO 12241:2022, Corrected version 2022-11)

10.2.33 **EN ISO 23993** Thermal insulation products for building equipment and industrial installations - Determination of design thermal conductivity (ISO 23993:2008)

10.3 National Standards (DIN, BS…)

10.3.1 **DIN 4140** Thermal insulation works on industrial installations and building equipment

10.3.2 **BS 5970:2012** Thermal insulation of pipework, ductwork, associated equipment and other industrial installations in the temperature range of -100 °C to 870 °C – Code of Practice

10.4 Specific Norms and Guidelines (VDI, AGI, ASTM, CINI…)

10.4.1 **VDI 2055** Technical basics for the verification of properties of insulation materials

10.4.2 **AGI Q132** Mineral wool insulation material for industrial installations

10.4.3 **AGI Q154** Insulation works at industrial installations: support and spacer constructions

10.4.4 **ASTM C795** Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel
ASTM C547 Standard Specification for Mineral Fiber Pipe Insulation
ASTM C592 Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
ASTM C612 Standard Specification for Mineral Fiber Block and Board Thermal Insulation

10.4.5 **CINI** Insulation manual for industries

DISCLAIMER

The information relating to the products and systems contained in this communication (“Information”) is accurate and reliable to the best of our knowledge as of its date issued and is subject to change without prior notice. No guarantee of accuracy is given or implied.

Since Paroc has no control over installation workmanship, accessory materials or conditions of application, no express or implied warranty of any kind, including those of merchantability or fitness for a particular purpose or course of performance or usage of trade, is made as to the performance of an installation containing Paroc products.

While the Information in this communication may relate to the technical application of certain Paroc products, it is in no event to be considered as technical advice on the basis of which Paroc may incur any liability.

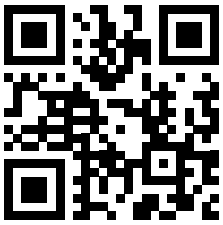
User is solely responsible for determining whether a Paroc product is fit for a particular purpose and suitable for user’s method of use or application.

Users of the provided Information assume full responsibility for all concept/design decisions made relating to the suitability of use.

Users must rely on their own judgment or that of a concept/design professional when determining how to best apply the data provided.

Users agree that Paroc is under no obligation to provide additional details, testing or test data on its behalf.

Liability of Paroc, if any, is strictly limited to replacement of product. In no event shall Paroc be liable for any other damages arising because of product failure, whether incidental, special, consequential or punitive, regardless of the theory of liability upon which any such damages are claimed.



Applications: 2024
1243TIEN0724