TECHNICAL INFORMATION

PatinaForma™

an Active Coating and a

-New Weathering Technology-

for weathering steel structures
(including High Performance Steel).

Presented by

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The International Corrosion Consultants

for

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and
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1. Introduction

An intrinsic characteristic of steel is RUSTING which occurs by reaction between steel and the atmospheric environment. This rusting often causes significant sectional losses of steel structures, a process which although continuous, is difficult to monitor. Weathering steel is generally known as anti-corrosion steel that forms a protective rust patina during the first 8 years of atmospheric exposure in locations of low pollutants (chlorine and sulfur), and good wet-dry cycling. Low chlorine surface deposition rates less than 5 mg/m^2.day, (0.05 mdd) are necessary for the formation of the protective rust layer. Under these conditions the average thickness loss of the protected weathering steel is reduced to the acceptable level of about 0.25 mpy/surface (6 μm/yr/surface). Exposure of the weathering steel structure to high chlorine depositions rates and/or high time-of-wetness (TOW), results in the formation of non-protective rust. These non-protective rusts that form in "adverse" exposure conditions are different in composition to the protective rust. They are not adherent, and do not protect the steel from further corrosion. In tropical marine locations, and regions of usage of road de-icing salts, a typical chlorine deposition rate on the steel is measured at the very high value of 100 mg/m^2.day (1 mdd). This is 10 times greater than the recommended limit to which weathering steel is exposed. The non-adherent, non-protective rust that forms, leads to weathering steel thickness losses greater than 2 mpy/surface (50 μm/yr/surface). This loss is linear with time and amounts to 1 mm total thickness loss for each 10 years of exposure.

The formation of the adherent and protective rust patina is necessary for the longevity of the weathering steel structure, which is the case of bridges is now 100 years in the USA and 150 years in Japan. Prior to the development of **PatinaForma™**, satisfactory use of weathering steel was limited to environments of low salinity and low TOW.

PatinaForma™ is a new active coating that permits the formation of the protective rust layer on weathering steel structures located in regions of high chlorine and/or high time-of-wetness. The active coating quickly reacts with the local corrosive environment to form a barrier layer that is impervious to the diffusion of chloride ions to the steel surface. **PatinaForma™** uses the same alloying elements as in weathering steel, to form the protective patina. The properties of the active coating also regulate water and oxygen diffusion to the steel surface and thus control the TOW at the steel surface. Other active compounds in the coating enhance the formation of the correct protective rust

that is identical to that observed on the protected steels exposed in low pollutant locations. The active coating forms the protective rust layer in less than 2 years. After 4-6 years exposure, only the protective rust layer is observed and the weathering steel takes on the normal dark brown coloration. However the active coating can be formulated to maintain a constant color to the structure is so desired.

2. **PatinaForma**™: The Active Coating

PatinaForma™ consists of several specific oxides and sulfates as well as usual paint species. This treatment enables the rapid formation of the protective coating composed mainly of densely aggregated rust particles and the specially designed chemical compounds that control chlorine, oxygen and water diffusion, as shown in Figure 1.

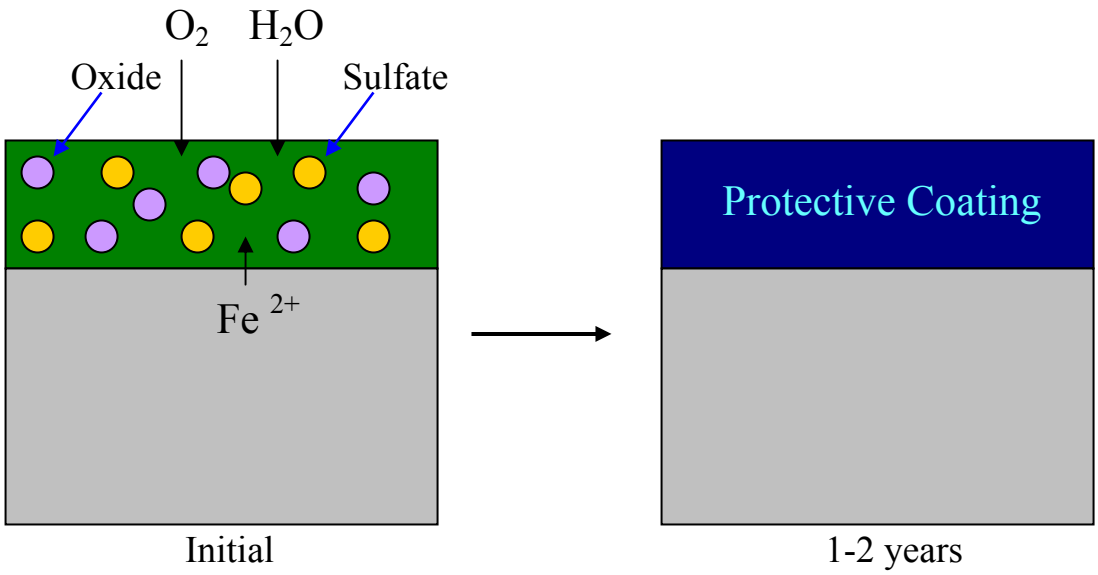

Fig. 1: Formation Process of the Protective Patina that is adherent to the steel.

3. Performance of **PatinaForma**™

The new active coating has been in continual development and improvement since early 2000. Coupons of Type A 588 Weathering steel, bare and coated, have been exposed in a severe tropical location for 4 years. Figure 2 shows the surface appearance of the bare and coated weathering steels, before and after 2

years corrosion in the environment with air-borne salt of 100 mg/m^2.day (1 mdd). The formulation of the top-coating of **PatinaForma™** permits many colors to be selected for the steel finish, and also prevents initial staining due to red rust.

Fig. 2 Surface appearance of bare and coated Weathering Steel coupons, before and after 2 years exposure to a marine environment having air-borne salt content of 100 mg/m^2.day (1 mdd).

The thickness loss due to the application of **PatinaForma™** active coating is much less than that of the bare Weathering steel, as shown in Figure 3. The thickness loss for the bare Weathering steel coupons was 2 mpy/surface, (50 µm/yr/surface) and followed the linear trend similar to Weathering steel bridges located in regions of de-icing salt usage in the US. The thickness loss for the coated coupons was reduced to an average of 0.2 mpy/surface, (4 µm/yr/surface) in the last 1.5 years of exposure. This follows the expected high corrosion rate in the first 6 months of exposure, due to the active compounds forming the protective rust. The active coating forms the adherent, protective patina at 4 times the rate of natural atmospheric corrosion, thereby reducing the time for protective rust formation and the complete protective patina to form.

The high performance of **PatinaForma™** active coating is shown to be due to the formation of the same protective rust layer that forms due to exposure of Weathering steel in environments of low pollutants and good wet-dry cycling. Spectroscopic analyses of the rusts on the exposed bare and coated coupons

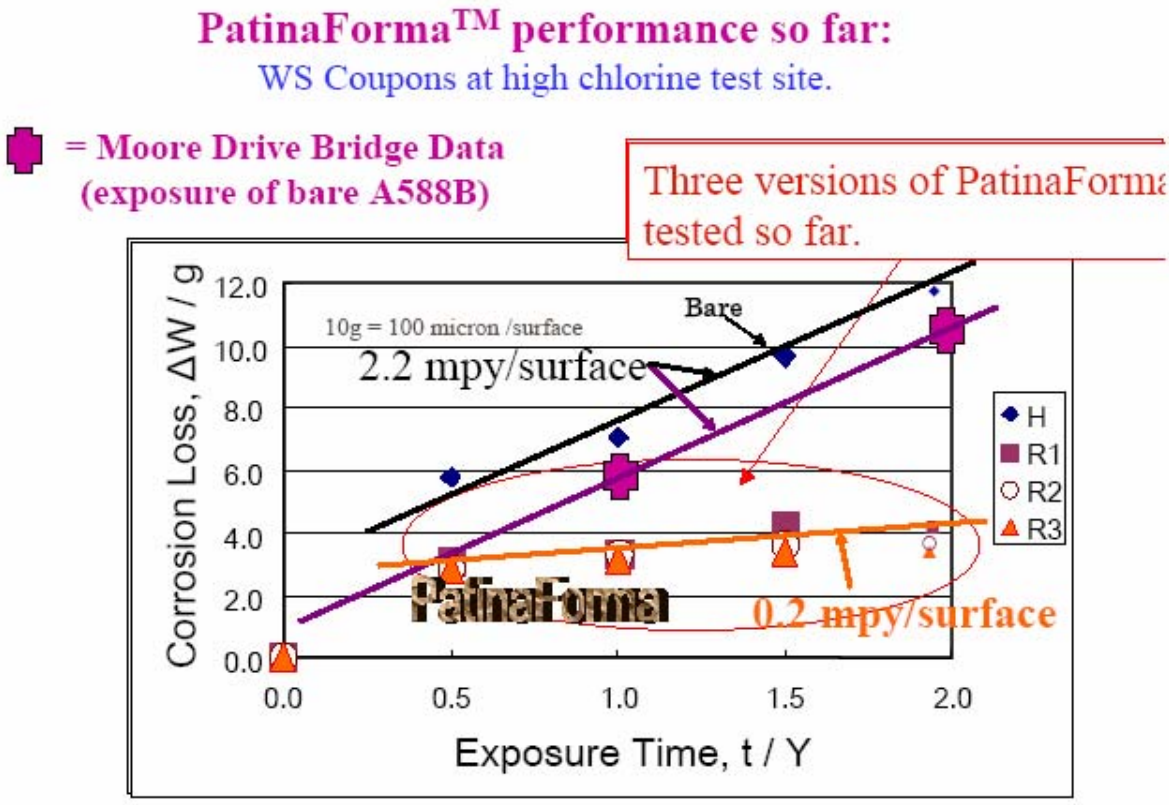

Fig.3 **Corrosion loss of weathering steel as a function of exposure term. Air-borne salt content is 100 mg/m^2.day (1.0 mdd).**

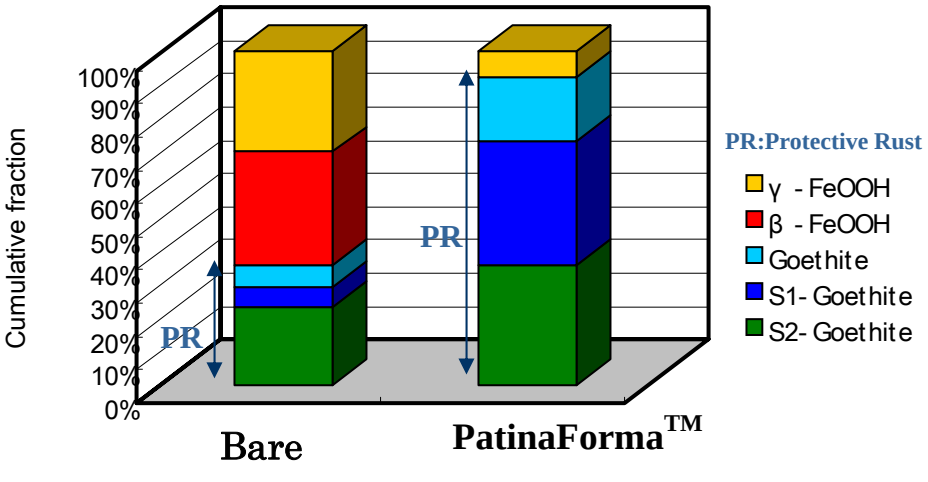

Fig.4: Relative composition of iron oxides making up the rust on the surface layer after 2 years exposure. Air-borne salt content is 100 mg/m^2.day (1 mdd).

are shown in Figure 4. The rust composition on the bare weathering steel is identical to the unprotective rust that forms on bare weathering steel bridges located in marine areas, and regions where road de-icing salt is used. The composition and layering of the rust formed after **PatinaForma™** was applied are nearly identical to the adherent, protective, and layered rust formed in low pollutant environments. The presence of a majority of goethite that is characteristic of the naturally formed protective rust in low pollutant locations was successfully formed in the high chlorine location with the application of **PatinaForma™**.

4. Applications for Rust

PatinaForma™ Active Coating was designed specifically for application to Weathering Steel structures (bridges, guard-rails, power poles), that are, or will be, constructed in regions having adverse environments that prevent the natural protective patina from forming. These are locations where the structure is exposed to high chlorine depositions and/or high Time-of-Wetness. **PatinaForma™** Active Coating may be applied on-site to the existing corroding structure, or may be applied in the prefabrication stage during construction of a new bridge. In the former situation the structure needs to be cleaned of all rust (SSPC-SP-10) and chloride contaminants.

5. Components of **PatinaForma™** Active Coating.

PatinaForma™ is a two-agent liquid consisting of the Main Agent “Liquid X1” and Hardener “Liquid X2” at mixing ratio of 4:1 in weight.

Only **PatinaForma™** is enough to obtain the protective rust coating. But it is recommended to apply finish coat **PatinaForma™** -Topcoat for best results to control the TOW at the steel surface and to permit the structure to have the color desired by the owner. Also, **PatinaForma™** -Thinner is usually used for easier spraying. The mixture of Liquid X1 and Liquid X2 should be used within 10 hours after mixing and applied before the onset of flash rusting of the cleaned structure.

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