"COST EFFECTIVE ALTERNATIVE METHODS FOR STEEL BRIDGE PAINT SYSTEM MAINTENANCE"

CONTRACT NO. DTFH61-97-C-00026

REPORT IX:
FIELD METALLIZING HIGHWAY BRIDGES

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Metallizing is a type of thermal spray coating (TSC) that produces a durable metal coating. The TSC metal typically applied to steel structures such as highway bridges is either pure zinc or a zinc/aluminum alloy. A feed wire of the TSC metal is heated to a molten state by flame or electric arc and propelled by air spray onto a surface. The metal solidifies upon contact with the substrate to form a durable metallic coating. Prior to TSC application on bridges, the surfaces are cleaned thoroughly using abrasive blasting.

The corrosion protection performance of metallizing is well proven.[1,2] It is widely accepted across different industries and guidelines are available for the specification and implementation of metallizing.[3,4] In spite of its apparent advantages, metallizing has seen limited exposure in the highway bridge maintenance market. Likely reasons for this have included a relatively high initial cost and a lack of familiarity and experience with metallizing among bridge painting contractors. This report will highlight the history of metallizing on highway bridges, point out the criteria and issues affecting the acceptance of this technology, and detail data from a recent site visit to a highway bridge metallizing project.

State of the Practice – Field Metallizing Highway Bridges

A survey of bridge painting contractors was conducted in order to gain an understanding of factors contributing to the acceptance of field metallizing on highway bridges.[5] This survey established basic information regarding metallizing work accomplished by bridge painting contractors and compiled comments from the contractors. Eight questions established pertinent information regarding the volume of work completed, metallizing alloys used, touch-up procedures, use of sealers, project costs, inaccessible areas, equipment used, and other application issues.

General Observations

Metallizing is a proven technology that has been used to protect steel bridges in the United States since the early 1930's. To date, TSC coatings have been applied to approximately 150 (out of 200,000) steel bridges in the United States, totaling just over 2 million square feet. The use of TSC is extremely limited when compared to the total number of bridges with conventional coatings in the United States. Contrary to this,

[1] "Appearance of Thermal Sprayed Coatings after 44 years Marine Atmospheric Exposure at Kure Beach, North Carolina," by S.J. Pikul

[2] National Cooperative Highway Research Program (NCHRP), Project 24-10, "Thermally Sprayed Metallic Coatings to Protect Steel Pilings," Work in progress by Corrpro Companies, Inc.

[3] Proposed AWS/NACE/SSPC Standard, *Guide for the Application of Thermal Spray Coatings (Metallizing) of Aluminum, Zinc, & Their Alloys & Composites for the Corrosion Protection of Steel*, Draft #2 Reballot, October 2, 2000.

[4] ANSI/AWS C2.18.6, "Guide for the Protection of Steel with Thermal Spray Coatings of Aluminum, Zinc, and Their Alloys and Composites."

[5] A list of 113 SSPC QP-2 Certified contractors was utilized. Data presented is based on responses from 25% of the SSPC QP-2 Certified contractors.

other countries have used TSC materials extensively for years. The United Kingdom, France, Belgium, and the Scandinavian countries consider TSC materials the preferred corrosion protection system for steel bridges.[6] Testament to this is the fact that the United Kingdom uses TSC technology on over 90 percent of all new steel bridges.

Quality and long term performance have grown as driving forces for the selection of coating materials and systems over the past decade. Changes in methods and materials have enabled contractors to perform TSC applications more efficiently, resulting in lowered costs to the bridge owners. Recent improvements in application equipment have doubled productivity rates to the point where initial costs are more competitive. As with conventional coatings, the ability for contractors to apply high quality cost effective TSC systems depends on the contractor's ability to perform work in an efficient and profitable manner.

Contractors are driven by owner requirements. Since initial job cost is typically the primary factor for coating selection and contracting methods, conventional coatings are most commonly selected for their low initial cost. Although bridge owners are hesitant to specify TSC on their projects, under highly corrosive conditions the total life cycle costs for TSC can be half the total life cycle cost of conventional coatings.[7] Limited requirements for TSC coatings on the part of the owners have kept the majority of contractors from investing in the equipment and training needed to perform metallizing. This keeps the overall capacity and competence levels of the contractors low in terms of ability and willingness to perform metallizing projects.

Data Summary

Survey responses were received from twenty-eight of the 113 contractors contacted. The contractors with no TSC experience generally had negative comments about the subject. These contractors indicated that they would purchase the necessary equipment and provide training for their employees if their customers (bridge owners) would require TSC. However, the majority of these contractors indicated that they had not submitted bids on any projects that required TSC. The contractors with TSC experience generally had favorable comments.

- Volume of Work. Seven contractors had experience with TSC on bridge structures and the total completed surface area was estimated at just over 500,000 square feet. Other relevant contractor experiences included one that had applied TSC to concrete and one that had significant shop experience with metallizing steel.

- Alloys Used. The majority of contractors used an 85% Zinc and 15% Aluminum alloy for their bridge applications. One contractor had experience with 100% zinc, and stated that his company felt that the zinc was easier to apply.

[6] T. Bernecki, K. Clement, E. Cox, R. Kogler, C. Lovelace, J. Peart, and K. Verma, "FHWA Study Tour for Bridge Maintenance Coatings" Federal Highway Administration, January 1997, pg. 29.
[7] Robert A. Kogler, J. Peter Ault, and Christopher L. Farschon "Environmentally Acceptable Materials for the Corrosion Protection of Steel Bridges" Report No. FHWA-RD-96-058, January 1997, pg. 84.

- Use of Sealers. Contractors reported use of epoxy, acrylic, and vinyl sealers while others used no sealer at all. Each of the seal coats used was applied at low dry film thickness (DFT) – approximately 1.5-2.0 mils.

- Touch-up and Repair Procedures. Repair usually included adding additional thickness of TSC. Removing thickness and/or re-blasting areas were minimal. Typical application requirements consisted of white or near white metal blasting and 8 to 14 mils of metallizing.

- Project Costs. No specific information was offered by contractors. Costs for additional equipment, training, and slower production have led contractors to quote higher prices for TSC work compared to work with conventional coatings.

- Inaccessible Areas. Contractors indicated that inaccessible areas were commonly painted using two or three coat epoxy coating systems. One contractor indicated that his company used 45-degree tips on the arc spray set-up to increase the ability to access all areas of the structure.

- Equipment Used. All contractors surveyed had used a wire feed arc spray set-up for their applications to bridges.

- Other Application Issues. The most common comment among contractors regarding field applied TSC was that the application rates were much slower than with conventional coatings. Several contractors had encountered problems with the wire feed spool, but overall equipment problems were minimal. None of the contractors questioned had any difficulty with metal vapors or overspray (fine metal dust that did not adhere to the substrate when sprayed). The consensus indicated that transfer efficiency was best when proper spray techniques were used, e.g., keeping gun perpendicular and close to the substrate.

Overall, TSC technology is gaining acceptance for DOT bridge projects.[8,9,10] Equipment and material have improved to a point where initial application costs are more competitive with conventional coatings. Contractors feel that if bridge owners specify TSC technology on more projects the speed and cost aspects of metallizing will continue to improve.

[8] Robert A. Kogler and Carl Highsmith, "Achieving Long-Term Coating Performance." Metallizing for Corrosion Control, September 2000.
[9] Bridge Coatings Technology Outreach Team, " Metallized Steel Bridge Coatings." Federal Highway Administration Bridge Coatings Technical Note, January 1997.
[10] Mr. Joseph T. Butler of Joseph T. Butler, Inc., and Mr. John Randall of the Ohio DOT were contacted to provide background used in this state of the practice report.

TECHNOLOGY OBSERVATION

Columbia County, New York: recoating highway bridges with 85/15 metallizing

During this project visit, Corrpro Companies, Inc. observed metallizing on a highway bridge crossing a small creek. The New York State Thruway Authority is the owner of the facility and the location was on the eastbound lanes on Interstate 90 near the Massachusetts State line. The painting contractor was Corcon Industrial Painting Inc. from Lowellville, OH.

The bridge was comprised of seven rolled girders and a cast in place deck. The bridge was coated with lead containing paints and showed approximately 15% deterioration of the webs and nearly complete rusting of the flanges on each girder. The containment system was a full platform constructed using the catenary cable and chain link fence type platform with two layers of impenetrable tarps laid on the platform.

The contractors equipment was stored at a nearby maintenance yard and the work-site was accessed during the daylight hours by closing the left shoulder and staging all equipment either on the left shoulder or in the median of the highway.

The project specifications dictated a white metal blast, followed by application of 8 to 10 mils of 85/15 Zinc/Aluminum metallizing. A non-pigmented epoxy seal coat was applied on each beam at and near the expansion joints and only along the bottom flange of each beam for all other areas. The areas that could not be accessed with the metallizing gun only included a few places at the abutments estimated at less than 0.2% of the total surface area. A four-coat epoxy system was brush coated over these less accessible areas.

There were four workers who either abrasive blast cleaned or metallized during each work shift. The crew consisted of two additional helpers to maintain equipment and restock supplies during all phases of work.

RESULTS & DISCUSSION

The production rate observed for metallizing the bridge was 177 ft^2/man-hr.[11] This rate was an average of production runs observed on four of the seven bridge girders. Four metallizers performed this work over a duration of approximately four hours. Each worker applied TSC to one-half of two adjacent bridge girders, so that workers were adequately separated from each other during the shift. The project superintendent performed thickness measurements on the applied TSC, so that re-applications to build the required film thickness were minimized.

[11] For comparison using similar equipment: ILDOT recorded 179 ft^2/man-hr in a production shop during 1997.

Cleaning and coating of the bridge was accomplished in 2-day intervals for each "workable" area. Day one was for production blast cleaning. At the end of this day, the containment was cleaned and the area was blown down. The second day began with sweep cleaning, followed by an inspection, and additional cleaning when necessary. Typically by 10:00 am, the containment was cleaned up and the steel was acceptable for TSC application. The metallizing units were Thermion Bridgemasters that consisted of a DC power supply unit (located in the utility truck parked adjacent to the bridge), the wire feed unit loaded with spools of 3/16 – inch diameter metallizing wire, and the arc-spray gun (both located on the work platform). A 375 cfm air compressor and three separate 75 kW generators were required to power the metallizing equipment.

The contractor noted that the metallizing equipment required frequent maintenance and/or checking to work at peak efficiency. Arc tips on the spray guns have a limited lifetime. The liners in the tubing that feeds the metallizing wire from the spools to the spray gun were a maintenance item. In this contractor's experience, the useful life of these liners is related to the amount of mobility the operator requires. Bending and twisting the spray gun should be minimized to promote longevity of the feed cables and related components. The contractor stated that the generators consume fuses and the power supply units require new relays on a regular interval. While none of these maintenance items alone is a significant cost, when all are considered cumulatively, they far exceed the maintenance required for traditional airless painting equipment.

Other observations noted by the contractor were directed at the application and performance of the TSC. Some bridge bearing components had qualitatively harder steel surfaces because of work hardening or flame cutting. Abrasive blasting does not produce as deep a profile on these surfaces. This resulted in poor enough adhesion of the TSC to the steel that several of these small areas were painted with the touch-up coating system. The Authority's inspector performed tensile adhesion test on representative areas of each bridge. While most areas spanning all ranges of the TSC thickness were acceptable, the areas with lesser adhesion tended to be areas with higher TSC film builds. The application speed for TSC was approximately two and one half times longer than the application of a three coat paint system via airless spray, however, the entire area was completed in a single work shift. This minimizes the potential for inter-coat contamination and delays associated with the dry times of multiple coat coating systems. If the time required to repeatedly access the area is considered for the airless painting production speed, then the application speed of TSC is less than two times that of traditional painting.

Overall, the project site observed for this report was "mature," as the site visit was approximately one year into the duration of the contractor's project schedule. The contractor performed the work efficiently with optimized work routines. Obviously, the impacts of inefficient scheduling and equipment maintenance may affect production and the overall job costs.

DISCUSSION (ECONOMIC VALIDITY)

Many factors must be considered when determining the economic impact of a technology on a bridge maintenance painting project. A cost model was developed for this FHWA study which estimates itemized project costs and evaluates economic impacts. The model takes into consideration many items including mobilization, profit and insurance. Within the cost model, we have divided the cost of a maintenance painting project into four main areas:

- **I. Mobilization/Demobilization**
- **II. Coating removal**
  - Productivity
  - Equipment Cost
  - Worker and Environment Protection
  - Waste Disposal
- **III. Coating Application**
- **IV. Staging/Containment**

During metallizing the existing coatings are removed and replaced with new TSC materials. This is similar to our assumed state-of-practice for repainting: 'Abrasive blasting with disposable abrasive followed by application of a three-coat paint system.'

The technology observation reported was for metallizing using recyclable steel grit for surface preparation. Since both recyclable steel grit and metallizing are different form our assumed state-of-practice, we will compare the site visit to a recyclable steel grit removal project with airless spray applied coatings. This will show the cost effects of the metallizing only, and not complicate the comparison by including two changes from the current state-of-practice.

Table 1 shows Cost Model data for the following scenarios:

1. Blasting with recyclable steel grit followed by application of a three-coat paint system with a stripe coat.
2. Blasting with recyclable steel grit followed by application of 85/15 Zn/Al metallizing.
3. Blasting with recyclable steel grit followed by application of 85/15 Zn/Al metallizing with a full sealer coat.

Table 1. Initial Cost/ft² Comparison of Three-Coat Paint System versus Metallizing Systems.

Bridge ft²	*3-coat painting*	*Metallizing*	*Metallizing with sealer*
5,000	$14.94	$17.51	$18.37
7,500	$10.15	$12.12	$12.72
10,000	$8.09	$11.12	$11.6
25,000	$4.57	$6.23	$6.47
50,000	$3.19	$4.95	$5.11

Notice that the cost for metallizing is consistently higher than the cost of the three-coat paint system. This is related to the additional costs for labor, equipment, and materials required for metallizing. These results are graphed in figure 1 so that the relational differences can be compared.

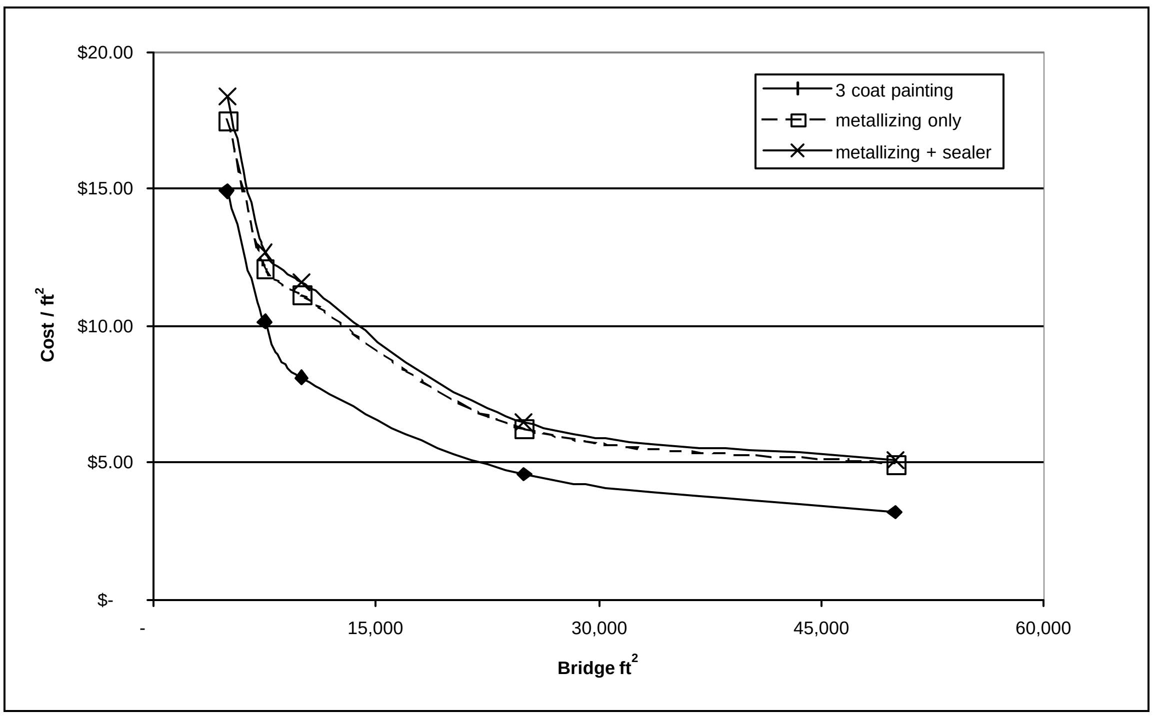

Figure 1. Initial Cost/ft² Comparison of Three-Coat Paint System versus Metallizing Systems

The relative cost difference between 3-coat painting and metallizing appears consistent in figure 1, however, the reasons for this difference vary as the size of the structure varies. On smaller bridges, the cost model indicates that the premium for metallizing is made of an even split between increased labor, material, and equipment costs. On larger bridge projects (25,000 ft² and greater), the cost of materials for metallizing begins to have more influence than the cost for labor and equipment. Regardless of the specific reasons for the cost difference, there is a consistently higher cost for a metallized coating compared to a three coat painting system. Given this situation the bridge owner may wish to consider other factors when making a maintenance decision such as comparing life-cycle costs, project time and/or access restraints, and available budgets. Several of the references provided in this report discuss approaches to life prediction and life cycle cost analysis.

CONCLUSIONS

1. The basis of this technology report was the observation of a normal production project that was competitively bid and was not a demonstration project. The observations recorded demonstrate that metallizing on highway bridges is a practical and feasible maintenance option and that a bridge painting contractor can efficiently complete this work.

2. The incremental cost of metallizing remains relatively constant with varying project size. Thus on a percentage basis, there is a lower cost increase associated with smaller projects (17% at 5,000 ft^2 versus 36% at 25,000 ft^2).

3. The quality assurance prescribed for a metallizing project is more critical than that typically associated with a bridge painting project. Because metallizing is applied in a single step, it is vital that the contractor has an effective quality control process in place.

4. Compared to traditional bridge painting, metallizing projects require specialized equipment be purchased and maintained. Contractor personnel familiar with painting techniques must be trained and prepared to efficiently operate and maintain metallizing equipment.