January 1, 1997

Federal Highway Administration
Bridge Coatings Technical Note

From: Bridge Coatings Technology Outreach Team

Topic: Metallized Steel Bridge Coatings

Description: Metallizing is a common term used to describe thermal sprayed metal coatings. This technology encompasses various techniques and materials, and has wide ranging applications. For corrosion control coatings on steel structures, metallizing refers to the thermal spraying of zinc or aluminum alloys as a coating directly onto steel surfaces. The coatings are created by using a heat source (either flame or electric-arc) to melt the metal which is supplied as a wire or in powder form. An airstream sprays the molten metal onto the steel surface in a thin film. Once the metal strikes the steel it resolidifies quickly to become a solid coating.

Metallized coatings provide corrosion protection to steel by sacrificial and barrier protection. The coating itself provides a barrier between the environment and the steel surface, especially when applied in combination with conventional sealer coatings (epoxies, polyurethanes, acrylics, etc.) as topcoats. Due to the electrochemical reaction between steel and zinc or aluminum in an aqueous and salt-contaminated environment, these coatings tend to “sacrifice” themselves to protect the steel at the site of any damage or holidays in the coating. This sacrificial protection is akin to the protection provided by zinc-rich primers or galvanizing.

Application Process: Metallized coatings may be applied in the shop or in the field using a variety of techniques and equipment. The metal or metal alloy is supplied in wire or powder form and is fed through a heat source and liquefied. The heat source may be either flame (i.e., oxygen-acetylene) or electric arc. The liquid metal is immediately propelled onto the prepared steel surface using air spray (similar to painting). Once on the surface, the liquid metal cools and drys very quickly to form a continuous protective coating over the steel surface. This application process has traditionally been measurably slower than paint application by air or airless spray equipment; however, recent improvements in electric arc metallizing equipment have dramatically increased metallizing production rates. Recent reports have measured metallizing application rates similar to conventional air spray paint application rates with this new equipment.[1]

Cost Impact: Recent cost estimates place metallizing as two to three times the cost of conventional painting on a square foot basis.[2,3,4] Other recent bids and estimates have shown metallizing to be somewhat more competitive, particularly when performed in the fabrication shop with newer high-productivity electric arc equipment.[5] Information regarding the cost of metallizing is highly variable due to the low volume of work currently performed by bridge fabricators and rework contractors. Most steel fabrication shops around the country are not mobilized for high volume application of metallized coatings. Higher volume specification and use would likely make the price of metallizing more competitive with conventional paint application on a square foot basis. In spite of current cost factors, metallizing may provide significant life-cycle cost savings in bridge applications, particularly for bridge

structures or components located in corrosion-prone areas. The primary benenfit of metallizing over other coating technologies is its durability and corrosion resistance in salt-rich environments. For this reason, the application of metallizing should be considered as an option for bridge structures in salt-rich environments or for areas or components of bridge structures which receive considerable exposure to salt and moisture from drainage and runoff. To-date the cost differences between application of metallizing and conventional painting options have been significant in most cases. For this reason, metallizing should be specified based on the results of life-cycle cost analyses of coating options on a case-by-case basis.

Performance Experience: Due to the higher initial cost of metallized coatings, long term, maintenance free performance is necessary for consideration of metallizing as a corrosion control option for bridges. When applied properly, these coatings have shown excellent long term performance when compared to more conventional paint systems, especially in more severe coastal and salt-rich environments.[6,7]

Recent and ongoing FHWA-sponsored test programs have found that metallized coating systems have performed very well, when applied over blast-cleaned steel (i.e., SSPC SP-10 or SP-5). These coatings have a dull gray appearance with a roughened texture as-applied, but may be sealed and topcoated with most conventional paints (except alkyds and chlorinated rubbers). Sealing is recommended by most existing guidelines as it tends to increase coating lifetime, reduce the deleterious effects of metallized coating porosity, and improve aesthetics. Sealers of various generic types exist and are compatible with a metallized substrate. It is important to use a sealer of sufficiently low viscosity to penetrate and fill any porosity in the metallized coating.
Metallized coatings provide the benefit of defect tolerance. The sacrificial nature of these coatings provides protection to the surrounding steel at the site of unintensional breeches in the coating film. Metallized coatings (particularly aluminum and aluminum alloys) also tend to be quite abrasion resistant.

Critical Application Parameters: Several application details for metallized coatings have proven to be critical to the success of these materials:

- Surface Profile and Anchor Pattern - the bond between the metallized coating and the steel surface is mechanical in nature. In addition, the adhesion of metallized coatings is sensitive to contamination. Surface preparation should be specified as SSPC SP-10, near-white (minimum) with a 2 - 4 mil anchor tooth profile. Conventional peening with rounded shot has produced poor adhesion.
- Consistent and Uniform Application - metallizing is a “solventless” coating application method and as such is somewhat less forgiving than conventional paint application. Applicators should be properly trained and experienced with the specific equipment and metals or alloys to be used.
- Film Build - because metallized coatings are inherently porous, achieving an adequate build (6 - 8 mils minimum) in an overlapping spray pattern is critical to coating life.

Summary of Supporting Data: In an FHWA sponsored study[8] zinc and 85% zinc/15% aluminum alloy (applied at 6 mils over an SP-10 near-white blasted surface) were the best performing coating systems of over 40 coating systems tested. These coatings were exposed for 7 years at a harsh marine exposure test site, both sealed and unsealed. The metallized panels showed virtually no corrosion and no cutback from intentional coating defects after this exposure.

The Ohio Department of Transportation has applied 85% zinc/15% aluminum alloy to approximately 10 bridges over the past 8 years with no reported failures. These bridges have 8 mils of metal by specification and are sealed with a clear phenolic topcoat. Ohio has developed a detailed specification for application of metallized coatings and has recently mandated metallizing in all expansion joint areas for new construction.[9]

A recent feasibility study performed by the Oregon Department of Transportation showed life cycle cost competitiveness between zinc-rich 3-coat paint systems and metallizing. These conclusions were based in part on performance experience of metallized coatings in Europe and Canada and on the recent costs of metallizing jobs in Ohio, Oregon, and other states.[10]

The American Welding Society and the U.S. Navy have performed extensive testing of metallized coatings applied to steel.[11,12] These studies show that properly applied metallized coatings (zinc, 85%Zinc/15%Aluminum, and Aluminum) of at least 6 mils thickness provide at least 20 years of maintenance free corrosion protection in wet,

salt-rich environments and are expected to provide 30 years of protection in most bridge exposure environments. A study performed on the Thomas Mathis Bridge by New Jersey DOT shows perfect performance of two metallized bridge spans after 8 years of marine exposure. One each of these spans received metallized zinc and 85% zinc/15% aluminum with epoxy and polyurethane topcoats. Other spans painted with different conventional coatings showed varying performance. Some of the zinc-rich coatings performed quite well, but the two metallized spans were the only ones showing absolutely no deterioration over the test period.[13]

Recommendation: The test results and field experiences detailed above demonstrate the merits of metallized coatings systems for corrosion protection of steel bridge components, particularly in severely corrosive environments. Metallized coatings should be considered as a durable corrosion control option for new steel during shop fabrication of bridge components for a harsh exposure environment. Metallizing technology may also be applicable to field maintenance coating operations where a long-term, durable corrosion protection coating is required. Application of metallized coatings in the shop, and, particularly in the field requires a technically sound specification with trained applicators and inspectors.

For further information, please contact a member of the Bridge Coatings Technology Outreach Team: Ron Andresen, FL-Cen.; Dan Brydl, IL Div.; Mark Clabaugh, FL-East; Dr. Shuang-Ling Chong, HNR-20; Carl Highsmith, Region 3; Joe Huerta, HNG-20; Bob Kogler, HNR-20; Mike Praul, ME Div.; Larry O'Donnell, MA Div.

References:

- USARMY- CERL Report prepared by BIRL-Northwestern Univ. 1996.
- Private communication with Jim Barnhart, Ohio DOT, 1995.
- "Field Evaluation of Zinc-Based Protective Coatings for Structural Steel - Final Report," Connecticut DOT, October 1995.
- "Steel Bridge Maintenance Painting - A Synthesis," Transportation Research Board, Unpublished DRAFT, 1996.
- Private communication with Tom Neal, Virginia DOT, 1994.
- American Welding Society 19-year Evaluation of Metallized Coatings.
- "U.S. Navy Experience with High Temperature Corrosion Control of Lagged Piping System Components Using Sprayed Aluminum Coatings," A.R Parks and R.A. Kogler, **Materials Performance**, National Association of Corrosion Engineers, July, 1990.
- "Environmentally Acceptable Materials for the Corrosion Protection of Steel Bridges - Final Report," (draft) Final publication in progress.
- Private communication with Ohio DOT Office of Bridge Maintenance, December 1995.
- Oregon DOT Report (Draft 1991), Feasibility of Metallizing Steel Bridge Components.
- "Corrosion Tests of Flame-Sprayed Coated Steel - 19-Year Report," American Welding Society C2.14-74.
- Corrosion Barrier Coatings, One-year Evaluation of Marine Coating Exposures, U.S. Navy, David W. Taylor Research and Development Center, 1985.
- "Structural Coatings Performance Evaluation (Mathis Bridge Study)," New Jersey Department of Transportation, Bureau of Materials Engineering and Testing, Revised October 1995.

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, Virginia 22101-2296