

Paper No.
16642



**The Importance of Surface Preparation method on the Corrosion Resistance
and Mechanical Properties of Zinc Rich Primers**

Dr David Morton
Hempel A/S
Lundtoftegardsvej 91
Lyngby, 2800
Denmark

Antoni Prieto, Tomas Alhambra, Raquel
Morales, Cristina Juni
Pinturas Hempel S.A.U
Carretera de Sentmenat 108
08213 Polinya
Barcelona, Spain

ABSTRACT

Surface preparation is a crucial factor to ensure good performance of coating system in an offshore environment. Both substrate cleanliness and surface profile (influence by the shape of abrasive) will improve the adhesion of the primer which has a direct influence on the performance of the coating system.

For a highly corrosive offshore environments the industry is specifying zinc rich primers for long service life. This paper will examine the performance of new, activated zinc rich epoxy primers compared to conventional zinc rich epoxy primers on steel prepared to different surface profiles using standard techniques used today.

Testing done has been the cyclic ageing according to ISO12944-9 (2018), blister box test according to ISO 6270-1 and the impact test according to ISO6272-1.

This testing will show the importance of surface preparation on the ability of the coating system to provide long term corrosion resistance in an offshore environment and on how the choice of zinc rich primer can improve tolerance to poor surface preparation and thus enhance the lifetime of the coating system.

Key words: Surface Preparation, Zinc Rich Primers, Maintenance

INTRODUCTION

The performance and durability of any coating system is significantly affected by the type and quality of the surface preparation that is done. The type of surface preparation is chosen depending on the condition of the substrate, the coating system to be used, the exposure and required coating durability, economic and environmental considerations. The practical performance of coatings systems is dependent on the condition of the surface prior to painting¹. The most relevant factors are the presence of rust and mill scale; contamination such as salts, oils, grease and dust; surface profile.

The primary objective of surface preparation is to provide maximum coating adhesion. The surface preparation has a two main functions; firstly to remove any extraneous, loose materials from the surface of the substrate and to eliminate chemically bonded scales, oxide films, and similar surface reaction products that cover active adhesion sites on the metal surface. The removal of such materials exposes the reactive sites so that the primers can have contact with them and develop the maximum adhesion possible. The second function of surface preparation is to increase the surface area by increasing the roughness of the surface and thus providing an anchor pattern on the surface. By this means, the actual exposed surface area per unit of actual area is greatly increased. By increasing this effective surface, many additional reactive sites on the metal surface are exposed, allowing for additional polar or chemical adhesion of the primer to the surface. This is extremely important, since increasing the opportunity for either primary or secondary valence bonding with the coating system is the key to the best possible adhesion of any coating. Surface cleanliness standards have been developed to reflect this and they are shown in Table 1.

Description	Swedish SIS 05 5900	American NACE	American SSPC	International ISO 8501-1
White metal blast	Sa 3	NACE #1	SSPC SP5	Sa 3
Near white blast	Sa 2 ^{1/2}	NACE #2	SSPC SP10	Sa 2 ^{1/2}
Commercial blast	Sa 2	NACE #3	SSPC SP6	Sa 2
Brush off blast	Sa 1	NACE #4	SSPC SP7	Sa 1
Power tool clean	St 3		SSPC SP3	St 3
Hand tool clean	St 2		SSPC SP2	St 2

Table 1: Surface preparation standards

Zinc rich primers, both organic and inorganic coatings, are primarily used in the corrosion protection of oil & gas structures that operate offshore when they are built. The beneficial effect of zinc rich primer on the longevity of protective coatings is primarily assumed to be due to a cathodic protection mechanism². Zinc rich coatings are protective in two different ways: they serve as galvanic cathodic protectors of steel surfaces and offer some barrier protection against ingress of water, regardless of the type of zinc rich coating used.

At new building; the surface preparation is to a high standard and the steel is usually in controlled conditions. These conditions are ideal for the use of both inorganic and organic zinc rich primers because they need good adhesion to the substrate to provide the best protection against corrosion.

This need of good surface preparation has made the application of zinc rich coatings during maintenance periods difficult or impossible; which leads to inferior protection of the steel after the first maintenance cycle. When maintenance is done it is often not possible to blast the surface because of

environmental concerns, complex geometry or health and safety issues. This means that the best preparation that can be done is either power tool cleaning, water jetting or just hand tool preparation. The surface cleanliness and roughness will be reduced.

The industry is evaluating the latest technologies available in order to reduce the associated maintenance and repairs cost. As well as systems that increase application productivity.

We have found all these benefits can be achieved with a new innovative anti-corrosion technology, based on activated zinc. Zinc rich coatings based on this new technology are more tolerant to surfaces with inferior preparation meaning that they are suitable in maintenance environments.

The purpose of this paper is to describe the performance of the new generation of activated zinc rich epoxy primers compared to standard zinc rich epoxy primers on surfaces prepared in different ways with different surface profiles. The methods of substrate preparation are divided in two categories: cleanliness and surface roughness. Cleanliness levels are Sa 2^{1/2} or NACE #2, ST3 and Wa2. Surface roughness levels for Sa 2^{1/2} are Grit medium, Shot medium and Shot fine according to ISO 8503³.

EXPERIMENTAL PROCEDURE

Hot-rolled mild steel was used for all the test panels of rust grade A according to ISO8501-1⁵. The steel was prepared to simulate actual conditions in real life.

Surface Preparation

All panels were hot rolled milled steel of rust grade A (ISO 8501 -1)⁴ and abrasive blasted to Sa2 ½ (ISO 8501-1) using steel grit G40 for standard testing.

A reduced surface profile was achieved by blasting to Sa2 ½ using a steel shot blend of S330/S170. Surface roughness was measured using an Elcometer 224 (Mark 2) according to ISO 8503-4³.

Panels conditioning prior to secondary preparation and testing

St3 according to ISO 8501-1 (Power tool cleaning)

Newly blasted panels were sprayed with deionized water using a conventional spray gun. The panels were then placed in an oven for 24 hours at 50°C to promote rust formation. The panels were removed from the oven and allowed to cool before bristle blasting to St3.

Water Jetting to Wa2 (ISO8501-4)⁵

Newly blasted panels were sprayed with deionized water using a conventional spray gun. The panels were then placed in an oven for 15 minutes at 50°C to promote flash rust formation. The panels were removed from the oven and allowed to cool. Flash rust was assessed as medium according to ISO 8501-4)

Panel preparation

Paints were applied, in a single coat, by brush or airless spray according to the following conditions:

Wagner Cobra 40:1 pump
Hose 1.5m
Nozzle : 5/17"
Pressure 160~200 Bar
Cabin Conditions

Room Temperature 26.2°C
Steel Temperature 26°C
Paint Temperature – 26.3°C
Relative humidity 58%

Test panels were cured for 21 days at 25°C and 50% RH prior to testing

Test methods

All systems were testing according to internationally recognized standards. The following test procedures were used:

ISO 12944-9 (2018) Cyclic ageing⁶
ISO 9227 Neutral salt spray⁷
ISO 6270-1 Continuous condensation⁸
ASTM D6677 Adhesion by knife⁹
ISO 4624 Pull-off adhesion¹⁰
ISO 4628-2,3,4 & 5 Panel Inspection after exposure¹¹⁻¹⁴
ISO 6262-1 Direct impact resistance¹⁵

Products Tested

Conventional zinc rich epoxy primer
Activated zinc rich epoxy primer

RESULTS

The products were tested as single layers of zinc rich primer over the various surface preparation methods to show how the primer behaved without the influence of any other part of a conventional coating system.

Surface roughness and DFT (dry film thickness) measurements

All results are an average of 6 readings from 3 panels and are shown in Table 2:

Blast media / description	Surface roughness (microns)	Zinc rich Primer DFT (microns)	Activated zinc rich primer DFT (microns)
Grit, medium profile , high density	82	106	
Grit, medium profile, high density	75		119
Shot, medium profile, high density	34	107	
Shot, medium profile, high density	33		110
Shot, medium profile, low density	31	103	
Shot, medium profile, low density	23		101

Table 2: Average surface roughness and dft readings

Secondary Panel preparation

All dft results are an average of 6 readings from 3 panels and are shown in Table 3:

Panel ref	Surface Preparation	Activated zinc rich primer DFT (microns)
R-770	Grit blast, medium, Sa2 ½	87
ST- 770	Bristle blast, ST3	72
FR-M-770	Flash rust medium	84

Table 3: average primer dft results

ISO12944-9 Cyclic Ageing⁶

Single coat systems were exposed to the testing requirements of this standard to compare performance of the primer. Panels were inspected after 4, 12 and 25 weeks to show progression of corrosion and adhesion loss of the primer.

The results are shown in the table 4 and photographs of the panels are shown in Figure 1:

Assessment methods	Grit, medium profile, high density		Shot, medium profile, high density		Shot, medium profile, low density	
	Zinc rich primer	Activated zinc rich primer	Zinc rich primer	Activated zinc rich primer	Zinc rich primer	Activated zinc rich primer
Blistering ISO 4628-2	0(S0)	0(S0)	0(S0)	0(S0)	0(S0)	0(S0)
Rusting ISO 4628-3	Ri0	Ri0	Ri0	Ri0	Ri0	Ri0
Cracking ISO 4628-4	0(S0)	0(S0)	0(S0)	0(S0)	0(S0)	0(S0)
Flaking ISO 4628-5	0(S0)	0(S0)	0(S0)	0(S0)	0(S0)	0(S0)
Corrosion Creep mm	0,6	0,0	3,0	0,0	4,2	0,0
Adhesion (reference) Adhesion Mpa	8.0 (A/B)	16.0 (-/Y)	7.0 (A/B)	13.0 (-/Y)	8.0 (A/B)	13.0 (-/Y, A/B)
	8.0 (-/Y)	5.0 (-/Y)	5.0 (-/Y)	3.0 (A/B)	3.0 (A/B)	3.0 (A/B)
Cross Cut adhesion	0	0	3	2	3	2

Table 4: assessment results after 4 weeks (700 hours) ISO12944 -9