Most outdoor enclosures used in the telecom industry are made of aluminum materials using an iron phosphate prewash and organic polyester powder coat. Factors that contribute to this common design strategy include resistance to corrosion, abrasion, and UV radiation; paint adhesion; flexibility; impact resistance; and appearance. This article examines whether a steel substrate could hold up to the rigors of the above mentioned requirements, and defines the correct process by which steel substrates can accomplish this task, thereby enabling further cost reduction of currently produced products without sacrificing quality demanded by the telecom industry.

Zinc plays a vital role in the corrosion resistance of steel-related products. Benefits of zinc applied to steel include the ability to protect the surface via galvanic corrosion. Zinc plays a critical role in the degree of corrosion resistance a steel product can withstand. It is necessary to understand how the material reacts to corrosive environments at the basic level to understand how zinc plays a leading role in the corrosion resistance of materials discussed.

Figures 1 and 2 demonstrate the anodic nature of zinc when introduced to an electrolyte, which in the telecom industry is usually salt water. The steel substrate functions as the cathode due to its higher potential difference. When the electrolyte is introduced to a discontinuity in the coating surface, a galvanic reaction occurs whereby zinc sacrifices itself rather than the steel substrate. As corrosion continues, zinc continues to erode until all surrounding zinc is consumed, after which the steel substrate begins to corrode. There is a direct correlation between zinc coating thickness and length of corrosion protection.

Material/surface treatment options

Cold-rolled steel. Generally, unfinished/un-treated cold-rolled steel does not have rust-inhibiting qualities suitable for use in an outdoor environment. The most common product designation used is ASTM A1008 CS (commercial steel) Type B (Fig. 3). This steel can be purchased in both coil and plate configurations with a matte finish and an oiled surface to prevent corrosion prior to forming. The benefit of

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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.

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using this material is its wide availability and low cost.

Hot-rolled steel generally has about the same corrosion-prevention capability as cold-rolled steel. A common product designation for this type of steel is ASTM A1011 CS Type B (Fig. 4). Pickling to remove mill scale improves paint adhesion. Hot-rolled steel also comes with an oiled surface to prevent corrosion prior to forming. This material, like cold-rolled steel, is cost effective and widely available.

Hot-dip pregalvanized material is the most robust corrosion-resistant steel of all zinc-coated steel due to the metallurgical bond between the substrate and the zinc coating and the availability of much higher coating weights, which directly impacts corrosion-resistant properties (Figs. 5 and 6). Coating weights available range from \( G_{60} = 0.60 \text{ oz/ft}^2 \) to \( G_{210} = 2.10 \text{ oz/ft}^2 \). The most readily available coating weight is \( G_{90} \) which works very well in most outdoor applications. The product conforms to ASTM A653. This material ranges in thickness from 10 to 28 gauge.

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Electrogalvanized steel is A1008 cold-rolled steel electroplated with pure zinc or zinc-iron alloy (15% Fe). The coating provides a layer of corrosion protection between the paint and the surface of the substrate (Fig. 9). However, it does not form a metallurgical bond with the steel substrate, but is merely a surface coating. The product conforms to ASTM A879. Some electrogalvanized products can be specified with an additional treatment called bonderizing, which applies a phosphate treatment to the surface of the galvanized steel for better paint adhesion. Electrogalvanized steel is generally not recommended for outdoor environments due to the thin coating weights that are most commonly available from local steel suppliers. The biggest issue arises when the finished product receives a scratch or a gouge during shipping or installation. Once the surface finish has been compromised, the electrogalvanized layer does not have a thick enough zinc coating to adequately protect the steel substrate.

Coating weights range from 10–100 g/m² (0.033–0.330 oz/ft²) in 10 g increments. Comparing electrogalvanized material to G90 hot-dip pregalvanized steel (zinc coating weight of 275 g/m²) illustrates the amount of corrosion protection electrogalvanized material can provide.
This coating weight is generally not available from most steel suppliers. The highest coating weights offered for electrogalvanizing without special order is 100 g/m², which is closer to a G30 material rating in hot-dip galvanized. Electrogalvanized material can be shipped oiled, prelubed, or dry. The zinc-iron coating is more elastic than the pure-zinc coating, which could provide an increase in impact resistance and minimize radial cracking of the paint over the pure zinc option, because failure between the paint and the zinc coating would be less likely to occur.

*Galvalume* is cold-rolled steel with a coating composition of 55% Al, 43.5% Zn, and 1.5% Si. It provides excellent corrosion protection in an outdoor environment, and is widely used in metal roofing, buildings, and appliance applications. This product has been known to outperform G90 material by a factor of ~3 to 4 in severe marine environments. The product conforms to ASTM A792, generally ranging from 26 to 18 gauge. It is most prevalent in the AZ 50 coating designation where 0.50 oz/ft² is the weight of the alloy. Due to the different density of the Al-Zn alloy compared to hot-dipped galvanized materials (234 versus 446 lb/ft³) this material cannot be compared by coating weight when comparing corrosion resistance. It is available with various surface treatments including chemical treatment (chromate), oiled, chemical treatment and oil, and dry.

Galvalume is produced the same way...
as other pregalvanized sheet; the only difference is the chemical makeup of the galvanizing bath. Figure 10 shows that about 1.5% Si is added to reduce the thickness of the intermetallic layer. Silicon has the innate ability to impede diffusion/growth of the intermetallic alloy layer. The intermetallic layer is held to very close tolerances to promote good adhesion characteristics between the substrate and the galvanized coating. Testing within the industry has shown that the thicker the intermetallic layer, the more easily the galvanized coating will separate from the substrate under forming or deep draw operations. Figure 11 shows the top surface of Galvalume material.

Galvannealed material is a standard hot-dip galvanized product that is annealed to improve formability and paint adhesion. During annealing, iron diffuses through the zinc creating an 8–10% Fe-Zn alloy surface (Figs. 11 and 12). Annealing provides better paint adhesion than similar hot-dipped products, and can increase impact resistance. The product conforms to ASTM A653, and is readily available from most suppliers in thicknesses from 10 to 24 gauge. Coating weights commonly offered are A25, A40, and A60. A60 equals 0.60 oz/ft², which is roughly equivalent to a G60 hot-dip galvanized material. Galvannealed material is not offered in higher coating weights because the higher hardness of the Fe-Zn coating can often cause powdering (loss of coating) of the corners during bending operations. Lighter coating weights help reduce this characteristic. Unpainted surfaces may show some reddish corrosion due to the small amount of iron dispersed throughout the zinc coating. Several different surface treatments are available including oiled, dry, chemically treated using chromate, and phosphate.

Aluminized material is steel that is hot dipped with aluminum (Fig.14). Two types of aluminized material are Type 1 and Type 2. Type 1 consists of an Al-Si (5 to 11%) alloy to promote better adhesion between the intermetallic layer and the substrate; it is used primarily in high heat applications. Type 2 consists of 100% pure hot-dipped aluminum for improved corrosion resistance, and is used primarily in air conditioners and corrugated roofing products. Material thicknesses range from 11 to 24 gauge. Type 1 is available from the majority of steel suppliers. Aluminized material conforms to ASTM A463. Surface treatments include a RoHS (restriction of hazardous substances)-compliant sealer and oiled surface. Either surface treatment provides good paint adhesion when applied correctly. The material has very good corrosion resistance in outdoor environments. A limitation of the material is that it does not have the ability to protect against dings, gouges, and scratches like pregalvanized material can, because the galvanic reaction between iron and the aluminum is not as strong as it is between iron and zinc.

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Look for Part 2 of this article discussing nonmetallic surface treatments and results of corrosion performance tests in the October 2012 issue of AM&P.