USE OF PRE-CONSTRUCTION PRIMERS IN MARINE CONSTRUCTION

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Abstract: Pre-construction primers (also known as shop primers or pre-fabrication primers) are very thin films applied to blast cleaned steel plates and shapes to provide preservation of the blasted steel during the shipbuilding or construction process. SSPC is developing an industry guide document containing information regarding the use of pre-construction primers (PCP) on structural steel in shipbuilding. This paper will review the technical details contained in the document including background on the reasons to use and retain PCPs, the types of PCPs and their application and inspection, and the secondary surface preparation processes that are used when PCPs are retained in the final, compatible primary coating system.

Introduction

Priming of carbon steel plates, beams, angle irons and other shapes prior to their fabrication into parts of industrial and marine structures has progressed from its earliest stages to the current block stage or module process. The earliest practices involved using full thickness of both organic and inorganic primers intended to become the first coat in multi-coat systems. It was quickly recognized that these full coat primers impeded progress of welding and led to porosities in the welds that compromised the integrity of the entire coating system. Extensive damage during the fabrication process led to a need for quicker processes with less intercoat adhesion problems.

The coatings industry met the need with more efficient inorganic zinc primers by adopting both thinner films and films with less zinc content as a means of meeting the production requirements of the fabricators (predominantly shipyards). These production requirements include the ability to resist corrosion for fabrications periods that often extend longer than 12 months. While some organic pre-construction primers (mainly water-based inhibitive epoxy) have been used, they did not match either the production efficiencies or the protection of the carbon steel afforded by inorganic zinc pre-construction primers. The major problems with organic PCPs include extensive burn back from the weld area, fabrication damage and noxious fumes during welding and cutting processes.
Inorganic Zinc Preconstruction Primers

Inorganic zinc PCPs are a special class of inorganic zinc primers. Whereas permanent inorganic zinc primers are formulated with zinc pigment content ranging from 65% to 92% depending on the manufacturer and the end-use requirement of 2-4 mil (50-100µm) dry film thickness (DFT), all inorganic zinc PCPs have reduced zinc pigment content and an end-use thickness requirement of 0.6-0.8 mils (15-20 µm) DFT. Inorganic zinc PCPs are designed to withstand the welding processes and handling damage during the fabrication process of blocks or modules prior to their incorporation into the permanent finished structure. Corrosion prevention is required, but only during the period from PCP application until the fabricated components are welded into modules that become joined into a completed structure. Application of the permanent protective coating system varies according to the shipyard’s individual production process.

Zinc content of PCPs is typically between 28% and 48%. Zinc content is often chosen based on a tradeoff between welding issues (which favor lower zinc content) and corrosion protection during storage (which favors higher zinc content). Other factors such as cost and usability will also contribute to the final formulation. Inorganic zinc PCPs may also contain zinc phosphate, zinc oxide, vitreous silica, and/or kaolin.

PCP selection is driven by welding as well as coating issues. The primer can have an effect on welding speeds and quality. The composition of the primer can have health and safety implications for the welding process. A 1973 National Shipbuilding Research Program (NSRP) report discusses these issues.¹

Pre-construction Primer Standards

A significant problem in the industry is that there is no standard for pre-construction primer material. A variety of coating materials have been marketed as PCPs. In the absence of a global standard, classification societies such as ABS, DNV, Lloyds, etc. issue type approval certificates for PCPs. These certificates indicate that the materials meet the class society’s requirements for PCPs. They do not establish a standard or meet a global standard. Competition among the classification societies creates the potential for less stringent standards.

The nearest thing to a standard is the International Maritime Organization (IMO) Resolution (MSC215(82)) PERFORMANCE STANDARD FOR PROTECTIVE COATINGS FOR DEDICATED SEAWATER BALLAST TANKS IN ALL TYPES OF SHIPS AND DOUBLE-SIDE SKIN SPACES OF BULK CARRIERS (PSPC). This resolution became mandatory through amendment of the SOLAS convention and applies to ships contracted on or after July 1, 2008. It specifies inhibitor free zinc silicate shop primer or equivalent. Equivalence is not defined; therefore the determination

¹ Improved Fabrication Primer for Protection of Steel, National Shipbuilding Research Program Report # 0032, General Dynamics, February 1973.
of equivalence is often determined by the manufacturer of the PCP and/or the classification society doing survey work in the shipyard. IMO PSPC is based on specifications and requirements which intend to provide a target useful coating life of 15 years for the entire coating system, which is considered to be the time period, from initial application, over which the coating system is intended to remain in “GOOD” condition. The actual useful life will vary, depending on numerous variables including actual conditions encountered in service.

The specific requirements of the IMO PSPC Resolution relating to PCPs include:

- Shop-primer is defined as the prefabrication primer coating applied to steel plates, often in automatic plants (and before the first coat of a coating system).
- The shop primer shall be zinc containing, inhibitor free zinc silicate based or equivalent.
- Shop primer compatibility with main coating system shall be confirmed by the coating manufacturer.
- The complete coating system comprising epoxy based main coating and shop primer shall have passed a pre-qualification certified by test procedures in [annex 1].
- The retained shop primer shall be cleaned by sweep blasting, high-pressure water washing or equivalent method.

ISO 8501-1:1998/Suppl:1994 provides photographic examples of grades Sa2½ or St3 surface preparation, but only for rusted flat steel surfaces without a shop primer. The photographic examples are not representative of pre-construction primed areas after assembly.

The Japan Ship Technology Research Association (JSTRA) published their Standard for the Preparation of Steel Substrates for PSPC-2008. (SPSS for PSPC) This photographic collection of surface preparation examples are intended as a reference when implementing the PSPC. These photographs may also serve as a reference when applying the Performance Standard to void spaces as well as cargo oil tanks developed or to be developed by the IMO. Several coatings manufacturers have their own process standards for preparing aged pre-construction primer prior to applying a coating.

SSPC Guide for Use and Retention of Pre-Construction Primer on Steel in Shipbuilding

In response to industry need, an SSPC technical committee has been formed to develop a guide document that will provide the specifier and user with information regarding the use of pre-construction primers (PCP) on structural steel in shipbuilding. It will provide background on the reasons to use and retain PCPs, the types of PCPs and their application and inspection, and the

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2 The annex describes a 180-day test of panels installed in a simulated ballast tank with wave movement.
secondary surface preparation processes that are used when PCPs are retained in the final, compatible primary coating system. Currently, the draft of this guide contains the following major technical sections:

Pre-Construction Primer Materials

There are two major types of PCPs currently in use: epoxies (organic), and inorganic zinc silicates. Both types may be commercially available as solvent borne or water borne coatings. Inorganic zinc silicate PCPs are the standard in shipbuilding as they provide temporary corrosion protection, have high heat resistance, and are compatible with most welding processes. Epoxies are typically removed from weld areas as they may burn or char at welding temperatures and can interfere with the weld quality.

Material Properties

Several material properties which should be considered when selecting a pre-construction primer are discussed in the guide. PCPs are designed to provide corrosion protection during fabrication. In addition, they should minimally interfere with the fabrication process (generally 6-12 months). This requires that they are compatible with subsequent welding processes, resist abrasion and mechanical damage which may occur during fabrication and handling, and have a dry to handle time which minimizes the laydown area dedicated to coating curing.

Selection of a Compatible Primary Coating System

The primary coating system must be compatible or appropriate for the intended service environment, included the desired service life and the owners coating maintenance strategy. In addition, manufacturer/vendor of the primary coating system should assure or claim compatibility of the primary coating system with the retained PCP. This is not always a trivial consideration since a single pre-construction primer will be used for the majority of a ship. Multiple primary coating systems (possibly from different vendors) will need to be compatible with this PCP. Finally, appropriate approvals of the system compatibility must be in place. This may require regulatory, Classification Society, Naval authority, or other approvals, obtained via documented past performance, or passing a test program.

Application of Pre-Construction Primer

In modern shipbuilding, primary surface preparation and application of the PCP are typically performed in a continuous process in a dedicated, automated conveyor line and facility. The facility may be operated by the shipyard, steel supplier or a third party. Automated processes dictate more of a process control mindset than is commonly associated with industrial painting. Automated application typically involves computer-controlled spray arms (also

Figure 1. Reciprocating spray arm in an automated PCP plate line
called reciprocators) positioned above and below the steel products in order to coat the top and bottom in a single operation. Proper adjustment of the distance of the nozzles from the steel surface, the movement speed of the arms, and the speed of the conveyor are all required to achieve the correct and uniform PCP film thickness.

Retained pre-construction primer eventually becomes part of the accepted coating system. As a result, the quality control records may need to be incorporated into the ship’s coating technical file. Generally, coating records are developed for each space or location being coated. However, during the process of pre-construction primer application QA data is typically only collected a few time per work shift rather than on each (eventual) ship space. A methodology for integrating process control data into the ships coating technical file needs to be developed when PCP is retained.

When to Retain Pre-Construction Primer

One of the biggest economic advantages using a PCP is the fact that, in most service environments, it does not have to be removed prior to applying the primary coating system. It is necessary to carry out some degree of secondary surface preparation prior to applying the primary coating system. The schedule and cost differences between complete removal of the PCP and secondary surface preparation help to determine the business case for PCP retention. One report estimated that retaining pre-construction primer could save the US Navy in excess of $7 million per year, the majority of which is associated with new construction.3

PCP cannot be retained for all service environments. PCPs must be removed from certain liquid cargo tanks prior to application of the primary coating system. It is generally recommended to remove them when the expected service environment will be acidic (pH < 5) or alkaline (pH > 10). PCPs may also need to be removed for shipboard potable water tank service, particularly if the PCP has not been certified as safe to use in drinking water. PCPs may also need to be removed from tanks holding fuel that may be adversely impacted by dissolved zinc.

Secondary Surface Preparation

In order to ensure satisfactory adhesion of subsequently applied primary coating system, the aged and weathered PCP has to undergo various degrees of secondary surface preparation. The degree and type of secondary preparation required before application of the full coating system depends on several factors, and varies with the fabrication work that been

3 Retention of Pre-Construction Primer, National Shipbuilding Research Program, November 2010.

Figure 2. Test panels showing the value of pressure washing to remove contaminants (contaminated panels at top, washed panels at the bottom).
performed: the condition of the retained PCP, the expected service conditions of the full primary coating system, and the prevailing specification requirements.

In broad terms, secondary surface preparation can generally be classified into two parts: steel fabrication finishing, and PCP cleaning and preparation. Secondary surface preparation may involve some or all of the following activities:

- solvent and other cleaning methods to remove soils, oil, and grease
- grinding or other mechanical treatments of weld areas to remove sharp edges, spatter, or other weld bead discontinuities
- grinding or radiusing of cut or formed edges created during fabrication
- abrasive blasting and/or power tool cleaning of erection break and other weld areas
- abrasive blasting and/or power tool cleaning of areas with corrosion or damaged PCP
- high pressure water cleaning or sweep blasting of the intact, retained PCP

**Summary and Conclusion**

Over 30 years of experience and test data has demonstrated the benefits of using pre-construction primers during steel fabrication. In many instances, materials can be used which are compatible with the welding process (i.e., “weld through”) and are compatible with the primary coatings system to be used (i.e., they can be “retained.” The use and retention of weld through pre-construction primer can have a positive impact on cost and production schedule. Standard practices and procedures for PCP materials and use will help to expand their use and reduce the cost of coating application during steel fabrication.