

COMMERCIAL COATINGS



# MINIMIZING THE EFFECTS OF GALVANIC CORROSION

PREVENTION IDEAS FOR THE DESIGN, ASSEMBLY,  
MAINTENANCE AND REPAIR OF HEAVY-DUTY TRUCKS  
AND SPECIALTY EQUIPMENT.



## THE COST OF CORROSION

Every year, businesses in the United States will spend \$276 billion repairing damage caused by corrosion. Of that, \$50 billion is spent by the transportation industry on vehicle repair/replacement and infrastructure.<sup>1</sup> Obviously, fighting corrosion effectively can be a major source of savings for companies that depend on transportation.

PPG Commercial Coatings is dedicated to helping manufacturers and fleet operators in their never-ending battle against corrosion. And that battle begins with knowledge.

This white paper provides an overview of galvanic corrosion, its causes, and finally, an examination of proven corrosion prevention strategies. From initial design to manufacturing to daily road use, this is insight you need in your fight against corrosion.

## WHAT IS GALVANIC CORROSION?

NASA defines galvanic corrosion as "...an electrochemical action of two dissimilar metals in the presence of an electrolyte and an electron conductive path."<sup>2</sup>

Basically, when two different metals are in contact, the more noble metal (cathode) decreases its corrosion potential at the expense of the more active metal (anode). In essence, the corrosion of one metal is decreased while the neighboring one is accelerated. The electrolyte—water or road salt, for instance—acts as the conductor of the potential change.

Finding samples of galvanic corrosion in the transportation industry is all too easy. Anywhere two different metals meet, you will almost always find a build-up of corrosion. Worst of all, this corrosion is often where engineers want it least—welds, seams, hinges, and fasteners.



## THREE PREREQUISITES FOR GALVANIC CORROSION

In order for galvanic corrosion to occur, all three of the following conditions must be met. If you can eliminate one prerequisite condition, galvanic corrosion cannot occur.

### DISSIMILAR METALS

In the simplest terms, every metal has corrosion potential, referred to as its anodic index. The farther apart two metals are in this rating, the stronger the rate of galvanic corrosion.

### METAL-TO-METAL CONTACT

The two different metals must be in direct contact with each other for the corrosion to transfer from the cathode to the anode. In the transportation industry, different metals are adjoined on hinges, steps, door frames, mounting brackets, and fasteners (screws and bolts).

<sup>1</sup> Source: Federal Highway Administration (FHWA-RD-01-156).

<sup>2</sup> Source: ksc.nasa.gov.

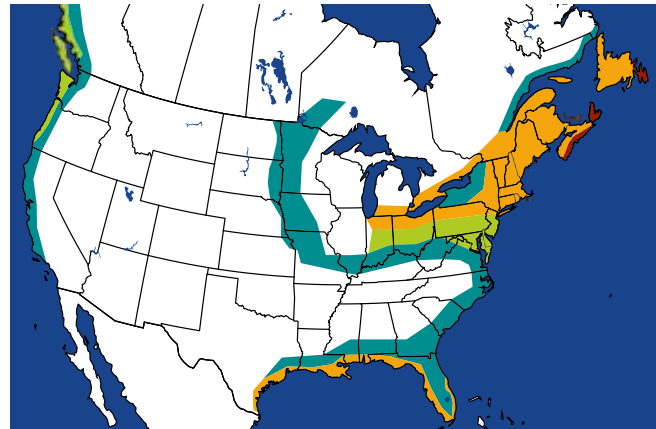
## EXPOSURE TO AN ELECTROLYTE

An electrolyte is an electrically conductive substance. It transfers corrosion from the more resistant metal (cathode) to the weaker metal (anode). Rain and road splash are naturally occurring electrolytes, but the most destructive electrolytes facing the industry are road de-icers. Road salts accelerate corrosion because they are excellent conductors. The most common conductors include:

**SODIUM CHLORIDE.** Spread on ice and snow, this salt is used as a solid, but dissolves to a liquid in snow and ice.

**CALCIUM CHLORIDE.** This road salt is also solid at room temperature, but it can work more effectively in lower temperatures than sodium chloride.

**MAGNESIUM CHLORIDE.** The use of different de-icers has changed over time. Magnesium Chloride is applied as a liquid on icy roads. It is considered more corrosive because of its very acidic nature and because it tends to be more active in the presence of atmospheric humidity, not just actual water present on the film.



CORROSION MAP FOR THE UNITED STATES<sup>1</sup>  
■ Extremely Severe ■ Severe ■ Moderate ■ Mild

Keep in mind that while most road salts are solids, these electrolytes can be drawn upwards with moisture. That's why manufacturers should consider protecting parts higher up on a vehicle and not just those near the ground.

## PREVENTING GALVANIC CORROSION

As previously stated, galvanic corrosion can only occur when all three of the prerequisites are met. While it is impracticable or impossible to not use different metals in modern manufacturing, you can still reduce the other two conditionals to corrosion.

### ELIMINATE OR INSULATE METAL-TO-METAL CONTACT

This can be achieved in a variety of ways, such as using a sacrificial liquid barrier product like Eck<sup>®2</sup> or a solid barrier product as an insulator, such as polyethylene tape, synthetic fasteners, nylon washers, and other specialty inserts.

### PREVENT ELECTROLYTES FROM COMING INTO CONTACT WITH METALS

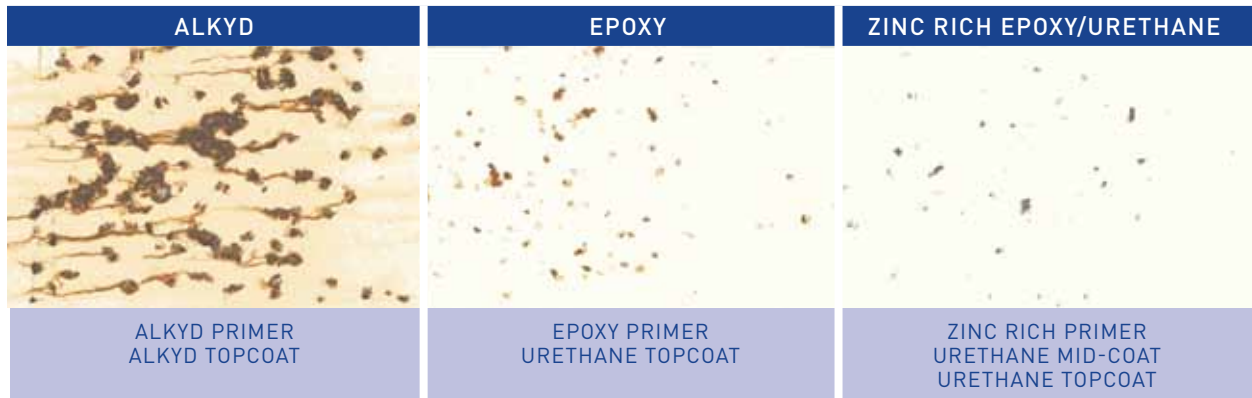
Erecting a protective barrier between metals and electrolytes will prevent or slow corrosion. Zinc rich primers provide the ultimate in protection. In addition, topcoats can keep the primer and undercoats safe from damage while providing cosmetic appeal.

<sup>1</sup> Reference: Pierre R. Roberge, Corrosion Engineering: Principles and Practice, McGraw-Hill, 2008

<sup>2</sup> Eck is a registered trademark of Van Nay LLC.

## PRIMER COATINGS

Primer coatings are a cost effective way to place a barrier between substrate metals and electrolytes. For a primer to perform optimally, it must adhere well to chemically-treated or bare substrates. It must provide a base for adhesion of topcoats and deliver protection against corrosion. Primers also offer increased resistance against rock chipping. If a coating is chipped down to the substrate, a potential corrosion point has been created. The most commonly-used coatings combinations are:



Panels were tested for chip resistance via ASTM D3170, then tested in a salt spray cabinet for three days.

## PRIMER COATINGS SELECTION

There are a wide variety of primer options, and the chemistry of each greatly affect its corrosion resistance. Your selection can be influenced by a variety of factors—climate, humidity, exposure to rain and snow, expected service life and production ease. There is also usually a strong cost/performance trade-off with primers, so we strongly recommend that you select coatings by performance expectations only. Primer performance is extremely important to the longevity of equipment.

If preventing and fighting corrosion is the highest priority, zinc rich epoxies provide the ultimate protection when used as part of a three coat system that includes epoxy or urethane primers and topcoats.

Within the family of primer chemistries, epoxies have the adhesion and corrosion properties that frequently make them the best option. Polyurethane primers are also used in some applications for fast cure speed and smooth appearance. Finally, alkyd primers fit the price sensitive market.

FEATURE	GOOD	BETTER	BEST
Adhesion	Alkyd	Urethane	Epoxy
Corrosion Protection	Alkyd	Urethane	Epoxy
Surface Tolerant	Alkyd	Urethane	Epoxy
Application Ease	Alkyd	Urethane	Epoxy
Mixing Ease	Urethane	Epoxy	Alkyd
Ultra-Violet Tolerant	Alkyd	Epoxy	Urethane
Through Dry	Alkyd	Epoxy	Urethane
Applied Texture	Alkyd	Epoxy	Urethane
Lowest Applied Cost	Urethane	Epoxy	Alkyd
Topcoat Gloss Holdout	Alkyd	Epoxy	Urethane
Recoat ability	Alkyd	Urethane	Epoxy

Under the same test conditions, you could expect the following general performance for salt spray corrosion resistance by primer chemistry:

#### ASTM B117 COMPARATIVE SALT SPRAY CORROSION RESISTANCE

	ALKYD	URETHANE	EPOXY	ZINC RICH EPOXY WITH MID-COAT
Time to reach 7A-8A rating*	250 hours	500-750 hours	1000 hours	>4000 hours

\*ASTM D1654 rating of 7A-8A = 0.5-2.0 mm scribe creep.

#### TOPCOATS

When we think of topcoats, we think of color, vibrancy, gloss and other appearance characteristics. But topcoats are more than just cosmetics—they can play a critical role in corrosion protection by shielding primers and undercoats from a variety of degradations.

Topcoats inhibit or slow the transport of electrolytes—one of the three ingredients of galvanic corrosion—such as water and road salts. Topcoats are also the first line of defense against mechanical damage, harsh weather and UV damage.

#### FINISH MAINTENANCE

Fleet managers and drivers can help prevent corrosion with regular care and maintenance. All cleaning and modifications should be in keeping with the industry's best practices.

New vehicles, however, should adhere to the following guidelines:

##### THE FIRST 30 DAYS:

- Avoid parking under trees. Sap and bird droppings can damage a new finish. If the surface is marred, rinse it off thoroughly.
- Avoid gravel roadways. Pebbles and grit can chip and scratch a new finish.

- Rinse chemicals immediately. Gasoline, antifreeze, transmission fluid and windshield solvent can damage a vehicle's finish.

#### THE FIRST 90 DAYS:

- Do not wax or polish. The finish needs three months to completely dry and harden. After 90 days, vehicles should be polished with a premium automotive product, but do not use silicone-containing wax or polish.

#### LONG-TERM VEHICLE CARE:

- Do not use ice scrapers or stiff bristle brushes on painted surfaces to remove snow or ice. This can cause scratches in the finish.
- Remove road salt and chemicals within a couple days of exposure. Wash and rinse vehicles with clean water.
- Remove road tar by washing with recommended cleaning solvent. Wipe off excess cleaner immediately.

#### WASHING RECOMMENDATIONS:

- Wash vehicle by hand. Automated commercial wash stations often use stiff brushes that can mar or damage the surface.
- Use cold water and mild dish soap.
- Use a soft cloth or sponge.
- Wash vehicles in the shade.
- Air dry or wipe dry with clean cotton rags.
- Do not "dry wipe." This will likely scratch the finish surface.

#### MOUNTING ADDITIONAL EQUIPMENT RECOMMENDATIONS:

When mounting additional equipment (lights, handles, brackets, etc.), extra attention should be taken to safeguard corrosion protection coatings.

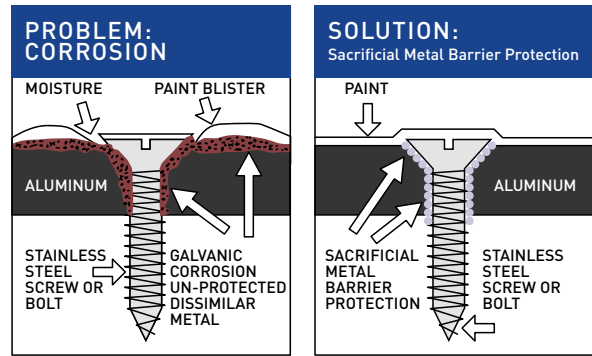
- Use a sharp drill bit.
- Remove all metal shavings.
- Before mounting equipment, apply a sacrificial barrier coating.
- Properly align screw threads between the body and the additional equipment. This will prevent corrosion blistering from dissimilar metal contact.

## BARRIER MATERIALS

Preventing dissimilar metals from touching each other is another simple, yet effective way to slow or prevent corrosion. For best results, manufacturers should consider this at every step of design, production, service and vehicle repair.

### PHYSICAL BARRIERS

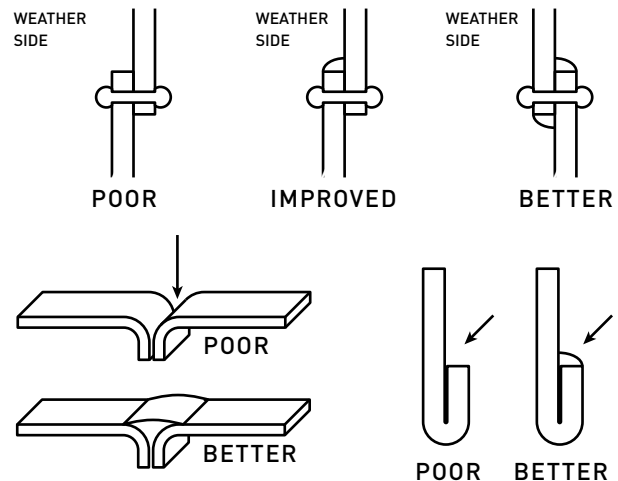
Blocking two different metals from each other is the easiest method of disrupting galvanic corrosion. These include Mylar® tape, synthetic fasteners, nylon washers and other kinds of non-conductive materials.



Reference: courtesy of Van Nay, LLC, manufacturer of ECK® corrosion barrier.

### SACRIFICIAL BARRIERS

A sacrificial barrier can be incorporated into designs. An anode metal is put in contact with a cathode metal, purposely creating galvanic corrosion. The anode metal is essentially “sacrificed” to protect the more important cathode metal.



## OVERALL PRODUCT DESIGN

Corrosion protection begins on the drawing board. In fact, smart manufacturing design can be as important as the types of metals used.

### MINIMIZE “TRAPS” FOR WATER AND SALT

Reduce the size and number of areas where electrolytes can collect and keep the substrate wet. Voids, crevices, sills, seams, jambs and mounted hardware can all be problem areas. Where possible, incorporate weep holes.

### USE INSULATING FILMS AND COATINGS

Keep dissimilar metals from coming into contact with barrier films and other barrier material. In addition, coatings can keep metals from being exposed to electrolytes.

### MIND SHARP EDGES

Sharp edges typically have poor paint coverage and therefore should be minimized during the manufacturing process.

## WARNING SIGNS AND REPAIR SUGGESTIONS

Damage caused by corrosion cannot be reversed, so it's especially important to identify distress as early as possible. Indicators of corrosion include: paint blistering (especially around hinges, fasteners and other items with dissimilar metals), surface roughening, cracking, lifting and peeling of the finish surface.

To maintain corrosion protection, only use repair facilities certified by the coatings manufacturer. If you conduct your own repairs, your staff should be certified by the manufacturer. Routinely verify that all training is up to date and use only approved products and systems. All work commissioned from an outside source should come with a warranty.



## SUMMARY

Unfortunately, there is no easy, one-step solution to stopping or slowing galvanic corrosion. The transportation and trucking industries need to adopt a multi-layer approach, incorporating prevention ideas and materials in every step of design, assembly, maintenance and vehicle repair.

To that end, follow these best practices for optimal corrosion protection:

- Isolate dissimilar metals
- Insulate dissimilar metals
- Use appropriate primers, undercoats and topcoats
- Select coating by performance expectations only
- Ask for process documentation from coatings supplier
- Train technicians with regular classes
- Protect exposed substrates when drilling holes
- Perform self audits to ensure optimal coating coverage
- Provide end users with an "approved" repair process as well as a care and maintenance guide

To learn about corrosion protection strategies individualized for your operation, we encourage you to contact your PPG representative. As a worldwide leader in performance coatings, PPG can customize a complete corrosion prevention strategy that works seamlessly with your production capabilities and manufacturing benchmarks. Our experts can also develop refinish specifications for your shop and outside repair facilities to ensure high-quality, cost-effective repairs.



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