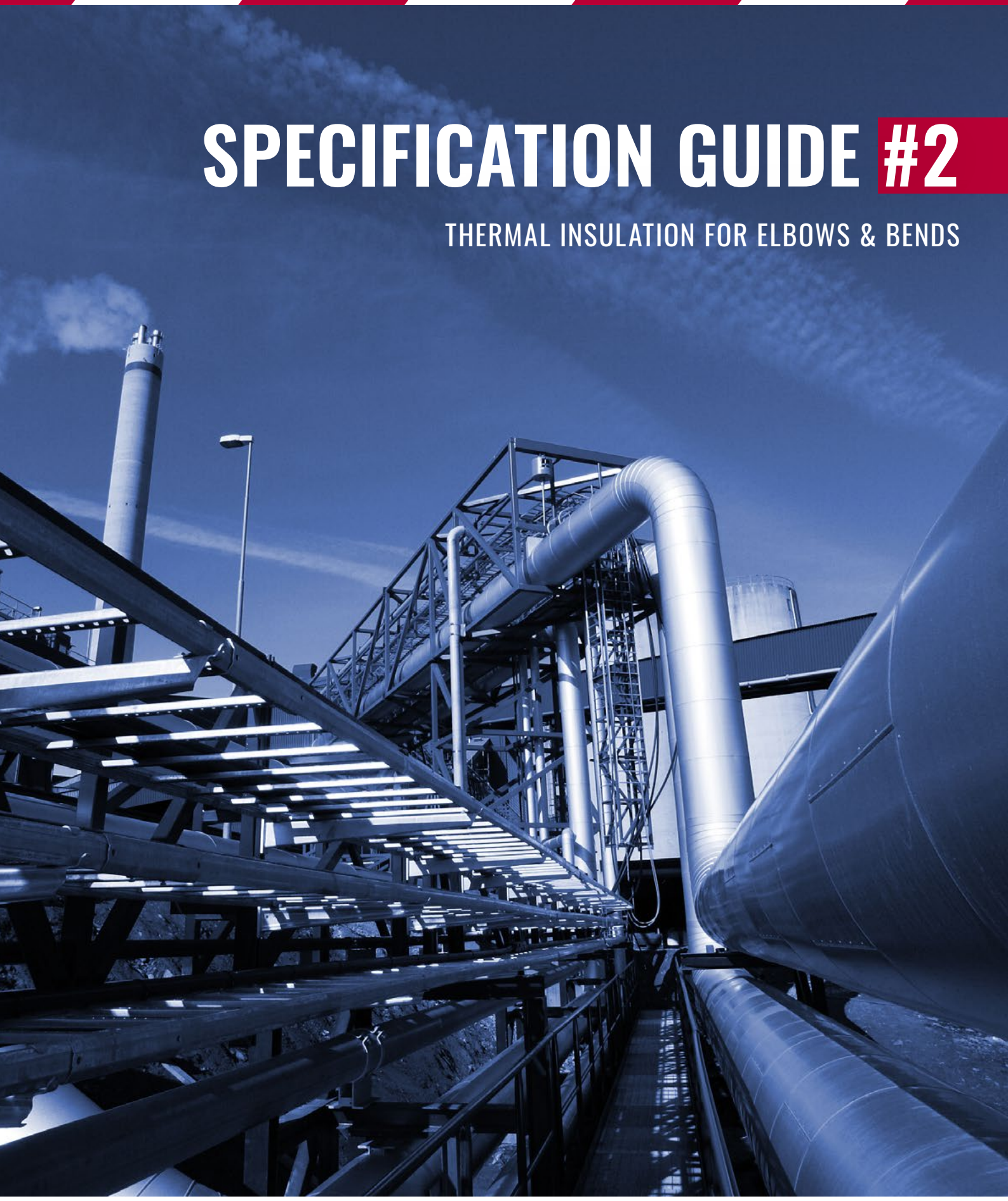
SPECIFICATION GUIDE #2

THERMAL INSULATION FOR ELBOWS & BENDS



OWENS CORNING® PAROC®

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EXTENT OF THIS SPECIFICATION

1.1 This specification covers the insulation of elbows and bends in hot pipes, installed above-ground, both in the open air or under cover.

1.2 The service temperature range extends from ambient up to 680 °C.

1.3 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.

1.4 Any additional system requirements such as fire protection and/or sound attenuation are described in separate specifications and have to be read and conformed to in combination with this specification.o

PRELIMINARY CONSIDERATIONS

2.1 Insulation products and all accessory materials should be transported, stored and handled with appropriate care. Products to be installed should be protected from the elements at all time. Direct contact with soil, humidity and contaminating agents should 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 should 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 for example mechanical impacts, unsatisfactory maintenance weather exposure can result in degradation and damaging the external cladding, it is important that the design of the insulation system as well as of all 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 ≤ 0.1 kg/m² after 300 °C prebake.

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 straight pipes 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 should 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 straight pipes 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, a close fit between object and insulation may not be preferred. Examples are: some particular acoustical solutions and the non-contact system for CUI avoidance purposes. 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 heat tracing system.

3.2 If additional requirements with respect to CUI avoidance, sound reduction 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+pipe+elbows#/).

3.4 Insulation works should be carried out in accordance to the respective operating temperature and insulation class, and in compliance with all communicated P&ID documents, piping arrangement drawings, piping isometrics, line designation table 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 should be carried out in a double-layer (or multiple-layer for thicknesses > 200 mm) configuration.

A double-layer configuration is also necessary for operating temperatures exceeding 250 °C, whatever the specified total thickness.

APPLICABLE PRODUCT TYPES

4.1 Pipes represent an essential component in industrial processes. Whether in power plants or process industries, well-designed and efficiently insulated pipework is one of the prerequisites for properly functioning operations and low maintenance costs. For industrial applications, PAROC offers a wide range of pipe insulation solutions, designed for various requirements and consisting of industrially manufactured, compatible insulation components for straight pipes, as well as for pipe bends.

4.2 PAROC elbow and bend insulation solutions, represented by PAROC Pro Segment (WR), PAROC Pro Bend (WR) and PAROC Pro Curve (WR) products, are dimensionally accurate and compatible with other factory-prefabricated components such as straight pipe sections. Installation is straight-forward and results in a technically superior thermal performance. The components have less need to be measured and cut-to-fit on site, nor do they require any additional metal cladding supporting structure, as is associated with wired mats. These important advantages can minimise a common root cause of unwanted heat losses and result in a rapid and economical installation, which is substantially less time-consuming when compared to the application of traditional mats or blankets.

4.3 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…).

4.4 Often single-layer solutions are suitable, but for more demanding requirements, double-layer applications should be considered.

A double-layer configuration is recommended for operating temperatures exceeding 250 °C and for thicknesses exceeding 100 mm.

4.5 With the “DL” products, PAROC offers both an economical and quality-assuring solution as these indicate a double-layer elbow segment system, with the first layer fitted inside the second layer. The parts are precisely measured during

production in order to perfect compatibility and fit, resulting in a highly performing insulation system, supporting first-class insulation properties.

These “DL” products are handled as a unique item, which means that each package includes all pieces required for both inner and outer layer, hence eliminating unnecessary waste. This characteristic eases logistics, which reflects positively on storage, transportation and handling costs on its way to the construction site, as well as on the site itself.

4.6 A further essential consideration to take into account when determining the applicable insulation products for a given situation is the relationship between operating temperature and insulation density.

We strongly suggest to use products with a density of 130-140 kg/m³ as a first layer when the operating temperature exceeds 350 °C.

4.7 In nearly all of the situations where the higher density of 130-140 kg/m³ is used to cope with a > 350 °C service temperature, the interface temperature between both layers drops sufficiently to allow for a 100 kg/m³ second layer. For example, a smart pipe elbow insulation solution assuring a fit for this combined 140 (1st layer) + 100 (2nd layer) situation, has been developed and is available as PAROC “DL 1”.

4.8 List with recommended insulation products for pipe elbows and bends:

Brand name	Nominal density (kg/m^3)	Max. service temp. (°C)
PAROC Pro Segment (WR) 100 (AluCoat)	100	640
PAROC Pro Segment (WR) 140 (AluCoat)	140	680
PAROC Pro Segment (WR) 140 Clad	140	680
PAROC Pro Segment (WR) DL 100 (AluCoat)	100	640
PAROC Pro Segment (WR) DL 1 (AluCoat)	140/100	680
PAROC Pro Segment (WR) DL 140 (AluCoat)	140	680
PAROC Pro Bend (WR) 100 (AluCoat)	100	640
PAROC Pro Bend (WR) 140 (AluCoat)	140	680
PAROC Pro Bend (WR) 140 Clad	140	680
PAROC Pro Curve (WR) 100 (AluCoat)	100	640
PAROC Pro Curve (WR) 140 (AluCoat)	140	680

4.9 Overview with recommended pipe elbow and bend insulation solutions as a function of service temperature and insulation thickness:

Service temp. (°C)	Optional systems	
≤ 250 °C and ≤ 100 mm	@ 1 layer	Pro Segment (WR) 100 (AluCoat) or: Pro Bend (WR) 100 (AluCoat) or: Pro Curve (WR) 100 (AluCoat)
≤ 250 °C and > 100 mm	@ 2 layers @ "DL"	1st: Pro Segment (WR) 100 or: Pro Bend (WR) 100 or: Pro Curve (WR) 100 2nd: Pro Segment (WR) 100 (AluCoat) or: Pro Bend (WR) 100 (AluCoat) or: Pro Curve (WR) 100 (AluCoat) Pro Segment (WR) DL 100 (AluCoat)
> 250 °C and ≤ 350 °C	@ 2 layers @ "DL"	1st: Pro Segment (WR) 100 or: Pro Bend (WR) 100 or: Pro Curve (WR) 100 2nd: Pro Segment (WR) 100 (AluCoat) or: Pro Bend (WR) 100 (AluCoat) or: Pro Curve (WR) 100 (AluCoat) Pro Segment (WR) DL 100 (AluCoat)
> 350 °C	@ 2 layers @ "DL1" @ "DL"	1st: Pro Segment (WR) 140 or: Pro Bend (WR) 140 or: Pro Curve (WR) 140 2nd: Pro Segment (WR) 100 (AluCoat) or: Pro Bend (WR) 100 (AluCoat) or: Pro Curve (WR) 100 (AluCoat) Pro Segment (WR) DL 1 (AluCoat) Pro Segment (WR) DL 140 (AluCoat)

Notes

The above-mentioned PAROC Pro Segment insulation products are available for pipe diameters from 114 mm and up. For small and medium size pipes (up to 168 mm diameter), PAROC Pro Bend insulation products can be used. The PAROC Pro Curve solution for elbow insulation is available for pipe diameters from 114 mm and up.

All of these products are manufactured in order to fit most common pipe elbow types:

- PAROC Pro Bend products are standardized for 90° elbows with 1.5 D radius
- PAROC Pro Segment products are standardized for 90° elbows with 1.5 D as well as 2.5 D radius
- PAROC Pro Curve products are standardized for 90° and 45° elbows with 1.5 D radius

Upon request, products for various other, deviating, radiuses can be manufactured.

4.10 Considerations with respect to the optional use of mats as an alternative to preformed Segments / Bends / Curves for the insulation of elbows and bends.

4.10.1 Preformed Segments / Bends / Curves are the standard system

PAROC has developed special solutions for pipe elbow insulation which perform as effectively as straight pipe insulation. Prefabricated PAROC Pro Segments (WR), PAROC Pro Bends (WR) and PAROC Pro Curve (WR) are a technically effective, fast and economic way to insulate pipe elbows and bends.

PAROC preformed Segments / Bends / Curves are dimensionally accurate and compatible with other factory-made components, such as straight pipe sections. Installation is straight-forward, in general easy, and results in a technically superior insulation performance. The components do not need to be further measured or modified on-site, nor do they require any additional metal cladding support structure associated with wired mats.

This can eliminate a common cause of heat loss.

The benefits of PAROC elbow and bend insulation solutions can be particularly significant as they consist of the same material, with identical properties, as used for pipe sections, hence without the need for on-site cutting and spacer rings that make installing traditional mat insulation so time-consuming.

One of the primary advantages of PAROC preformed elbow and bend solutions over a wired mat insulation system is the ease and accuracy of the installation process.

The insulation thickness can be reduced significantly with these preformed elbow and bend insulation solutions, due to omission of cladding spacer thermal bridges, as described in ISO 12241:2022. This lesser insulation thickness also reduces insulation material costs, cladding costs, labour costs and the total installed mass. With the preformed solutions, the overall installation time is shorter. This means that scaffolding and other equipment is needed for a shorter period and that general on-site costs are lower.

4.10.2 Wired mats option

The use of wired mats should be avoided for pipe diameters < DN 250.

Joints should be tied together by means of hooks or sewn with tie wire. The eventual need of spacer rings and supporting rings and the exact dimensioning and location thereof must be considered at all times.

Disadvantages:

- Proper installation is time-consuming because:
  - mats have to be adequately measured and cut in order to achieve a perfect fit on elbows and bends
  - spacer rings need to be installed
  - securement of all joining seams by means of tie wire or hooks is needed
- Less thermal performance because of:
  - thermal bridges due to risk of imperfect joint closing
  - thermal bridges due to need of spacer rings
  - the risk of imperfect contact to the elbow surface
- Higher design thermal conductivity values when compared to preformed elbow insulation components, hence higher thicknesses needed for a similar thermal performance

Advantages:

- Practical when elbows and bends are irregularly shaped and/or dimensioned, for example in the case of non-standard radius and/or angle
- More readily available on site for quick response jobs and urgent maintenance interventions
- Very good thermal behaviour at very high operating temperatures. Wired mats (especially the higher density mats > 100 kg/m³) are an option for the temperature range 350 °C → 700 °C

4.10.3 Lamella mats option

Due to the exceptional compressive strength when compared to wired mats, lamella mats can be considered as an alternative to preformed elbow and bend insulation components for certain cases.

The use of lamella mats should be avoided for pipe diameters < DN 250 or for operating temperatures > 500 °C, or for a first layer in a double / multi-layer system.

Joints should be taped together by means of self-adhesive tape and secured by means of steel bands.

Disadvantages:

- Proper installation is time-consuming because:
  - mats have to be adequately measured and cut in order to achieve a perfect fit on elbows and bends
  - taping over of all joining seams and fastening with steel bands is needed
- Less thermal performance because of:
  - thermal bridges due to risk of imperfect joint closing
  - risk of imperfect contact to the elbow surface
- Higher design thermal conductivity values when compared to preformed elbow insulation components, hence higher thicknesses needed for a similar thermal performance

Advantages:

- Practical when elbows and bends are irregularly shaped and/or dimensioned, for example in the case of non-standard radius and/or angle
- May be a practical solution for quick response jobs and urgent maintenance interventions.

INSULATION APPLICATION DETAILS

5.1 PAROC Pro Segment (WR) / Pro Bend (WR) / Pro Curve (WR) products are delivered as preformed components with a specific design and geometry in order to facilitate convenient handling and easy installation along the pipe elbow / bend and to assure a perfect alignment with the adjacent straight pipe insulation sections.

5.2 For elbows/bends in the horizontal plane, the lineal slits / seams are located as follows:

- PAROC Pro Segment: at 0:00 - 6:00 hr. positions
- PAROC Pro Bend: at 3:00 - 9:00 hr. positions
- PAROC Pro Curve: at 3:00 - 9:00 hr. positions

5.3 For horizontal pipes, supporting structures are not needed. For vertical pipes, the need for supporting structures ought to be determined, based upon a number of considerations as: pipe size, local situation, weight of the insulation and cladding, presence of lugs, tie-ins, T-pieces, piping supports and so on.

A reasonable standard approach is that, if the vertical height of the pipe exceeds 4 m, a support ring should be provided right above the bottom elbow or flange or Tee. As a minimum, further supports should be added every 4 m. Pipes with an inclination angle ≥ 45° should be considered as vertical pipes.

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

5.5 Securement of the preformed elbow and bend insulation components should be accomplished by means of lacing wire, preferably made of galvanised steel, 0.7 mm diameter, or stainless steel, 0.5 mm diameter.

- PAROC Pro Segment: each separate elbow insulation segment should be secured by at least one wire lacing. Maximum spacing between lacings, measured on the outer curvature, should not exceed 300 mm.
- PAROC Pro Bend: should be secured by means of minimum 2 wire lacings. Maximum spacing between lacings, measured on the outer curvature, should not exceed 300 mm.
- PAROC Pro Curve: should be secured by means of minimum 2 wire lacings. Maximum spacing between lacings, measured on the outer curvature, should not exceed 300 mm.

5.6 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 250 °C
- **c** Specific layering with intermediate foils is specified, for example to meet acoustical requirements
- **d** Specific engineering obligations need to be met, for example to facilitate the implementation of “soft” heat tracing, which is installed in between 2 separate insulation layers

5.7 When installing a double-layer insulation, layering and staggering of the elbow insulation need to be aligned with the adjacent straight pipe insulation and all joining insulation parts need to be neatly pressed together in order to avoid thermal bridges.

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

5.8 For pipes with a diameter exceeding 250 mm, the securement of the outer insulation layer should be accomplished by means of galvanized or stainless steel bands with minimum dimensions 12 mm x 0.5 mm. Application and spacing details are the same as mentioned above.

5.9 Wired mats option: joints should be tied together by means of hooks or sewn with tie wire

5.10 Lamella mats option: joints should be taped together by means of self-adhesive tape and secured by means of steel bands.

INSULATION APPLICATION DETAILS

5.11 Special consideration should be taken with respect to the integration of spacer rings and support rings within the pipe insulation system.

5.11.1 Spacer rings: definition and construction details.
Spacer rings 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.

- Minimum 3 spacers (distancers) per ring for steel spacers, minimum 4 pcs for ceramic spacers
- Maximum interspace between 2 spacers (distancers): 400 mm for steel spacers, 250 mm for ceramic spacers

5.11.2 Support rings: definition and construction details.
Support rings 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 rings. In some cases, screwed or clamped rings can be used if they can be securely anchored by already present pipe components or attachments.

5.11.3 Need for spacer rings.

- **Preformed elbow insulation:** usually, no spacer rings are needed.
- **Lamella mats:** recommended in case of strong vibrations. Lamella mats should not be used for service temperatures > 300 °C.
- **Wired mats:** provision of spacer rings is typically needed. As a standard these should be located under the exterior cladding overlap.

As an exception, spacer rings for wired mats can be omitted if the application simultaneously meets following conditions:

- Pipe diameter ≤ DN 400
- Insulation outer diameter ≤ 500 mm
- Insulation thickness ≤ 100 mm
- Wired mat density ≥ 80 kg/m³. For lower density wired mats, spacer rings are recommended for pipe diameters > DN 100 and insulation thicknesses > 50 mm

A very beneficial alternative for spacer rings is the use of preformed PAROC Pro Cladding Supports 100 or 140. These pipe section pieces could replace spacer rings in the case of mats without creating thermal bridges.

5.11.4 Need for support rings.

The provision of support rings is obligatory for long vertical pipe runs. Type, location and interspacing should be engineered in compliance with the actual design details. Parameters to be considered: 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
- Pipe size, material, schedule...

Typically, support rings will be necessary in case of vertical pipe runs > 4m. The maximum interspacing between support rings is 4m for wired mats, 6 m for pipe sections.

NOTES ON OPTIONAL INSULATION FINISHES

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
- Fire resistance of the insulation system
- Eventual acoustic requirements
- 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 pipe size, 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 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 able to reduce the required thickness.
PAROC Pro Segment (WR) 140 Clad articles are ready cut segments for medium and large size pipe elbows and bends, made of non-combustible stone wool pipe sections, provided with a UV-resistant fibre reinforced aluminium coating.

PAROC Pro Bend (WR) 140 Clad articles are prefabricated insulation components for small and medium sized pipe elbows and bends, made of non-combustible stone wool, provided with a fibre reinforced aluminium coating.

The above-mentioned PAROC Pro Clad products are mainly designed to be used in outdoor applications. 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.

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 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.

DESIGNED SYSTEMS AS A SOLUTION FOR SPECIFIC REQUIREMENTS

7.1 Corrosion under insulation (CUI)

7.1.1 Description

CUI is one of the biggest challenges when it comes to insulation solutions for industrial applications.

Corrosion under insulation 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 pipes 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

7.1.2 General solution

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. Partial immersion tests (EN 1609/ EN13472) from independent test laboratories (Eurofins, 2019) 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 pipe sections can therefore maintain effective protection against CUI by providing outstanding water absorption properties. Above-mentioned tests prove that the water-repellent properties of PAROC Pro Section WR 100 for example are substantially better than the toughest 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

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 necessity. 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 should 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 pipe.

Summarizing, proper CUI mitigation measures should include:

- Adequately engineered piping 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

As far as the use of PAROC mineral wool on austenitic stainless surfaces is concerned:

- 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

7.1.3

In order to minimize the risk of CUI, PAROC has developed a specific non-contact insulation system: **PAROC CUI SPACERS** + **PAROC PRO WR** prefabricated stone wool products.

When it comes to CUI, elbows and bends in pipes commonly represent the weakest parts of the insulation. Fortunately, PAROC has designed a very adequate solution for this problem: the combined application of PAROC Pro Curve WR with PAROC CUI Spacers substantially reduces the risk of CUI and saves valuable installation time.

There are 2 options to install the spacers:

- Mounted on a belt for diameters ≥ 200 mm
- As single spacers with springs for smaller diameters

PAROC CUI Belt is a PTFE ring qualified for high-temperature environment, tailored to accommodate and align PAROC CUI Spacers around a pipe. Together, these constitute an elegant solution for minimizing corrosion under insulation.

PAROC CUI Belt can act as support structure for PAROC CUI Spacers, facilitating easy installation and a minimum 13mm air gap between the insulation material and the pipe surface, allowing moisture to dry out and leading water away from the pipe surface. For dimensioning guidance, please refer to the separate dimensioning guide.

PAROC CUI Spacer is a silicone distance block qualified for high-temperature environment, placed on a PTFE belt (PAROC CUI Belt). Together, these constitute an elegant solution for minimizing corrosion under insulation.

PAROC CUI Spacers are made of a high-temperature and high-performance silicone material creating a 13 mm air gap between the insulation material and the pipe/elbow surface, allowing moisture to dry out and leading water away from thepipe/elbow surface. For dimensioning guidance, please refer to the separate dimensioning guide.

PAROC CUI Spacers and Belts can be used in systems with a continuous temperature up to 200 °C, with peak temperatures up to 230 °C. **One size fits all pipe dimensions**, allowing easy installation. The 13 mm airgap even provides space for electrical tracing, as well as the above-mentioned moisture, water accumulation, or corrosion detection systems.

7.2 Acoustics

High-speed air, steam and liquid movements in industrial processes usually create a lot of noise, which can adversely affect the working environment of employees. Due to their porous fibre structure and high density, PAROC products – especially when installed as multi-layer solutions – provide good sound insulation, creating a more pleasant working environment.

As far as noise in pipes is concerned, international Standard ISO 15665:2003 “Acoustic insulation for pipes, valves and flanges” defines the required acoustic insulation performance of the systems in order to reduce the noise levels, produced by pipes and related components.

In compliance with this Standard, PAROC provides competitive and certified solutions: PAROC mineral wool products can function as the important porous layer in the acoustic insulation assembly. This layer can act as a resilient vibration-isolating support for the outer cladding, actually converting acoustic and vibrating energy into heat.

Therefore, porous layer material should simultaneously fulfil the requirements of not exceeding a specific maximum mechanical stiffness and having an optimum airflow resistivity for the oscillatory flows occurring in sound fields.

PAROC Pro Segment (WR), PAROC Pro Bend (WR), PAROC Pro Curve (WR) as well as wired mats in the density range from 80 kg/m³ up to 120 kg/m³ typically meet these combined criteria.

PAROC specifically designed pipe insulation systems meet the defined insertion loss requirements for Acoustic Classes A, B, C and D (Shell Class).

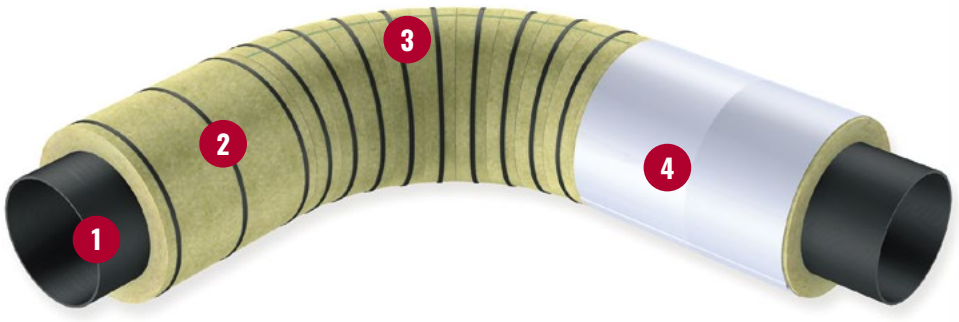
Detailed test reports, describing system build-up and measured performances, referring to the different insulation classes of the above Standard, are available.

ATTACHMENT A:
TECHNICAL DRAWINGS WITH INSTALLATION DETAILS

8.1 Single layer elbow insulation

Typical design:

- Single-layer PAROC Pro Segment (WR) on pipe elbow
- Single-layer PAROC Pro Section (WR) on adjacent straight pipe

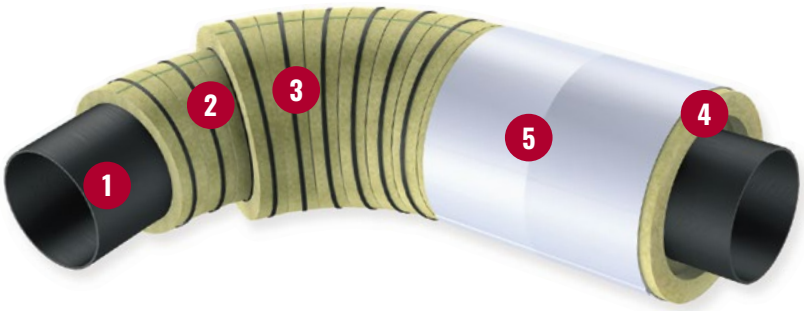


1. **Pipe / elbow**
2. **PAROC Pro Section (WR) with proper securement**
3. **PAROC Pro Segment (WR) with securement**
4. **Insulation system finish**

8.2 Double-layer elbow insulation

Typical designs depending on service temperature:

- two layers of PAROC Pro Segment (WR) 100 (AluCoat)
- 1st layer of PAROC Pro Segment (WR) 140 +
  2nd layer of PAROC Pro Segment (WR) 100 (AluCoat)
- PAROC Pro Segment (WR) DL 100 (AluCoat)
- PAROC Pro Segment (WR) DL 1 (AluCoat)
- PAROC Pro Segment (WR) DL 140 (AluCoat)

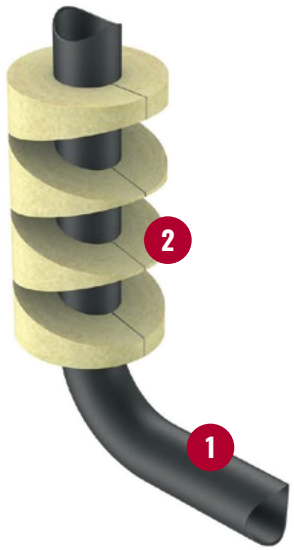


1. **Pipe / elbow**
2. **PAROC Pro Segment (WR), 1st layer**
3. **PAROC Pro Segment (WR), 2nd layer**
4. **PAROC Pro Lock on adjacent pipe**
5. **Insulation system finish**

8.3 Single-layer elbow insulation on small diameter pipe elbow

Typical designs depending on service temperature:

- Single-layer PAROC Pro Bend (WR) on pipe elbow
- Single-layer PAROC Pro Section (WR) on adjacent straight pipe

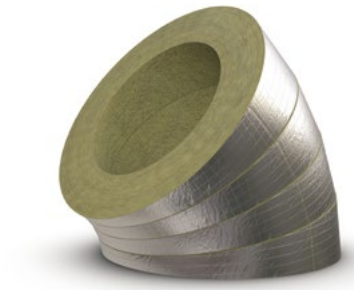


1. **Pipe / elbow**
2. **PAROC Pro Bend (WR)**

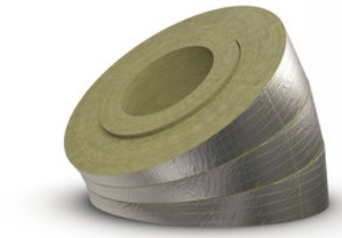
8.4 Elbow insulation solutions, provided with a factory applied finish

Typical solutions:

- PAROC Pro Segment (WR) AluCoat
- PAROC Pro Segment (WR) DL AluCoat



PAROC Pro Segment (WR) AluCoat

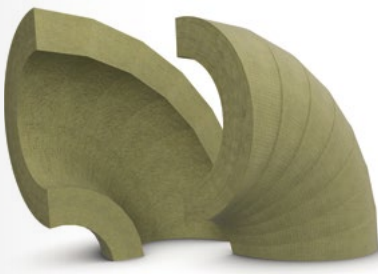


PAROC Pro Segment (WR) DL AluCoat

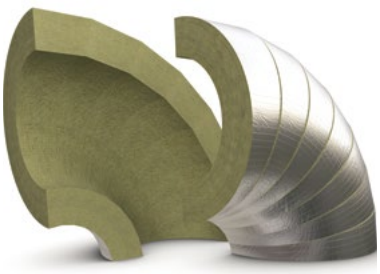
8.5 Curve-type elbow insulation solutions

Typical designs with optional factory applied finish:

- PAROC Pro Curve (WR)
- PAROC Pro Curve (WR) AluCoat



PAROC Pro Curve (WR)



PAROC Pro Curve (WR) AluCoat

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

10.1.4 **ISO 15665** Acoustic insulation for pipes, valves and flanges

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 **EN 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 354** Acoustics - Measurement of sound absorption in a reverberation room (ISO 354)

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

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

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

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

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

10.2.31 **EN ISO 11654** Acoustics - Sound absorbers for use in buildings - Rating of sound absorption (ISO 11654)

10.2.32 **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)

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

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

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 InsulationSteel

10.4.5 **CINI** Insulation manual for industries

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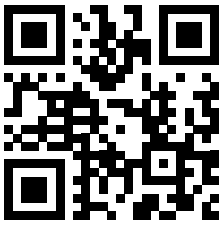

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