Materials and Surface Treatments for Use in Telecom Industry Environments:

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Proper selection of materials for optimal service in outdoor environments found in the telecom industry requires knowledge of their corrosion resistance characteristics.

Most outdoor enclosures used in the telecom industry are made of aluminum alloys with an iron-phosphate prewash and organic polyester powder coat, which provide corrosion, abrasion, and UV-radiation resistance, as well as paint adhesion, flexibility, impact resistance, and appearance. This article examines different surface treatments on steel substrates to determine if they can provide similar performance required by the telecom industry in these outdoor environments at lower cost. Part 1 of this article (September 2012 AM&P) discussed zinc-based coatings for corrosion protection of steel products. This article discusses other types of protective coatings and how the coating types performed in salt fog spray tests.

Substrate preparation for painting

Numerous pretreatment options are available to prepare the steel substrate for painting. Iron phosphate is commonly used in the industry and is applied by spraying and dipping. It has less stringent environmental regulations than other processes and costs less overall to implement. Most chemical suppliers claim iron-phosphate pretreatment can be used on aluminum, steel, and zinc-coated alloys, but test results show that treated steel substrates do not hold up under severe salt fog environments. Paint adhesion on steel and zinc-coated alloys is a problem for outdoor environments. Figure 1 shows a typical iron-phosphate pretreatment line consisting of alkaline cleaning, rinsing, cleaning/etching, phosphatizing, rinsing, and drying.

Zinc phosphate applies a zinc crystalline grain structure to the steel surface. An advantage over other processes is the ability of zinc to sacrifice itself via galvanic reaction to protect adjacent scrapes and scratches through the paint from corrosion. A typical zinc phosphate line includes alkaline degreasing, acidic degreasing, activation (grain refining), zinc phosphating, and a final seal using a nonchromate sealant (Fig. 2).

Acidic degreasers must not be used on high-carbon steels as hydrogen embrittlement results. Activation increases the number of nucleation sites (or seed sites) on the surface from which zinc crystals can grow. Decreasing grain size decreases corrosion resistance while increasing paint adhesion. Passivation (or a final sealing) completes the process by applying a chromate-free sealant to the pores of the phosphated material to prevent moisture from contacting the surface of the substrate through the microporous phosphate coating. Zinc phosphating decreases corrosion undercutting of paint and covers all punched holes and raw edges of the steel substrate. It is certified by federal standard TT-C-490-Type I as an approved process for pretreating steel substrates.

Oxsilan is a proprietary pretreatment developed by Chemetall GmbH, Frankfurt, Germany, to replace both iron-phosphate and zinc-phosphate pretreatments. It uses organosilane polymers to seal the substrate surface, promoting good paint adhesion (Fig. 3). Compared to other systems, it is a thinner coating (Fig. 4), which improves impact resistance; is environmentally friendly; does not require an activation step or final seal, and it works at room temperature. A disadvantage is that it...
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does not sacrifice itself galvanically to protect exposed areas of the substrate such as scratches, gouges, and dings. In recent corrosion tests, Oxsilan proved to be a very competitive product.

**Thermoset coating options**

**Epoxies** have very good corrosion resistance and paint adherence compared to other coatings. They are specifically used in the automotive industry as a primer via the electroplating process known as E-coating, are generally water based and, therefore, environmentally friendly. Advantages include greater impact resistance, thereby reducing chances of radial cracking; an additional layer of corrosion protection, and ability to be used as a top coat. A disadvantage is minimal resistance to ultraviolet light, tending to “chalk” when exposed to UV environments.

**Organic polyester TGIC (triglycidyl isocyanurate)** coatings are prevalent in the telecom industry. Advantages are good salt spray resistance, UV performance, durability, and good edge coverage. They work very well on steel and aluminum substrates.

**Epoxy polyester hybrid** paint combines the properties of each system, providing very good durability and corrosion resistance with the added benefit of slightly better UV resistance.

**Urethane polyesters** offer improved surface finish characteristics and are often used for decorative finishes on a wide range of consumer products. The film has outstanding toughness and excellent appearance.

**Acrylics** offer a tough surface with good appearance. Acrylic powder coating is often used for clear coats in the automotive industry due to its quality, appearance, and durability.

**Zinc-related coating options**

**Hot-dip galvanizing** is prevalent throughout the telecom industry to coat plinths, pole mounts, wall mounts, and any outdoor item that requires a high level of structural integrity. The process produces zinc coating thickness ranging from 1.4 to 3.9 mils depending on the metallurgical characteristics and surface condition of the material being coated. ASTM A123 specifies the minimum coating thickness required for various material thicknesses. For example, 15 to 11-gauge materials require a minimum average coating thickness of 2.6 mils. A smooth surface finish does not promote growth of the zinc crystalline structure as well as does a rough finish. Cold-rolled steel has underperformed in this area because of its linearity structure as well as does a rough finish. Cold-rolled surface finish does not promote growth of the zinc crystal.

**Metallizing** involves the use of a spray gun to apply a zinc-rich coating to the substrate surface. The process is purely mechanical and does not metallurgically bond with the substrate like galvanizing. There is no zinc-iron alloy produced, which could lead to coating failures under certain load-bearing conditions where flexing of the material is encountered. Metallizing allows application of thicker zinc coatings (up to 10 mils), and can be applied in the field. A disadvantage includes higher labor costs and the inability to provide adequate protection in recesses and cavities.

**Zinc-rich paint** contains zinc dust particles (65-94% Zn concentration) suspended in an organic (epoxies) or inorganic (alkyl silicates) solvent-based compound. Organic versions are generally used for primers, while inorganic versions can be used as top coats if needed. Zinc dust in the paint helps limit the occurrence of corrosion undercutting due to abrasions, scratches, and scars in the painted surface. Coating thicknesses vary from 0.6 to 5 mils. The paint can also be applied in the field for repairs of existing galvanized coatings. A limitation of zinc rich paints is their inability to sacrifice themselves galvanically.

**Protective coating test results**

All specimens were subjected to 720 hours of salt fog in accordance with ASTM B117 to determine corrosion resistance and paint-adhesion properties. Coupons were prepared from 28 gauge cold-rolled steel sheet unless otherwise noted, and had scribe marks that cut through the coating down to bare material to simulate scratches, dings, etc. in real life situations. Enclosure-type products such as plinths were also tested to determine the corrosion resistance characteristics of a preformed product and how the manufacturing process could affect corrosion resistance.

Unpainted G90 (0.90 oz/ft² Zn) hot-dip galvanized steel has good corrosion resistance (Fig. 5). The yellowish gold color on the surface is the result of the chromate seal reacting with the salt fog environment. The white zinc-hydroxide powder along the edges indicates the steel substrate is being protected from corrosion.

The iron oxide seen in Fig. 6 reveals the weakness of 16-gauge unpainted electrogalvanized material (up to 0.20 oz/ft² Zn) in a salt fog environment compared to G90 material. Electrogalvanized material works best when painted and used indoors.

Unpainted 16-gauge Type 1 aluminized (90% Al-Si)
material performs better than electrogalvanized material, but it still rusted through the aluminum surface (Fig. 7). A Type 2 aluminized material (100% pure Al) would likely perform better in a corrosive environment.

G90 material with an Oxsilan pretreatment and polyester powder coat protects the substrate in a salt fog environment after severe abrasion (Fig. 8). The G90 zinc surface sacrificed itself along the scribed portions of the substrate to prevent corrosion and maintain good paint adhesion.

Figure 9 shows cold-rolled steel with an Oxsilan pretreatment and polyester powder coat. While corrosion resistance was poor at scribed areas, paint adhesion was very good and survived the salt fog environment. Figure 10 shows painted cold-rolled steel with an iron-phosphate treatment instead of Oxsilan pretreatment. Both pretreatments provide similar corrosion resistance, but Oxsilan provides less depth of corrosion undercutting (amount of corrosion creep under the paint), while iron phosphate has better reduction in the width of corrosion creep under the paint.

Cold-rolled steel with a zinc phosphate pretreatment and polyester powder coat (Fig. 11) provides only a slight improvement over other pretreatments regarding depth of corrosion undercut. It is possible that the zinc-phosphate crystalline structure was not dense enough or thick enough to provide adequate sacrificial protection.

An 18-gauge G90 hot-dip galvanized chromated material with a zinc phosphate pretreatment and a polyester powder coat (Fig. 12) exhibited very good results with no corrosion present and no visible paint adhesion issues. However, chromating is not a reliable treatment for good paint adherence.

A plinth made of painted cold-rolled steel with an iron-phosphate pretreatment (Fig. 13) was subjected to an in-house salt spray procedure prior to testing at the National Technical Systems lab (Plano, Tex.). Salt water was sprayed on the plinth once a day for two weeks, and the plinth was placed in a humidity chamber for five days at a temperature of 40°C and 95% relative humidity. The bottom left corner in Fig. 13 was abraded and scribed to verify corrosion performance of the paint system. Corroded areas were repaired by sanding, cleaning, and applying a self-etching primer with an additional topcoat of touch-up paint to determine if there was an acceptable way to repair corroded products in the field. In subsequent lab corrosion tests, the paint had adhesion problems in numerous locations and corrosion resistance was extremely poor.

Figure 14 shows the same part as Fig. 13, but with a zinc phosphate pretreatment instead of iron phosphate. While the part did not have any scribe marks through the painted surface, corrosion resistance was very good suggesting zinc phosphate offers increased corrosion protection, paint adhesion, and better contaminant removal.

A hot-dip galvanized cold-rolled steel plinth (Fig. 15) did not pass GR487 re-
quirements due to corrosion pits over the surface of the substrate, which were believed to be caused by iron contaminates in the zinc bath. Another possibility is that the cold-rolled steel with a smooth surface finish results in less diffusion of zinc into the surface of the steel during the galvanizing process which often leads to a thinner coating.

**Conclusion**

Pregalvanized steel, specifically G90, is the best material for corrosion resistance while still providing the required durability for installation, periodic maintenance, and end of life replacement. A zinc-phosphate pretreatment or an Oxsi-lan pretreatment is the best way to prepare a chromate-free G90 material substrate for painting. Both treatments provide excellent paint adhesion and offer increased corrosion protection. Using this combination of treatments with a common polyester powder coat will provide decades of corrosion protection.

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**Fig. 12** — Painted G90 material with zinc-phosphate pretreat.

**Fig. 13** — Painted cold-rolled steel plinth with iron-phosphate pretreat; black circles indicate repaired areas.

**Fig. 14** — Painted cold-rolled steel plinth with zinc-phosphate pretreat.

**Fig. 15** — Hot-dip galvanized cold-rolled steel plinth.