Corrosion under insulation and insulation material

By Søren Nyborg Rasmussen, ROCKWOOL Technical Insulation

Background
Corrosion under insulation – CUI – has been neglected for many years, but is now recognized as one of industry’s greatest challenges with respect to materials. CUI has been the cause of several accidents involving the loss of human life and personal injury, fire and pollution. One oil company estimates that CUI accounts for 40-60% of its pipeline maintenance costs. Globally, billions of euros are spent every year on problems arising from corrosion under insulation.
Corrosion occurs when unprotected metal (steel and stainless steel) comes into contact with water and oxygen, which is nothing out of the ordinary. We know about this from our old cars and other metal that is exposed outdoors. **With CUI, you cannot see the metal is corroding because the metal is concealed by insulation and cladding. In some cases, the corrosion isn’t discovered until a pipeline begins to leak.** The environment under insulation can also be extra corrosive due to high temperatures and sometimes the presence of salts (e.g. chlorides) and other substances that accelerate corrosion. But why does corrosion under insulation occur? You typically protect steel with a coating or metallization: cladding on the outside to prevent the penetration of water, so the environment should be warm and dry.

Unfortunately, theory and practice do not agree on this point. Equipment design is often not optimized to counteract water penetration. Pipes may not have the correct coating system, or a mistake may have been made or damage caused when installing the coating, insulation or cladding. **But even the perfect system can be damaged in service, and systems will age.** Water can be expected to enter the system at some point and the coating system will no longer offer 100% protection.

Corrosion under insulation is therefore a systemic challenge and must also be treated as such from the design phase through to scrapping. Important elements are:

- **The design** must prevent water penetration and water traps inside the system, but also ensure there is sufficient space to apply a correct surface treatment and install the insulation and cladding.

- **The coating system/metallization** is the primary corrosion protection and must be chosen according to the temperature – bearing in mind the system may be exposed to very hot water. Installation of the coating, including surface preparation, is critical for service life and performance.

- **The insulation material** must be optimized so that it does not accelerate corrosion.

- **Cladding** must be installed correctly so that water drains away from the surfaces, assemblies must be sealed, and drain holes provided.

- **Quality control** is important throughout the process.

- Lastly, **inspection routines** must be drawn up and cladding, insulation and coating systems under the insulation must be maintained after commissioning.
CUI is highly likely in equipment operating in the temperature range of 50-175°C, in both ordinary steel and stainless steel, and very highly likely in ordinary steel operating in cyclic service in the range of -20 to 320°C. Corrosion is accelerated in environments with high salt concentrations (offshore and coastal installations), in humid environments and generally where equipment operates in cyclic temperatures.

Oil company ExxonMobil has reported that 80% of its CUI events (such as corrosion resulting in leakages) are on pipes, of which approximately 80% is on 4-inch or smaller diameter pipes.

So what role does the insulation material play in all this?

ROCKWOOL Technical Insulation arranged for the independent corrosion laboratory METALogic in Belgium to conduct a test in accordance with ASTM G189-07, the only international CUI test standard:

- The test equipment was designed so that six separate panels could be tested in a single test.
- The panels were made of carbon steel.
- A complete insulation system was installed (insulation and cladding).
- Water was added through a hole drilled in the top of the insulation system and drained through 2 holes in the bottom.
- The insulation was moistened/dried in a series of cycles: cold/wet (140°F/ 60°C) and hot/dry (302°F/ 150°C).
- The (demineralized) water was recirculated so that any washed out salts could influence the rate of corrosion.

<table>
<thead>
<tr>
<th>Cyclic test</th>
<th>One cycle</th>
<th>No. of cycles</th>
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<tbody>
<tr>
<td>Time</td>
<td>20 hours</td>
<td>4 hours</td>
</tr>
<tr>
<td>Temperature</td>
<td>140°F/ 60°C</td>
<td>302°F/ 150°C</td>
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<tr>
<td>Wet/dry</td>
<td>Wet</td>
<td>Dry</td>
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The results can be seen in the following images, but have also been measured in detail as a loss of metal weight due to corrosion, as well as the depth of corrosion. The circulated water also underwent chemical analysis.
As expected, there was corrosion present under all of the insulation materials. In this test, where water was introduced onto the surface of the steel, the pipes insulated with diffusion open insulation materials coped better than those with diffusion sealed materials. Products with higher salt (chloride) concentrations suffered significantly more corrosion, regardless of the type of insulation material.
We presented the complete test results at the annual NACE conference in New Orleans in March, 2017. Contact us to get a copy of the paper containing more detailed information.

The results largely agreed with NACE SP 0198-2016 that describes exactly how corrosion can occur under all insulation materials and how you can reduce the amount/rate of corrosion by carefully selecting insulation material. NACE specifies that the essential parameters are: salt (specifically chloride) content, the capacity of the material to absorb water and to dry again, and the propensity of some organic insulation materials to produce acid during ageing, which can accelerate corrosion.

NACE concludes that the insulation material that contains the least amount of water and dries most quickly is the best material to combat corrosion.

What are we doing to prevent corrosion?

Here at ROCKWOOL Technical Insulation, we are constantly looking for ways to improve the corrosion performance of our products. Our stone wool products are open to water vapour diffusion, which means that any water that enters the insulation can also exit again.

In addition, the products have neutral to low alkalinity, which is also a positive factor in combating corrosion. All our products are treated to ensure they are water-repellent.

Our products for the process industry (ProRox series) are produced with a very low soluble salt content. Most are even supplied with a declaration that they contain less than 10 ppm (parts per million) of chloride.

We recently upgraded our ProRox pipe section series, ProRox PS 960, ProRox PS 970 and ProRox PS 978 with WR-Tech (Water Repellency Technology), so that these products now have even better water-repellent properties – proven 5 times less water absorption than any other mineral wool product on the market. These water-repellent properties are maintained at temperatures up to 482°F/250°C, which is also unique on the market. As the products absorb less water, they also dry more quickly, and as NACE states, this results in less corrosion.

Although the water-repellent properties are significantly improved, the water vapour diffusion properties are not reduced, and the products remain diffusion open.

Internationally recognized CUI experts believe that the best insulation system to minimize the risk of CUI is, “non-contact insulation”. Non-contact insulation works by creating a cavity between the steel and the insulation, so when water enters the insulation system it is not retained on the steel surfaces. This means that the steel dries more quickly, resulting in significantly less corrosion.

Non-contact insulation works best in combination with a diffusion open insulation material and in a test Statoil in Norway concluded that stone wool in combination with non-contact insulation was the system that produced the least corrosion.

We also have a flexible non-contact insulation spacer system - ProRox NCS 2000 which is made from a high temperature resistant polymer.

Summary

Corrosion under insulation is one of industry’s greatest challenges with regard to materials. There is no simple solution. Industry must deal with the challenges associated with CUI throughout the lifecycle of a project, from design to scrapping. In terms of materials, the most important focus areas are coating/metallization, cladding and insulation.

Corrosion can occur under all insulation materials when there are problems with the installation or when damage occurs. But you can influence the rate of corrosion by selecting the right insulation material.

The field of CUI is developing fast, with better coating systems, better insulation materials and new insulation systems, such as non-contact insulation, all of which aim to reduce the risk of corrosion.

About the author: Søren Nyborg Rasmussen is a chemical engineer with 28 years’ experience in corrosion protection coating and insulation for Industry, Marine and Offshore. Contact Søren if you are interested in receiving further information about corrosion under insulation and what ROCKWOOL Technical Insulation can do: soren.nyborgrasmussen@rockwool.com

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