# Field Testing of New Novel Technique for Controlling Crevice Corrosion on Rocker Assemblies

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ABSTRACT: Deterioration of bridge expansion rocker assemblies has been an on going problem for bridge maintenance management. Typical coating systems cannot sustain the high compressive loads and movement of assembly. This paper reviews design, installation and five year performance of a new environmentally benign gel protection system to provide long-life corrosion protection.

## INTRODUCTION

Corrosion continues to cost the Department of Transportation untold billions of dollars annually. According to a study by NACE (2003) the cost of corrosion in the highway bridge sector averages $8.3 billion per year. In citing that study, the GAO (2003) estimated that the indirect costs due to traffic delays and lost productivity at more than 10 times the direct cost.

This paper describes the background of a new technology being tested for application in highway bridge corrosion protection applications. The information presented in this paper is a follow on from the work done by Soucie & Heimann (2001) in reporting on the development of a gel coating as a deterrent to pipe corrosion and extended life of structures exposed to harsh environments such as highway bridges.

## TECHNOLOGY BACKGROUND

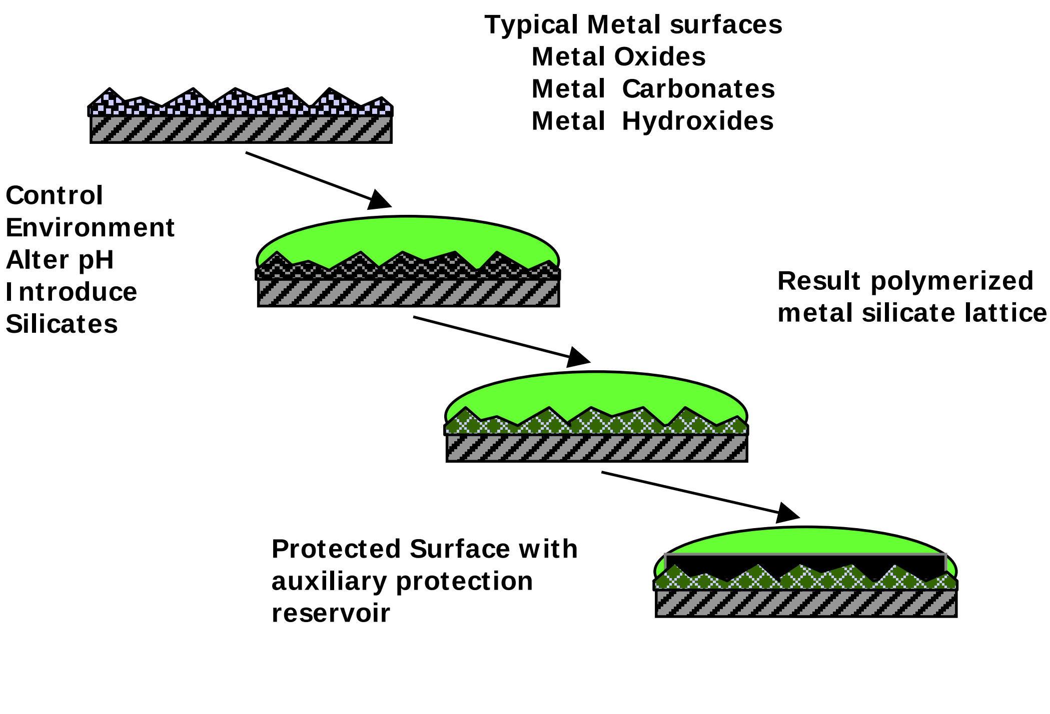
Surface Mineralization (SM) technology is the process of forming a thin mineral film on the surface of metals used as protection, decoration, insulation, thermal barrier, primer for topcoats. Zinc and ferrous surfaces are mineralized for corrosion control by chemicals delivered to those surfaces by synthetic lubricants, gels or tapes.

Current marine applications of this technology for corrosion control include the use by the U.S. Navy to protect anchor chain detachable link cavities, weather deck watertight and airtight door dogging mechanisms, DDG cargo doors, and CV/CVN aircraft elevator wire ropes.

Surface mineralization technology offers a superior performing replacement for undesirable heavy metals such as chromium (e.g., hexavalent chromate), cadmium, and lead-based products to provide corrosion protection to structures and fasteners. The surface mineralization corrosion protection system is not a coating in the conventional understanding of the word. Rather, the mineralization process is a conversion at the molecular level of the naturally occurring surface compounds of oxides and hydroxides to a silicate. The mineral is chemically bonded to the metal substrate. Hence the resulting mineralized surface is not a coating that can be lifted or undermined as a coat of paint may be.

Much of the success of the SM surface chemistry can be attributed to the reaction mechanism (Figure 1).

**Figure 1 - Surface Mineralization Reaction Mechanism**



This mineral reaction mimics chemistries found in nature and is tailored to metal finishes. The process creates a tightly adhering interface between the metal and silicate by binding the silicate components with the metal ions from the substrate surface. This method offers many advantages including a simple application and two forms of surface protection, adding a physical barrier and alloying with the metal substrate to make it less galvanic, thus more resistant to corrosion.

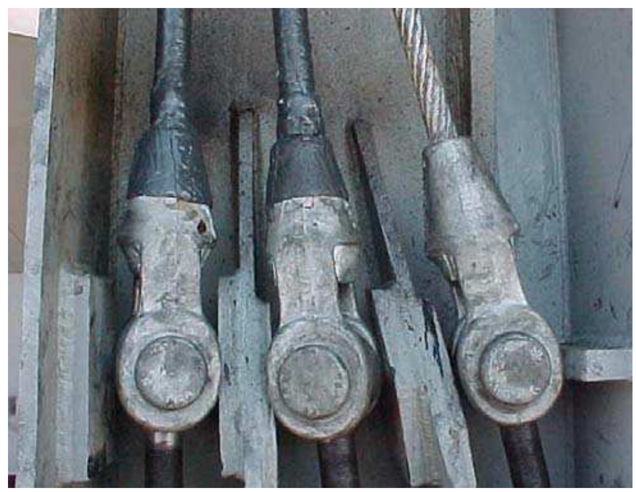
Following successful laboratory, pier side, and shipboard demonstrations of the effectiveness of the surface mineralization gel in preventing crevice corrosion in anchor chain detachable link cavities, the Navy in 1999 changed the Planned Maintenance System (PMS) to specify the use of the gel as the replacement for white lead and tallow in all surface ship anchor chain detachable links.

Also in 1999, following extensive testing, the Navy issued MACHALT 526, which changed the design of the internals of weather deck watertight and airtight door dogging mechanisms to a new design. The basis of that design is the use of a mineralizing lubricant inside the spindle sleeve in the doorframe to stop the corrosion that had been the cause of dogging mechanism failure. In May 2002 a second MACHALT, 544, was approved to apply the same technology to ballistic type dogs in three WT doors in DDG-51 Class ships. The solution represented a significant savings for the fleet. The watertight door dogging mechanism corrosion problem was one of the top maintenance issues for the fleet.

Adaptations of surface Mineralization technology have also been incorporated in to wire rope corrosion remediation. This particular system has been installed on approximately 40% of NS Navy aircraft carrier deck edge elevators (Figure 2 & 3).

**Figure 2 – Typical Corrosion on US Navy Deck Edge Elevator Cables**

**Figure 3 - US Navy Deck Edge Elevator Corrosion Remediation**



HIGHWAY BRIDGE EXPANSION ROCKER ENVIRONMENT

Corrosion protection of Expansion rockers in bridge applications is difficult to accomplish due to the nature of the environment, the typical characteristics of coating materials available, movement of components in the assembly, and the relatively high contact stresses applied in service. Typical coating systems rely primarily upon barrier properties to provide corrosion protection. The high contact stresses and relative movement makes paints or other polymer coating systems impractical. Typical greases and lubricants are subject to displacement and washout due to the environment. Based upon these conditions an alternative approach was developed to improve corrosion protection of the devices.

Several gel based materials are currently being used for marine applications where corrosion protection, high washout resistance and environmental safety were primary design requirements. Based upon the demonstrated performance of these products in other applications a test and evaluation program was established to determine the applicability of these materials in expansion rocker conditions. In

December of 1998 evaluation of the functionality of Elisha E-2400 was initiated.

TEST LOCATION - A highway overpass bridge on the south bound lanes of US highway 63 approximately 5 miles south of Moberly Missouri was selected as the evaluation site. This particular bridge is supported by conventional expansion rocker assemblies. The rocker assemblies located at the bridge abutments at each end of the span were chosen for ease of access and the demonstrated high corrosion exposure caused by the collection of deicing salts through the expansion gap between the bridge deck and the abutments.

APPLICATION - On December 29, 1998, alternating rocker assemblies were cleaned to remove debris and Elisha E-2400 gel was applied on the bearing plate and the rocker contact surface. In addition the locator bolts holes were filled with E-2400 to minimize the potential for water infiltration via this pathway. On one rocker assembly the exposed area of the wrist pin joint was also coated with E-2400 to determine the effect this product on inhibiting corrosion in this area.

The rocker assemblies were inspected periodically to collect data with regard to the progression of corrosion on the standard rocker assemblies and the units that were protected using E-2400 gel. Photographs of the progression of corrosion are shown in Figures 4 – 8.

**Figure 4 – Rocker Assembly Before Application - December 1998**


**Figure 5 – Rocker Assembly After Gel Application - December 1998**


**Figure 6 – Rocker Assembly Inspection – April 2000**


**Figure 7 – Rocker Assembly Inspection – October 2003**

**Figure 8 – Uncoated Rocker Assembly Inspection – October 2003**

SUMMARY RESULTS/ OBSERVATIONS - After five years exposure, the rockers not protected by the E-2400 gel continued to exhibit corrosion activity. The assemblies protected by the gel have not exhibited recurrence of corrosion in the areas where the gel was applied. The gel appears to resist washout and displacement by movement as evidenced by minimal displacement of material from the original installation. Some leaching of protective material is occurring, as evidenced by progression of oil to a distance of 0.75" from the mass of the product. The gel material remains tacky and compliant on the surfaces of the rocker. By remaining pliable, the gel is able to maintain contact with the surfaces to be protected. Dust dirt and debris have collected along the edges of the application but his collection has not impaired the functionality of the gel as a corrosion inhibitor. E-2400 is recommended for incorporation into bridge design, construction, and maintenance engineering specifications.

HIGHWAY BRIDGE STAY SPLASH ZONE ENVIRONMENT

Bridge stays adjacent to the traffic deck are subjected to high frequency spray from vehicle traffic. The area where the stay passes through the bridge structure is particularly hard to protect due to the mechanical forces of vibration, contraction, deflection, and expansion that serve to accelerate the corrosion forces from corrosive spray exposure. Typical materials to protect this area are caulk. However, unsupported caulkings materials break down due to the above mechanical forces allow spray to enter the crevice area created by the breakdown of the caulk.

Discussions with bridge engineers identified bridge stay splash zone applications as a significant maintenance issue on suspension bridges. A maintenance procedure to remediate the problems mentioned above was requested.

Based upon the corrosive conditions, an alternative approach was developed to improve corrosion protection of the devices. The design path was "design by similarity" to the deck edge elevator wire rope application that has been successfully employed by the US Navy (Figure 3). The deck edge kit has been installed in 40% of the applicable vessels in the US Navy. Many of the same design factors come to play in this application as with the deck edge elevator application. As with the deck edge elevator application, washout is a significant concern. Therefore, a splashguard was incorporated with gel application in order to provide mechanical and corrosion protective materials. In March of 2004 evaluation of the functionality of an Elisha repair kit was initiated.

TEST LOCATION - A highway bridge over the Missouri River on I-35 (Paseo Bridge) in Kansas City, Missouri was selected as the evaluation site. This bridge was selected by Missouri bridge engineers as a potential site for remediation evaluation.

APPLICATION - Stay connecting points were cleaned with wire brush to remove debris. Elisha E-1270 wire rope lubricant was injected into the wire rope stay with a pressure injector for a distance of approximately four feet above the traffic deck (Figure 9). Stretch film was spiral wrapped around the application. A two-step mechanical protective sleeve of DPS 601 mastic material was applied. The base was covered with two pieces of mastic material extending approximately two inches up the wire rope. A large piece was cigarette wrapped around the bottom 12" of the application with a one-inch overlap. A stainless steel band clamp was used at the top of the application to compression the top entry (Figure 10).

SUMMARY RESULTS/ OBSERVATIONS - The installation is scheduled for inspection September 2004. The design is recommended for further evaluation and incorporation into maintenance specifications.

**Figure 9 – Bridge Stay**
**Pressure Lubrication – March 2004**

**Figure 10 – Bridge Stay**
**Finished Application – March 2004**

## CONCLUSIONS

The highway corrosion environment is highly corrosive, with great cost, estimated with direct and indirect costs of over $80 billion per year. The corrosion of highway structures is due to a combination of corrosive salt exposure and aggravated by inherent movement required in the highway structures.

Based upon results of field trials in bridge applications and the corrosion improvement in other non-highway applications, this technology provides an effective and environmentally benign alternative for improving corrosion resistance of highway structures.