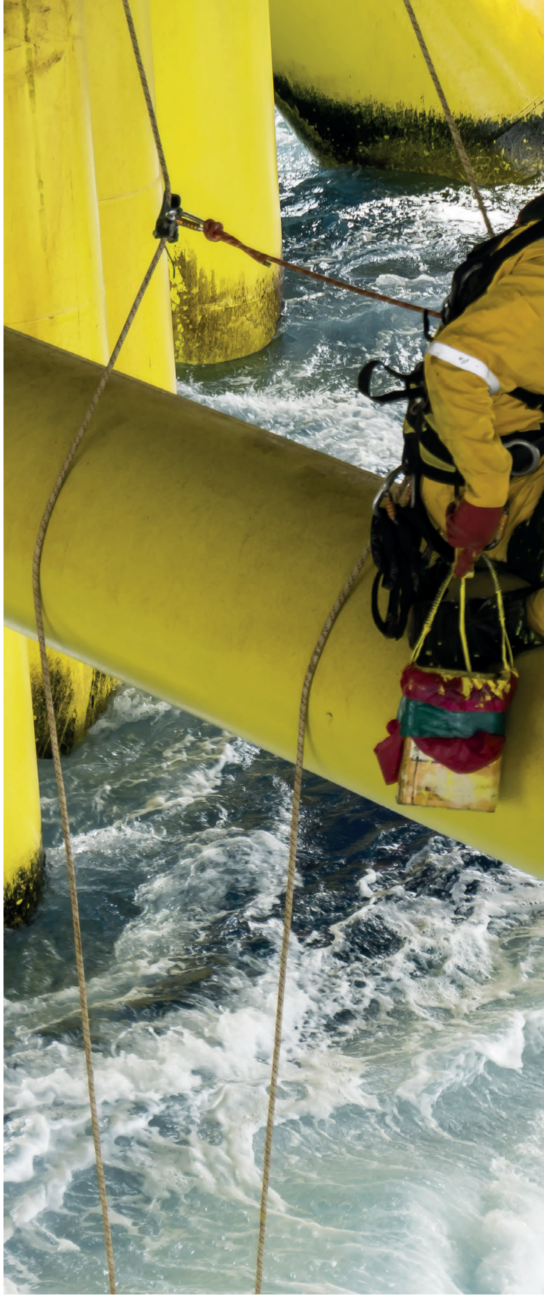
Manage corrosion or fight it?



Is there anything that can be done to prevent or protect against corrosion? This is a question which preoccupies many in our industry. There are many types of corrosion, which in fact is a natural process, so it seems it's like trying to hold back the tide. Is there anything that we mere humans can do to stop it? Jo van Montfort, director and coating specialist at Bjond, gives PES his expertise and thoughts on 'atmospheric corrosion'.

What is corrosion?

As all material in the universe strives to return to its lowest energy state, pure metals, such as steel also strive to revert to their lowest energy state, which they were as sulphides or oxides. All man-made structures disintegrate until the lowest energy content is reached. A well-known example of this is corroding or rusting of steel, in which the energy that is supplied to make the steel out of ore is released again and the material disintegrates into rust.

Unprotected, unalloyed steel or carbon steel exposed to a marine environment gets back to where it came from unless we add energy to it. This can be done e.g. by applying a protective coating for the parts above the water line. These parts are mainly exposed to what is defined as 'atmospheric corrosion'.

What is 'atmospheric corrosion'?

Carbon steel corrosion is mainly determined by the environment to which the steel is exposed. In the case of offshore structures, the dominant type of corrosion above the waterline and in the splash-zone is so called 'atmospheric corrosion'. Under the water line other types of corrosion occur, such as e.g. microbiological induced corrosion.

Atmospheric corrosion of unalloyed steel is a generally defined as a uniform and local form of thickness loss that depends on the presence of water and oxygen at/on the steel surface. However, water films are not always visible, especially if an amount of rust has already been formed. Atmospheric corrosion can also occur locally depending on what is going on at the steel surface; contaminations, failing paint layers etc.

The corrosion product of steel: 'rust' is porous and voluminous, 7-9 times the volume of steel, and therefore well permeable to water and oxygen. This means that when we observe a corrosion layer of about 1 cm thick, approximately 1.4 – 1.1 mm of underlying steel is lost.

If the relative humidity is lower than 40%, the corrosion rate is negligibly low because there will be virtually no condensation. Above 60%, the steel will corrode due to condensation and the possible presence of salts and/or gases in the atmosphere chlorides, sulphates, NOx, CO_2, etc. This principle is used for example to protect the inner side of hollow bridge sections. The air, in the internal parts of hollow bridge structures, is dried using dehumidification equipment until there is no possibility of condensation, resulting in extremely low corrosion rates.

Under humid conditions, outside and offshore, the corrosion rate is highly dependent on the following environmental conditions:

- Time of wetness; no wetness, no corrosion.
- Temperature changes; higher temperatures, higher corrosion rates.
- Surface texture; e.g. condensation from capillary voids in the steel or rust layers.
- Geometry and orientation construction; certain parts of the structure that remain wet longer are more affected by corrosion.
- Salt and gas contaminations in the air; for example (chlorides, sulphates, NOx, CO_2,

etc.) can higher corrosion rates of up to 1-2 mm/year.

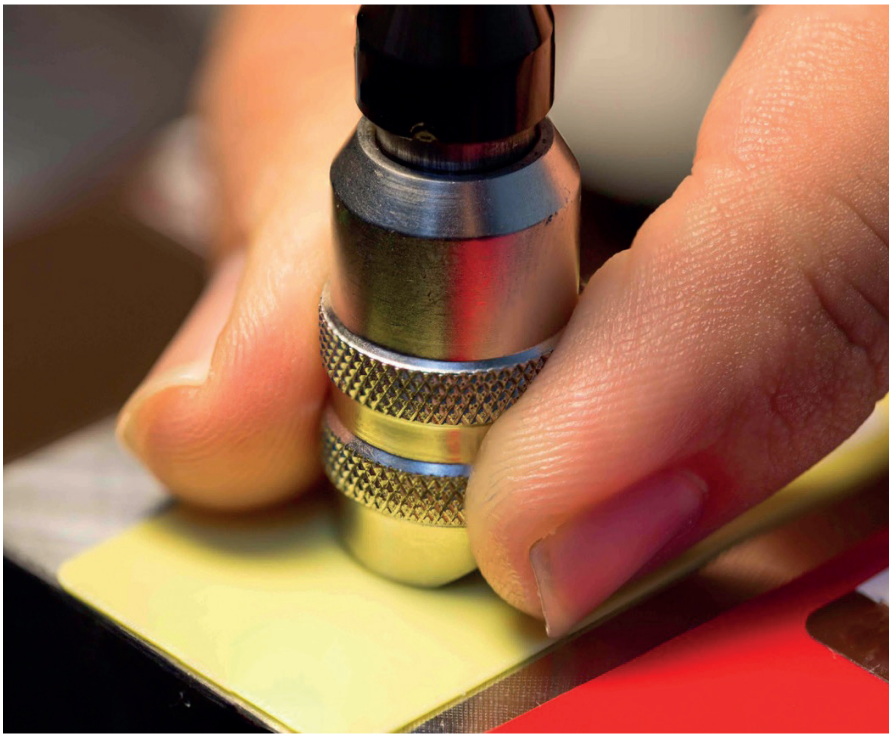
- Deposits of corrosion products or contaminants can lead to local (pit formation) attack rates of 1-3 mm/year.

Doing nothing?

Understanding the definition of 'atmospheric corrosion' correctly means that in a marine environment, in most cases, the use of a corrosion protection is justified. Corrosion rates are that high that within a few years structural integrity and the safety of unprotected carbon steel structures will be compromised. On top of that, local attack rates can make it even worse. Therefore assuming the design life of the structure is at least 25 years, means that doing nothing is not an option.

Complexity

Steel structures are designed by structural engineers from a perspective of bearing loads. In most cases a certain amount of extra steel is prescribed with the intention of extending the service life,



by scarifying this extra amount of steel, the so-called corrosion allowance. For this it is assumed that steel corrodes and loses thickness uniformly.

However, from the definition of atmospheric corrosion we learned that in real life this assumption is not always correct. Small deposits, structural details such as reinforcement plates, bolts/nuts, etc. are responsible for the occurrence of local attack and refuting the assumption of uniform corrosion.

The design of structural details sometimes reaches such a level of complexity that achieving long-term protection against corrosion is not only challenging but almost impossible.

In those cases, a war has to be fought against two enemies:

1. Nature that wants bring back everything to its lowest energy content
2. Structural complexity not taking into account that a corrosion protection, (coating) has to be applied (paintable).

We corrosion engineers are not always consulted about these matters during the design process. We experience a certain unawareness of incompetence in this field. Bjond strongly advocates working together from the early design stage of the process. This will result in the best of both worlds: practically the most perfect structural design, fulfilling all structural requirements and which can be protected long term by a coating system. Initial and maintenance costs can be greatly reduced and better managed.

How to select a fit for purpose coating system?

The most common way of (atmospheric) corrosion protection is done by using an organic coating system also called ‘paint’. The question is then which coating system? How many layers? What dry film thickness (DFT) and which type of binder, pigmentation etc.?

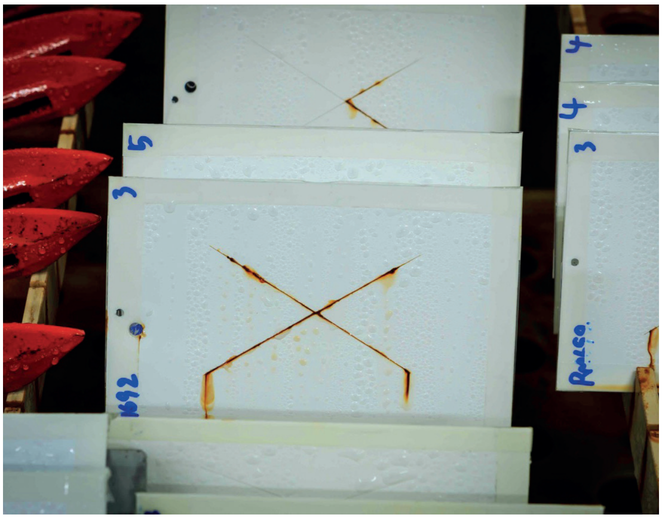
ISO 12944-5 the standard for paints and varnishes - Corrosion protection of steel structures by protective paint systems - provides a general description of coating systems, e.g. use a four-coat epoxy coating comprising of:

- 1st layer; Epoxy Primer DFT 80 µm
- 2nd layer Epoxy coating DFT 160 µm
- 3rd layer Epoxy coating DFT 160 µm
- 4th layer Polyurethane coating DFT 80 µm

In our opinion this part of the standard is too general and does not result in the best fitting solution. We hope everyone agrees that no prediction of performance can be generated from a general description of a coating system. This might be the reason why in many offshore paint specs, the coating system needs to comply with the Norsok standard M501.

This means that a coating system, applied under laboratory conditions on a flat panel, needs to pass a cyclic corrosion test in the laboratory. Coating systems fulfilling these requirements are considered suitable.

However, from our experience we almost never face coating failures on flat parts of structures. On the contrary cracks resulting



in unwanted and early, often localised corrosion, are mainly found on edges, welds, rims etc. But these effects are excluded from the tests.

The standard tests also exclude issues such as tolerance for less ideal conditions, for example low temperature or high relative humidity during application. It should be clear that complying with these tests and standards gives only a limited assurance for a long-term performance.

Bjond Approach

We at Bjond select a coating system which is fit for purpose, by conducting a thorough analysis of the functional requirements and expected circumstances during application and during service.

This results in a complex pyramid of requirements, starting with 1) user requirements which are translated into 2) functional requirements which are turned into 3) performance requirements and at the very end into specifications (descriptive requirements). This way of thinking is not new and actually the same systematics are used by structural engineers during a design process.

Issues which should be considered during the selection process of a coating system and a coating spec are:

- The more layers the more chances of mistakes
- Relevant track records are always better than tests
- Use test results but always in the right perspective
- Making a paint specification is not a copy-paste action but customisation
- A good paint spec is more performance based than descriptive
- Use independent know how and experience to manage corrosion

Some good advice

As we explained, fighting corrosion becomes more complex as the complexity of structures increases. This of course also applies to the protection of the steel substrate with a coating system. Based on our experiences, we conclude that fighting atmospheric corrosion under offshore conditions is almost impossible.

Coating systems will continue to fail because nature will always win in the end. But there is still hope. Using all available know-how and experience, in this very interesting field of technology and joining forces with all parties involved, will lead to better ‘war’ management against corrosion.

By understanding the impact of test results and using proven selection strategies, corrosion can be managed more effectively. This will not only reduce maintenance costs but also improve the image of the protective coating world.

Recognising the need for looking outside the box, beyond the existing rules and standards is the beginning of the progress needed to manage corrosion protection.

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