Surface Preparation for Ballast Tank Corrosion Control

Loren L. Hatle
Corrosion Exchange, LLC
20523 Whiteberry Ct.
Humble, TX 77347

ABSTRACT

Coating breakdown and corrosion starts on Day 1, as poor surface preparation and coating application are the prime causes of premature coating breakdown and corrosion. For shipbuilding or refurbishment, the correct surface preparation and coating of ballast tanks is critical. According to IACS rules, coating in the worst “area under consideration” must be “Good”, as a class notation for the affected area can impair a ship’s ability to trade properly. Tank coatings must remain “Good” for life if ship operations are to remain profitable.

Substantially improvements in surface preparation to properly addresses chlorides and iron sulfides can help reduce or eliminate premature coating failure and introduces advanced coating systems that can be applied to new or refurbished tanks. The suggested improvements offer solutions that lead to reduced maintenance, increased adhesion reliability and better resistance to cracking, thus increased longevity and performance. Implementing these measures eliminates the need for expensive additional inspections required by the Class Societies and Port State authorities due to poor coating conditions increase operating costs and reduce operating time and profitability.

INTRODUCTION

Ballast tanks within the cargo area or adjacent to the cargo area must be protectively coated with a material compatible with environmental factors likely to be encountered. (e.g. chlorides, heat, chemicals, expansion, moisture, abrasion, fuel, oil) Inferior levels of metal hygiene in surface preparation and poor coating suitability are prime factors in coating breakdown and eventual corrosion in ballast tanks.

According to IACS rules, coating in the worst “area under consideration” must be “Good”, as a class notation. Any other notation will impair a ship’s ability to trade. Tank coatings must remain “Good” for life if ship operations are to remain profitable. However, current performance of conventional coatings (in particular widely specified high-solid epoxies) often fall short of IMO’s 15-year target service life; the duration for remaining “Good” is 8-10 years or less in actual service.

Ballast tank IACS good class notation.

Coating Condition	**Class Notation**	
Minor spot rusting	Good	
Light rusting over >20%	Fair	
General breakdown >20% and hard scale >20%	Poor	
Epoxy Coating Nominal Dry Thickness	**# of Coats**	**Expected Service Life**
200 microns	1	5 ± 3 years

300 microns	2	10 ± 3 years
300-400 microns	3	15 ± 3 years

Note: expected service life only if substrate surface salt content is < 50mg/m^2 before coating

Coating Cracking

Over areas such as block joint areas and on butt, seam, and fillet welds, internal stress can cause cracking failures of high solid epoxies that may occur within a shipbuilder's 12-month warranty, but may also take longer than a year to develop, resulting in unexpected repair costs for owners.

Wu describes the problems faced in mitigating the development of coating cracking: "Development of service cracks in epoxy-based corrosion protective coatings limits the life of the substrate structure. If cracks develop, corrosion protection is lost and costs of repair and re-protection of large marine structures can be crippling. Factors controlling development of cracks in the coating are poorly understood, and predictions of coating lifetime approximate." Wu (2014).

Understanding main factors behind internal stress factors has made important strides in recent years. A recent study on internal stresses and mechanical properties of coatings points to adhesion as probably the most important factor in preventing cracking. "Adhesion however is not a fundamental property of the coating/substrate interface rather it is the consequence of the interaction between the polymer and the substrate. It is these interactions which must be understood to provide answers to the cracking issue." Reed (217)

Weld issues

One of the greatest challenges to welding is preventing contamination of the molten puddle. Welding over contaminants can form gases that cause metal to oxidize. When a metal oxidizes, it will not respond well, often resulting in weaker weldments. Heat-affected-zone (HAZ) adjacent to the weld are particularly vulnerable to corrosive attack, requiring extra attention in surface preparation and coating.

Surface Preparation

Optimal surface preparation is essentially a matter of metal hygiene. To maximize adhesion and impermeability, coatings must perfectly and permanently match the surface and pores of the surface. The distance between the surface of the substrate and the coating should be as small as possible, with no microcontamination between substrate and coating to prevent perfect adhesion. Reliable, fail-safe surface decontamination in the field is therefore critical to creating an optimally receptive surface for coating.

Sulfides are extremely hygroscopic, ionically charged, difficult to remove and ubiquitous in steel and other metals. In recycled metal, the presence of sulfides greatly accelerates corrosion. "In older vintage and low-quality steels, hydrogen blistering is associated with dirty steel (i.e. high sulfur) with highly oriented slag inclusions or laminations. These materials have produced large internal blisters in plate steels used to construct pressure vessels and tanks. In some cases these blister can reach a size of 30 cm (1 ft) diameter or greater" Burt (2015). Optimal surface preparation is, in essence, a matter of metal hygiene. Removing sulfide and sulfate contaminants logically increases resistance to cracking.

Testing for Sulfides and Hidden Salts

"Intergranular contaminants such as sulfides and chlorinated hydrocarbons are more elusive to quantify since they are more difficult to remove. There is no generally accepted standard for either chloride, sulfate or sulfide contaminant levels under coating and lining systems" Vincent (1998) Kits are available to test for chlorides prior to coating, but not for sulfides (which are insoluble). Current field testing is purely qualitative, it does not give an accurate quantitative measure, as chlorides beneath iron sulfide films are undetectable. Accurate testing for intragranular contaminants requires SEM and EDS analysis. Therefore testing is unlikely to reveal the true state of metal hygiene.

New Technology for Optimal Metal Surface Hygiene.

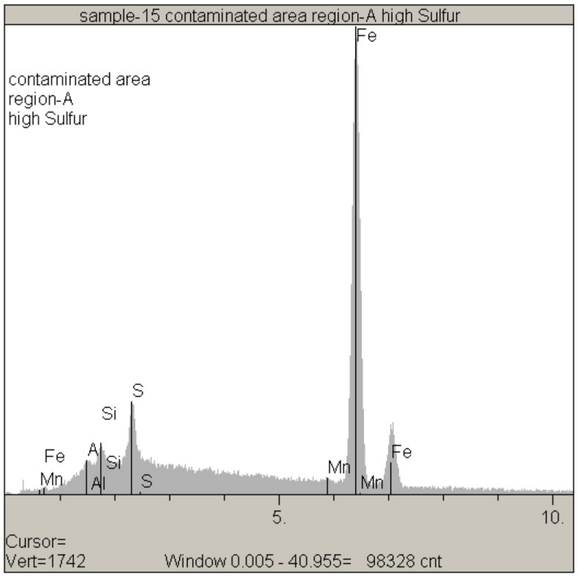
Salt removal and rust removal products only remove soluble salts; they cannot remove sulfides or chlorides hidden beneath sulfide films. Indeed, it is difficult even to detect such hidden salts. "iron sulfide is insoluble; therefore, water cleaning is not possible. Sulfides to penetrate into the intergranular crevices in metal substrate" and are difficult to remove. *Decontamination of Metal Substrates Vincent, L.D. 1998 NACE International Houston TX*

Understanding that ensuring wholesale removal of sulfides and other microcontaminants is needed to promote maximum coating adhesion and consistent contact at the coating/substrate interface, a novel metal decontamination technology was developed to remove ionic and highly hygroscopic microcontaminants (i.e. sulfides, sulfates chlorides, nitrates and microbial byproducts) from metal surfaces by penetrating the sulfide film, breaking the sulfide bonds and rinsing away microcontaminant detritus to ensure more reliable and complete surface preparation outcomes. The product may be used with small-footprint portable wet abrasive vapor blast (WAVB) units. The decontamination product is added to the blast tank to simultaneously decontaminate during blast cleaning. The resulting surface hygiene requires no additional processes or products (i.e.: salt removers, inhibitors, dehumidification, rust removers) before coating

Summarized Findings

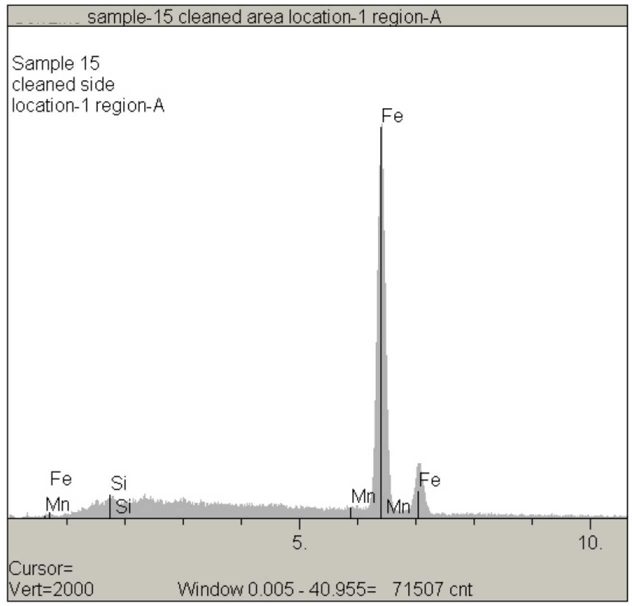
The purpose of the testing (performed by Anastas Technical Services in 2012) was to and evaluate the effectiveness of the metal decontamination product as a surface preparation method by comparing contrasting treated and untreated areas. A baseline contaminant-free surface was created and verified. It was then intentionally and methodically contaminated with known elements and corrosive compounds (sulfur, chlorine, iron sulfides, iron chlorides) to easily locate and identify contaminated areas. One side was treated with the metal decontamination product. The other was not treated, as a control. Findings from each location were compared, visually and quantitatively using SEM and EDS. Test findings confirmed, both visually and analytically, that the metal decontamination product effectively removed contaminants.

Field A, Region A, before Metal Decontamination Product



Elt.	Line	Intensity (c/s)	Error 2-sig	Conc	Units	
Al	Ka	5.09	0.583	0.871	wt.%	
Si	Ka	14.24	0.974	1.846	wt.%	
S	Ka	50.59	1.836	4.423	wt.%	
Mn	Ka	2.79	0.431	0.320	wt.%	
Fe	Ka	490.90	5.720	92.540	wt.%	
				100.000	wt.%	Total

Field B, Region A, after Metal Decontamination Product



Elt.	Line	Intensity (c/s)	Error 2-sig	Conc	Units	
Si	Ka	5.46	0.603	0.869	wt.%	
Mn	Ka	1.92	0.357	0.221	wt.%	
Fe	Ka	444.66	5.445	98.910	wt.%	
				100.000	wt.%	Total

Brine Pit Case Summary

Senior pipeline engineer Stephen Waguespack wrote in correspondence to the manufacturer regarding field testing he had performed field testing in 1995 on brine pit piping in Markham, Texas. Three similar sites that were under maintenance were selected. Two of the sites were treated with traditional methods, then coated. The third site was treated with the decontamination product, then coated with the identical epoxy coating. No problems in application were noted. Eleven years late, the site was revisited for inspection. The pipe treated with the decontamination product was still fully intact. The sites treated with traditional methods had undergone three maintenance events in the previous decade.

Refinery Tank Case Summary

In 2011 correspondence, NACE Inspector Pablo Reyna reviewed a particularly difficult case. Eight, 125,000 barrel (142' x 50'), tanks were built in San Diego, California. “Following construction, the tanks were unknowingly hydro-tested with extremely contaminated water that immediately resulted in some of the worst corrosion I had ever seen. The contractors had tried multiple abrasive applications in conjunction with a product commonly used in the industry for surface preparation, with no success. The project was running behind schedule with no solution in sight. … In addition to providing acceptable visual standards, {the decontamination product} also removed the problem causing surface contamination that had delayed the project for several months.”

CONCLUSION

Although the novel decontamination product has not yet been tested in ballast tanks, the technology could easily be transferred to ballast tank surface preparation procedures which use similar equipment for surface cleaning and is predicted to see similar improvements in metal hygiene, as the contamination problems are essentially the same. The modest cost of metal decontamination is immediately recouped by eliminating the expense associated with re-work attempts often needed to meet surface preparation standards. By preventing re-work, metal decontamination has allowed owners to recouped profits previously lost to downtime and unscheduled maintenance. The suggested surface preparation technology has proven to promote adhesion, thus enhanced resistance to cracking, in brine pit piping and refinery tanks, with associated increased longevity and performance, in brine pit piping and refinery tanks. Adopting this process for implementation in ballast tank surface preparation will prevent expensive additional inspections required by the Class Societies and Port State authorities due to poor coating performance, decrease operating costs and increase ship's operating time and profitability.

REFERENCES

T. Y. Wu et al., "Fatigue Crack Development in Epoxy Coatings on Steel Substrate: The Role of Coating and Substrate Properties in Determination of the Onset of Fatigue Cracks", *Advanced Materials Research*, Vols. 891-892,2014. pp. 854-859.

Reed, C., & Eliasson, J. (2017, April 27). "Coatings Cracking in Water Ballast Tanks: A Different Look", CORROSION 2017, paper no. 9088. Houston, Texas: NACE International. March 26-30, 2017. 8 pgs.

V. Burt, ed. Corrosion in the Petrochemical Industry, Second Edition. Materials Park, Ohio. ASM International. 2015. 426 pgs,

Vincent, L.D. "Decontamination of Metal Substrates". CORROSION 98, paper no. 98620. Houston, Texas: NACE International. 1998 NACE International Houston TX. March 22-27, 1998. 7 pgs.