Corrosion Under Insulation (CUI):
Industrial Technical Overview

ProRox®
Industrial insulation

NEW
PRODUCT
NAMES

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We share our knowledge to your advantage

ROXUL® 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 have a full offering of sustainable products and systems providing the best available solutions for thermal and firesafe insulation. 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 ROXUL Technical Insulation solutions meet applicable 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 endeavor to develop ever more efficient products and to constantly optimize 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 petrochemical, 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 available 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 ROXUL 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.roxul-rti.com or contact us at 1 800 265 6878.

The ROCKWOOL Group
ROXUL® 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. ROCKWOOL International has 28 factories in Europe, North America and Asia, and over 11,000 employees.

ROXUL has a melting point above 2000°F
ROXUL products withstand temperatures up to 2150°F (1177°C), making them 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. ROXUL insulation aids in fire safety and does not promote the spread of flame nor toxic smoke.

Stone wool protects people and the environment
ROXUL products offer effective protection and optimal performance for the entire life cycle of the installation. According to independent research ROXUL 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, ROXUL insulation will save more than 20,000 times the carbon emissions caused by its production. The fire resistant and fire insulating characteristics of our stone wool products deliver superior protection to people, property and the environment.

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Globalization is moving faster than ever and, in the world of insulation, ROXUL® Technical Insulation is leading the way. With businesses from different countries collaborating to engineer new industrial and power generation facilities, ROXUL Technical Insulation has launched product branding that speaks the same language anywhere in the world. It’s a strategy that brings uniformity to specifying, matches products to performance and streamlines communication.

Introducing ProRox® and SeaRox®. Our ProRox products provide insulation solutions for industrial process and power generation. SeaRox products do the same for marine and offshore applications.

Clarity: Our naming structure allows you to quickly find the right product for the right application. It also aligns ROXUL with other participating ROCKWOOL companies to provide a true global product offering.

Performance: ROXUL products provide superior thermal and acoustical value and are fire resistant, water repellent, non-corrosive and resistant to mold. Our technical expertise and global approach to product specifications will help take your business to a new level of performance.

Structure: Our identification system links to a product and performance characteristics selector. The example below illustrates the advantages of this simple yet highly efficient structure.
It’s all about conditions ...

Corrosion is undoubtedly one of the costliest problems facing industry today. Due to corrosion of piping and equipment under insulation many companies have to repair and/or replace major parts at a considerable cost, reported to run into billions of dollars annually. Clearly this considerably reduces the potential service life of industrial facilities. 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. 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 insulation (CUI) is a strong possibility. CUI necessitates repairs and replacements, along with higher than expected heat losses in the design phase.

Preventing CUI (Corrosion Under Insulation)
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 and fittings are positioned to shed water as much as possible.
- The right anti-corrosion 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 preventative maintenance plan.

ROXUL® and CUI
ROXUL ProRox® products for industrial use comply with mechanical insulation standards and are considered by many to be one of the most cost-effective, thermally efficient insulation products currently on the market, with excellent sustainability credentials.

- ROXUL industrial insulation is hydrophobic, providing effective protection against moisture penetration across the entire insulation thickness.
- ROXUL industrial insulation has a fibrous open-pore structure that is vapor open. So ROXUL products reduce the risk of surface wetting by allowing any bulk water to drain and the structure to dry out naturally.
- ROXUL products are permeable, so they do not absorb water.
- ROXUL insulation is chemically inert to steelwork to mitigate risk of corrosion. It meets the requirements of the North American and European corrosion standards for use.
Industrial plant insulation is everywhere. A medium-sized oil refinery contains 356 miles of insulated piping and more than 25 football fields worth 1.4 million ft² of insulated equipment, vessels and tanks. The plant temperature can easily exceed 1100°F (538°C), making insulation essential to protect people and maintain operational efficiencies.

Prompt and proper 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 increased 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% more than expected. Damaged insulation cladding often 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.

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

![Graph showing heat losses from damaged insulation](image)

**Design Conditions:** Steam Pipe, T 608°F, 8 inch (NPS), ambient temperature 50°F, ROXUL insulation: ProRox® PS 960

**Source:** National Insulation Association and ROXUL calculations

### Additional energy losses

<table>
<thead>
<tr>
<th></th>
<th>Mid-Size Chemical plant</th>
<th>Refinery (150,000 barrels per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation damage</td>
<td>19.2%</td>
<td>21.3%</td>
</tr>
<tr>
<td>Corrosion</td>
<td>250,000 USD annually</td>
<td>500,000 USD annually</td>
</tr>
<tr>
<td>Additional energy loss [0.0159 USD/kWh]</td>
<td>1,766,622 USD annually</td>
<td>10,300,307 USD annually</td>
</tr>
</tbody>
</table>

Source: Steam digest vol. IV, 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

- **Mining** 1% ($0.1 billion)
- **Petroleum Refining** 21% ($3.7 billion)
- **Chemical, Petrochemical, Pharmaceutical** 10% ($1.7 billion)
- **Pulp and Paper** 34% ($6 billion)
- **Agricultural** 6% ($1.1 billion)
- **Food Processing** 12% ($2.1 billion)
- **Home Appliances** 9% ($1.5 billion)
- **Oil and Gas Exploration and Production** 8% ($1.4 billion)

Source: http://events.nace.org/publicaffairs/images_cocorr/ccsupp.pdf

Corrosion costs and preventive strategies
2. The Issue: Insulation and Corrosion

Corrosion occurs in the presence of water and oxygen so if the steelwork under insulation remains dry it minimizes the risk of corrosion. Keeping insulation dry can be challenging and it is essential that every effort is made to keep it dry during storage and installation. Failure to do so leads to water ingress into the installation which can lead to steelwork corrosion, commonly referred to as corrosion under insulation (CUI). In practice CUI commonly appears in the temperature range between 55°F (13°C) and 395°F (202°C) or where there is cyclic operation of the equipment. CUI is found underneath all types of insulation when you have installation issues or damage as stated above.

Types of corrosion

When applying insulation, 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 leach 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 insulation that does not meet material standards. Austenitic stainless steel is generally susceptible to this type of attack in the temperature range of 55°F (13°C) and 395°F (202°C).

The corroded surface is mostly hidden by the insulation system and will not be identified 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. 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 is 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. Temperature and ambient conditions are an inevitable part of the process plus the surrounding environment and cannot be controlled. Other factors can be controlled effectively and 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 and 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 or interrupted/intermittent.
- Operating temperatures.
- Metals used (non-alloy, low alloy steel, austenitic stainless steel or copper).
- External factors.

Before applying the corrosion protection coating, the surface must be free from grease, dust and acid plus 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.

ASTM C795: 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. The requirements of this standard include tests as per C 692 and C 871.

ASTM C665: Corrosiveness to Steel

This specification covers the composition and physical properties of mineral-fiber blanket insulation. The test ensures that the composition of the insulating material does not create a potential for corrosion on certain metals in the presence of water or water vapor.
Watch out for electrochemical corrosion!
Electrochemical corrosion is a risk when metals with different electrochemical potentials, such as aluminum and copper, come into contact with one another. This can be avoided using intermediate isolating layers, such as non-metallic straps. The presence of moisture will intensify electrochemical corrosion. The following table shows the initial risk of electrochemical corrosion when different combinations of metals are used.

<table>
<thead>
<tr>
<th>Material</th>
<th>Surface ratio in proportion to combination material</th>
<th>Zinc</th>
<th>Aluminium</th>
<th>Ferritic steel</th>
<th>Lead</th>
<th>Austenitic stainless steel</th>
<th>Copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc</td>
<td>Small</td>
<td>—</td>
<td>M</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>H</td>
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<tr>
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<td>Large</td>
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<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Aluminum</td>
<td>Small</td>
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<td>—</td>
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<td>H</td>
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<td>H</td>
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<td>—</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Ferritic steel</td>
<td>Small</td>
<td>L</td>
<td>L</td>
<td>—</td>
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<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Lead</td>
<td>Small</td>
<td>L</td>
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<td></td>
<td>Large</td>
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<td>L</td>
<td>L</td>
<td>—</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Austenitic stainless steel</td>
<td>Small</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>—</td>
<td>—</td>
<td>M</td>
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<td></td>
<td>Large</td>
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<td>L</td>
<td>L</td>
<td>—</td>
<td>—</td>
<td>L</td>
</tr>
<tr>
<td>Copper</td>
<td>Small</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>—</td>
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</tr>
</tbody>
</table>

L - Light or little corrosion to material  
M - Moderate corrosion to material, for example, in very humid atmospheres  
H - Heavy electrochemical corrosion to material  

NOTE: 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” and “heavy” means: “large-scale in proportion to the combination material”.

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

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

Based on German DIN 4140 standard.
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 and if necessary, apply corrosion protection. Insulation material should be stored and installed in dry conditions. Various conditions must be fulfilled to ensure the insulation does not 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 220 lbs or greater (weight including any tools and equipment 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 damage/removal 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 to accommodate the support structure.
- Collars and sealing discs have been fitted.
- Line taps are long enough to ensure that flanges lie outside the insulation and can be screwed on without hindrance.
- Supports are designed so insulation, vapor retarders and cladding can be properly 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 to be resistant to foot traffic.

Note

Walking on insulated pipes with low compressive strength should be avoided if possible, 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 loss 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. ROXUL® ProRox® PS 980NA offers a solution to damage from foot traffic due to its high compressive strength and durability.

Illustration 1: Pipe Insulation resistant to foot traffic

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 minimize risk of CUI, it is also important that the insulation does not affect the steelwork, does not absorb any water and is open to vapor, 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 in accordance with 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 vapor resistance factor defined as $\mu$ should be close to 1.0. This means that the vapor resistance is negligible and usually felt similar to air.

The potential corrosiveness of the insulation towards carbon and stainless steel is determined by quantitative and qualitative tests such as ASTM C1617 and ASTM C692. 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
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 of 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.

Note
It is commonly, but wrongly assumed that closed cell insulation protects the installation against corrosion. It is important to note that 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 the CUI issue by trapping moisture against the steel. ROXUL® Technical Insulation complies 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.
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. Easy to remove 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. The coverings are fastened to the object with lever fastenings, which are fixed directly onto the covering or on to straps. Take the following suggested 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 2”.
- The pipe insulation should end at the flanges, leaving a gap equal to the bolt length plus 1.2” 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 0.4” diameter drain holes in the removable covering.

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

- \( a = \text{distance flange to normal insulation} \)
- \( a \geq 2” \)
- \( x = \text{bolt length} + 1.2” \)
- \( s = \text{insulation thickness} \)
ROXUL Technical Insulation offers a wide range of high quality stone wool products for the insulation of mechanical equipment. All products are designed and engineered with the following features that will minimize the risk of corrosion under insulation.

- ROXUL offering includes rigid insulation that allows for easy installation, routine maintenance and protection against damage from mechanical loads.
- Is compatible with anti-corrosion surface treatments.
- Can be supplied with scrim and foil facings to facilitate the use of an appropriate weather protection system.
- Is fibrous and water repellent allowing water to drain away and for vapor to dry.
- Is chemically inert which minimizes corrosion potential caused by chloride contents.
- Complies to relevant corrosion standards.

Each product has been designed for a specific application (pipework, boilers, storage tanks, etc.), and when properly installed in a complete overall system, corrosion risk can be mitigated.

- **ProRox® PS 960NA and ProRox® PS 980NA:**
  ROXUL Pipe Sections are supplied, split and hinged for easy snap-on assembly and are suitable for thermal and acoustic insulation of industrial pipework. ROXUL Pipe Sections are available in a wide range of diameters and thicknesses.

- **ENERWRAP® MA 960NA:**
  Available with either a black scrim or foil facing, ENERWRAP® MA 960NA is a flexible stone wool blanket insulation that is non-combustible and engineered for hard-to-fit, high-temperature surfaces such as large-diameter pipes, vessels, boilers, tanks, furnaces and irregularly shaped mechanical equipment.

- **ProRox® BOARD, FLEX, and WRAP:**
  ProRox® is available in rigid, semi-rigid and wrap (mat) products in a variety of densities and dimensions. ProRox® is suitable for use in petro-chemical, power generation plants, boilers, furnaces, towers, ovens and drying equipment.
Why choose ROXUL® Technical Insulation?

ROXUL products have been proven in service for over 25 years. They are recognized and approved by most major plant owners and engineering companies worldwide.

- ROXUL 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 minimize the impact of water ingress, ProRox® insulation is hydrophically treated. This makes it difficult for water to penetrate into the insulation and repels water coming from the outside. Minor amounts of 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 vapor diffusion transmission.
- The vapor resistance of ProRox® products is negligible, and is usually felt to be similar to air. ROXUL 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. 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.
- ROXUL ProRox® insulation meets the requirements of the most recent ASTM Standards (C692 & C1617) for use over stainless and carbon steels.

ROXUL products for industrial applications comply with all of 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 (mineral wool) was discovered on the islands of Hawaii at the beginning of the century. It occurs there naturally as a byproduct of volcanic activity. In its manufactured state, stone wool combines the power of rock with the characteristics of typical insulation wool. In addition, thanks to its non-directional fiber orientation, it also exhibits some unique and valuable. The production process for stone wool begins with the fusion of volcanic rock at a temperature of 4950°F (2732°C).
5. Norms & standards

The relevant test standards are generally divided into test standards for reactivity to 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 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 ≤ 10mg/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 ions are 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 C795 “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 C692, for stress corrosion effects on austenitic stainless steel, and ASTM C871 for quality control chemical requirements. ASTM C795 shows the results of ASTM C871 to illustrate a range of acceptable chloride concentrations in conjunction with sodium plus silicate concentrations [see graph below].

![](image)
Water repellency

Thermal conductivity and product performance 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.

ASTM C1104 / 1104M

“Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation”

This standard covers the determination of the amount of water vapor sorbed by mineral fiber 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 120°F and 95% relative humidity for 96 hours. The water vapor 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 CUI 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 been developed to determine the potential risk of CUI.

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 compared to 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 C871. The solution is placed within a PVC tube on a heated flat plate (230°F) for 4 days.
- The test coupons are dripped with 8.45 oz. of the solutions per day during four 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. 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.

ASTM C665: Corrosiveness to Steel

This specification is a qualitative test that ensures that the composition of the insulating material does not create a potential for corrosion on certain metals in the presence of water or water vapor. When tested, the metal plates in contact with the insulation shall show no corrosion greater than that observed on the comparative plates in contact with sterile cotton.
ASTM C692: Contribution to external stress corrosion cracking

“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 transfer distilled or deionised water by wicking from 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.
6. Frequently asked questions

Can wet insulation material be reused after drying?
ROXUL® insulation is treated to be water repellent and its thermal properties will be restored after drying, provided there is no physical and chemical degradation. However, when the risk of contamination with chlorides cannot be avoided, 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 (i.e. chloride) to prevent corrosion 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.

Can ROXUL products be used in heavily diluted areas?
ROXUL insulation is highly water repellent but it cannot 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 impervious material and impermeable jacketing systems are recommended.

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.

Can aluminum foil protect austenitic steel surfaces?
It has been proven that aluminum 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.

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 fibers. 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.
Our people’s in-depth expertise is the best guarantee that end users in the petrochemical, power generation, shipbuilding, and construction industries are given the best and most reliable insulation solutions. They are the real key to our success. Thanks to their expertise and extensive experience, we can offer you exceptional products, they are the real key to our success. Thanks to their expertise and extensive experience, we can offer you exceptional services for the benefit of the client. Besides excellent insulation products, they are the key to our success. Thanks to their expertise and extensive experience, we can offer you exceptional services for the benefit of the client.
Preventing corrosion under insulation is a serious concern, which must be addressed with the right expertise.
ROXUL® Technical Insulation

ROXUL® 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 fire-safe 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.

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The ROCKWOOL Group

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Stone wool is a versatile material based on one of nature’s most abundant resources. It forms the basis of the following ROCKWOOL Group businesses: building insulation; industrial & technical insulation for process industry, marine and offshore; acoustic ceiling systems; exterior cladding; horticultural substrate solutions; engineered fibers; noise and vibration control.

The ROCKWOOL Group was founded in 1909 and insulation production started in 1937. The Group’s head office is located close to Copenhagen. The company is listed on the NASDAQ Copenhagen stock exchange.

The Group’s operations have a large presence in Europe and we also have facilities in North America, Russia, India and East Asia. Our more than 11,000 employees in more than 35 countries cater for customers in a large part of the world.

For more information, please visit www.rockwool.com.

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