Technical Support White Paper

Date: May 21, 2020

Title: The Acrylic Advantage

Products Affected: Galvanized Steel

Topic: Selecting the Best Surface Treatment for Galvanized Steel Applications

Overview:

Galvanized steels have been in widespread use for many decades due to the sacrificial corrosion protection of the zinc coating. The steel industry has developed methods to provide additional protection to formation of white rust. These include passivation of the zinc surface with a chemical treatment or the application of a barrier coating to prevent water from contacting the surface.

Passivation coatings for galvanized steels are typically some form of a chromate treatment applied to the sheet surface immediately after galvanizing of the coil. These coatings are intended to provide temporary protection during transit and initial storage, typically about six weeks. A rust-preventative oil can be applied overtop of the chemical treatment to provide additional protection. However, proper storage conditions are still necessary to avoid formation of white rust or noticeable changes in surface appearance. While the presence of white rust can significantly impact cosmetic appearance, the zinc coating will continue to provide sacrificial corrosion protection to the steel.

Acrylic coatings are a thin, organic-based barrier which prevents moisture from contacting the surface and creating white rust. Acrylic differs from other pre-painted coatings as it is generally a clear finish and chemically similar to plexiglass. Applied in a continuous roll coating operation on the galvanizing line, the thin coating does not alter the natural metallic appearance of the zinc coating which can occur with some chromate applications. Numerous manufacturing benefits can also be realized when choosing to use acrylic coatings.

Summary of the Issue:

Like most metals, zinc coating is subject to natural corrosion that can result in objectionable changes to surface appearance over life of the product. The corrosion product which is most undesirable is known as white rust. This is a white, flaky deposit which forms on the surface, and chemically is a zinc hydroxide ($Zn(OH)_2$). White rust usually forms when galvanized steel is continually exposed to moisture or condensation with inadequate air movement. Transit problems, improper or outdoor storage of coils, cut sheets and stacks of formed parts can provide the conditions for this to occur.

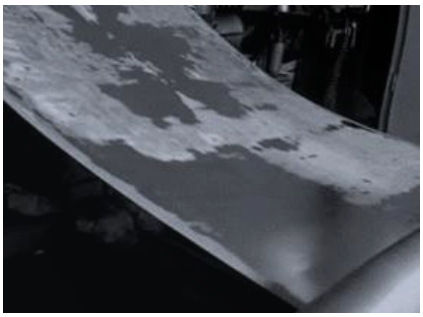

Image 1: Onset of white

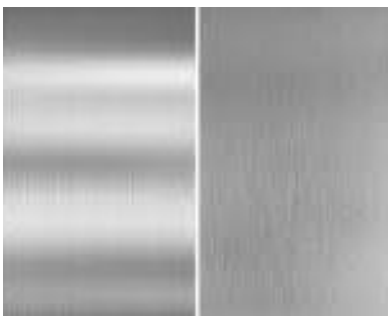

Image 2: Acrylic coat (left) vs. No acrylic (right)

Product Analyses:

Corrosion Protection of Acrylic

The most important requirement of these surface treatments is delaying or preventing the onset of white rust on the galvanized surface. All treatments are effective in this when the transit, storage and job site conditions are environmentally controlled. A 2019 study at Worthington Industries was conducted to show the relative differences between acrylic and two types of chromate passivation coatings in the amount of time before onset of white rust. The acrylic coating was Gardobond PC 4610/1 applied at an aim range of 1.5 to 2.5 mg/sq. ft., and coating weights were at the high end of this normal range. This was compared to two chemical passivations, Permatreat 2510, a chromate containing both hexavalent and trivalent chrome, and Gardolene 6811, a trivalent RoHS formulation. The chromate coatings were applied at an aim range of 1.5 to 2.5 mg/sq. ft., with Permatreat at the middle and RoHS chromate at the high end of this range, all at normal levels. The results in Figure 1 clearly show the superior performance of the acrylic coating over these chemical treatments.

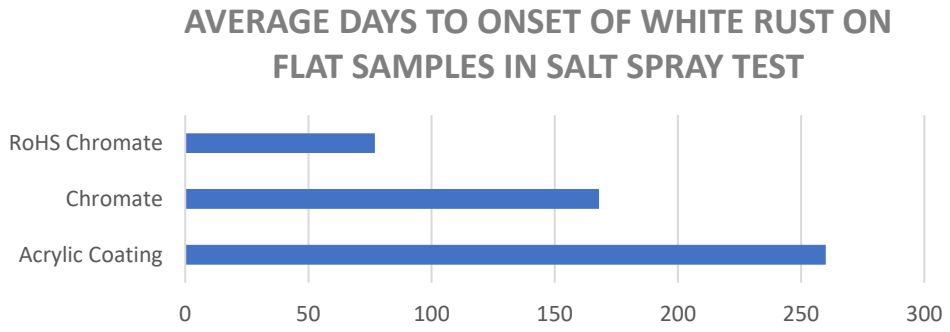

Figure 1. ASTM B117-18 Salt Spray test results on flat samples

The barrier protection of acrylic provides a much greater time before any white rust is observed. In addition, the volume of white rust formed was significantly greater for the passivated steels within the time period tested.

Surface Properties of Acrylic

The acrylic surface offers several benefits for a variety of manufacturing processes and applications. The coating is thin, highly adherent and flexible. These attributes make it particularly suitable for applications with moderate forming, including roll forming and corrugating manufacturing processes. Acrylic provides a slippery surface with low coefficient of friction without the application of any oils. This eliminates cleaning of equipment to remove oil buildup with related housekeeping concerns. The acrylic coating can also reduce the amount of wear on tooling and rolls because of its surface characteristics.

Samples of the acrylic and chemically passivated galvanized steel were tested for surface friction values. A modification of ASTM D1894 was used to measure friction between these surfaces and a hardened alloy steel sled measuring 0.25” x 2.5” x 2.5”. A diagram of this test procedure is shown in Figure 2.

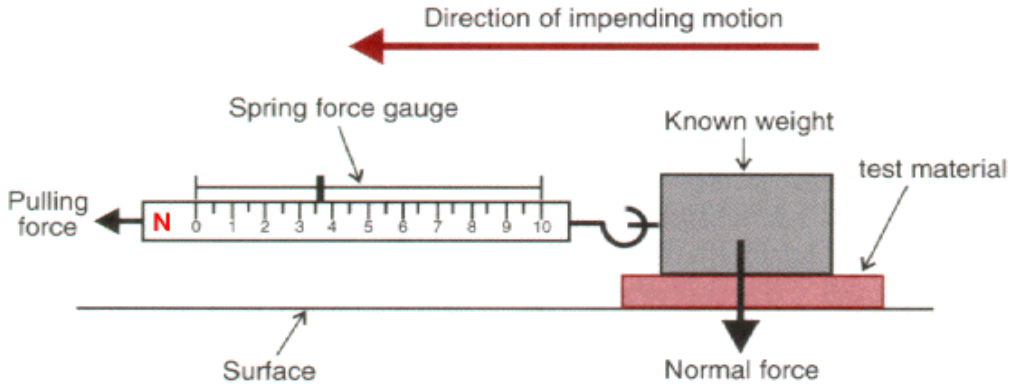

Figure 2. ASTM D1894-mod Friction Test sample and test sled

The test was intended to simulate the surface interactions that occur during forming operations. This determined both static friction and sliding (kinetic) friction, providing insight into the relative “lubricity” of the different surfaces. This is an important attribute of the acrylic finish, as it provides a “slippery” surface without any oil. The chemically treated samples had a light, electrostatic application of oil when produced, but still displayed higher friction values than the dry, acrylic coating. A comparison of the average kinetic coefficient of friction for these three surfaces is presented in Figure 3. A lower value indicates reduced friction between the steel surface and the test sled, which is beneficial to forming. For roll forming applications, incorporating chrome plating of rolls could be used to provide further benefits in part quality and finish in addition to extending the life of rolls. The use of acrylic alone has many quality and appearance benefits, but coupled with Cr-plated rolls, there is likelihood of even greater benefit to customers’ operations and quality.

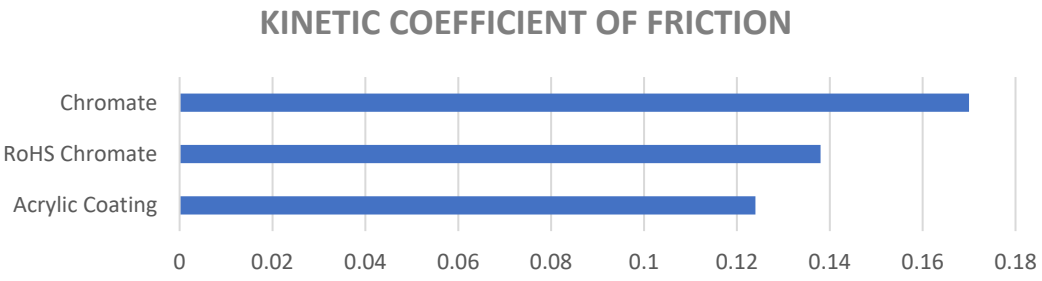

Figure 3. ASTM D1894-mod Coefficient of Friction test results on flat samples

The gloss of acrylic coating also contributes to the superior cosmetic appearance of the galvanized steel. In addition to delaying the onset of white rust, the appearance of the acrylic surface will remain unchanged when the steel is properly stored prior to use. This translates into more uniformity of

appearance and eliminates difficulties in managing inventory to compensate for appearance variations in the passivated surfaces. Parts can be made from various shipment dates and assembled together for an application with minimal concern of variability in appearance. Eventually the acrylic will disappear from weathering and the zinc will acquire the normal gray patina finish, like the chromate passivated surfaces. However, the acrylic barrier delays this weathering process until much later than with the passivated finishes. As a result, the uniform metallic brightness of the galvanized steel will be retained much longer.

Adhesion Characteristics of Acrylic

The acrylic coating is applied from a water-based liquid in a continuous, roll-coating operation located downstream from the zinc pot on the galvanizing line. The strip entering this coater is ultra-clean and free of any contaminants after zinc coating. Following application of the acrylic, the coated strip passes through an induction heater which bakes the acrylic at a high temperature. This provides an excellent curing and bond of the thin coating to the zinc surface and maintains sound adherence in subsequent forming operations.

One means of evaluating the adhesion of the acrylic coating was through corrosion testing. Salt spray testing was performed on bend and impact samples of each coating type to determine how much the forming affected results. Bend testing was done at approximately 60 degrees over a 3/16" radius, which caused a moderate amount of stretching of the steel surface. The impact tests were made with a 1" hardened steel ball that severely stretched the steel close to the breaking point. The excellent adhesion of the acrylic with moderate forming was evident in this corrosion test. The bend test sample with acrylic outlasted all others to a significant degree as shown in Figure 4. The amount of deformation in the impact test was severe and likely compromised the coating. As a result, white rust ensued in a relatively short amount of time, similar to the chromate-passivation impact and bend samples.

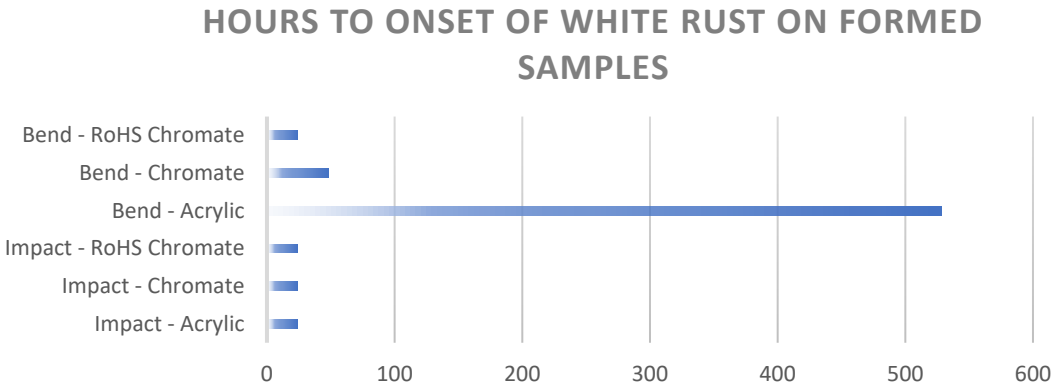

Figure 4. ASTM B117-18 Salt Spray test results on formed samples

This corrosion test result correlates well with the excellent track record of acrylic for many applications, including roll forming and light to moderate stamping.

Key Benefits

There are several benefits to consider when choosing an acrylic coating for a specific application:

Key Benefit	Result
Acrylic is superior to passivation coatings in delaying the onset and growth of white rust	Extra protection is provided during less than ideal storage conditions or job site locations
Acrylic-coated steel is more consistent in appearance shipment to shipment, with less color variations than passivation coatings	Inventory management can be made easier with less concern for mixing steels of varying color and gloss appearance resulting in cost/time savings
Acrylic exhibits a lower coefficient of friction than passivation coatings	Provides less wear over the life of rolls and tooling which equates to production cost savings (particularly with roll forming and corrugating processes)
Acrylic coatings have proven to minimize the creation of zinc fines created during manufacturing processes	Acrylic coatings help minimize the zinc fines buildup during roll forming, resulting in maintenance related cost savings and lower down time
Acrylic does not require oil coatings overtop, and in many cases a lubricant is not necessary during moderate forming processes	Safe work environment with less housekeeping due to the elimination of oil buildup on equipment and floors

Outcome:

Acrylic coatings are ideally suited for roll formed or corrugated parts with light to moderate forming. This coating is suited for flat or formed panels for a variety of construction and agricultural uses. While acrylic coatings are not recommended as a means of reducing zinc coating weight, they are proven to extend the time period of a uniform metallic surface appearance. Acrylic coatings have the potential to reduce manufacturing costs while providing a safer and more environmentally friendly work environment compared to alternatives tested in this study. These coatings have been used in the steel industry for many years and their benefits, including surface quality and cost savings, are well understood.