THE COMPLETE GUIDE TO CORROSION

WHAT IT MEANS, HOW MUCH IT COSTS AND WHAT WE CAN DO ABOUT IT

Corrosion is the reason for Thomas Industrial Coatings. It's a destructive and expensive natural phenomenon, but without it we wouldn't exist. This relentless chemical process will undoubtedly set in if the proper precautions aren't taken. But precisely because effective precautions have been discovered, it's possible to keep corrosion at bay.

And it's turned into big business. According to a study conducted by the National Association of Corrosion Engineers (NACE) and the Federal Highway Administration, corrosion costs the U.S. economy an estimated $276 billion annually and affects nearly every sector of industry.

Standard definitions of corrosion usually leave open the possibility that it can occur on other materials—wood, plastic, concrete, etc.—but the term is most commonly applied to the degradation of metals. In essence, corrosion is simply the reaction of a surface material to its environment.

As simple as that sounds, there's actually quite a lot to it. But we'll set aside the advanced chemistry for now. For our purposes as industrial painters, corrosion refers to the chemical or electrochemical process that degrades metal surfaces to the point where its physical properties, such as strength and hardness, no longer resemble the original.

Oxidation, or the electrochemical reaction of iron to oxygen, is one of the most common forms of corrosion. When oxygen reacts with iron, iron oxide, or rust, is formed. Since iron tends to be the largest component of steel, the most commonly used alloy used in modern infrastructure, the corroding of iron makes up the bulk of what is encountered on bridges, pipelines, penstocks and other structures.

NACE names five factors that have a large affect on the rate of corrosion: oxygen, temperature, chemical salts, humidity and pollutants. The presence of oxygen, high temperatures, chemical salts, frequent humidity and acid rain all accelerate rates of corrosion and need to be accounted for in a corrosion prevention strategy.

Corrosion can be an eyesore. But more than that, it can seriously compromise the structural stability of an asset and cause enormous financial setbacks if not adequately prevented. Whatever the costs of protecting a structure against corrosion, the costs of not protecting it are surely greater. That's why there are so many people devoting so much of their time and energy to understanding corrosion and how to prevent it. Research and development, coatings production and application are all links in a chain, every one of which must be sound in order to win the battle against corrosion.

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The different types of corrosion

Broadly speaking, corrosion can be separated into two distinct types: generalized and localized. It's possible to further subdivide corrosion from here, but dividing a corrosion problem is a good place to start. If corrosion on a particular asset is generalized, diagnosis and treatment will be relatively straightforward. Localized corrosion, however, can be a bit trickier both to spot and to remedy.

Generalized corrosion

Generalized corrosion, as its name suggests, affects the entire surface area of an asset. It can take the form of a more or less uniform loss of surface material or a generalized thinning which spans the entirety of a metal surface. It is also sometimes referred to as "uniform corrosion."

Because generalized corrosion is predictable, treatable and easy to detect, it is widely regarded as the less treacherous of the two types of general corrosion. Metal surfaces affected by generalized corrosion, for the most part, show visible signs of being affected prior to becoming structurally compromised. Hence, maintenance normally occurs long before this type of corrosion completely ruins an asset. If left unchecked, however, uniform corrosion will eventually result in the complete degradation of an asset.

Localized corrosion

Localized corrosion, once again as its name implies, is corrosion affecting a specific location on a metal surface. Because localized corrosion usually occurs in areas not plainly visible, it is often the more difficult of the two types of corrosion to detect. It is commonly the result of a failed or improperly applied coating.

Additionally, since localized corrosion often occurs in areas that are ostensibly already protected against such corrosion, asset owners often don't even suspect they should be on guard against it. This makes localized corrosion even more likely to evade detection.

According to NACE, the two most predominant forms of localized corrosion are pitting corrosion and crevice corrosion. Filiform corrosion is another type of localized corrosion that can become an issue given the appropriate conditions.

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- **Pitting corrosion** – Pitting corrosion occurs when localized holes or cavities form at points of failure in a passivation corrosion control system. Compared to generalized corrosion, the relatively small areas that characterize pitting corrosion incidents make this type of corrosion more difficult to spot, and hence more likely to progress to the point of becoming a serious failure. Pitting corrosion also has a tendency to appear small and concentrated on the surface of a metal, when it is in fact large and widespread beneath the surface.

- **Crevice corrosion** – Also known as contact corrosion, crevice corrosion occurs at a point of contact between either a metal and a metal, or a metal and a non-metal. This type of corrosion typically occurs under gaskets, washers, clamps, or even between a metal and barnacles in the case of permanently and frequently submerged assets. Because the surfaces afflicted by crevice corrosion are partially shielded from exposure to the outside environment by the materials adjacent to them, this type of corrosion is also very difficult both to detect and to defend against. Often crevice corrosion is addressed during the building phase, where instances in which it might occur are deliberately engineered out.

- **Filiform corrosion** – Filiform corrosion occurs when moisture penetrates a protective barrier and settles between the barrier and the metal surface. The barrier could be a protective coating, metal plating or some other measure meant to provide added protection for a surface. It often results from improper surface preparation. Corrosion under insulation (CUI), a common problem in many processing facilities, is a form of filiform corrosion.

All of the above forms of corrosion are avoidable. But when ignored, the costs to the American economy are astronomical.

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What does corrosion cost?

Corrosion is an eyesore. Few will argue that. But while it may be an unsightly occurrence, looks are nothing compared to the potentially devastating health and safety effects of unchecked corrosion. And it's the corrosion that goes unseen that's often the most dangerous. Governments and asset owners are not always pleased when it comes time to re-up on their structure's corrosion defenses, but not doing so will undoubtedly prove more costly in the long run.

It's those costs, both in monetary and in health and safety terms, that makes what we do here at Thomas Industrial Coatings about more than just coatings. It's about protecting the infrastructure that allows us to continue with business as usual, most of us without giving much of a thought to corrosion.

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Corrosion and public safety

Not all corrosion is created equal. Some types of corrosion are better able to escape notice than others. These represent the largest hazard to human health and safety because, when they occur, they are able to degrade an asset to the point of failure before they're even noticed. While ugly, generalized corrosion is usually easy to spot and hence more likely to be dealt with before a serious failure occurs.

The steel rebar that supports our highways, the steel beams and trusses beneath our bridges, the pipes and tanks that hold our drinking water— all are susceptible to localized corrosion that can be both difficult to detect and expensive to repair. Without repair, roadways can crumble, bridges can collapse and drinking water can become contaminated, all threatening the well being of the general public.

Corrosion in dollars

It's probably unsurprising to most of us that corrosion costs money. What may be a surprise is exactly how much money it costs the country. According to SSPC, corrosion of metals cost about $276 billion annually. NACE estimates that unmitigated corrosion costs the U.S. economy roughly 3.1 percent of the country's total GDP.

Many studies have been dedicated to the cost and prevention of corrosion in the food and beverage industries. When it occurs on cooling and cooking equipment, food is in danger of being contaminated. Some studies place the costs associated with keeping stainless steel kitchen equipment in the billions of dollars.

Given the costs of unchecked corrosion, it's no surprise that a lot of money is also spent on preventing it from occurring in the first place. NACE also estimates that, on average, $100.5 billion is spent annually on the raw materials and labor to combat corrosion.

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Because it's typically far more expensive to coat a new structure than to re-coat and repair an existing one, regular coatings maintenance represents a huge opportunity to reduce overall corrosion-related expenditures. Current best practices in the corrosion industry are estimated to save billions of dollars annually in damages. Technological breakthroughs in the maintenance of oil and gas pipelines, highway bridges and water and wastewater treatment plants have greatly increased the returns proactive corrosion prevention strategies deliver to these industries.

Keys to corrosion prevention

So far, we've defined corrosion, differentiated between different types of corrosion and assembled some facts and figures regarding what corrosion costs the American economy. Now we'll turn to how corrosion can be prevented. As you may or may not know, this is what we would call our sweet spot.

Methods of corrosion prevention

The goal of corrosion prevention is to preserve the integrity of an asset as well as to preserve the integrity of any materials an asset may contain. In the case of a water storage tank, this would mean keeping the water inside potable by keeping it from becoming contaminated. In the case of a storage tank holding more volatile contents, such as jet fuel, the corrosion prevention solution must be resilient enough to protect the storage container without reacting to the contents inside.

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According to NACE, the following are the four most common methods for the prevention of corrosion:

- **Corrosion inhibitors** – Inhibitors are a class of chemicals that have the ability to slow the corrosion of a metal or alloy. They are typically added to electrolytes in small amounts, often in closed systems such as tanks and piping. This type of corrosion prevention is common in the oil and gas extraction and processing industries.

- **Cathodic protection** – This form of protection makes use of metals more susceptible to corrosion—such as magnesium, zinc or aluminum—as a sacrificial barrier to protect an asset from corrosion. These sacrificial metals, or anodes, corrode preferentially to the substrate they protect, keeping the asset corrosion free.

- **Material selection** – Prevention by material selection and design seeks to engineer out the most common sources of corrosion. This can mean manufacturing from metals less reactive than steel, such as platinum or stainless steel, or by avoiding corrosion "hot spots" during the design phase. No metal is completely immune to corrosion, but some are able to resist the process for longer. Obviously, price becomes a major consideration when evaluating this method.

- **Coatings and linings** – By far the most common strategy for corrosion prevention, coatings and linings are often used in conjunction with cathodic protection for optimal protection. The type of coating or lining used, and the thickness at which it is applied, vary greatly and must be tailored in order to most effectively fight corrosion given the environmental conditions of an asset.

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Corrosion control programs

Whichever method of corrosion prevention is right for an asset, one or more of the above strategies will play a part in a broader corrosion control program. This program will detail the specifications for the prevention method to be deployed, the surface preparation necessary to effectively implement the method and provisions for quality assurance and quality control.

Another aspect of a comprehensive corrosion control program will address the issue of contractor selection. But before an application contractor is selected, asset owners need to do their research. That's why we've put together this guide for what to consider when hiring an industrial painter. It's not meant to be a stand-in for all the research that should precede making a hire, but it's a good start to this crucial portion of a comprehensive corrosion control program.

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About Thomas Industrial Coatings

Incorporated in 1991, Thomas Industrial Coatings has since grown to become one of the most trusted names in industrial painting and coatings. Our philosophy is based on achieving one feeling: Pride. We believe that if we take pride in all that we do, quality workmanship will naturally follow. One way we achieve Thomas Pride is by keeping safety at the heart of all we do.

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We're constantly updating our website with original content, company news and the latest from around the industrial coatings industry. Keep up to date by subscribing to our newsletter, connecting with us on LinkedIn or "Liking" Thomas Industrial Coatings on Facebook.

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