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

CONTRACT NO. DTFH61-97-C-00026

Report II:
ELECTROSTRIP™ FOR THE REMOVAL OF LEAD-BASED PAINT

WRITTEN FOR THE FEDERAL HIGHWAY ADMINISTRATION
BY: CORRPRO COMPANIES INC.
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Technology Introduction

The ElectroStrip™ process causes coating delamination from a steel-substrate by applying DC current to a painted metal substrate. An electrolyte is contained in a liquid-absorbent material to which a counter electrode is attached. This apparatus, often combined with a liner, is attached to the painted metal surface (typically steel) with magnets. To facilitate current flow, the existing coating surface is scored prior to attaching the apparatus. A DC voltage of 8 to 10 volts is applied for ½ to 2 hours. After electrochemical treatment, the ElectroPad™ is removed and paint fragments are recovered. No particles become airborne. Up to 160 ft^2 of ElectroPad™ can be energized simultaneously using an 8000 Amp rectifier.

Project Description

Between May 12 and 19, 1998 Corrpro Companies Inc. observed and documented various aspects of the ElectroStrip™ process during its eight-day demonstration. ElectroStrip™ Corporation (Export, PA) was contracted to remove the existing coating system from one interior beam on the west abutment span of structure 2067 utilizing their ElectroStrip™ technology. EMEC Consultants (New Kensington, PA) was tasked by ElectroStrip™ Corporation to provide personnel and equipment and assist with the process. Superior Painting & Contracting Co., Inc. (Baltimore, MD) provided rigging and supplemental labor support for the ElectroStrip™ portion of this project. Pilot scale equipment was used for this demonstration.

The structure carries Interstate 66 over Westmoreland Street in Arlington, VA. The existing coating was an alkyd primer with an acrylic topcoat. The ElectroStrip™ demonstration was performed on the first internal beam (south side) of the east abutment span. After the demonstration, Superior Painting & Contracting Co. completed the maintenance painting of the structure using traditional hand-tooling/power-tooling methods.

Approach

The ElectroStrip™ process consisted of five steps.

- Scoring
- Application of ElectroPad™ (~60ft^2/run)
- Energizing the Rectifier
- Removal of ElectroPads and Scraping of Loose Paint
- Freshwater Wash to Remove Electrolytes

Scoring:

In order for the ElectroStrip™ Process to work there must be a direct electrical pathway from the ElectroPad to the painted metallic structure once the current from the rectifier is activated. To facilitate this electric pathway, the painted surfaces were scored in a gridline formation. The gridlines were spaced about ½ inch apart. A vacuum attached star-wheel cutter, made by Desco, was used for this scoring; areas not accessible to this power tool were hand tool scored. It was important that these score marks penetrated the entire coating system to bare metal to ensure current to flow through the otherwise insulating paint layers.

Application of ElectroPads™:

The ElectroPads™ were manufactured in 1ft x 1ft pieces. Each ElectroPad™ consisted of one flat piece of carbon steel mesh between two pieces of absorbent membrane material. All ElectroPads™ were saturated with a sodium sulfate electrolyte solution prior to installation. The membrane material allowed the ElectroPad™ to remain saturated. Each ElectroPad™ was secured to the steel girder using magnetic plates. Electrical leads were attached to the metal mesh of each ElectroPad™, while the structure was grounded to complete the circuit. Up to $60ft^2$ of the pads were applied in one production run.

Rectifier Power:

Rectifier Statistics:

Clinton Power model # S4018S0S

Input Voltage:	480 V
Output Voltage:	3 to 18 V
Input Amperage:	126 Amps
Output Amperage:	4000 Amps
Output Power:	72 Kilowatts

The rectifier was connected to the structure (constant ground) and the ElectroPads™ via wire leads. A busbar was located next to the internal demonstration beam. Wire leads connected this busbar to the ElectroPads™ during the ElectroStrip™ process. A small area of coating was removed on the bottom flange of the adjacent fascia beam to attach ground leads.

Each production run ($40ft^2$ to $60ft^2$) was conducted under constant voltage with the current changing to compensate for changing resistivity of the circuit. The resistivity between the ElectroPads™ and structure throughout each production run tended to increase. This was primarily due to the absorbent material of the ElectroPads™ losing moisture through evaporation because of the generation of heat at the ElectroPad™/structure interface. For each production run the rectifier was operated for one and one half hours. During this time, operators would spray the ElectroPads™ with the sodium sulfate solution to keep them saturated and the resistivity of the circuit low.

It should be noted that low-voltage DC electrical energy is not inherently safe. Connections made while under electrical load will arc with high-intensity light flash and high temperature, capable of causing injury. Faulty ground may also result in personal injury if a worker provides an alternate path to ground. Care must also be given when applying the electrolyte solution as to not cause a short circuit. The high current in the system may interfere with electronic medical devices such as pacemakers. OSHA standards 29 CFR 1910.306 and 29 CFR 1926.406 address electrical safety measures and may be applicable to the ElectroStrip™ process. In addition, ANSI/NFPA 79,70, and 70E provide guidance regarding protection for personnel against electrical shock.[1]

Removal of the ElectroPads™:

After the current from the rectifier was turned off the ElectroPads™ were removed along with magnetic brackets holding the ElectroPads™. The ElectroPads™ were placed in drums for disposal. Once a section of ElectroPads was removed, the resulting surface was scraped to remove loose flakes of paint.

Freshwater Rinse:

Once a significant area had been ElectroStripped, the surface required cleaning to remove residual electrolyte contamination. A pressure washer fitted with a vacuum recovery unit was used to remove residual electrolyte from the steel's surface and to contain wastewater.

RESULTS

Productivity Data:

Upon completion of the demonstration, approximately 610 ft^2 of the structure had been prepared using the ElectroStrip™ process. During this demonstration, lessons were learned that allowed the workers to become more productive as the week progressed. A maximum productivity rate of 10 ft^2/man-hr was observed during the demonstration. The last two days showed a drop in productivity because the contractor did not assist with the process. The ElectroStrip Corporation chose to wait until the end of the project to perform water washing, which is the reason for the very low productivity on the last day. Production data is summarized in Table 1.1.

Table 1.1 Productivity Data

Date	ft^2 Removed/run	ft^2 Removed/day	ft^2/hr	man-hours/day	ft^2/man -hr
12-May	40, 40	80	10.00	72.30	1.11
13-May	40,40	80	10.00	38.25	2.09
14-May	60	60	7.50	41.20	1.46
15-May	60, 60, 30	150	18.75	25.00	6.00
16-May	60	60	7.50	6.00	10.00
18-May	60, 70	130	16.25	15.09	8.61
19-May	20	20	2.5	29.54	0.68

Although the ElectroStrip™ process removes the paint at up to 10 ft^2/man-hr, areas of intact paint, ranging from 40-60 percent of the area prepared, often remained on the surface after hand

[1] Dave Vance, CSP, Acordia of Northeast Ohio, Inc. Insurance Brokers and Consultants

scraping. Some production runs were more successful than others, but all left intact paint. Subsequent ElectroStrip™ runs on areas where intact paint remained did remove additional paint, but were unable to completely remove all paint.

Occupational Data:

Personal air monitoring data, located in Table 1.2, shows that worker 2 on May 12 was exposed to concentrations of air borne Lead dust that exceeded the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for lead of 50 $\mu g/m^3$ during an eight-hour Time Weighted Average (TWA). This confirmed the need for Personal Protection Equipment (PPE) for the workers during the scoring operation. The impact to the local community seems to be minimal as indicated by the lead levels measured in the general vicinity of the work area. Air monitoring during the Hand/Power tool cleaning of the remainder of the structure showed the air borne Lead dust levels were well over the OSHA PEL for Lead. Surface wipe sample results, located in Table 1.3, show that rinsing the substrate after the surface has been ElectroStripped is essential to removing residual lead dust.

Table 1.2 Lead Monitoring Results

Test Performed	**Air Monitoring TWA ($\mu g/m^3$) for ElectroStrip™**		**Air Monitoring TWA ($\mu g/m^3$) for Hand/Power Tool Cleaning**	
Date	12-May	13-May	8-Jun	3-Jul
Worker 1 (vacuum scoring)	9.34	NA	223.7	395.1
Worker 2 (vacuum scoring)	64.37	NA	NA	58.6
Inside Work Area	5.24	13.67	NA	NA

Table 1.3 Wipe Samples ($\mu g/ft^2$)

	Lead Wipe Sample ($\mu g/ft^2$)
Stripped surface before rinse	25,090.00
Stripped surface after rinse	8,713.00

High-volume ambient air quality monitoring was performed during ElectroStrip operations and hand/power tool cleaning operations. The EPA National Ambient Air Quality Standard (NAAQS) for lead is an average of 1.5 $\mu g/m^3$ for Total Suspended Particulates (TSP) in air over a 24-hour, 90-day period. For respirable dust, the EPA NAAQS is a 24-hour average of 150 $\mu g/m^3$. The following table summarizes the results of testing for TSP-lead dust and respirable dust. All monitoring showed results that were under the EPA NAAQS limits. Results are summarized in Table 1.4.

Table 1.4 High-volume ambient air quality monitoring

Date	Location	TSP- Lead (μg/m^3)	Respirable Dust (μg/m^3)
5/11/98	Background -100' S of bridge	<0.07	23.21
5/12/98	60' SE of bridge	<0.05	15.13
5/13/98	60' SE of bridge	<0.07	74.94
6/8/98*	45 ' S of bridge (downwind)	0.82	29.31

* Hand tool/power tool cleaning of remainder of bridge.

ECONOMIC DISCUSSION

Many factors must be considered when determining the economic impact of a technology on a bridge maintenance painting project. The cost for a maintenance painting project can be broken down into four main areas:

I. Mobilization/Demobilization

II. Coating removal

Productivity
Equipment Cost
Worker and Environment Protection
Proper Waste Disposal

III. Painting

IV. Staging/Containment

In order to validate a technology one must first compare it to the current state of practice. The current state of practice in this industry is abrasive blasting with 'once-through' abrasive, which cleans ~ 100 ft^2/hr/blaster to an SSPC SP-10, while providing a negative pressure containment, PPE for workers, and hazardous disposal of all waste.

The ElectroStrip™ process can remove approximately 40-60 ft^2 per run per setup. The process requires a 'bake' time of approximately 1.5 hours. Conceivably during the bake time other tasks could be accomplished allowing the productivity rate to attain a maximum of 40 ft^2/hr. Yet, it requires approximately three workers, which makes the comparable productivity rate 13.33 ft^2/man-hr. 'Once-through' abrasive blasting will typically have two blasters, one helper, and one foreman having an equivalent productivity rate of 50 ft^2/man-hr. This shows the ElectroStrip™ process to be about 73% less productive. Yet, savings can be realized in three other areas of a maintenance painting project:

- Containment
- Worker PPE
- Waste Disposal

The ElectroStrip™ process would most likely only require ground tarpaulins to catch falling debris as opposed to abrasive blasting which requires full negative pressure containment. Worker exposure to hazardous paint is also greatly reduced. This means that workers can use half face respirators for PPE as opposed to air feed hoods, which are required by blasting operations. Therefore, cost savings could be realized through a reduced effort in containment and PPE for workers. The amount of hazardous waste generated is less than that created by once through abrasive blasting and would contribute to cost savings.

Using a cost model developed for this FHWA study an estimation for the cost to use the ElectroStrip™ process for the total removal and repainting of a steel bridge structure was conducted. The cost model estimates the entire project cost taking into consideration, among other issues, mobilization, profit and insurance. This cost model calculated a price range of \$17.06-\$11.17 per ft^2 for a typical steel bridge with square foot range of 5,000-200,000. The same model was used to estimate the cost of using once through abrasive for the same structure which gave a price range of \$13.15-\$6.22 per ft^2. The data shows that the price per square foot to complete the project using ElectroStrip™ rather than once through abrasive would increase 30-80%.

CONCLUSIONS

1. While the technology is founded on sound scientific principles, the product is not yet commercially viable. The process still requires secondary hand tool cleaning to effectively remove all the old coating. The productivity is slow and the overall project cost is relatively high in its current state of development.

2. The ElectroStrip™ process does not impart a profile to the substrate and would therefore require a surface tolerant primer.

3. ElectroStripping is effective in reducing worker and environmental exposure to hazardous paint during removal, as compared to abrasive blasting. The process reduces the need for costly containment and worker health and safety actions.

4. The data shows the technology to be more economically suited for small bridge structures.

5. Process improvements such as increasing the area cleaned per cycle, decreasing the requirements for scoring, or decreasing the time required per cycle may increase the productivity, potentially making the process viable.

EMEC Consultants
4 August 1999

COMMENTS BY EMEC CONSULTANTS TO CORRPRO DRAFT OF REPORT ON ELECTROSTRIPT"

<a> 'While structure was grounded to complete the circuit'
perhaps the following would be clearer:
'While the connection to the inherently grounded structure completed the circuit'

<b> Faulty ground as occupational hazard:
voltages not exceeding 18 V (max. voltage of our rectifier) are generally considered to present no shock hazard.
Your remarks regarding sparking on shorting are appropriate.

<c> June and July data do not directly relate to ElectroStrip™ activity, but they may be of interest for comparison purposes.

<d> "Bake time" depends on coating characteristics; we used 1 1/2hours in Arlington.
We originally planned to work with coverages of 50 ft but found that our pilot equipment could accommodate up to 80 ft^2.

<e> Reduced costs for air monitoring may be significant cost savings.
In addition, the process may be preferred in cases where reliability of measures to protect the environment is particularly important.

<f> Cost projections appear reasonable. We would be interested to get to know the model and what the input figures were. If the range given reflects merely the range of structure size, we would have expected a weaker dependence of square-foot costs on bridge size for the ElectroStrip™ approach with its low mobilization costs.
We are projecting that a full-grown operation would involve a 8,000-A rectifier, 3 laborers and 1 technician (1/2 technician if two crews would be involved), and a production rate of 100 ft/hr or 25 ft^2/man-hr.

<e> Electrostripped areas exhibited lack of flash rusting.

<f> Repaintability of Electrostripped samples without profile (there was a profile in Arlington) was studied by EMEC Consultants in cooperation with Lehigh University and KTA-Tator. After rigorous freeze-thaw cycling, adherence of the two coatings systems employed was good, without significant differences in comparison to sandblasted comparison samples.

<g> In Arlington, it was the first time EMEC Consultants worked with a contractor (who had no practical experience in applying the technology). It also was the first opportunity for practicing the technology over a time period exceeding one day. Some correctable shortcomings and ways to optimize the process became evident.