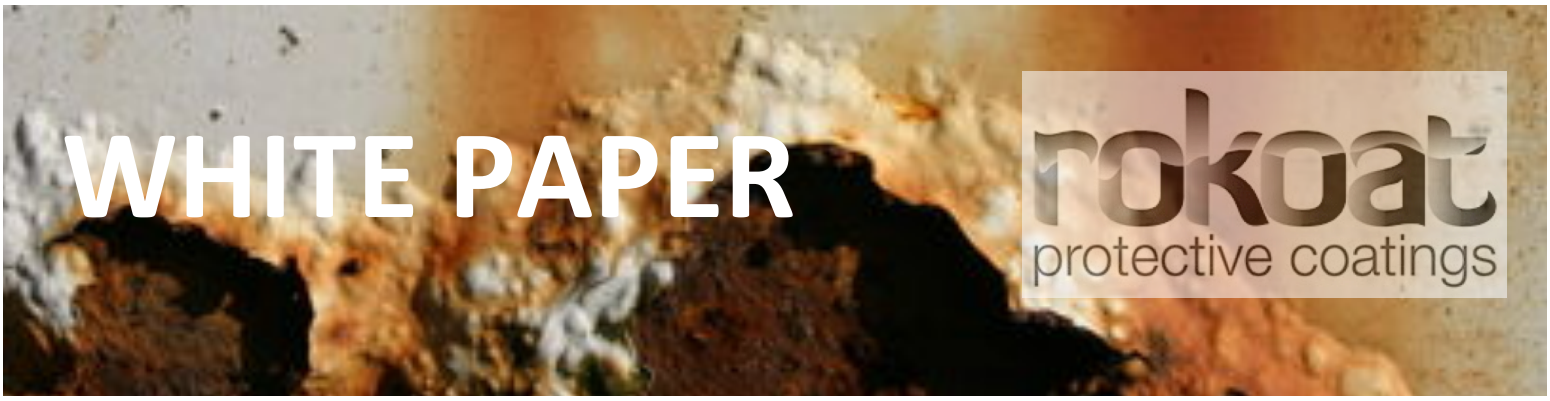


Understanding Corrosion

Overview

According to a NACE IMPACT study released in 2017, globally corrosion costs around US$2.5 trillion, accounting for around 3.4% of the globes GDP. Corrosion is a costly problem. However, by understanding its root causes, effective steps can be taken to prevent and combat it.

There are several types of corrosion costs that we must consider:

- Direct loss or damage of metal structures due to corrosion. An example is a hot water tank that has corroded and must be scrapped.
- Maintenance costs attributed to corrosion. Any metal surface that must be painted every few years to control corrosion falls into this area.
- Indirect losses resulting from corrosion. These losses may result from leakage and fires. Explosions attributed to leakage, power failures, facility shutdown and labor losses are also indirectly the result of corrosion.

The first step toward controlling these costs requires understanding what corrosion is, and what causes it.

What is rust ?

When iron or steel corrodes, the result is iron oxide, or what we call rust. Steel is mostly composed of iron ore. In its natural state, iron ore looks much like rust: dark red and finely grained, with a tendency to hold moisture.

Iron ore is a stable substance until it is converted into iron or steel, naturally weaker elements. When steel is exposed to moisture and oxygen, it immediately starts regressing to its natural state. Although protective measures have been taken, a large part of the steel made in this century has already rust back to an oxide, its natural state.

Three elements are required for corrosion to exist: a protected metal, a corroded metal, and a current-conducting medium between the two. When two dissimilar metals are brought into contact, one will become the protected metal, and the other will become the corroded metal. There are many environmental situations that are conducive to corrosion.

For example:

- If galvanized fittings are used on steel pipe, the galvanized (zinc) fitting will become

corroded, while the steel remains protected.

- Steel or other metals under stress will become corroded, while the unstressed steel is protected from corrosion. This is the reason you see rust pitting on steel.
- Freshly cut steel will corrode more rapidly. Threads cut on pipe will always rust first.

Even if a piece of steel is not in contact with another metal, neither under stress nor freshly cut, it will rust when exposed to weather. This is because steel is not entirely uniform in composition – slight variations in density and composition will occur within a single piece of steel, which results in corrosion.

The third ingredient needed for steel to corrode (the current conducting medium) is an electrolyte. This is normally a liquid or water-containing substance that conducts the corrosion's current from the protected metal to the corroded metal. The most common current-carrying substance is water. Rain, dew, humidity and condensation, all serve as efficient electric conductors. Steel corrodes very slowly in desert climates where humidity is low and rainfall rare. In areas of high humidity and frequent rain, protecting steel is critical. The following environments offer electric currents that speed the corrosion process:

- Adding salt to water greatly enhances its current-carrying ability. Thus, steel exposed to seawater or salt spray will corrode more rapidly than steel in fresh water. Atmospheric corrosion is greater in areas near the oceans, due to the effect of salt air. Concentrated brine solutions, such as those used in the food-processing industry, cause severe corrosion.
- Industrial smoke and fumes contain acids, alkalies and other chemicals, which serve as current conductors. Consequently, atmospheric corrosion in industrial areas is more severe than in rural areas.
- Soil, clay and earth materials are also good conductors of electricity. Pipelines and other steel buried in the ground will be prone to corrosion unless protected. Just as soil varies considerably in composition, it also varies in its electric conductivity: some soils cause more severe corrosion than others.

Corrosion control

To make the use of steel and other metals practical in construction and manufacturing, some corrosion-protection practices must be employed. Otherwise, the life of steel and other metals will be limited, reducing efficiency and escalating the cost of maintenance. There are several effective ways to stop corrosion:

1. *Impressed current.* By using suitable current-generating equipment and controls, it is possible to reproduce a current equal in strength to the corroding current, but flowing in the opposite direction. This type of protection is generally limited to pipelines, buried tanks, etc., and requires careful engineering and layout. Used improperly, an impressed current can promote corrosion.
2. *Sacrificial metals.* Steel can be protected by adjacent placement to a dissimilar metal. For

example, if zinc or magnesium is placed in direct contact with steel, it protects the steel from corrosion. Here, zinc and magnesium serve as sacrificial metals that not only protect the area of immediate contact, but also protect beyond the metal in each direction. Protection from rust by sacrificial metals is commonly used in several forms:

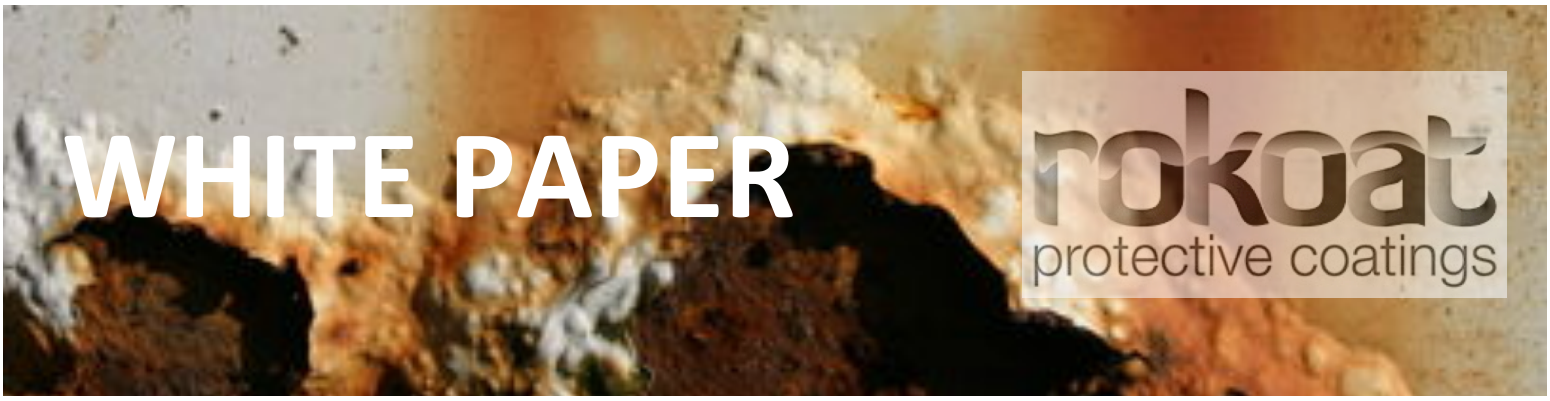
- Zinc or magnesium blocks are often used to protect ship hulls, water tank interiors and other submerged surfaces.
- Complete covering of the steel with the sacrificial metal is often done. Galvanized steel, for example, is steel covered with zinc. The zinc is sacrificial and will protect the base steel.
- Zinc-rich coatings may be applied to a steel surface to provide cathodic protection. Zinc-rich coatings consist of 85% to 95% zinc metal in a suitable binder. The zinc particles, deposited by painting, protect the steel.

3. *Primers.* Primers and finished coatings are the most cost effective corrosion control and protect metal surfaces by providing a barrier between the steel and the corroding elements. They also prevent moisture from reaching the surface of the steel. A coating film protects underlying metal substrates in three ways:
   - Coatings can slow the rate of diffusion of water and oxygen from the environment to the metal surface. This slows the corrosion process.
   - The coating can slow the rate of diffusion of corrosion products from the metal surface. This also slows the corrosion process.
   - The anti-corrosive pigments contained in quality primers change the surface properties of the base metal. The metal develops a high electrical resistance as a result. Different pigments accomplish this reaction in different ways. Primers absorb and tie up moisture so that it does not react with the steel.

How to choose a rust proof coating

Considering the following criteria can reveal the most effective type of rust-proof coating needed for a specific project.

- *Quality of coat/application* - What level of anti-corrosive coating is needed? How important is it for the coating to be fade-resistant and/or abrasion-resistant? How often do you expect to reapply? Is there an application preference: brush/roller or spray?
- *Aesthetics* - What materials are going to be coated? How important is it for the coating to look attractive? Is colour retention important?
- *Price* - Typically, higher quality increases the price. Are touch-up applications being considered when estimating the maintenance costs? What is the value of the coating selected? How often will it need to be recoated?
- *Environmental regulations* - What are the local environmental regulations for paint and coatings? Is the paint within these standards? How will the coating process affect nearby surroundings? Since the turn of the century governments globally have enacted stringent regulations controlling VOC limits in paints and coatings.



Coatings

There are three general types of coatings used in maintenance painting. Based on quality, price, application and aesthetic requirements, appropriate choses can be made from the following:

• *Alkyd enamels* - Alkyd enamels are designed for indoor and outdoor surfaces in moderate to severe conditions. This coating offers solid corrosion resistance for up to 3-5 years. Alkyd enamels provide high-gloss colour, resist against colour fading, and can be applied using a brush roller or spray.

• *Epoxy coatings* - Epoxy coatings are used for indoor or outdoor surfaces in industrial environments where color retention and gloss are not important. The quality of the coat will be better than an alkyd enamel since it withstands harsh industrial environments. Epoxy coatings are best applied by spray, but brushes and rollers can also be used.

• *Polyurethane coatings* - A polyurethane coating is generally regarded as the best quality and highest priced of three options. It withstands most severe environments and is long lasting. It provides strong colour and gloss retention and is resistant to abrasion, making it appropriate for external applications. Polyurethane coatings are applied by spraying.

Conclusion

Protective primer coatings and paint work because they slow down corrosion by reducing the rate of current flow in the electrochemical corrosion process. By understanding corrosion we can predict where rust is likely to occur, and recognize the environmental factors that promote corrosion. The good news is that while corrosion can be costly, it doesn't have to be. Coatings are a cost-effective measure to ensure protection from corrosion. Regular maintenance can minimize the appearance and effects of corrosion.