

Enhancing Corrosion Mitigation via Novel Surface Treatment Application

Sarah E. Specht
PPG
4325 Rosanna Dr
Allison Park, PA, 15101
USA

Julia Heigl
PPG
4325 Rosanna Dr
Allison Park, PA, 15101
USA

Melinda J. Dent
PPG
4325 Rosanna Dr
Allison Park, PA, 15101
USA

Mary Lyn C. Lim
PPG
4325 Rosanna Dr
Allison Park, PA, 15101
USA

Brianne Georgic
PPG
4325 Rosanna Dr
Allison Park, PA, 15101
USA

Rebekah Wilson
U.S. Army Corps of Engineers
Engineer Research & Development Center
Construction Engineering Research Laboratory
2902 Newmark Dr.
Champaign, IL, 61826
USA

Arif Mubarok
PPG
4325 Rosanna Dr
Allison Park, PA, 15101
USA

ABSTRACT

Coatings remain the most dominant mode of protection against environmental degradation across a wide range of industries. Coating systems that are used in most industries are comprised of pretreatment followed by one or more organic layer(s). This pretreatment layer is highly effective to enhance corrosion protection. However, when protecting infrastructure in marine environments, a pretreatment process is not traditionally utilized. This is largely due to the size and scope of these projects and their incompatibility with traditional pretreatment methods. In this paper we introduce a novel surface engineering technology and compare the performance of conventional coatings utilizing this innovative preparation against traditional preparatory methods.

Key words: Surface preparation, steel, pretreatment, corrosion, corrosion protection, ISO 12944

INTRODUCTION

Coatings remain the leading mode of protection against corrosion for large steel structures in many harsh environmental conditions, such as marine environments.^{1,2} Critical infrastructure in such environments must successfully withstand years of corrosive atmospheric exposure between re-coatings to remain structurally viable.² In such environments, the first coating layer following surface preparation is often a primer containing either organic or inorganic zinc.³ Subsequent coatings usually include an epoxy type mid-coat and polyurethane top-coat. These coating layers are typically applied at very thick dry film thicknesses to achieve efficient protective capacity.

Smaller steel assets that are commonly produced in industrial or automotive markets have traditionally used a different approach to achieve a high level of corrosion protection: deposition of an inorganic pretreatment layer prior to coating application.⁴ The use of phosphate conversion coatings or thin-film inorganic layers under the coating system provide an added level of protection to the steel.⁴ While these assets are not typically subjected to the same level of corrosive atmosphere as infrastructure in coastal or marine settings, the pretreatment layer does provide additional corrosion mitigation leading to reduced maintenance and coating material required to maintain an acceptable lifecycle. This additional protection would be highly beneficial for marine assets as well.

However, the use of pretreatment for large assets in marine environments is not a trivial proposal. At present, pretreatment layers are deposited by immersion of the asset in a liquid solution of the desired inorganic pretreatment or via a spray application of the pretreatment solution at elevated temperature.⁴ Immersion application is prohibitive for large assets due to the large tank size required as well as the number of tanks required for the entire process. For example, traditional metal phosphate (e.g. Zn or Fe) pretreatment requires several stages consisting of cleaning, rinsing, and pretreating to achieve the final pretreatment layer.^{4,5} Even spray application would be prohibitive due to the temperatures required to apply the pretreatment. Most pretreatment applications require controlled temperatures greater than 100 °F;^{4,5} to apply such a temperature to a large structure in the field in a controlled manner would be physically challenging and fiscally impractical. Furthermore, waste management for large tanks of chemicals in the field would incur astronomical costs.

Due to these limitations, the use of pretreatment methods on large steel structures in harsh environments has not been pursued to date. However, postulating that there may be value gained from the use of pretreatment technologies, we have developed a method for applying pretreatment to large structures without adding additional steps to the coating application method through a novel surface engineering method.⁶ Our method imparts the qualities of a pretreatment layer to the surface of an asset through the traditional surface preparation method of media blasting. Typically, media blasting is used to remove old coatings from a structure, as well as provide a rough surface profile to aid in adhesion for newly applied coatings.⁷ In this work, we expand beyond the use of blasting as a surface preparation to also include corrosion inhibitor application via a novel surface engineering approach. In particular, we have explored this technology with different types of systems to understand the benefits, specifically for single coat and more traditional three-coat systems. The test systems were subjected to accelerated corrosion testing to evaluate for rust creep as a demonstration of the corrosion protection afforded by the novel surface engineering method. Target performance metrics were selected based on ISO corrosivity categories,⁸ specifically to demonstrate the value that our novel surface engineering approach might bring in extending the lifetime for a direct-to-metal epoxy designed for use in C4H environments and conventional 3-coat zinc-rich primer – epoxy mid-coat – polyurethane top-coat systems designed for C5 and CX exposure environments.

EXPERIMENTAL PROCEDURE

Steel panels (12 gauge, 75 mm x 150 mm) were used in this study and prepared by either a conventional media blasting approach or by the novel surface engineering approach to impart a 2.5 mil