Several thousand state bridges are scheduled for maintenance painting in both Tennessee and Missouri. On the Caruthersville Bridge (I-155 Mississippi River Bridge), the northernmost bridge over the Lower Mississippi River, overcoating with a calcium sulfonate alkyd is an ongoing project. Although overcoating increases the risk of coating incompatibility (stress, premature failure, etc.), use of a calcium sulfonate system on this unique asymmetrical structure was a viable option that the Tennessee Department of Transportation (TDOT) spearheaded and the Missouri Department of Transportation (MoDOT) supported. This option provided both DOTs with an initial low cost and extended the coating life of the bridge, thus extending corrosion protection.

Every type of generic coating system has its requirements for surface preparation and application as well as its advantages and disadvantages in terms of performance and life expectancy. Meeting the application and inspection challenges of a calcium sulfonate on this project has provided invaluable experience and knowledge of this system. The project-specific challenges have been evaluated, researched and successfully solved to the satisfaction of the respective DOTs. This article discusses the requirements of a calcium sulfonate system as learned from its use on the Caruthersville Bridge. The interaction among the DOTs, inspection firm and painting contractor is presented to assist in future design and construction contracts that specify a calcium sulfonate alkyd system.

**Background**

The Caruthersville Bridge is a steel through-truss deck bridge that spans the lower Mississippi River from the outskirts of Dyersburg, Tennessee to Caruthersville, Missouri. Construction of the bridge began in 1971 and was completed, including coating application, in 1976. The four-lane bridge is 78 feet wide and is approximately 7,102 feet long. The total length of the bridge consists of 1,030 feet of Missouri approach spans; a 2,150-foot main structure; 920-foot and 520-foot main spans; and 2,480 feet of Tennessee approach spans. The bridge has approximately 1,324,000 square feet of painted structural steel. The original coating system remained largely intact for over 30 years.

The bridge is not symmetrical. The Tennessee side structure is much longer.
than the Missouri side structure due to the natural curve in the river. Rip-rap (rock or other material) was placed on the outside bank to keep it from eroding further and bypassing the bridge.

The bridge consists of inspection ladders, a catwalk underneath the bridge, and 12 steel spans flanked by prestressed concrete approach spans. The structure is supported by reinforced concrete piers and abutments that rest about 6 miles from the New Madrid Fault. A 1993/1994 study found that the bedrock was 2,700 feet under the ground surface. The bridge also has two truss spans, eight plate girder spans, and two multi-girder spans. The bridge deck is approximately 99 feet above the Mississippi River. It is understood that the structure was abrasive blast cleaned before application of the original coating system. The Caruthersville Bridge had an original coating system consisting of a three- and sometimes four-coat alkyd system. A shop-applied alkyd primer was applied to all of the structural steel. An additional two coats were applied in the field to floor beams and lateral braces, while an additional three coats were applied to members at the bridge deck level. Figures 1 and 2 depict the original coatings of the bridge.

An initial field investigation of both approaches of the bridge revealed coating breakdown and minor surface corrosion on approximately 3% of the painted surfaces. Pinpoint corrosion was also found on the underside of the bottom flanges of lateral bracing as well as the underside of the girder bottom flanges (Fig. 3). Corrosion along the edges of box beams and minor areas of coating breakdown were found on edges of the supporting members of the inspection walkway (Fig. 4). The webs, stiffeners, and top flanges of both girders and floor beams exhibited very little corrosion. Chalking was evident throughout the structure.

Coating adhesion was assessed in accordance to ASTM D 3359, "Adhesion by Tape Test," using Method A (X-Cut), and Method B (Cross-Cut). No adhesion results were below 3A and 3B, indicating that the majority of the original coating system still adhered well to the bridge. The original coating system along the floor beams and lateral bracing is a three-coat alkyd, with an orange primer and intermediate coat and a green topcoat. Based on the original report and the condition survey, its average dry film thickness ranges from 3.6 mils to 17.4 mils, with the low millage on the stiffeners.

Thus, the initial investigation revealed that the majority of the painted structural steel is in excellent condition after more than 30 years of service, with some isolated areas of coating breakdown. The coating is in the beginning life cycle segment of coating degradation. Considering that there is approximately 1% to 3% of coating breakdown of the total surface area of the steel, both DOTs have agreed that this is the optimal time to perform an overcoat maintenance painting repair to extend the life of the existing coatings for many years, thus reducing the bridge's total life cycle maintenance costs.
Coating samples were removed and sent to an independent laboratory to test for heavy metals. The laboratory test revealed that part of the alkyd system, presumably the red lead primer, has heavy metal content of 16% lead, 0.2% chromium, and less than 0.01% cadmium. Although the primer was not expected to be disturbed during cleaning and preparation, appropriate worker and environmental protection measures were taken in case of accidental disturbance of any heavy metals.1

**Containment**

In accordance with the *Tennessee Department of Transportation Standard Specifications for Road and Bridge Construction*, 2006 edition, Section
"Containment," before beginning surface preparation, the contractor submitted drawings of the containment system to the engineer for review. The contractor also obtained all permits required for the project. The additional requirements for containment were given in the project site plans. To protect the traveling public and the environment from loose paint chips, wastewater, solvent, coating drips and overspray, the containment was designed in accordance with SSPC Technology Guide No. 6, "Guide for Containing Surface Debris Generated During Paint Removal Operations."

The containment system was thus designed to contain debris generated from SSPC-SP 3, "Power Tool Cleaning," and SSPC-SP 12, "Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating." That is, the framework was constructed with a chain link support system and a tarp impermeable to air and water. Following the design of an SSPC Class 2P containment, the system
workers had their blood samples tested by an independent laboratory for lead and zinc protoporphyrin (ZPP). All of the workers used proper personal protective equipments (PPE) to ensure a minimal risk to lead. The workers used half mask respirators with high efficiency particulate air (HEPA) filters with appropriate cartridges, gloves, goggles with side shield protectors, protective suits, steel toe boots and ear plugs to reduce the levels of noise below 90 decibels. The power tools were equipped with HEP A filters to collect debris generated from removing loose coating on the surface of the steel bridge. Wash and change stations were positioned inside of the contractor's regulated area to promote worker hygiene and to keep all contaminated articles of clothing at the jobsite for proper removal and cleaning.

Coating Selection and Inspection Concerns

Overcoating maintenance painting and repair with 1% to 3% breakdown of the original system to extend its service life expected to save the DOTs well over $15 million over the bridge's total life cycle maintenance costs. When a coating starts to deteriorate, it tends to break down exponentially rather than linearly (Fig. 7), so the DOTs considered overcoating optimal at the 1% to 3% point of breakdown.

While overcoating is a viable alternative to a costly complete removal and recoating of the bridge, both DOTs understood that overcoating presents challenges. Alkyds are susceptible to attack from coatings blended with a strong solvent or with a high solvent content. The best way to minimize the stress on the existing coating was to overcoat the existing structure with another alkyd, and the DOTs selected a two-coat calcium sulfonate alkyd system, with the primer and topcoat differing only in tint base (red primer and beige topcoat).

Prior to surface preparation of the areas showing some breakdown, the entire structure was cleaned in accordance with SSPC-SP 12, “Low Pressure Water Cleaned,” with maximum pressures of 3,000 psi. Areas with loose coatings and rust were power tool cleaned in accordance with SSPC-SP 3, “Power Tool Cleaning.” There was no bare steel after surface preparation. A penetrating sealer was applied to areas of back-to-back angles. Bolts and crevices were stripe coated, followed by two coats of the alkyd on the entire structure, which exhibited at least a 3A adhesion rating.

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However, because alkyd systems are flexible, dry slowly, and cure by reaction with oxygen from the air (oxidation), they present several inspection concerns: foreign particles can be embedded into the soft surface and the soft surface can accidentally be damaged during quality assurance measures. And unless the (relatively slow) curing mechanism is modified to prevent residual tackiness, the mechanism allows the ambient (humidity, temperature, etc.) conditions to play a major role during the curing process.

In accordance with ASTM D3363, “Pencil Hardness Scale,” which determines the hardness of a coating on a scale from 6B to 6H, soft to hard respectively, the alkyd selected is a 5B, indicating that the system is soft. This is a point of concern because if a coating is soft and slow drying, its abrasion resistance is poor. Bleeding or color migration can occur if the prime coat’s color drastically contrasts that of the topcoat once the topcoat has been compromised by abrasion. A bleeding effect can also occur in isolated areas of the bridge that do not have an adequate amount of sunlight. In such areas, at high pressures (3,600 psi), the airless spray gun partially impregnates the finish into the soft, tacky red primer and allows the primer to slowly show through the topcoat over several days. In these areas, it is understood that
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the red primer, which is still tacky, has interface layers that show through the topcoat even with adequate topcoat thickness of 4 to 6 mils, for example. This bleeding phenomenon occurred on the project (Fig. 8).

Color migration and bleeding of the primer also occurred due to an under-cured primer and low mils around the nuts and bolts of the structure while striping between coats (Fig. 9). The soft film also allows foreign particles (e.g., dirt) to become imbedded onto the surface and to a certain degree into the coating before it dries to touch (Fig. 10).

Industry experience has shown that this coating can remain soft for several months at a time. The amount of dirt that imbeds into the coating before its full cure can greatly affect its color and gloss retention. Although the surface
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contaminants affect the coating’s aesthetic appearance, its corrosion protection properties are not compromised and the expected life of the system should be achieved.

To eliminate the bleeding effect from striping the nuts and bolts, the coating manufacturer recommended that the striping be performed with the topcoat instead of the red prime coat. The coating manufacturer also recommended that the contractor stop applying the red prime coat (over the existing coating) approximately two feet from all striped areas to prevent overspray to those areas. The contractor was then to apply a final (beige) topcoat to all the areas to provide adequate coverage and film build and avoid color migration. Replacing the red primer with the beige topcoat during striping procedures would eliminate migration of the red to the beige coat, thus providing a uniform appearance to the bridge.

The soft, flexible, surface tolerant calcium sulfonate allows a steel substrate to contract and expand without causing the coating to crack. However, due to the slow curing and drying nature of this alkyd system, measuring the film thickness with a dry film thickness gauge proved to be unreliable. Therefore, the inspection staff monitored the average film thickness with a wet film thickness notch gage. The film thickness of the final coat was also calculated daily with a notch gage, supported with square footage calculations and deductions of approximately 20% for overspray and waste.

**Project Completion**

The Caruthersville Bridge Project was scheduled to be completed by the end of painting season 2010. The first phase in painting season 2009 consisted of preparing the surfaces of the Tennessee and Missouri approaches to be primed and topcoated with the calcium sulfonate system. The second phase of the project was scheduled to begin early 2010 and to be completed by November 2010.

At the time of this writing, the project is on schedule, with SSPC OP 1- and OP 2-certified VHP Enterprises performing the surface preparation and coating work.
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