The World Corrosion Organization estimates the global cost of corrosion at $2.5 trillion (USD). Therefore, any money saved by preventing corrosion, including the cost of lost productivity because of outages, delays, failures, and litigation; labor; and new equipment to replace failed parts, directly improves profitability.

Consider the petrochemical refining industry where processing equipment, electrical systems, and lighting need protection against pitting, corrosive gases, and water intrusions. In the U.S. alone, the industry's annual direct cost of corrosion is estimated at $3.7 billion. Of this total, maintenance-related expenses are estimated at $1.8 billion, vessel turnaround expenses at $1.4 billion, and fouling costs are approximately $0.5 billion. In a commodity-driven industry, investment in more effective corrosion control strategies often takes a backseat to across-the-board cost-cutting measures to the detriment of long-term profits, environmental safety and operational productivity.

When specifying electrical products for harsh environments choosing the right materials to ensure adequate corrosion-resistance is crucial. In offshore oil and gas operations, for example, equipment is under constant exposure to seawater and salt spray, both of which are highly corrosive due to the autocatalytic action of sodium chloride and other dissolved chlorides. Corrosive substances such as hydrogen sulfide and carbon dioxide also occur naturally in oil and gas fields. Other corrosives that affect a wide range of industries include chlorine, bromine, hydrochloric acid and ammonia.

IRON & STEEL TYPES

Most industrial electrical products worldwide are still made of coated metal. The most commonly used metals are ferrous, taking advantage of iron's strength, versatility, workability and relative affordability. Unfortunately, with the exception of stainless steel, ferrous products are also the most susceptible to corrosion.

PROTECTIVE COATINGS

Various finishes can be applied to help isolate metallic surfaces from the surrounding corrosive environment. The most familiar example is ordinary paint applied to steel to prevent rust. However, there are several other methods including baked enamel, epoxy powder coat and PVC coating. For effective protection, coatings must be applied properly and protected against damage during installation and use. The zinc surface on galvanized steel serves both as a protective coating and, if damaged, a sacrificial anode that will corrode in preference to the exposed steel.

Galvanization and Finishes

Galvanization of iron and steel products can greatly improve corrosion-resistance in wet or weather-exposed environments. In particular, galvanized cast iron and non-stainless steel products are often used in wet and weather-exposed locations with the expectation that they can safely remain in service for many years. Yet the same products would likely be unsuitable for direct exposure to corrosive chemicals. A wide variety of liquid and powder coat finishes can be applied to iron and steel products – including galvanized products – to help seal out water, air and corrosive chemicals. Their effectiveness depends on thorough coverage, reliable adhesion and suitable resistance to impact and abrasion in the field. Resistance to chemical degradation is also important. Epoxy powder coat is one example of a finish that provides excellent resilience and strength while remaining impervious to heat and most chemicals.

Galvanization: Providing two forms of protection against rust in a single process.

The only effective way to fight rust is to prevent the corrosive processes from beginning. This is normally done in one of two ways: by adding a barrier i.e.,paint, that prevents oxygen and electrolytes such as rainwater from reaching the surface, or by introducing a sacrificial anode, which corrodes preferentially to the iron or steel part. Galvanization provides both of these protection methods simultaneously.

Protective Properties

The galvanizing process creates a metallurgical bond between the zinc coating and the underlying steel or iron. This bond provides much stronger adhesion than any type of paint, including epoxies. The galvanized surface forms in multiple layers, with zinc and iron alloyed in varying ratios. The outer layer of pure zinc is relatively ductile, while the inner layers are progressively harder – harder than steel, in fact. These qualities combine to provide excellent resistance to both impact and abrasion, helping protect against surface damage.

In addition, when left unpainted, zinc exposed to the wetting and drying of weather gradually forms a patina of zinc carbonate over a period of a few months to a year. This patina provides an additional barrier against corrosion. Because it "grows" outward from the surface, this patina is especially effective at protecting edges and corners where paint could be easily damaged.

The most important advantage of galvanizing over paint, however, is the anodic property of zinc in a galvanic couple with iron. If the galvanized coating is damaged – whether by accident or through an intentional action such as cutting or drilling – the zinc will act as a sacrificial anode that corrodes first while protecting the more noble iron or steel.

This protective action will continue until the damage is repaired by applying a zinc-rich paint to the damaged area, for example, or until all the zinc has corroded.
Depending on the thickness of the galvanized layer and the corrosiveness of the surrounding atmosphere, the service life, defined as time to first maintenance, can be a couple of decades to a hundred years or more.

Epoxy Powder Coat

Unlike liquid paint, powder coating uses an electrostatic process to apply a finish to metallic parts in a dry state. Once applied, the finish is heat-cured to create a finish that is thicker, tougher, more even on all outer surfaces and edges, and more durable than most paints. This makes epoxy powder coat one of the preferred protection choices for oil and gas, wastewater and other harsh, corrosive industrial applications. To ensure proper adhesion and maximum durability, correct surface preparation and application quality are essential. The goal should be to apply multiple, well-bonded coats to provide optimum resistance against impact and abrasion. Components should be periodically inspected for finish damage that exposes the metal underneath to salt spray or other corrosive elements. Epoxy powder coat can also be degraded by UV radiation, so service life may be shortened for products installed in areas exposed to intense direct sunlight.

INDEPENDENT PERFORMANCE TESTING

In order to determine the corrosion resistance of various protection methods used on conduit bodies, Emerson turned to Intertek, an independent Total Quality Assurance provider to industries worldwide with more than 1000 laboratories and 44,000 employees. This test shows the relative corrosion resistance of the specimens visibly, but is not designed to evaluate product functionality. Intertek conducted ASTM-B117 Salt Fog performance testing on iron conduit bodies from three major manufacturers, including Emerson's Appleton™ brand. A total of 39 conduit bodies were tested, all in the 3/4- inch trade size.

The salt solution used was 5% plus/minus 1% according to ASTM B117-18 "Standard Practice for Operating Salt Spray (Fog) Apparatus." To prevent salt- fog from entering the interior of the conduit body, all iron test samples had steel (zinc-plated) Appleton PLG plugs installed, with aluminum plugs with Teflon™ tape in the aluminum samples. Test samples were subjected to the salt-fog for 1008 hours (42 days), being removed only for inspection and photography at fixed intervals.

All testing was conducted in the Arlington Heights, Illinois (USA) Intertek laboratory in January 2019. Test samples were sorted into 15 groups according to metal and protection types, i.e., iron (plated/painted), die-cast aluminum (painted), cast iron (plated/painted), cast aluminum (unpainted), et cetera. All samples were purchased at electrical distributors straight from their inventory and not sourced direct from the manufacturer. In this paper, we will look at the results from testing various iron and cast iron samples.

TEST RESULTS

TEST GROUP #1: IRON

Consisted of three (3) iron conduit bodies protected by:

- Appleton Form 35: Triple coat finish featuring (1) Zinc, (2) Chromate, (3) Electrostatically applied epoxy powder coat
- Competitor A: Zinc plate, Acrylic paint
- Competitor B: Zinc plate, Acrylic paint

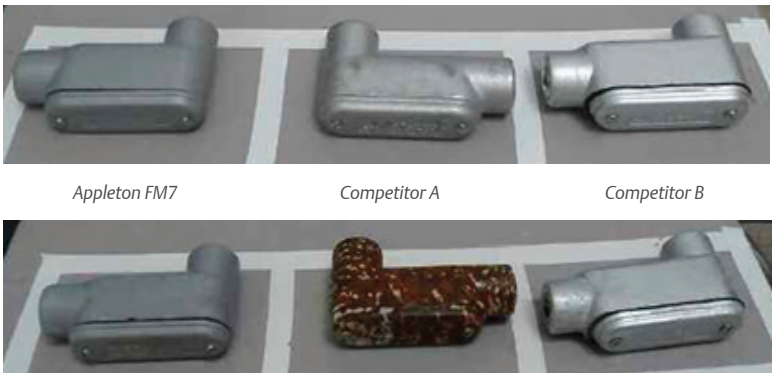
Appleton Form 35 *Competitor A* *Competitor B*

Before and after photographs. Above photo are new conduit bodies and below photo shows same conduit bodies after 42 days in salt fog

TEST GROUP #2: CAST IRON

Consisted of three (3) iron conduit bodies protected by:

- Appleton FM7: Triple coat finish featuring (1) Zinc, (2) Chromate, (3) Electrostatically applied epoxy powder coat
- Competitor A: Zinc plate, Acrylic paint
- Competitor B: Zinc plate, Acrylic paint



Appleton FM7 *Competitor A* *Competitor B*

Before and after photographs. Above photo are new conduit bodies and below photo shows same conduit bodies after 42 days in salt fog

FINAL WORD: TRIPLE COAT IS THE BEST DEFENSE AGAINST CORROSION

Not all industries have the same corrosion problems, but all industries do need to take the possibility of corrosion seriously and choose the right protection for their particular operations and environment. Start by checking the certifications and ratings required for your application. Next, discuss these requirements and concerns with the manufacturer. Becoming informed is the best way to ensure the product you select will provide the corrosion protection and service you expect over its lifetime.

Both in this study and in real-world applications, Appleton's triple coat finish has shown to be far more effective than conventional paint finishes, without question. It's formed when a zinc electroplate, chromate dip and epoxy powder coating is combined to achieve greater corrosion protection in wet or harsh environments, assuring long, trouble-free service in locations such as petrochemical and chemical plants, refineries, and other process industries.

Triple coat protection comes standard on most Appleton iron products."For details on which products fall into this category, check our catalog for specifications. This finish provides superior protection at no extra cost.

Our triple coat finishes consist of:

Coat #1: Zinc Electroplate
Zinc is one of the most important nonferrous metals. When applied onto the surface of ferrous (iron- containing) metals, it creates a formidable corrosion-resistant barrier. It is resistant to atmospheric attack, and fresh and salt waters, and is highly effective at keeping moisture from reaching the surface of the coated object.

Coat #2: Chromate Dip
Chromate coatings act as paint does, protecting the zinc from white corrosion, thus making the part considerably more durable. It also destroys organic growth on the surface. While conventional paint coatings have long been popular, they're simply not as effective in resisting corrosion as Chromate. Paint is hard to apply evenly, so it tends to drip and bubble, miss small crevices, and thin out at the edges, leaving these areas more exposed. Because of its chemical composition and method of application, Chromate is not subject to paint's limitations.

Coat #3: Epoxy Powder Coat
As a final finishing step, Epoxy powder is applied to fittings electrostatically. Drawn to the metal like a magnet, the powder covers evenly, reaching into the smallest crevices. The powder is then slowly oven baked to cure the coating and ensure a strong bond. Because powder coating does not have a liquid carrier, it can produce thicker coatings than conventional liquid coatings without running or sagging. Products are more resistant to mechanical damage since the powder coat finish does not crack or chip like painted surfaces.

By merging the strengths of Zinc, Chromate and Epoxy Powder, the triple coat process results in a thick, uniform layer of protection that seals out the harshest corrosives, including:

- Sulfur oxides
- Nitrogen oxides
- Chlorine and chlorides
- Ammonia and ammonia salts
- Hydrogen sulfide

Triple coat is extremely durable. It is flexible so it stays intact when the underlying metal expands and contracts during temperature changes and stress fluctuations — unlike paints. It also adds value through fewer callbacks and lower operation costs, while helping to safeguard the environment by virtually eliminating overspray particulates. On the job, there is no better way to safeguard your operations, profitability and employee safety than Appleton triple coat protection.

The test results shown for Appleton Form 35 and FM7 products above are valid only for Appleton's triple coated products. While most Appleton iron products are triple coated, a small number of the products in our lines cannot be triple coated. See an Appleton catalog for more information on the full line of Appleton applications that are triple coated. To learn more, visit emerson.com to view a full copy of the test report.

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