GalvInfoNote	Introduction to Painted, Metallic-Coated, Steel Sheet Products
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Introduction

Paint is usually considered to be a means of making a surface more appealing. Metals, including coated steel sheet products, are often painted for this reason. However, in addition to the use of paint to provide color, there is another reason to paint coated steel sheet; namely, **additional corrosion protection!**

Unpainted galvanized and other metallic coatings on steel sheet provide good, long-term protection from corrosion. Many years of protection can be obtained through the astute use of the metallic coatings available today. Nevertheless, the application of high quality paint can add substantially to the overall life of coated steel sheet products. A classic example of the improvement in product life provided by a good paint system is the enhancement achieved with exposed automotive body steels. The metallic coating on automotive body panels is relatively thin compared to that used on steel sheet for many other types of applications, yet the synergy produced by the paint and an automotive metallic coating creates a system that enables auto body panels to resist corrosion for a long time.

Of course, automotive paint systems are quite complex, as they are meant to withstand severe conditions. Typically, they include a phosphate pre-treatment, a high quality thick electrophoteric primer, a color coat, and a clear coat. These types of complex, thick paint systems are not needed to gain a very substantial improvement in the life of many non-automotive coated sheet products. There are many examples of increased service life using paints (primer plus topcoat) as thin as 1-mil (0.001 inch).

Why Do Paints Improve Product Life?

Paints add additional protection to metallic coated steel by two primary means:

1. Acting as barrier between the coating and moisture, oxygen, and other corrosion-inducing agents.
2. By containing specific corrosion-inhibiting agents.

Although paint acts as a barrier film, it is not impervious to moisture. Water can penetrate the paint, and reach the metallic coating if the panels are wet for long periods. For this reason, the barrier aspect of the paint alone is not sufficient. There must be corrosion-inhibiting agents at the interface between the paint and metal coating to mitigate corrosion of the metal. This is important to prevent loss of adhesion (blistering) between the paint and metal coating. Also, at locations where the paint integrity is lost, such as at a scratch or cut edge, the presence of the treatment and other corrosion-inhibiting agents help prevent undercutting corrosion of the paint.

The improvement in product life after painting is dependent on many factors. These include:

- Thickness of the paint,
- Stability of the paint (resistance to degradation by sunlight, moisture, etc.),
- Use of a paint pre-treatment containing corrosion inhibiting agents,
- Use of a primer coating beneath the paint, and
- Additions to the paint that reduce the water permeability of the paint.

Each aspect of the total paint system plays a role in providing long life. Paint and treatment technology have both evolved to the point that each application needs to be considered individually to optimize the paint, treatment, and metallic coating type.

Product Life

Product life can be defined in many ways. For some applications, the life of a paint coating is the time until some degree of fading has occurred. In these instances, it is important to select a paint that has high stability when exposed to ultraviolet light. In another instance, failure might be defined as when the paint

loses adhesion to the coated-steel sheet. In this case, it is therefore important to properly clean the metal surface and select a good pre-treatment and primer coating to maximize the adhesion of the paint to the metal coating. For another type of application, the product life might be defined as the time until a specific amount of steel corrosion (red rust) is observed. In yet another end use, the product life might be defined as the time until the steel sheet is corroded to perforation.

For applications where chalking and/or fading of the paint constitute “failure”, it needs to have excellent resistance to ultraviolet light and chemicals that might be in the environment. This type of service depends primarily to the properties of the paint, and is best discussed with the paint manufacturer involved.

For applications where failure is defined by **excessive corrosion** of the metallic coating and steel sheet, it is important to address the entire coating system; the metallic coating type and its thickness, the type of pre-treatment and its compatibility with the metallic coating, the type of primer and its thickness, and the type of paint and its thickness. All of these factors need to be addressed to maximize product performance. The specific environmental conditions must be taken into account. For example, is the environment close to the sea? Is it in an industrial zone? Is it an environment that has constant high humidity, or high times-of-wetness?

Corrosion failures of painted, metallic-coated steel sheet are the result of a corrosion reaction that typically consumes bulk amounts of the metal coating and the steel sheet itself. It is especially important in these types of applications to consider the performance of the metallic coating, and how it impacts the total system performance.

In the applications where bulk corrosion of the metal coating and steel are important considerations, it is important to maintain the integrity of the paint in order to maintain the life of the coated steel indefinitely. This means, when evidence of paint failure is noticed (blisters, edge creep along scratches, etc.), repair painting and/or complete repainting should be done to regain the full original corrosion-resisting integrity of the metallic-coated sheet. For more details on the repair painting of prepainted sheet, see GalvInfoNote 4.3.

A classic example of the improvement in product life possible by painting is a metal roof exposed to the atmosphere. In a moderately corrosive environment, a G90 galvanized coating might last about 12 to 15 years before red rust becomes evident. This red rust occurs in areas where the galvanized coating has been completely consumed by corrosion. If a high quality paint system is applied prior to exposure, the life before initial signs of red rust might extend to 20 to 25 years, or longer. Furthermore, if the roof is repainted or repair painted when the initial signs of steel corrosion are visible, the life of the roof might be extended another 10 to 15 years before corrosion is again evident.

What is a High Quality Paint System?

Paints can be applied to coated sheet steel either by “prepainting” the sheet while still in coil form (prepainting or coil coating), or by “post- painting” the sheet after it has been shaped into the final part design. Either way, the “system” most often consists of:

- A thin **pre-treatment** coating to improve the adhesion between the paint and the metal and in turn the corrosion resistance, and
- A **primer** coating that provides added adhesion, and added corrosion resistance, and
- A **topcoat** paint that consists of an organic binder and various pigments to provide the desired color, gloss, and resistance to ultraviolet light degradation.

Pre-treatments are designed to optimize the performance on specific types of metal coatings. Not all pre-treatments are compatible with all metallic-coating types. For example, zinc phosphate is an excellent pre-treatment for galvanized sheet, but is not acceptable for 55% aluminum-zinc alloy-coated sheet.

Similarly, **primers** are often made for very specific types of metal coating, although there are "universal" primers available in the marketplace that work very well on all the common types of metallic coatings.

Types of Paint Systems

There are many types of paints used for topcoats. Typically, most topcoats are compatible with all types of metallic coatings. The important step is to make sure that the topcoat is compatible with the primer type and that the topcoat's properties are consistent with the end users' needs with respect to chalk resistance, color stability, flexibility, hardness, gloss, etc.

Some paints (topcoats) are specialty paints applicable for very specific applications. Others are quite universal, both in their applicability for most environments and their ability to provide a cost-effective desired color. Some offer very excellent colorfast qualities; that is, excellent resistance to fading when exposed to sunlight. Others are very hard, and offer tremendous resistance to marring. Others are very glossy and reflective. Still others offer a high quality, uniform matte finish. Some paint coatings are very thick and relatively soft, offering good corrosion protection in harsh environments.

It is not our intention to elaborate on all the special types of paint available in the marketplace today. This issue is best discussed with the individual paint-company technical experts.

A document that provides a general review of the available paints for metallic coated steel sheet products is ASTM *Specification A755/A755M, Steel Sheet, Metallic-Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products*. This specification can be obtained at ASTM's website, www.astm.org . Another source of information is Tool Kit #8 from the National Coil Coaters Association at www.coilcoating.org .

Paint System Durability

Although paint systems offer a significant enhancement to the life of metallic-coated steel, the system does eventually "fail" in some fashion. This can take the form of chalking or fading to a color that is no longer acceptable to the user. It can also take the form of blistering or flaking, which can occur by separation along the paint/primer bond line, the primer/pre-treatment bond line or the pre-treatment/metallic coating bond line. The specific nature of blistering and/or flaking, if either one occurs, is dependent on many factors associated with the specific combination of paint, primer, pre-treatment, metallic coating, and the environmental conditions. Corrosion of the steel sheet substrate can also cause the failure of the system.

Loss of paint adhesion can take several forms. The most common are:

1. Lateral undercutting corrosion at a scratch in the paint or at a sheared edge (where the paint/primer/metallic/coating/steel is all exposed to potential corrosion). The net effect of this lateral undercutting corrosion is the loss of adhesion between the paint and the metal substrate. The corrosion can occur by a chemical reaction along the paint/metallic coating interface that can cause the chemical adhesion bond to be degraded, or by bulk corrosion of the metallic coating leaving the paint totally "unconnected" to the steel sheet.
2. Blistering beneath the paint caused by corrosion reactions under the paint film. Remember, paints are not impervious; water can penetrate through the paint to the substrate surface during times of wetness. If the initial bond strength is not good, if the pollutants in the environment are particularly insidious for the type of paint system used, or if the "time of wetness" is unusually long, blisters can develop even though there are no discontinuities in the paint. As the blisters grow larger and begin to combine, the net effect can be gross flaking of the paint in large areas.

To minimize the tendency for loss of paint adhesion through undercutting corrosion or blistering, take into account any specific recommendations from the steel supplier and paint manufacturers. The "best" coated product design requires that the user pay attention to the type and thickness of the metallic

coating, the type of pre-treatment, the type and thickness of the primer, and the type and thickness of the topcoat. The recommendations from the suppliers will take into account issues such as:

- Types and concentrations of corrosive contaminants
  - Acid rain,
  - Coastal salts,
  - Manufacturing plant effluents in the area, if any, etc.
- Wetness of the environment, particularly the duration of the wet periods (time of wetness)
- Amount of ultraviolet light exposure
- Customer expectations with respect to performance and aesthetics
  - Paint fading
  - Chalking of the paint
  - Rust stain at sheared edges
- Desired product life

For information on achieving good performance of pre-painted, metallic-coated steel sheet for building panels, refer to GalvInfoNote 4.2.

Summary

When properly designed and applied, paints add considerably to the life of metallic-coated steel sheet products. The long life that is desired requires careful selection of the:

- Type and thickness of the metallic coating,
- Type of pre-treatment,
- Type and thickness of the primer,
- Type and thickness of the paint topcoat, and
- The application

Also, it requires that the metallic coating be properly prepared (cleaned) to remove any oils, dirt, etc. prior to painting regardless of whether the paint is applied via prepainting (painting prior to manufacture of the end product) or a post-painting (painting after fabrication of the end product).

Furthermore, to optimize the life of the painted metallic-coated steel, periodic repair painting and/or complete repainting may be needed. The need for repainting depends on many factors. These include the aesthetic requirements, the desired product life, and the severity of the environment, among others. By proper attention to the paint integrity and the degree of degradation that occurs over time, very long life of metallic-coated steel sheet products can be attained. For example, many exterior applications are visible today where the proper selection of metallic coating and paint system has led to high performance for 20 years or longer without the need for any repainting.

For more information on the use of these products in building applications, refer to GalvInfoNote 4.2 – Prepainted Metallic-Coated Steel Sheet for Building Panels – Assuring Good Performance. For information on repair painting, see GalvInfoNote 4.3.