

It's all
about
conditions...

ProRox
Industrial insulation

**How to prevent
corrosion?**

ROCKWOOL®
TECHNICAL INSULATION

We share our knowledge to your advantage

ROCKWOOL® Technical Insulation – a subsidiary of the ROCKWOOL Group – develops innovative technical insulation solutions for the process industry and the shipbuilding & offshore market. Through our comprehensive product lines ProRox and SeaRox we offer a full spread of sustainable products and systems guaranteeing the highest possible thermal and firesafe insulation of all technical installations. Our +75 years of experience are reflected in a complete set of high-grade products and expert advice. Today, our dedicated and technically experienced people remain fully committed to providing the very best service and tools in the market and a total range of cutting-edge insulation solutions.

Excellent insulation products, outstanding people

All ROCKWOOL Technical Insulation solutions meet the most stringent quality and safety standards. All ProRox and SeaRox products and constructions have been tested according to the latest regulations and approved by all major classification societies. As an innovation-driven company we demand excellence. In every segment we keep searching for new systems, methods and solutions. We endeavour to develop ever more efficient products and to constantly optimise production processes and processing technologies. And we deliver! Our people know your market down to the smallest detail and provide continual knowledge and service for the benefit of the client. Besides excellent insulation products, they are the real key to our success. Thanks to their expertise and extensive experience, we can offer you exceptional stone wool solutions, expert tools and an impeccable service.

The best solutions, built on solid expertise

Our people's in-depth expertise is the best guarantee that end users in the petrochemicals, power generation, shipbuilding, offshore and the process industries are given the best and most advanced insulation solution. Both in the process industry and in the marine & offshore industry, our stone wool



products offer the highest possible protection against heat and energy loss, fire, noise and other unwanted influences. Our experts will be delighted to share their knowledge and advise you in drawing up technical and project specifications.

Up-to-date information and expert tools

As a highly skilled professional you are always looking for the best possible end result. The quickest way to achieve that is with ROCKWOOL Technical Insulation premium products, and the detailed information and expert tools that come with them, which always incorporate the latest technical findings. That's why you should always check that the information and tools you have are up-to-date. If you have any questions about specific application issues, working methods or product properties, please visit our website at www.rockwool-rti.com contact one of our local sales organisations (see the ☎ on the back of this brochure).

The ROCKWOOL Group, +75 years of experience

ROCKWOOL Technical Insulation is a subsidiary of the ROCKWOOL Group, the world's largest and most experienced producer of stone wool products. ROCKWOOL International A/S is based in Hedehusene, Denmark. The parent company has net turnover of around € 1.97 billion in 2012. ROCKWOOL International has 27 factories in Europe, North America and Asia, and has around 9,700 employees.

ROCKWOOL has a melting point above 1000°C

ROCKWOOL products withstand temperatures up to 1000°C, making them exceptionally resistant to fire. This resistance can slow a fire's progress and buy precious time for rescue operations while helping to protect the building's structure from unnecessary damage. Yet while heat and flames are bad enough in a fire, smoke is the serious danger. It can suffocate occupants, and it can incapacitate people who might otherwise have been able to escape. ROCKWOOL insulation keeps toxic smoke from insulation to a minimum for even greater safety.

Stone wool protects people and the environment

ROCKWOOL products offer effective protection and optimal performance for the entire life cycle of the installation. According to independent research ROCKWOOL is one of the most durable products available with an unequalled combination in the field of environmental improvement, energy savings, CO₂ reduction, acoustic insulation and fire safety. A positive 'carbon footprint': During its entire life cycle, ROCKWOOL insulation will save more than 20,000 times the carbon emissions caused by its production. The fire retardant and fire insulating characteristics of our stone wool products deliver superior protection to people, property and the environment.

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Founding Partner of EIIF

■ ROCKWOOL Technical Insulation was one of the founding partners of the European Industrial Insulation Foundation (EIIF), which has established itself as a resource for industries that need to reduce CO₂ emissions.





It's all about conditions ...

Corrosion is undoubtedly the costliest problem facing industry today. Due to corrosion of piping and equipment under insulation many companies have to repair and/or replace major parts at considerable cost, reported to run into billions of dollars annually. Clearly this considerably reduces the potential service life of industrial plants. More frequently, essential shutdowns and overhauls impair plant efficiency, driving up operating costs.

It is commonly, but wrongly assumed that open or closed cell insulation also protects against corrosion. But if steelwork is not protected with a suitable coating and insulation is not installed under dry conditions and protected by adequate weather-resistant cladding, corrosion under the insulation (CUI) will be a strong possibility. That necessitates repairs and replacements, as well as higher than expected heat losses in the design phase.

Preventing CUI

Making the right decisions to find the right solution is a complex process. With this in mind, preventing corrosion is a serious concern, which must be addressed in the design phase.

- Pipework and equipment must be **designed properly** to ensure supports, fittings and so on are positioned to shed water as much as possible
- The right **anticorrosion surface treatment** must be applied to pipework and equipment and regularly checked as part of a robust maintenance plan
- The **right insulation layer** must be selected to ensure the product is fit for purpose and will not be the source of additional corrosion
- The **right weather protection system** must be chosen. It must be fit for purpose, compatible with the underlying insulation and regularly checked as part of a robust maintenance plan

ROCKWOOL and CUI

ROCKWOOL ProRox products for industrial use comply with all industrial insulation standards and are considered by many to be the most cost-effective, thermally efficient insulation products currently on the market, with excellent sustainability credentials.

- ROCKWOOL ProRox insulation is **hydrophobically treated**, providing effective protection against moisture penetration across the entire insulation thickness.
- The vapour resistance of ProRox products is similar to air. So ProRox products **reduce the risk of condensation** and allow structures to dry out naturally because they can wick away moisture.
- ProRox products are **non-capillary, so they do not absorb water**.
- ProRox Insulation is inert to steelwork. It meets the requirements of the latest European and American standards for **use over stainless and carbon steels**.

Interested? Read this brochure for more details.

1. Insulation is everywhere

Industrial plant insulation is everywhere. A medium-sized oil refinery contains 222 km of insulated piping and more than 26 football pitches worth 130,000 m² of insulated equipment, vessels and tanks. The plant temperature can easily exceed 600°C, making insulation essential to protect the people and to keep the heat inside.

Proper, prompt maintenance

In many cases, insulation is not promptly or properly maintained, simply because it is not considered to be a risk. For years, industry has estimated that 10% to 30% of exposed insulation becomes damaged or missing within one to three years of installation. That percentage is likely to rise over time, depending on the operating environment and exposure to the elements. Many plant operators know that steam-generating capacity must be increased when it rains to continue to provide the heat the plant needs to operate efficiently.

Damaged insulation leads to higher heat losses and corrosion costs

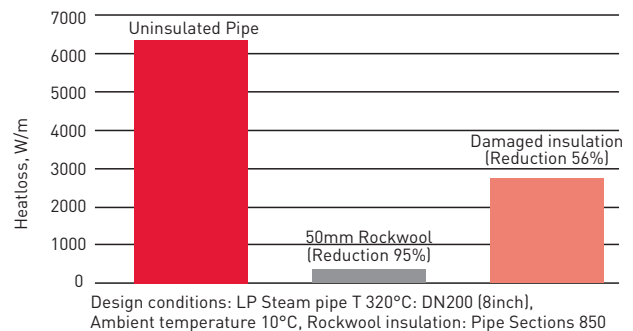
The impact of damage can be substantial. In many cases, the actual reduction in heat loss is up to 40% less than expected. Damaged insulation cladding often also allows water to penetrate into the insulation, which can cause corrosion. Costs due to corrosion, downtime and additional unanticipated energy losses are substantial. The costs of inspection and repair, which can often be carried out during operation, are negligible compared to the potential savings.

	Mid-Size Chemical plant	Refinery (150.000 barrels per day)
Insulation damage	19.2%	21.3%
Corrosion	182,000 euro annually	365,000 euro annually
Additional energy loss (0.012euro/kWh)	1,335,036 euro annually	7,783,942 euro annually

Source: US steam digest, insulation management and its value to industry

The reported annual cost of repairs, replacement and production losses run into millions of dollars every year. The National Association of Corrosion Engineers (NACE) estimates the annual costs of corrosion in production manufacturing in the USA to be around US\$17.6 billion.

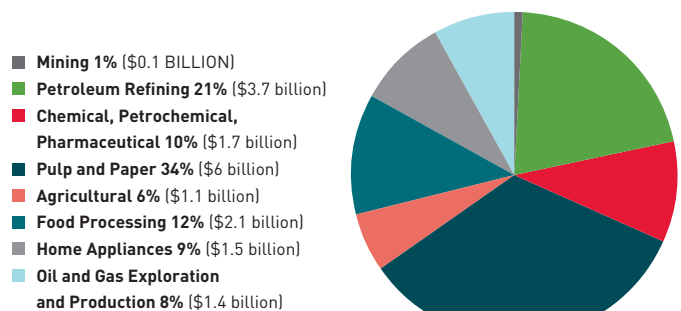
Heat losses from damaged insulation can be up to 8x greater



Between 10% to 30% of the insulation becomes damaged or missing within 1 to 3 years

Source: National Insulation Association and RTI calculations

Production and manufacturing (\$17.6 billion)



Annual cost of corrosion in the production & manufacturing category

Source: http://events.nace.org/publicaffairs/images_cocorr/ccsupp.pdf
Corrosion costs and preventive strategies

2. The Issue

Corrosion occurs in the presence of water and oxygen. So, obviously, if the steelwork under insulation remains dry there is no corrosion problem. Keeping insulation dry can be difficult. It is essential that every effort is made to keep the insulation dry during storage and installation. Failure to do this correctly leads to water ingress into the installation which can lead to steelwork corrosion, commonly referred to as corrosion under insulation (CUI). In practice CUI especially appears in the temperature range between -50°C and 200°C or in case of cyclic operation of the equipment. CUI is found underneath all types of insulation when you have installation issues or damage as detailed above.

Types of corrosion

When applying insulation and taking measures to prevent corrosion, the corrosion resistance of the metal surface to be insulated is an important factor. The most frequently occurring types of CUI are:

- General and pitting corrosion of carbon steel, which may occur if wet insulation comes into contact with carbon steel, particularly if acidic product can be extracted from the insulation material itself
- External stress corrosion cracking (ESCC) of austenitic stainless steel, which is a specific type of corrosion mainly caused by the action of water-soluble chlorides from rainwater or, say, the insulation material not meeting the appropriate requirements. Austenitic stainless steel is generally susceptible to this type of attack in the temperature range of 50°C to 200°C.

The corroded surface is mostly hidden by the insulation system and will not be observed until the insulation is removed for inspection or in the event of metal failure leading to health and safety incidents. The necessity of protection against corrosion must be determined for each individual plant. This brochure will help you address the most important CUI issues.

A common but incorrect assumption is that insulation also protects against corrosion. But if steelwork is not protected with a suitable coating and the insulation is not installed in a dry state under dry conditions and protected by adequate weather-resistant cladding, CUI will be a strong possibility.

Corrosion Under Insulation (CUI) refers to the external corrosion of piping or equipment that occurs underneath externally cladded insulation due to water or moisture penetration.



3. Preventing corrosion

Making the right decisions to find the right solution is a complex process. With this in mind, preventing corrosion is a serious concern, which must be addressed in the design phase. Numerous factors are involved in causing or preventing corrosion under insulation. Some, such as temperature and ambient conditions, are an inevitable part of the process or the surrounding environment, and so cannot be controlled. Others can be controlled effectively. Generally, three issues should be addressed:

- Protecting steelwork
- Designing and planning insulation work
- Inspection and maintenance

Protecting steelwork

The necessity of protection against corrosion must be determined for each individual plant. If it is, the appropriate measures have to be identified. Generally, the design of the insulation system and corrosion protection depends on the following parameters.

- Operation of the plant: continuous, interrupted/intermittent
- Operating temperatures
- Metals used (non-alloy, low alloy steel, austenitic stainless steel, copper)
- External impacts

Before applying the corrosion protection coating, the surface must be free from grease, dust and acid and the priming coat should be roughened for better adhesion. Blasting is the recommended surface preparation method (for austenitic stainless steel, use a ferrite free blasting abrasive). Follow the coating manufacturer's processing guidelines.



Best practices may vary by country and/or standard

ISO 12944-1 to 7

Corrosion protection is often designed in accordance with EN ISO 12944-1 to 7 "Coating materials – Protection against the corrosion of steelwork by means of coating systems". However, since this standard does not adequately take into account the specific features of corrosion protection in insulation systems, the requirements of AGI Q151 "Protection against corrosion in the case of hot and cold insulation in industrial plants" must also be considered.

DIN 4140

DIN 4140 gives the following advice on corrosion protection:

- In the case of cold insulation, if the object is made of non-alloy or low alloy steel, it must be protected against corrosion
- In the case of objects made from austenitic stainless steel or copper, the installation must be tested in each individual case by the planner to determine whether corrosion protection is necessary
- Objects made from austenitic stainless steel do not require corrosion protection if the temperature never exceeds 50°C, even briefly

CINI

CINI recommends applying corrosion protection prior to insulation work at any time.

- In all phases, pay attention to corrosion under insulation prevention: design, construction, paint & coating work, application of the insulation system, inspection and maintenance. Equipment and piping sections, such as nozzles and supports, should be designed and maintained to prevent water ingress into the insulation system.
- Paint specifications are split into: construction materials (carbon steel, stainless steel) and temperature ranges -30°C to 540°C with special attention for the temperature range between -20°C and 150°C.
- Corrosion protection can be achieved using aluminium foil wrapping, thermal sprayed aluminium (TSA) or paint
- Corrosion protection is not necessary for plants operating continuously under extremely cold conditions (< -30°C)

Watch out for electrochemical corrosion!

There is a risk of electrochemical corrosion when metals with different electrochemical potentials, such as aluminium and copper, come into contact with one another. This can be avoided using intermediate insulating layers, such as non-metallic straps. The presence of moisture will intensify electrochemical corrosion. The following table, which is based on the German DIN 4140 standard, shows the initial risk of electrochemical corrosion when different combinations of metals are used.



Material		Combination material					
Metal	Surface ratio in proportion to combination material	Zinc	Aluminium	Ferritic steel	Lead	Austenitic stainless steel	Copper
Zinc	Small	—	M	M	H	H	H
	Large	—	L	L	L	L	L
Aluminium	Small	L	—	L	H	H	H
	Large	L	—	L	M	L	H
Ferritic steel	Small	L	L	—	H	H	L
	Large	L	L	—	L	L	L
Lead	Small	L	L	L	—	H	H
	Large	L	L	L	—	M	M
Austenitic stainless steel	Small	L	L	L	L	—	M
	Large	L	L	L	L	—	L
Copper	Small	L	L	L	L	L	—
	Large	L	L	L	L	L	—

L - Light or little corrosion to material

M - Moderate corrosion to material, for example, in very humid atmospheres

H - Heavy electrochemical corrosion to material

Observation: The table shows the corrosion of the “material”, and not that of the “combination material”.

“Light” means: “small-scale in proportion to the combination material”, “heavy” means: “large-scale in proportion to the combination material”.

Example 1: Material is a zinc galvanised screw in combination material, a cladding made from austenitic stainless steel: Row “zinc small”: “H” - heavy corrosion of the screw.

Example 2: Material, a cladding made from austenitic stainless steel screwed on with a screw galvanised with combination material zinc: Row “austenitic stainless steel large”. “L” - the corrosive attack upon the austenitic steel is light.

Design & planning of the insulation work

The requirements of the planned insulation work must be factored in during the industrial plant design and construction phase. It is therefore advisable to involve all project managers at an early stage to preclude unnecessary and unanticipated problems during insulation work.

All preparatory work must be completed in accordance with the relevant insulation standard, such as DIN 4140, BS5970, AGI Q 05 or the CINI manual. If necessary, the object will have been protected against corrosion. Insulation material should be stored and installed in dry conditions. Various conditions, including the following, must be fulfilled to ensure insulation can be applied without any obstacles that could contribute to the corrosion of the steelwork later on.

Note

An insulation system resistant to foot traffic must not become permanently damaged if a person weighing 100 kg (weight including any tools being carried) walks on it. It is not designed to bear additional loads, such as the placing of heavy equipment. For the purpose of the safety regulations, a durable insulation is not considered to be a walkable surface.

Ready to go: all preparations have been made so subsequent insulation removal/damage is not necessary

- Tracing and technical measurement equipment have been installed
- Welding and bonding work has been carried out on the object
- The surface displays no coarse impurities

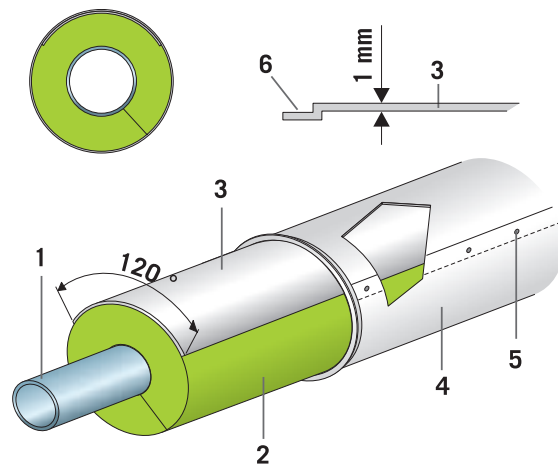
Design

- Mounting supports have been installed on the object to accommodate the support structure
- Collars and sealing discs have been fitted to the object
- Taps on the object are long enough to ensure that flanges lie outside the insulation and can be screwed on without hindrance
- Supports are designed so that insulation, water vapour retarders and cladding can be professionally installed
- Where necessary ladders, bridges and so on have been installed to prevent anyone from walking or climbing on the insulation. If this is not possible, the insulation should be designed in such a way so that it is resistant to foot traffic.

Note

Walking on insulated pipes should be avoided, as this can damage the insulation. Damage caused by foot traffic includes dented sheet cladding and gaps at the sheet seams. Water can penetrate the insulation through these gaps and cause lasting damage to the entire insulation system. The result is often greater heat losses and corrosion. If this is not possible then the insulation should be designed in such a way so that it is resistant to foot traffic.

Example 1: Pipe Insulation resistant to foot traffic



1. Pipe - 2. Insulation: ProRox PS 970 pipe section - 3. Reinforcement sheet - 4. Cladding - 5. Sheet-metal screw or rivet

Example 2: Watertight insulation protection of an insulated tank roof with ProRox Rocktight



Insulation selection

When making a considered insulation selection, it is important to think about not only obvious properties, such as the thermal conductivity or maximum service temperature of a product. To minimise risk of CUI, it is also important that the insulation does not **affect the steelwork, does not absorb any water and is open to vapour**, so that moisture can easily egress the insulation. These requirements are laid down in the following standards and test methods.

- Chemically inert: steel corrosion accelerates rapidly, particularly if acidic compounds can be extracted from the insulation material. An aqueous extract of the insulation material should be slightly alkaline, so the danger of corrosion of unprotected steel is diminished.
- Chloride content: chlorides in insulation may be leached out and can cause external stress cracking. The **water leachable chloride content** of insulation material should be less than 10 mg/kg in accordance with EN13468 or ASTM C871.
- Water repellency: the concentration of extracted chlorides and acidic compounds in water strongly influences the scale of corrosive attack on the steelwork. Water absorption should be less than 1 kg/m² in accordance with EN1609
- Water vapour resistance factor defined as μ and measured in accordance with EN12086 should be close to 1.0. This means that the vapour resistance is negligible and usually felt similar to air.

The potential corrosiveness of the insulation towards carbon and stainless steel is determined by ASTM C1617 and ASTM C692 respectively. The main criteria are:

- No visual cracking of the stainless steel after a 28-day corrosion test
- The Mass Loss Corrosion Rate of the carbon steel should be less than a reference test

Note

It is commonly, but wrongly assumed that closed cell insulation protects the installation against corrosion. But if insulation is not correctly installed in a dry state under dry conditions, water will leak into the insulation or condensation water will be trapped between insulation and steel.

The above requirements make clear that selecting the wrong insulation can exacerbate CUI issue, by trapping moisture against the steel. ROCKWOOL ProRox industrial products comply with all the above requirements and are considered by some to be the most cost-effective thermally efficient insulation products currently on the market, with excellent sustainability credentials.

Note

Making the right decisions to find the right solution is a complex process. But errors of judgment can prove very costly. Such as opting for a manufacturer's system that offers no real guarantee of long-term performance. Success depends hugely on the design of the insulation, anti corrosion coating, the type of insulation material, the skill off the installer and weather conditions during installation. The most considered approach is to look at the big picture and think about a more cost-effective insulation type. You also have to ensure the insulation is installed in a dry state, protected from the weather and properly maintained.



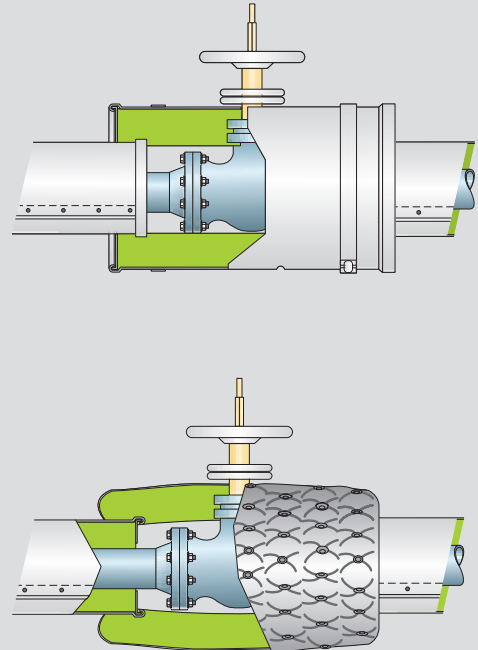
Maintenance & Inspection

To avoid unnecessarily complicating routine maintenance and inspection work, high-maintenance areas must be taken into account, especially in the design phase. Removable insulation, such as coverings and hoods, could be fitted in such areas. Easily removable coverings or so called insulation hoods are recommended, to allow rapid disassembly. Both are generally fastened with quick-release clamps, which can be opened without special tools.

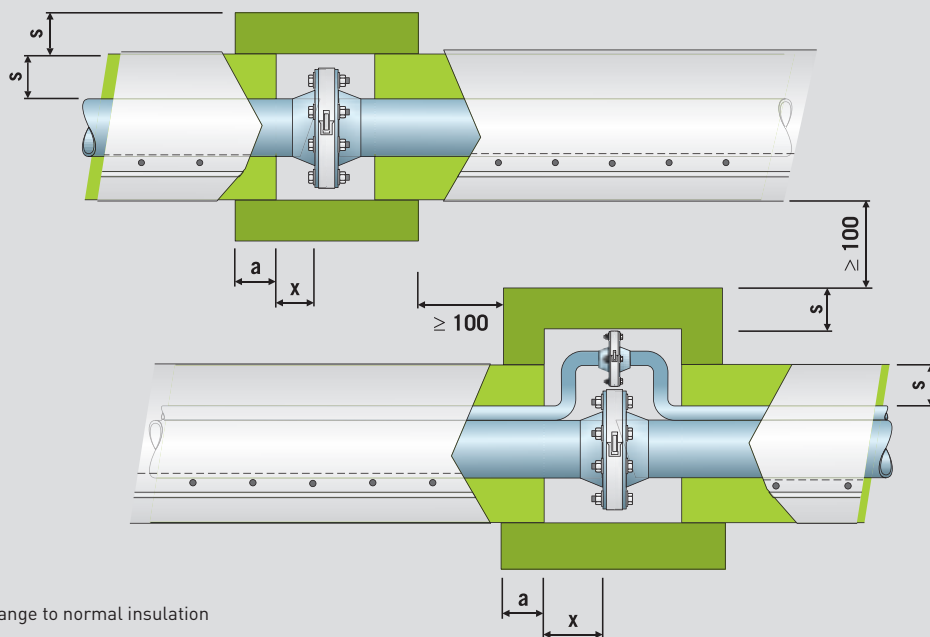
Removable coverings or hoods are usually insulated from the inside with wired mats. The coverings are fastened to the object with lever fastenings, which are fixed directly onto the covering or on to straps. Take the following conditions into account when designing insulated coverings for fittings and flanges:

- The overlap distance of the insulated covering over the insulated pipe should be at least 50 mm.
- The pipe insulation should end at the flanges, leaving a gap equal to the bolt length + 30 mm and should be closed off with a lock washer so the flange can be loosened without damaging the insulation.
- With valves, an extended spindle should preferably be fitted horizontally or below the pipe to prevent leakage along the spindle shaft.
- The cladding must be fitted to prevent the ingress of moisture in the insulation. On inclined or vertical piping, for example, mount rain deflectors above the removable coverings. If the ingress of moisture into the insulation is unavoidable, make 10 mm. diameter drain holes in the removable covering.

Insulation of valves should be designed with removable coverings or hoods



Minimum distances within range of pipe flanges (dimensions in mm)



- a = distance flange to normal insulation
 $a \geq 50 \text{ mm}$
 x = bolt length + 30 mm
 s = insulation thickness

4. ROCKWOOL & corrosion prevention

ROCKWOOL Technical Insulation offers a wide range of high-quality stone wool insulation products for the insulation of industrial plants. All products are part of our extensive ProRox range for technical insulation. Each product has been designed for a specific application (pipework, boilers, storage tanks).

■ ProRox pre-formed Pipe Sections:

ProRox Pipe Sections are supplied, split and hinged for easy snap-on assembly and are suitable for thermal and acoustic insulation of industrial pipework. ProRox Pipe Sections are available in a wide range of diameters and thicknesses. The use of ProRox pipe sections ensures optimal insulation.



■ ProRox Wired Mats:

ProRox Wired Mats are lightly bonded rock wool mats stitched on galvanised wired mesh with galvanised wire. Wired mats are available in a wide range of densities and thicknesses up to 120 mm. Stainless steel wired mesh and wire are available upon request. Wired mats are suitable for thermal and acoustic insulation of industrial pipework, boiler walls, furnaces and industrial smoke exhaust ducts. The use of ProRox wired mats provides both flexibility and quality of insulation.

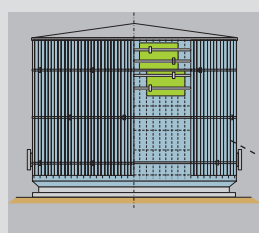


■ ProRox pre-formed Slabs:

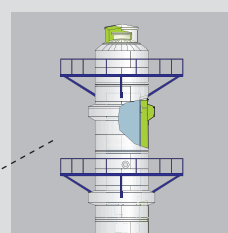
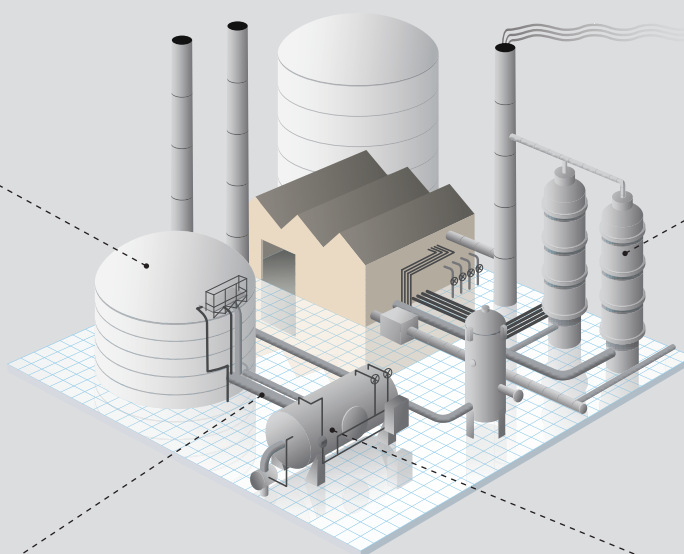
ProRox Slabs are available in a wide range of densities and well suited to thermal and acoustic insulation of flat surfaces.



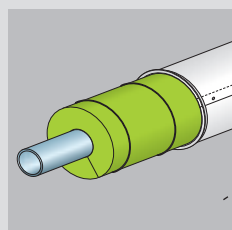
1. Firesafe 2. Acoustical 3. Thermal 4. Durable 5. Sustainable



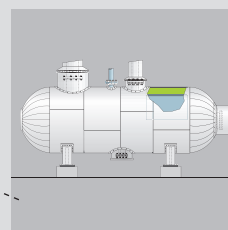
Storage tanks



Columns



Pipework



Vessels

Why choose ROCKWOOL stone wool?

ROCKWOOL ProRox products have a proven track record spanning more than 70 years. They are recognised and approved by most major plant owners and engineering companies worldwide.

- ROCKWOOL is made by melting volcanic rock. Air trapped in the rock provides the rock's thermal properties. The use of natural/inorganic materials and our unique production process guarantees a **long life** and optimal performance.
- To minimise the impact of water ingress, ProRox insulation is **hydrophobically treated**. This makes it difficult for water to penetrate into the insulation and repels water coming from the outside. Hydrophobic oil is added during the mineral wool manufacturing process, forming a protective film around each fibre. This provides effective protection against moisture penetration across the entire insulation thickness. Hydrophobic treatment does not affect the water vapour diffusion transmission.
- The vapour resistance of ProRox products is negligible, and is usually felt to be similar to air. ROCKWOOL products therefore **reduce the risk of condensation** and allow structures to dry out naturally because they can wick away moisture.
- ProRox products **are non-capillary, so they do not absorb water. They do not draw water into the insulation.**
- An aqueous extract of our products is slightly alkaline, so the danger of corrosion of unprotected steel is diminished. ProRox products are inert to steel.
- ROCKWOOL ProRox insulation meets the requirements of the most recent European (AS-Quality EN13468) and American standards (ASTM C692 and C1617) for **use over stainless and carbon steels**.
- ROCKWOOL ProRox insulation complies with the latest requirements for technical insulation (EN14303) and will be CE-marked starting August 2012.

ROCKWOOL products for industrial products comply with all off the above requirements and are considered to be one of if not the, most costs effective & thermally efficient insulation products in today's market place with excellent sustainability credentials and we consider ourselves as being part of the CUI solution.



What is stone wool?

Stone wool is a wholly natural material spun into wool from rock. ROCKWOOL stone wool is a natural material formed from one of the earth's most abundant materials - volcanic diabase rock over 200 million years old. ROCKWOOL uses diabase rock from the closest source. This reduces the transport compared to sourcing from further afield and lowers the overall carbon footprint of the ROCKWOOL product. The ROCKWOOL process resembles the natural action of the volcano: stone wool is made by melting rock, limestone and recycled briquettes with other raw materials at 1500°C in a coke-heated cupola furnace. The resultant liquid stone melt is spun into fibres. Binder and impregnating oil are added to make the material stable and water repellent. The stone wool is then heated to about 200°C in order to cure the binder and stabilize the material for final processing into a variety of products. Environmental equipment - filters, pre-heaters, after-burners, and other cleaning and collection systems - makes the 'tamed volcano' an environmentally responsible process. ROCKWOOL is sometimes referred to as stone wool and is part of the larger group of mineral wools.

5. Frequently asked questions

Can wet insulation material be reused after drying?

ROCKWOOL insulation is treated for high water repellency and its thermal properties will be restored after drying, provided there is no physical and chemical degradation. However, the risk of contamination with chlorides cannot be excluded, so the insulation should be removed and replaced by dry insulation.

Does specially inhibited insulation reduce the risk of stress corrosion cracking?

The assumption when using **sodium metasilicate** inhibited mineral wool insulation is that the water will seep through the insulation, leaching out inhibitor as well as chloride to cause cracking. However, the vast majority of moisture whether that be rainwater, sea water, run off water or droplet condensation on the stainless steel surfaces, is commonly believed to enter the installation without penetrating the insulation at all. Not having passed through the insulation, the water will not be inhibited. Even if water does penetrate the insulation, the very high solubility of the sodium metasilicate will cause almost all the inhibitor to enter the solution at the first time of water ingress.

What type of protection should be used for pipe and equipment conservation?

Protective coatings or paints play a vital role in preventing corrosion under insulation. There are many types of coatings and paints based on organic or inorganic compounds. Each one is designed to protect a specific metal in a specific temperature range. More information is provided in section 3.

Can aluminium foil protect austenitic steel surfaces?

It has been proven that aluminium foil applied between the austenitic stainless steel surface and the insulation layer will significantly reduce the risk of stress corrosion in insulated stainless steel surfaces. The foil acts as a physical barrier, which stops chloride-containing fluids migrating towards the stainless steel surface. But the most important effect is that it provides cathodic protection in wet insulation systems, which prevents pitting and cracking. The foil is simply wrapped around the pipe or equipment with approximately 50% overlay to shed water along vertical lines.

Up to what temperature can ProRox Wired Mats be used on austenitic stainless steel?

Standard ProRox wired mats are faced with galvanised mesh and stitched with galvanised wire. Zinc melts at 419°C and if it reaches 450°C it diffuses and penetrates into stainless steel. This can lead to stress cracking within a very short timeframe. With this in mind, never use wired mats with galvanised wire mesh and galvanised stitching wire on the hot side of stainless steel, at service temperatures above 350°C.

Why is it important to use water repellent insulation?

The use of water repellent additives reduces the water content inside the insulation. Moisture in insulation materials has a number of negative impacts. The thermal conductivity of water is substantially greater than that of air, which is trapped between the fibres. An increase in moisture content therefore results in an increase in the thermal conductivity of the insulation and, correspondingly, a decrease in the insulation efficiency. A moisture content of even 1% can increase the thermal conductivity by 25%. A higher moisture content also significantly increases the weight, which, as a rule, is not taken into account in the static design of an insulation system. Moisture causes many types of corrosion that almost never develop in a dry system.

Can I use hydrophobically treated ROCKWOOL in heavily diluted areas?

ROCKWOOL ProRox insulation is highly water repellent but it can not withstand the mechanical impact of e.g. water hoses and it will not protect the steel against ingressing water. If the insulation has to be pressure cleaned or will come into contact with seawater (marine or offshore applications), application of a rigid watertight insulation protection, such as ProRox Rocktight, is recommended.



6. Norms & standards

The relevant test standards are generally split into test standards for inertia to the steelwork, water-leachable chloride content and water repellency. Additional qualitative and quantitative standards have been developed to evaluate the impact of the insulation material on corrosion rate and external stress cracking.

Corrosion-relevant test standards

Inert to steel

The corrosion of the steel is rapidly accelerated, especially if acidic compounds can be extracted from the insulation material. An aqueous extract of the insulation material should be slightly alkaline to reduce the risk of corrosion of unprotected steel. The pH value should be measured in accordance with EN13468 or ASTM C871.

Water-leachable chloride content

The corrosion resistance of steel is increased by adding alloying elements such as chromium, nickel and molybdenum. Alloying produces an austenitic (face-centred cubic) atomic structure. These types of steel are also called austenitic steels. Despite their general high resistance to corrosion, these steels tend to exhibit stress corrosion under the influence of chloride ions. An insulation material with an extremely low water-leachable chloride content must therefore be used to insulate objects made from austenitic stainless steel. For this application, only those insulation materials manufactured with a low water-leachable chloride content can be used. The classification criteria will depend on the standard followed. In general, a distinction can be made between US ASTM standards and European EN standards.

■ AS-Quality (AGI Q135 – EN 13468)

The following acceptance criteria apply to insulation materials of AS-Quality. The average of six test samples must exhibit a water-leachable chloride content of $\leq 10\text{mg/kg}$.

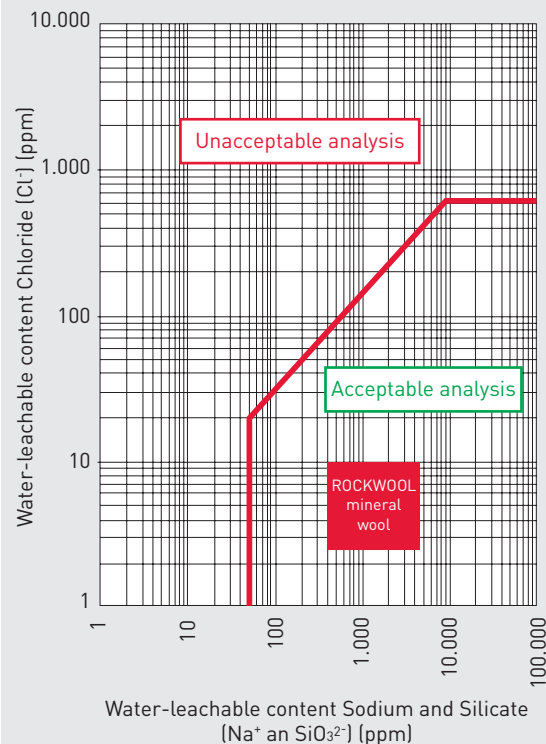
■ ASTM C871 “Chemical analysis of thermal insulation materials for leachable chloride”.

This standard covers the laboratory procedures for the determination of the ions, which accelerate stress corrosion of stainless steel. If the results of the chemical analysis for the leachable chloride, sodium and silicate are ions within the acceptable area of the graph in ASTM C795 and also pass ASTM C692, the insulation material should not cause stress corrosion cracking.

■ ASTM C 795 “Thermal Insulation for Use in Contact with Austenitic Stainless Steel”.

This specification covers non-metallic thermal insulation for use in contact with austenitic stainless steel piping and equipment. In addition to meeting the requirements of this standard, the insulation materials must pass the preproduction test requirements of ASTM C 692, for stress corrosion effects on austenitic stainless steel, and the quality control chemical requirements when tested in accordance with ASTM C871. ASTM C795 shows the results of ASTM C871 in a graph to illustrate a range of acceptable chloride concentrations in conjunction with sodium plus silicate concentrations (see graph below).

ASTM C 795 acceptability of insulation material on the basis of the plot points of the Cl^- and the Na^+ an SiO_3^{2-} analyses



Water repellency

Thermal conductivity – and so insulating capacity – is considerably impaired by the penetration of moisture into the material. Wet insulation material can also contribute to corrosion. So insulation materials must be protected against moisture during storage and installation, as well as post-installation. The water repellency of an insulation material can be tested in accordance with several European, American and local standards.

■ EN 1609 & EN 13472 Partial Immersion

Tested in accordance with two mineral wool standards (EN 1609 for slabs and DIN EN 13472 for pipe insulating products). The maximum permissible water absorption in these testing procedures must not exceed 1 kg/m². ROCKWOOL insulation products are hydrophobically treated and so meet these requirements.



■ BS 2972 Section 12 Total Immersion

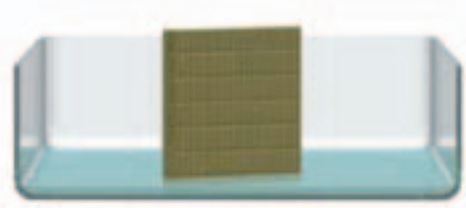
“Determining the Water Absorption of Unfaced Mineral Fibre Insulation exposed to Total Immersion”
This standard covers the determination of the degree of water absorption by mineral fibre insulation. The test sample is immersed completely in tap water for two hours with the upper surface approximately 25 mm below the surface of the tap water. After the immersion period, the sample must be drained for 5 minutes. The water absorption is calculated using the weight difference before and after testing and is expressed in volume percentage.



■ BS 2972 Section 12 Partial Immersion

“Determining the Water Absorption of Unfaced Mineral Fibre Insulation exposed to Partial Immersion”

This standard covers the determination of the degree of water absorption by mineral fibre insulation. The test sample is immersed vertically with one 150 mm* 25 mm side 6 mm below the surface of tap water for 48 hours. After the immersion period the sample must be drained for 5 minutes. The water absorption is calculated using the weight difference before and after testing and is expressed in kilograms per square metre.



Note

British Petroleum (BP) places specific demands on the water repellency of mineral wool products. In accordance with the BP172 standard, the samples are heated for 24 hours at 250°C. The water repellency is subsequently tested in accordance with BS 2972 Section 12 Partial Immersion. Special water repellent grade (WRG) products are available on request.

■ ASTM C 1104 / 1104M

“Determining the Water Vapour Sorption of Unfaced Mineral Fibre Insulation”

This standard covers the determination of the amount of water vapour sorbed by mineral fibre insulation exposed to a high-humidity atmosphere. The test samples are first dried in an oven and then transferred to an environmental chamber maintained at 49°C and 95% relative humidity for 96 hours. The water vapour sorption is calculated using the weight difference before and after testing and is expressed in weight percentage or volume percentage.



Corrosion test standards

There is no single test method that can be used to predict or measure the amount of corrosion under insulation that will occur when an insulated pipe or equipment is exposed to environmental conditions. There are simply too many variables and too many different combinations of exposure possible. Therefore several laboratory test methods have developed to determine the potential risk of corrosion under insulation.

Quantitative accelerated evaluation ASTM C1617

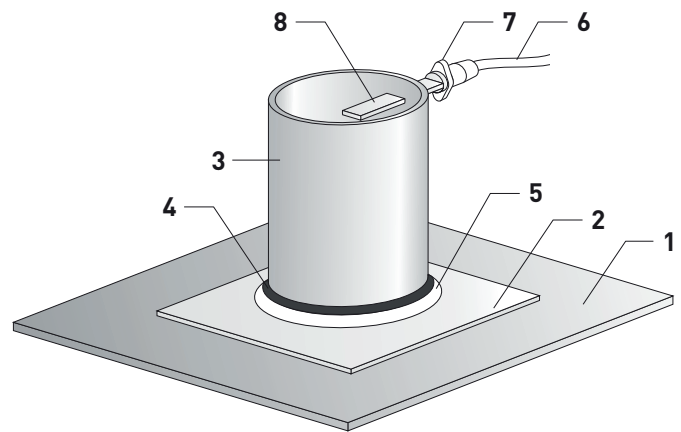
“Quantitative Accelerated Laboratory Evaluation of Extraction Solutions Containing Ions Leached from Thermal Insulation on Aqueous Corrosion of Metals”. The primary intent of ASTM C1617 is to test the aqueous corrosion of carbon steel under influence of thermal insulation material. This is done by determining the Mass Loss Corrosion Rate (MLCR) caused by exposure of the metal coupons to the insulation. The standard uses controlled amounts of corrosive reference solutions compare the corrosion resulting from the insulation material solutions to that of known corrosive solutions.

Test procedure

- Three samples of the insulation material are extracted in accordance with ASTM C 871. The solution is placed on a PVC tube on a heated flat plate (110°C) for 4 days. Due to the heat, the solution evaporates quickly, producing an air (oxygen) interface and facilitating thousands of wet-dry wet cycles within a short timeframe.
- The test coupons are dripped with 250 ml of the solutions per day during four days. At the end of the test the coupons are carefully cleaned, dried and weighed.
- The calculation of the MLCR per year is based on the weight loss of the steel coupons and is compared against the MLCR of standard reference tests (usually a 5 ppm chloride solution) to estimate the corrosiveness of the soluble ions in the solution

Contribution to external stress corrosion cracking (ASTM C692)

“Evaluating the Influence of Thermal Insulations on External Stress Corrosion Cracking Tendency of Austenitic Stainless Steel”. This standard covers the procedures for the laboratory evaluation of thermal insulation materials that may actively contribute to external stress corrosion cracking (ESCC) of austenitic stainless steel due to soluble chlorides within the insulation. In this corrosion test insulation specimens are used to conduct distilled or deionised water by wicking or dripping to an outside surface through the insulation to a hot inner surface of stressed stainless steel for a period of 28 days. If leachable chlorides are present, they will concentrate on the hot surface by evaporation. At the conclusion of the 28-day test period, the stainless steel coupons are removed, cleaned and inspected for stress corrosion cracks. To pass the test, no cracks may be found on the surface of the coupons.



1. Hot plate - 2. Test coupon - 3. PVC tube - 4. O-ring - 5. Silicone sealant - 6. Tubing - 7. Barbed connector - 8. Straw

Notes

ROCKWOOL Technical Insulation

ROCKWOOL® Technical Insulation, a subsidiary of the international ROCKWOOL Group, is the worldwide market leader in technical insulation. With our comprehensive product lines ProRox and SeaRox we cover the whole industrial market and marine & offshore industry, providing a full range of products and systems for the thermal and firesafe insulation of technical applications. Besides sustainable products we offer reliable expert advice, from documentation to delivery and after sales service. Throughout the whole chain from specifier, through dealer to contractor and installer we aim to add value. We don't just sell products, we supply solutions. It's this total approach that makes us the ideal choice for professionalism, innovation and trust.

All explanations correspond to our current range of knowledge and are therefore up-to-date. The examples of use outlined in this document serve only to provide a better description and do not take special circumstances of specific cases into account. ROCKWOOL Technical Insulation places great value upon continuous development of products, to the extent that we too continuously work to improve our products without prior notice. We therefore recommend that you use the most recent issue of our publications, as our wealth of experience and knowledge is always growing. Should you require related information for your specific application or have any technical queries, please contact our sales department or visit our website www.rockwool-rti.com

The ROCKWOOL Group

The ROCKWOOL Group is the world's leading supplier of innovative products and systems based on stone wool, improving the environment and the quality of life for millions of people. The Group is amongst the global leaders within the insulation industry. Together with other building-related products such as acoustic ceilings, cladding boards and our consultancy business, the Group ensures energy efficient and firesafe buildings with good acoustics and a comfortable indoor climate. We create green solutions for the horticultural industry, inventive special fibres for industrial use, effective insulation for the process industry and marine & offshore as well as noise and vibration systems for modern infrastructure.

Our more than 9,700 employees in more than 40 countries cater for customers all over the world. The Group's head office is located close to Copenhagen. In 2012 the Group generated sales of EUR 1.97 billion. The company is listed on the NASDAQ OMX Nordic Exchange Copenhagen. The Group's operations have a main presence in Europe and we are expanding production, sales and service activities in North and South America and Asia. Together with a broad network of business partners, this ensures that the Group's products and systems reach almost every corner of the globe. For more information, please visit www.rockwool.com

ROCKWOOL Technical Insulation

Delfstoffenweg 2
6045 JH Roermond
The Netherlands
Tel. +31 (0) 475 35 36 18
Fax +31 (0) 475 35 36 01
E-mail: info-rti@rockwool.nl
www.rockwool-rti.com

for Belgium: +32 (0) 2 715 68 20
for Germany: +49 (0) 2043 408 389
for France: +33 (0) 1 40 77 82 11
for UK: +44 (0) 871 222 1780
for Italy: +39 02 34 61 32 40
for Export: +31 (0) 475 35 38 35
for Poland: +48 683 850 126
for Czech Republic: +420 725 741 008

for Slovakia: +421 903 235 027
for Baltics: +370 69 94 33 92
for Denmark: +45 29 25 21 71
for Sweden: +46 705 710 815
for Norway: +47 91 13 62 49
for Finland: +358 400 824 260
for Spain & Portugal: +34 (0) 93 318 90 28

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