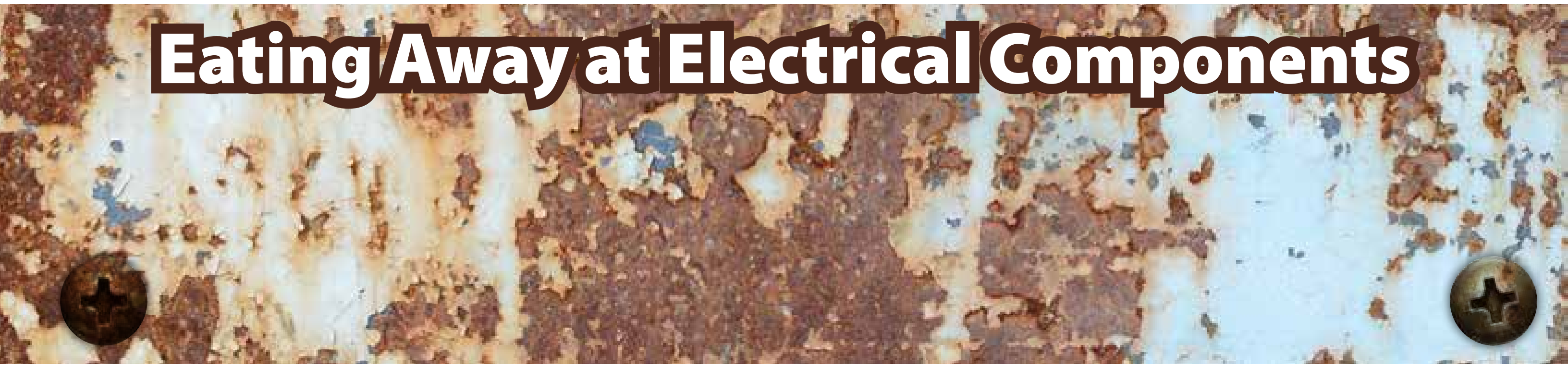
CORROSION:

Eating Away at Electrical Components



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According to NACE International, the corrosion of metal on infrastructure, buildings, equipment, and vehicles costs the world's consumers, businesses, and governments more than $1 trillion each year. Electrical component manufacturers and their customers bear a significant portion of that expense, yet the best strategies for designing and coating electrical enclosures, transformers, switchgear, and lighting fixtures to protect against this nemesis are often an afterthought.

This is problematic for several reasons. For one, electrical equipment may be required to withstand decades of service in harsh environments. That makes metal coatings a critical first line of defense for sensitive instrumentation and controls. There also are hidden costs for corrosion-related maintenance and repairs, as well as the damage done to the manufacturer's brand image by having their name affixed to unsightly equipment.

It's no wonder that buyers consider metal equipment design and coatings in light of total lifecycle costs—including maintenance and repair requirements—rather than initial purchase and installation price only.

Causes of Corrosion

Metal components corrode for any number of reasons, including the intersection of two metals with different corrosion thresholds, or factors such as continuous or repeated exposure to high temperatures and humidity, acid levels, electrolytes, chemicals, ultraviolet (UV), and sunlight.

The most effective way to select the right coatings for metal electrical equipment is a total system approach that considers and accounts for the following variables:

- Composition of the metal substrate
- Types of lubes and coolants used to fabricate the equipment
- Materials selected to pretreat the metal
- Type of finish coat, including film build and cure requirements

Beauty's Not Skin Deep

A common misconception is that coatings are painted on metal. In most corrosion protection systems, coatings are applied to the pretreatment layer on top of the metal substrate, which serves as the first line of defense against corrosion.

In addition to reducing surface corrosion, pretreatment products enhance the ability of coatings to adhere to coated metal parts, thereby preventing delamination. There are multiple pretreatment chemistries available—from iron-phosphates and zirconium-based products to zinc-phosphates and cleaner-coaters. The best chemistry for a particular application depends on substrate type, fabrication method and materials, and the desired performance requirements of the full coatings system, including the primer and topcoat.

Three major coating technologies can be deployed individually or in combination with one another. They include liquid, powder, and electrocoating.

Liquid coatings use solvents or water. They are applied to pretreated metal with electrostatic spray, dipping, and other conventional methods, then air-dried or force-cured. When used as part of an integrated primer, pretreatment, and topcoat system, liquid coatings offer exceptional corrosion and chemical resistance, excellent sag resistance, and strong adhesion.

Powder coatings are formulated for applications that require the ultimate combination of corrosion resistance, weathering performance ,and operational attributes. Powder coatings are typically formulated with polyester resins and are favored for their excellent corrosion resistance, chemical resistance, and all-around application versatility. Because they are made without solvents, they generate virtually no volatile organic compound emissions, which can help achieve environmental compliance.

During the electrocoating process, pretreated metal substrates are immersed in an electrically charged paint bath. Charged coating particles form a tightly packed, insulating layer that reaches every recessed area of the coated part. At the end of the coating line, the metal part is baked, creating a tough finish that offers more thorough protection than spray-applied coatings.

Another important criterion for selecting the right coating chemistry is the design of the finished part. Components with sharp corners, recessed areas, or intricate shapes can be finished with coatings that are formulated with high-transfer efficiencies.

Coatings manufacturers offer a variety of resin chemistries to improve resistance to corrosion and UV exposure, including epoxies, polyesters, urethanes and acrylics, as well as hybrid coatings, which incorporate a combination of resin chemistries. Each has its strengths and weaknesses. For instance, epoxies are ideal for chemical resistance and mechanical properties but lack in UV resistance and weatherability. Polyesters, urethanes, and acrylics have exceptional weathering characteristics, but each offers a different benefit, such as great physical properties for polyesters; chip, scuff, and mar resistance for urethanes; and superior surface appearance for acrylics.

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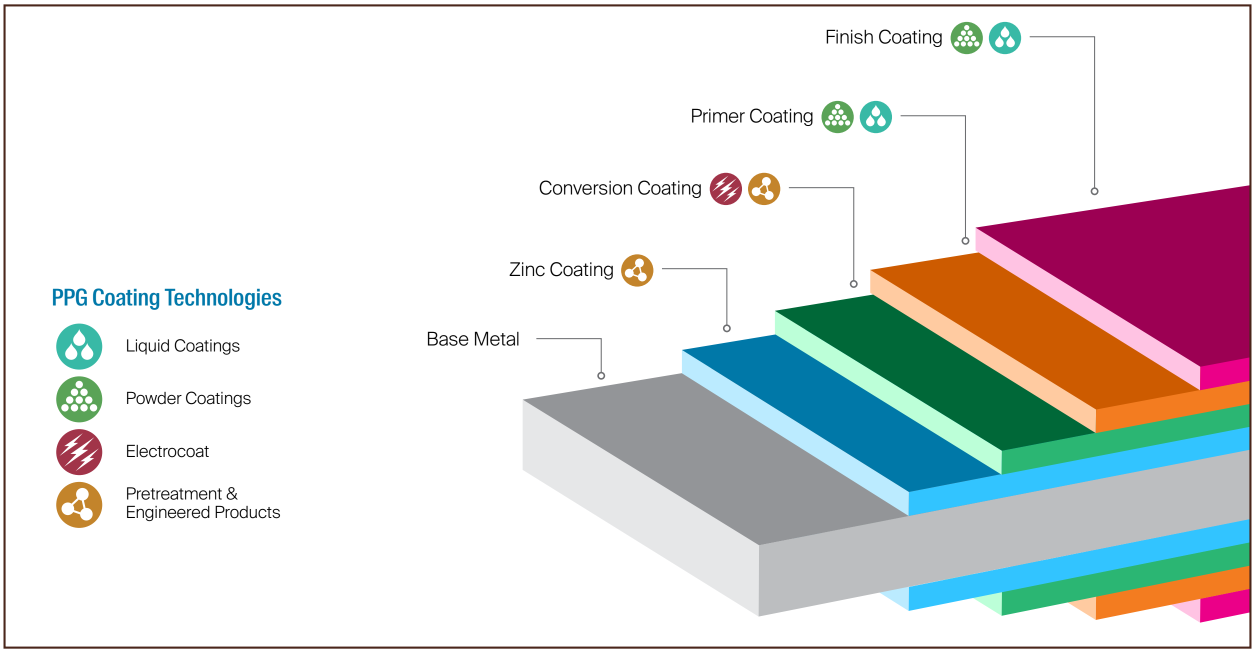

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Typical solutions include two-coat systems featuring a primer coat for corrosion protection and topcoat for color, appearance, and UV resistance. Other popular options include one-coat hybrid systems that combine a mixture of resin chemistries to provide an optimal balance of corrosion protection and UV resistance.

Troubleshooting

When coatings fail, determining the cause begins with basic questions:

- Is the corrosion visible on all parts or does it appear randomly?
- Is the corrosion confined to parts used in a specific geographic region, or do coatings fail in multiple climates and environments?
- Are failures widespread or sporadic? Is there a discernable pattern?

One parameter to analyze is phosphate coating weight. A phosphate coating weight that is too low will not provide enough corrosion protection, while one that is too high can compromise the structure of the coated part and cause it to crack or become brittle.

It is also important to look at crystal size in zinc-phosphate pretreatments and coating uniformity in iron-phosphate treatments. It is evaluated by viewing the failed coating under a microscope. This is the only way to determine whether a coating has the proper coverage and molecular structure to resist corrosion. The presence of bacteria also can negatively impact the conductivity of the paint (i.e., its ability to adhere to the metal substrate).

Another parameter is film build (or paint thickness). If the film build on a coated part is too thick, it can lead to problems with adhesion, peeling, and sagging. If the film build is not thick enough, the result is less protection from the environment and greater vulnerability to corrosion.

Paint cure is a variable that should be monitored carefully by running data packs through cure ovens to ensure that operating temperatures and other variables meet system specifications. Low cures can result in poor adhesion and insufficient mar and abrasion resistance. High cures produce peeling and cracks in the paint film.

A final consideration is laboratory-based performance tests that are designed to mimic real-world performance environments. While many coatings systems are robust enough to pass industry-accepted performance tests, they can fail in the field because the real-world conditions are more difficult to survive.

Matching Coatings to Performance

When evaluating a coating system for electrical equipment, it is important to understand all of the product requirements and the possibility that multiple chemistries may be required to optimize service life and corrosion performance.

For example, the exterior coating on a transformer may require corrosion, weather and chemical resistance, while the interior coating may need to be compatible with certain oils, lubes, and chemicals.

Coatings for switchgear and electrical enclosures may need to meet additional demands, such as insulative properties that allow them to trap heat or permeability that enables them to dissipate it. Humidity and heat oxidation also can affect a coating's ability to protect against corrosion, and equipment with sharp edges or complex shapes require a coating that is capable of fully covering such areas, which are common pathways for moisture penetration and corrosion.

Last, whether you are considering a coating system for a transformer or electrical enclosure, or to enhance the design of a lighting fixture, it is important to specify a coating that is both mar-resistant and abrasion-resistant, as these units are commonly exposed to contact with people, tools, or other pieces of equipment that can further increase susceptibility to damage and potential for corrosion.

When beginning the design of a new product or the next-generation of an existing product, evaluate the best paint system early in the design process. This will help ensure not only that the product can perform well in its service environment but also that it will require less maintenance throughout its lifespan.

It also helps to involve paint and pretreatment suppliers as early as possible in the product design process. Proven paint suppliers typically have a deep understanding of the coatings process from start to finish, along with a wide range of products and resin chemistries that have been tested according to industry-standard criteria. They also act as a partner in identifying potential vulnerabilities to corrosion and in helping their customers to select the right products to prevent it.

Understanding the causes of corrosion and variables help manufacturers develop a comprehensive coating specification.