GalvInfoNote 8	Introduction to Painted, Metallic-Coated, Steel Sheet Products Rev 2.2 Sep-03

Introduction

One usually looks at paint as a way to add an attractive color (appearance) to a surface. Metals, including coated steel sheet products, are often painted for this reason. But, in addition to the use of paint to provide color, there is another reason to paint coated steel sheet. That reason is: **additional corrosion protection!**

Certainly, galvanized coatings and other metallic coatings on steel sheet provide good, long-term protection from corrosion. One can obtain many years of corrosion protection through the proper use of the metallic coatings available in today's market. 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 that a good paint system can provide is the enhancement achieved with automotive-body steels. The metallic coating on automotive body panels is quite thin compared with the metallic coating thickness on sheet panels used for many other types of applications, but with the synergistic effect of the paint systems used by the automotive industry, the life of the body panels is very long.

Of course, the automotive paint systems in use today are quite complex. Typically, they include a phosphate pre-treatment, a high quality thick electrophoretic primer, a color coat and a clear coat. However, this type of complex, thick paint system is not needed to gain a very substantial improvement in the overall life of many coated sheet products. There are many examples of substantially improved life associated with paints (primer plus topcoat) as thin as 1-mil (0.001 inch).

Why Do Paints Improve Product Life?

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

1. acting as barrier between the coating and moisture, oxygen and other corrosion-inducing chemicals, and

2. formulated using specific corrosion-inhibiting agents.

Although paint acts as a barrier film, it is not impervious to moisture. Water can penetrate through the paint, and reach the metallic coating. For this reason, the barrier aspect of the paint alone is not sufficient. There have to be corrosion-inhibiting agents at the interface between the paint and metal coating to mitigate corrosion of the metal coating. 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 to 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,
- 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 very extensively over the years 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. For another application, failure might be defined as when the paint loses adhesion to the coated-steel sheet. In these applications, it is important to properly clean the metal surface and select a good pre-treatment and primer coating to do all that can be done 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 another type of application, the product life might be defined as the time until the steel sheet is completely corroded-through.

For applications where chalking and/or fading of the paint constitutes “failure”, one needs to use paints that exhibit excellent resistance to ultraviolet light and chemicals that might be in the environment. This “failure” is related primarily to the properties of the paint type, and is best discussed with the individual paint manufacturers.

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 the product performance. One needs to take into account the specific environmental conditions. 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?

Excessive corrosion failures of painted, coated steel sheet are associated with 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.

A classic example of the improvement in product life that is obtainable by painting is a metal roof that is exposed to the atmosphere. In a moderately corrosive environment, a G90 galvanized coating might last about 12 to15 years before red rust becomes evident. This red rust occurs at sites 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. For even longer life, 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 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,
- 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 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. This same treatment is not acceptable for Galvalume.

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

Types of Paints

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, they offer 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.

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.

The sponsorship of the GalvInfo Center includes two companies who are extremely knowledgeable with pre-treatment and paint technology. They are:

- **Henkel Surface Technologies**
  - Pre-treatment technology
- **PPG Industries**
  - Paint technology

For detailed assistance with treatment and paint selection, please contact these companies. They are linked to the Home Page of the GalvInfo Center.

A document that provides a general review of the available paints for metallic coated steel sheet products is ASTM Specification A 755/A 755M, Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products.

Paint Durability

Although paints offer a significant enhancement to the life of metallic-coated steel, they do 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. Both blistering and flaking 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.

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

1. Lateral undercutting corrosion at a scratch in the paint or at a sheared edge (where the paint/primer/metallic/coating/steel are 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 which can cause the chemical adhesion bond to be degraded, or (b) bulk corrosion of the metallic coating leaving the paint totally "unconnected" to the steel sheet.

2. Blistering beneath the paint caused by corrosion reactions beneath 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 real 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 beneath the paint 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, one needs to take into account very 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

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 no matter 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, one can attain very long life performance for metallic-coated steel sheet products. 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 #20 – Prepainted Metallic-Coated Steel Sheet for Building Panels – Assuring Good Performance.