BRIDGE STEEL COATINGS TOLERANT OF MINIMAL SURFACE PREPARATION

Construction Report
June 1996

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16. ABSTRACT

In 1993 and 1994, the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) initiated regulations that radically altered practices in the paint industry. Many of these measures apply to lead abatement, practices devised to eradicate lead-based paint hazards. These changes in legislation are designed to promote domestic, worker and environmental safety. The organizations that must implement these changes are finding that complying with the new rules are complicated and extremely expensive.

The Oklahoma Department of Transportation (ODOT) selected seven bridges to overcoat with coating systems that meet the new standards for evaluation. The systems selected require minimal surface preparation, that is, removal of loose debris and dirt instead of the removal of an existing paint system on the steel beams, prior to application. Research, Development and Technology Transfer of ODOT monitored the application of several different paints to these bridges. An eighth bridge was cleaned using an abrasive cleaning method then coated with a lead-based paint that no longer meets the new regulations; this will be the control bridge for this study.

This construction report presents the observations and application procedures of these coating systems to the above mentioned bridges with emphasis on compatibility testing, SSPC SP2, SSPC SP3 and SSPC SP6 standard cleaning methods, construction procedures, and cost analysis.

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SI (METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units					*Approximate Conversions from SI Units*				
Symbol	**When you know**	**Multiply by**	**To Find**	**Symbol**	**Symbol**	**When you know**	**Multiply by**	**To Find**	**Symbol**
		LENGTH					**LENGTH**		
in	inches	25.40	millimeters	mm	mm	millimeters	0.0394	inches	in
ft	feet	0.3048	meters	m	m	meters	3.281	feet	ft
yd	yards	0.9144	meters	m	m	meters	1.094	yards	yd
mi	miles	1.609	kilometers	km	km	kilometers	0.6214	miles	mi
		AREA					**AREA**		
in^2	square inches	645.2	square millimeters	mm	mm^2	square millimeters	0.00155	square inches	in^2
ft^2	square feet	0.0929	square meters	m^2	m^2	square meters	10.764	square feet	ft^2
yd^2	square yards	0.8361	square meters	m^2	m^2	square meters	1.196	square yards	yd^2
ac	acres	0.4047	hectares	ha	ha	hectares	2.471	acres	ac
mi^2	square miles	2.590	square kilometers	km^2	km^2	square kilometers	0.3861	square miles	mi^2
		VOLUME					**VOLUME**		
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.0338	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.2642	gallons	gal
ft^3	cubic feet	0.0283	cubic meters	m^3	m^3	cubic meters	35.315	cubic feet	ft^3
yd^3	cubic yards	0.7645	cubic meters	m^3	m^3	cubic meters	1.308	cubic yards	yd^3
		MASS					**MASS**		
oz	ounces	28.35	grams	g	g	grams	0.0353	ounces	oz
lb	pounds	0.4536	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000 lb)	0.907	megagrams	Mg	Mg	megagrams	1.1023	short tons (2000 lb)	T
		TEMPERATURE (exact)					**TEMPERATURE (exact)**		
°F	degrees Fahrenheit	(°F-32)/1.8	degrees Celsius	°C	°C	degrees Celsius	9/5+32	degrees Fahrenheit	°F
		FORCE and PRESSURE or STRESS					**FORCE and PRESSURE or STRESS**		
lbf	poundforce	4.448	Newtons	N	N	Newtons	0.2248	poundforce	lbf
lbf/in^2	poundforce per square inch	6.895	kilopascals	kPa	kPa	kilopascals	0.1450	poundforce per square inch	lbf/in^2

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Executive Summary

In 1993 and 1994, the Occupational Safety and Health Administration and the Environmental Protection Agency initiated regulations that radically altered practices in the paint industry. Most of these measures apply to practices devised to eradicate lead-based paint hazards. The organizations that must implement these changes are finding that complying with the new rules are complicated and expensive. Overcoating structures in need of maintenance, instead of paying the high cost of proper hazardous waste disposal, is becoming a popular way to handle these expenses.

The Oklahoma Department of Transportation selected seven bridges to overcoat with paints that meet the new standards for evaluation. These bridges were cleaned using the Steel Structures Painting Council's (SSPC) hand tool and power tool cleaning specifications. An additional bridge, the control in this study, was cleaned using the SSPC blast cleaning specification; this bridge required the handling and disposal of hazardous waste. Research, Development and Technology Transfer (RD&T) monitored the paint compatibility testing, cleaning, and painting of each of the eight bridges.

When an analysis of the construction costs was made between bridges that were overcoated without hazardous waste disposal and the control bridge using only the average painting and disposal costs, there was no significant difference in price.

RD&T will continue to monitor the eight bridges in this study semiannually and relate the findings in a final report three years after maintenance was completed.

Introduction

In 1993 and 1994, the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA) initiated regulations that radically altered practices in the paint industry. Recent studies have generated new concerns regarding hazardous and toxic materials found in paints, particularly paints containing lead. Many of the new regulations apply to lead abatement, practices devised to eradicate lead-based paint hazards. These changes in legislation are designed to promote domestic, worker, and environmental safety. The organizations that must implement these changes are finding that complying with the new rules are complicated and extremely expensive.

The cost of tests, containment, protective equipment, removal, and proper disposal for lead-based paints on structures that require maintenance can be an economic strain. With the rising costs of lead abatement, many parties are seeking alternatives to removing lead-based paints. One of the more popular methods for treating structures that have been painted with lead-based paints is overcoating.

The Oklahoma Department of Transportation (ODOT) selected seven bridges to overcoat with coating systems that meet the new standards for evaluation. The systems selected require minimal surface preparation, i.e., removal of loose debris, mill scale and dirt instead of the removal of an existing paint on the steel beams, prior to application. Research, Development and Technology Transfer (RD&T) at ODOT monitored the application of several different coating systems to the bridges that were cleaned using one or two methods for minimal surface preparation. An eighth bridge was cleaned using an abrasive cleaning method then coated with two paints that no longer meet the current standards, that is, they contained lead. This bridge will be the control bridge for this study.

The objectives of this study are to:

1. Monitor the application of each coating system over bridge steel which contains lead-based paint and has been prepared to Steel Structures Painting Council (SSPC) SP2 or SP3 cleaning standards. A description of these standards is located in the "Construction" section of this report.

2. Record the results of the ASTM D 5054 "Standard Practice for Conducting a Patch Test to Assess Coating Compatibility" and ASTM D 3359 "Standard Test Methods for Measuring Adhesion by Tape Test" for each coating system.

3. Compare the cleaning and application cost of the different coatings to the existing method of sand blasting the bridge steel to an SSPC SP6 specifications where containment and disposal of the lead particulates are required.

4. Compare the performance of coatings placed over SSPC SP2 hand tool cleaned steel to coatings placed over SSPC SP3 power tool cleaned steel.
5. Compare the performance of each coating over a three year period using the ASTM D 5065 "Assessing the Condition of Aged Coatings on Steel Surfaces."

This construction report presents observations and application procedures of these coating systems to the aforementioned bridges with respect to the first three objectives.

Background

The adverse effects of lead poisoning are not new revelations. In 1992, the United States Congress found that low levels of lead poisoning in children results in reduced attention spans, impaired hearing, and behavior problems. Nearly three million children were contaminated with low levels of lead poisoning. These children were exposed to lead in their homes by inhalation of dust and involuntary ingestion of paint chips from old paint. These children were also exposed to lead when adults in the home who routinely work with lead-based products, brought the substance home in their work clothes and hair. Reports suggest a relationship between high blood lead levels and homes painted with lead-based paints. Congress documented their findings and signed the "Housing and Community Development Act of 1992" into law. This bill includes a section that addresses these problems more specifically, "Title X: Residential Lead-Based Paint Hazard Reduction Act of 1992."

As a result, modifications were made to lead levels in house paints and exposure of workers who apply lead-based products to decrease the risk of lead poisoning. The restrictions that were outlined in the bill had a ripple effect that spilled over to the construction industry. As EPA regulations were tightened, the composition of coating systems was altered, and a number of tests and training courses were implemented.

Coating systems should now be "lead-free." A lead free paint is "any paint that contains 0.06 percent (600 parts per million by dry weight) or less lead by weight in the dry film" as defined by the Consumer Product Safety Commission on paints. Currently, these paints are more expensive to produce.

In addition to paints being lead-free, changes have been made to the levels of lead that can be introduced into the environment. Virtually no lead products should be released in to the surrounding environment. When lead-based paints are removed from structures, particularly when blast cleaning methods are used, the paint chips and fugitive dust must be contained and properly disposed of.

A number of methods can be employed to contain debris and waste varying from using tarpaulins to catch debris as is falls to total enclosure of a structure to prevent environmental contamination. Hazardous waste can be disposed of by either mechanical, chemical or physical means depending on the level of toxins in the debris. These methods can be very costly.

In order to make sure that these regulations are adhered to, testing is performed during each phase of the operation. Lead-based waste products are tested for their level of toxicity and presence in the air, soil and water before, during and after removal from structures.

Finally, workers and their employers have to be trained and properly equipped to handle these new changes. In short, for each change in the paint construction industry, addition of training courses, and advance in technology, there is a corresponding financial cost that must be met by the appropriate parties. Many agencies have structures in need of maintenance but do not have the necessary funds to spend on these items.

ODOT has a highway system that contains 2,299 steel bridges. Approximately 85% of these bridges were painted with lead-based paints; many need to be painted again soon. Overcoating may provide a viable economic solution to this problem. Minimal surface preparation required for overcoating bridge steel does not create as much waste as blast cleaning. In theory, less waste should be less expensive to contain, treat and dispose of.

Location of Bridges

The eight bridges under evaluation are located in the areas on the map shown in Figure 1. Table 1 lists the length and number of spans for each bridge in this study. Table 2 lists the location of each bridge and the name of the manufacturer's coatings.

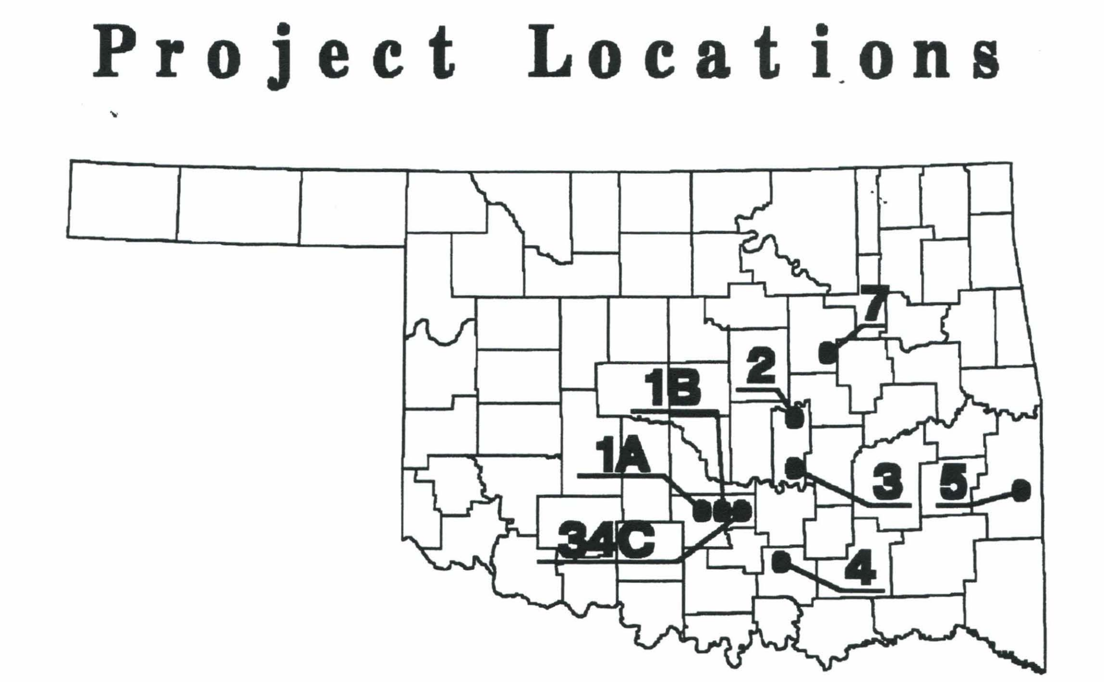

Figure 1. Geographical Project Locations

Table 1. Bridge Information

Bridge	Bridge Length (meters)	Number of Spans
Bridge 1(A)	24	3
Bridge 1(B)	43	3
Bridge 34(C)	28	3
Bridge 2	40	5
Bridge 3	40	5
Bridge 4	40	5
Bridge 5	38	3
Bridge 7	167	13

Table 2. Project Location

Bridge	County	Location	Coating System Manufacturer	Coating Systems
Bridge 1(A)	Garvin	SH 19: near Stratford	Dupont	DuPont 25P Imron 326
Bridge 1(B)	Garvin	SH 19: near Stratford	Tnemec	Tnemec 135 Series 74
Bridge 34(C)	Garvin	SH 19: Stratford	Coating Systems West	Sealmark Topcoat
Bridge 2	Seminole	SH 99 A: Little	Republic Powdered Metals	Carbozinc 11 Polyclad 936
Bridge 3	Seminole	SH-56: near Byng	Republic Powdered Metals	Alumanation Alumaclad
Bridge 4	Johnston	SH-99: Pontotoc	Republic Powdered Metals	Rustbond Carboline 3358 Carboline 3359
Bridge 5	LeFlore	SH-83: Poteau	Republic Powdered Metals	Rust Grip
Bridge 7	Creek	SH-75 A: Mounds	Wasser Coatings	MC-Zinc *Ferrox A Miomastic

* MC-Ferrox A and MC-Miomastic

Bridge 2 is the control bridge in this evaluation.

Compatibility Testing

Test Procedure

Prior to cleaning steel beams and applying a new coating system, a compatibility test is performed in accordance with the ASTM D 5054 "Standard Practice for Conducting a Patch Test to Assess Coating Compatibility" and ASTM D 3359 "Standard Test Methods for Measuring Adhesion by Tape Test" designations.

For the purpose of this evaluation, the objective of this test is to determine if the new coatings will be compatible with the existing paint on the bridge steel. Two different types of adhesion tests are cited in the ASTM 3359 designation, method A and method B; method B was used here.

To perform test method B, a minimum of three test patches measuring at least 0.93 square meters (10 square feet) was selected, cleaned, painted, then allowed to dry for at least 7 days. After the curing period, several incisions 20 mm (0.75 in) long and 2 mm (0.8 in) apart are made through the new and old paint to the bridge steel. Several more incisions are made perpendicular to the first set of cuts. A semitransparent tape is placed firmly over the incisions then pulled back. Figure 2 shows an example of the grid cut for the test patch. The visual appearance of the paint on both the tape that has been removed and on the beams is noted and a rating is assigned. Normally, if the systems are not compatible, the new paint will be left on the tape while the old paint will remain on the substrate.

Compatibility tests results are rated from 0 to 5. A rating of 5 indicates no peeling or removal between the new and old coatings. A rating of 4 indicates trace peeling or removal along the incisions or at their intersections between the new and old coating. The ratings continue to decrease as the amount of paint that is removed or peels away increases. A rating of zero indicates that more than sixty-five percent of the new paint has peeled away from the old paint. Table 3 lists the average test results for each bridge.

The text that follows describes any unusual circumstances that occurred when the compatibility test was performed. When no descriptions are given for a bridge, neither compatibility tests results nor testing conditions deviated from the expected norm.

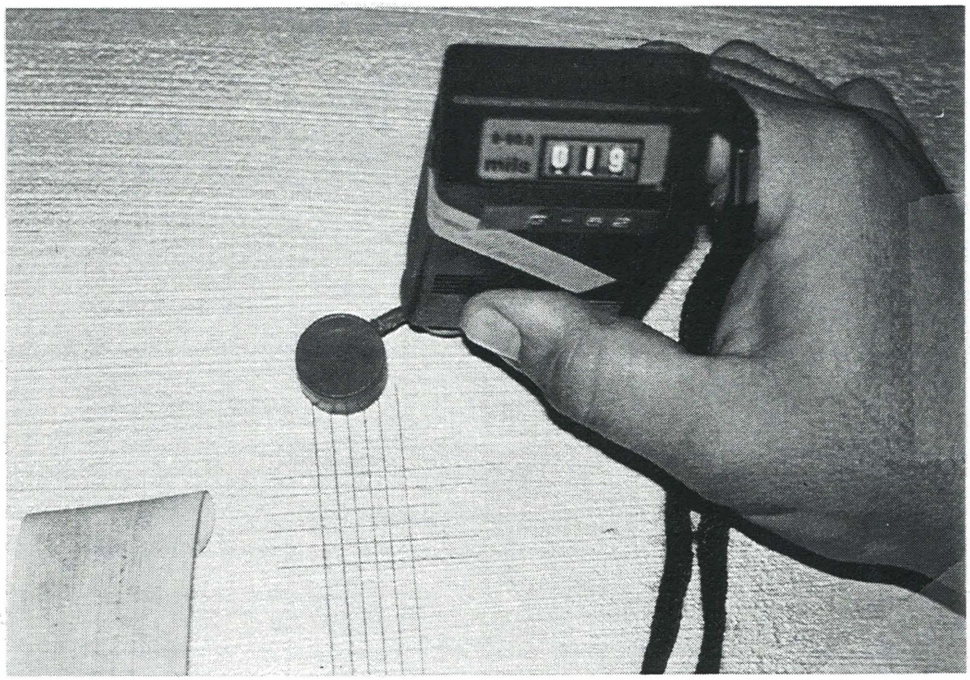

Figure 2. Compatibility Test

Test: Bridge 1(B)

Before testing was performed on the bridge, the contractor expressed concern about the amount of rust on the beams. There was also some speculation that it would be difficult to remove all of the rust and mill scale with only SSPC SP2 and SP3 cleaning methods. When the compatibility test was performed, it was difficult to determine the location of failure. Most of the test area showed an area of failure between the old paint system and the substrate; however, it was difficult to tell if the failure occurred between the new and old painting systems. The individuals conducting the test and interpreting the results expressed some reservations with the results and initiated a change-in-plan to clean the bridge by commercial blasting before painting.

Test: Bridge 34(C)

Two attempts were made to prepare a test section for the compatibility test. On the first try, the humidity underneath the bridge was 90%. The contractor applied the Sealmark with a brush. It quickly ran down the beams and collected on the bottom flange in a puddle. The representative then used a roller to apply the paint and had the same results. The group returned several days later when the humidity was below 70% and the paint still ran but not as quickly. The test was performed ten days later. Apparently, the difficulty with application had no bearing on the results.

Table 3. Compatibility Test Results

Bridge	Test Results on Exterior Beam
Bridge 1(A)	¬5B
Bridge 1(B)	4B
Bridge 34(C)	5B
*Bridge 2	5B
Bridge 3	5B
Bridge 4	5B
Bridge 5	5B
Bridge 7	5B

¬ The letter B in this table indicates the test method used for the compatibility test.

* Control Bridge

Construction

The eight bridges evaluated in this study were painted at different times between September 1993 and September 1994. Before the paint systems were applied, paint compatibility testing was performed on each bridge to ensure adhesion to the existing coating system. In addition to this compatibility test, a small 305 mm (12 in) diameter area in the center of this test section was hand tool cleaned to bare metal and painted to determine if the primer would lift the edges of the existing paint coatings in areas where the old paints had been worn away.

The bridges in this evaluation were cleaned in accordance with one of the SSPC cleaning standards listed in Table 4. A tarpaulin was used to collect debris and wash water. Bridges were enclosed when blast cleaning was necessary. An example of the debris and rust on the bridge steel beams before cleaning is shown in Figure 3.

Table 4. Steel Structures Painting Council Cleaning Standards

Specification	Cleaning Method	Desired Results	Notes
SSPC SP1	Solvent Cleaning	Removal of oil, grease, and foreign contaminants using a solvent	Does not clean rust, rust scale, or mill scale.
SSPC SP2	Hand Tool Cleaning	Removes loose coating, rust and mill scale with hand tools	Normally used in small limited areas.
SSPC SP3	Power Tool Cleaning	Removal of loose mill scale, rust, or faulty paint with power tools	Requires that oil and grease be removed; visual standard may be used.
SSPC SP6	Commercial Blast Cleaning	At least 67% of each square inch must be free of all visible residue.	A visual standard may be used for comparison here.

Scaffolds and ladders were used as an aid when painting areas that were not easily accessible from the ground. The flanges were painted first by hand with brushes or rollers. The beams were then painted using an airless spray setup shown in Figure 4. The tip sizes used to paint the steel beams were within the range specified by the manufacturer listed in Table 5. Blank spaces left in the table indicate that no tip size was listed in the information available at the time that this report was written. The manufacturer's recommended dry film thickness is also listed in this table. Exceptions to these values are noted in the text.

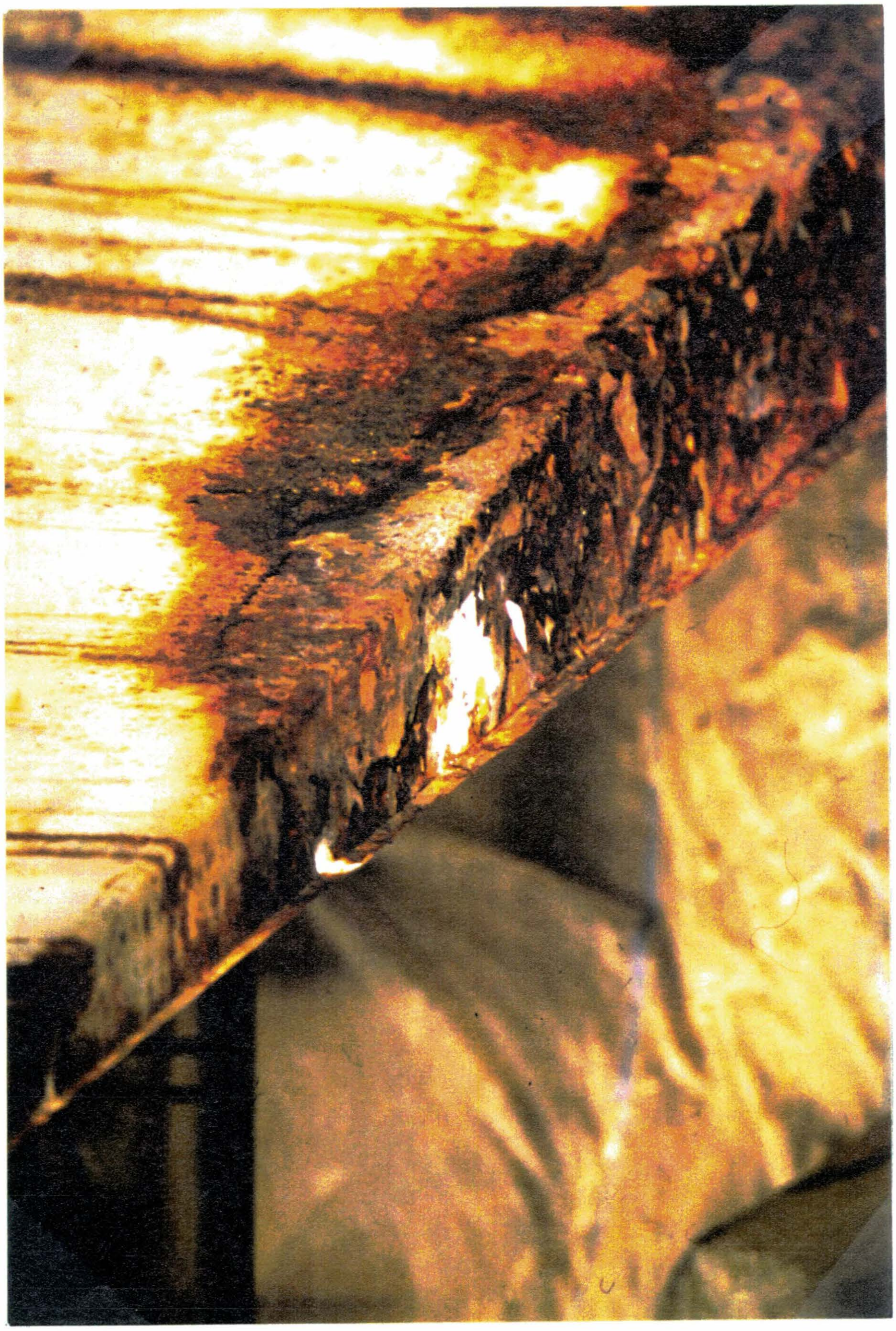

Figure 3. Rust and Calcium Deposits

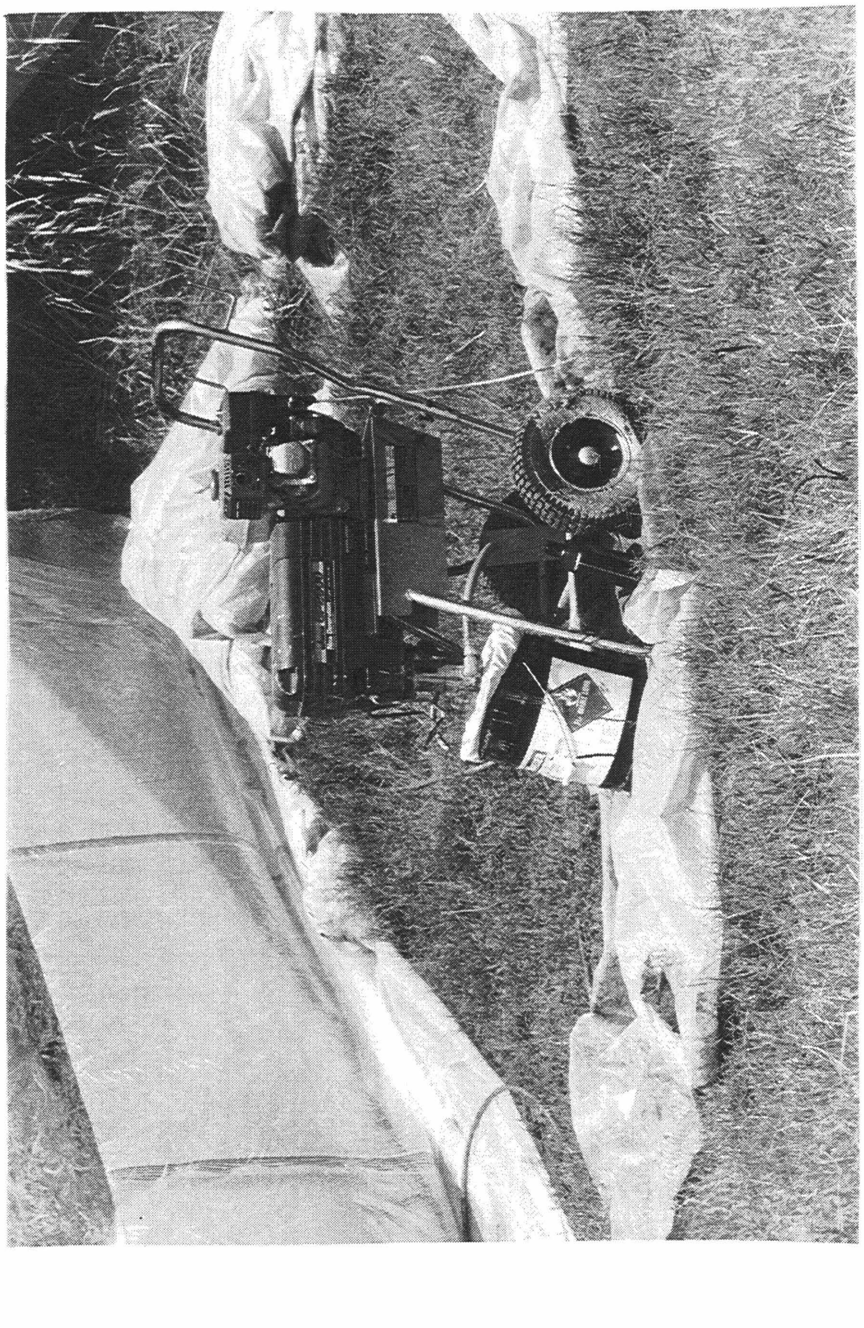

Figure 4. Airless Spray Equipment

Paint Information

Paint is made up of three primary parts: solvents, resins, and pigments. Solvents are the particles that evaporate into the atmosphere. Volatile organic compounds (VOCs) are a component of the solvent. High concentrations of VOCs are harmful to the ozone layer and they are being monitored very carefully. Although there are no current restrictions imposed by the EPA on VOC levels, changes are expected to occur in the near future. The VOC levels are noted in Table 5. The cost of each paint and the method that was employed to clean each bridge is also listed in Table 5.

Table 5. Coating System Information

Bridge	Coating Systems	Cost per Liter (dollars)	Volatile Organic Compounds (grams per liter)	Recommended Tip Size (Average in millimeters)	Recommended Dry Thickness (millimeters)	Method of Cleaning (SSPC Standard)
Bridge 1(A)	Dupont 25P Imron 326	11 10	419 264	0.4572	0.13	** SP3
Bridge 1(B)	Tnemec 135 Series 74	10 14	142 253	0.4572 0.2794	0.15 0.08	SP6
Bridge 34(C)	Sealmark Topcoat	6 6	24 348		0.15	SP3
*Bridge 2	Carbozinc 11 Polyclad 936	9 7	491 419		0.08	SP6
Bridge 3	¬ Alumanation Alumaclad	7 7	419 96	1.2446 0.9906	0.20 0.13	SP3
Bridge 4	Rustbond Carboline 3358 Carboline 3359	15 10 10	24 168 144		0.05 0.08 0.08	SP3
Bridge 5	Rust Grip	18	420	0.4572	0.10	¬ * SP1 SP3
Bridge 7	MC-Zinc MC-Ferrox A MC-Miomastic	9 9 13	336 324 407		0.08 0.08 0.08	SP3

In this study, cleaning to SP3 standards implies that SP2 cleaning has also been used prior to power washing. * Control Bridge; ** Commercially Blast Cleaned in Spots; ¬ Alumanation (Center and West Spans) Alumaclad (East Span); ¬ * SP1 (East Span) SP3 (Center and West Spans).

Construction Procedures

Bridge 1(A) - Garvin County

Most of the debris was removed from the beams with hammers and scrapers (SP2). The beams were power washed (SP3) and allowed to dry overnight. Several areas on this bridge had major rusting that could not removed by power washing. These areas were commercially blasted (SP6) with an abrasive, BlastOx, before paint was applied.

The beams were covered with two coats of paint. The primer, DuPont 25P is a gray high solids epoxy mastic that dries to a glossy finish. DuPont 25P was applied with both brushes and airless sprayers. Areas that had major rusting and hard to remove mill scale were painted with rollers, other areas with sprayers. This system went on easily and ran only when applied too thickly in spots. The paint was dry to touch in approximately two hours.

Imron 326, the top coat, is a white high gloss polyurethane enamel that also went on smoothly with a wet film thickness of 0.20 mm (8 mils). There were no significant problems with the application of the DuPont system to the bridge.

Bridge 1(B) - Garvin County

At the time of compatibility testing for the Tnemec coating system, the contractor expressed several concerns about the amount of rust on this structure. The engineer and inspector agreed with the observation and initiated a change-in-plans. The structure was cleaned with Blast Ox. Details are noted in the "Compatibility Testing" section of this text.

The rest of the operation went without further complication. The paint was easy to apply and dried to a brown high gloss finish. A representative from the Tnemec company was present for much of the construction to ensure that the specifications were followed and that there was enough paint to finish the job to specifications.

Bridge 34(C) - Garvin County

The original coating system specified for this bridge was the State of California Pb-201 paint. There were several problems obtaining test samples for this system. A few weeks prior to application, an alternate system, Sealmark, was proposed to use for this bridge.

Sealmark, manufactured by Coating Systems West, is a rubber-based coating system traditionally used to coat roofs. The primer is very humidity sensitive. It is clear and tacky to touch even when dried well past the manufacturer's recommendations.

There was no abrasive blasting to remove any rust or mill scale from the steel beams. According to the manufacturer, the primer will bond with rust and/or prevent it from spreading. The bridge was power washed and allowed to dry overnight before applying the prime coat.

During the application of this paint, the painters had to stop several times to clean the tips of the sprayers to prevent clots. Representatives from Coating Systems West discouraged thinning the paint because it caused the paint to run easily and puddle on the bottom flange when applied. The top coat was not as difficult to apply. The paint dried to a matte light gray finish and could be imprinted with a fingernail several days after application.

Bridge 2 - Seminole County

This bridge is the control for this evaluation. The bridge was cleaned according to SSPC SP6 cleaning standards. The debris was contained with a tarpaulin.

Carboline was the supplier of the paint for this bridge. The average dry film thickness for this bridge is 0.15 mm (6 mils). The beams were smooth when the paint was applied. The primer is a zinc rich paint, Carbozinc 11. Polyclad 936, the top coat, is an aluminum paint. The paints were not difficult to apply and did not run quickly or easily.

Bridge 3 - Seminole County

Bridge 3 in Seminole County was painted using two different types of paint. The center and west spans were painted with Alumanation. The east span was painted with Alumaclad. Both coating systems are gray.

Alumanation is an asphaltic mastic paint that has a rubbery feel when dry. This system is also used in painting the roofs of metal buildings. Alumanation had to be mixed thoroughly before use. The paint was thick and could be flaked off with a fingernail when dry. The prime coat averaged 0.46 to 0.76 mm (18 to 30 mils) thick when wet; the top coat averaged 0.18 to 0.20 mm (7 to 8 mils) when wet. Figure 5 shows indentations made in the paint with a dry mil thickness gauge and a finger more than three hours after application.

Alumaclad is a water borne paint system with a low VOC level of 96 grams per liter (0.2 pounds per gallon) that goes on easily. Many of the older paints have VOC levels that are greater than 419 grams per liter (3.0 pounds per gallon). The paint covered the rust in one coat. This paint appeared thinner than Alumanation when applied and was still soft and pliable after 24 hours.

At the final inspection of the bridge a few weeks after application, the parties participating in the inspection were not pleased with the appearance of the coating systems, particularly the Alumanation. It was difficult to get an even coating from this paint system. When applied, the paint appeared to have shadows and looked as if it were several different shades of gray. The contractor agreed to touch-up the bridge with paint in several problems spots to the engineers' specifications before the project was finished. The contractor went over the beams with a fine mist of the Alumanation paint for the center and west spans approximately 0.10 mm (4 mils) thick when wet.

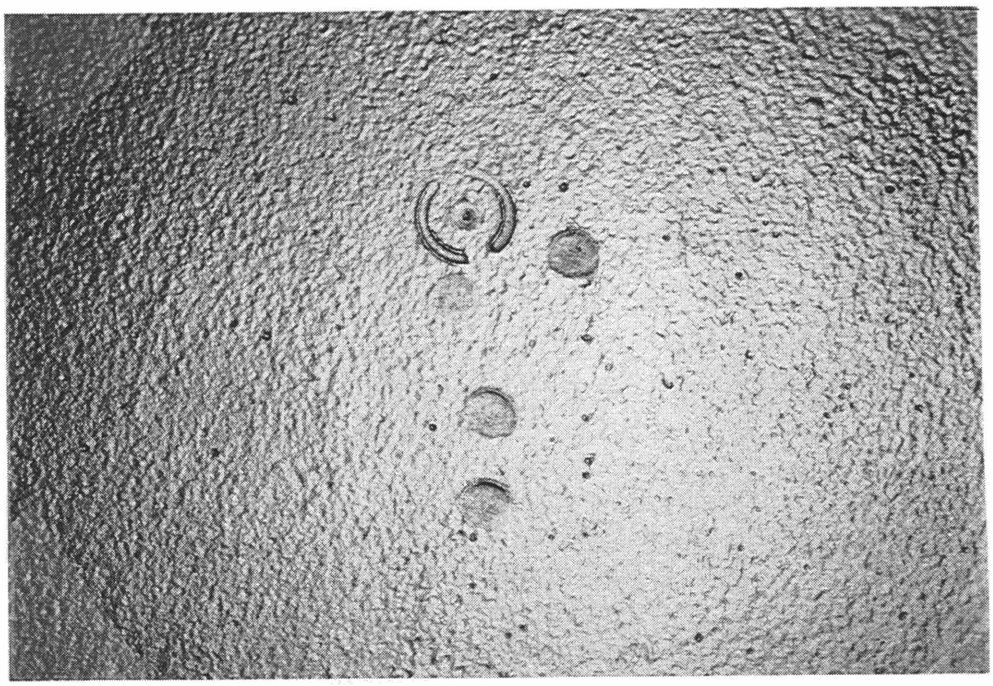

Figure 5. Bridge 3 - Alumanation Coating

Bridge 4 - Johnston County

A lot of rust and mill scale was present on this bridge that was not removed from the steel beams using the specified cleaning method. The contractor requested permission to blast the debris from the bridge in addition to hand and power tool cleaning; however, in keeping with the guidelines set for this study, abrasive blasting was not permitted.

The beams were painted with Rustbond and Carboline Acrylic paint. Painting proceeded after the beams were cleaned according to specifications. No other unusual construction problems were noted for the overcoating of this structure.

Bridge 5 - LeFlore County

The three span bridge in LeFlore County is located over a railroad track. Trains that frequently passed under the construction site made this a very labor intensive project. Each time a train was scheduled to come through, scaffolds, plastic containment covers, and equipment had to be moved a safe distance away from the track.

When this bridge was constructed, a blast plate was placed across the steel beams near the center of the bridge to protect the beams from the steam generated by trains. The blast plate was not removed from this structure. Consequently, cleaning and painting operations were completed around the plate. The plate was cleaned in the same manner as the center and west spans then painted with the coating system. Power washing did not remove all of the rust scale from this bridge and it was not blasted with an abrasive.

The east span of this bridge was cleaned with the Rust Grip cleaning solvent. The solvent eliminated the need for tarpaulins according to the inspector. After the solvent was applied, the beams were cleaned with compressed air.

The center span of this bridge was painted first then the remaining two spans. The contractor used a 0.432 mm (0.017 in) diameter tip to apply the paint. Rust Grip ran easily when applied, shown in Figure 6, and took four coats of paint for complete coverage. The manufacturer's representative suggested a larger size tip, 0.533 mm (0.021 in) diameter, for better coverage and fewer runs. A size 0.635 mm (0.025 in) diameter airless paint tip was used but this seemed to make little difference in the coverage and paint still ran.

When the coating system dried, it was very difficult to remove or scrape a section of the paint off even with the edge of a key. With the exception of the train schedule and runs, the operation proceeded with little incident. Figure 7 depicts the appearance of the bridge during application.

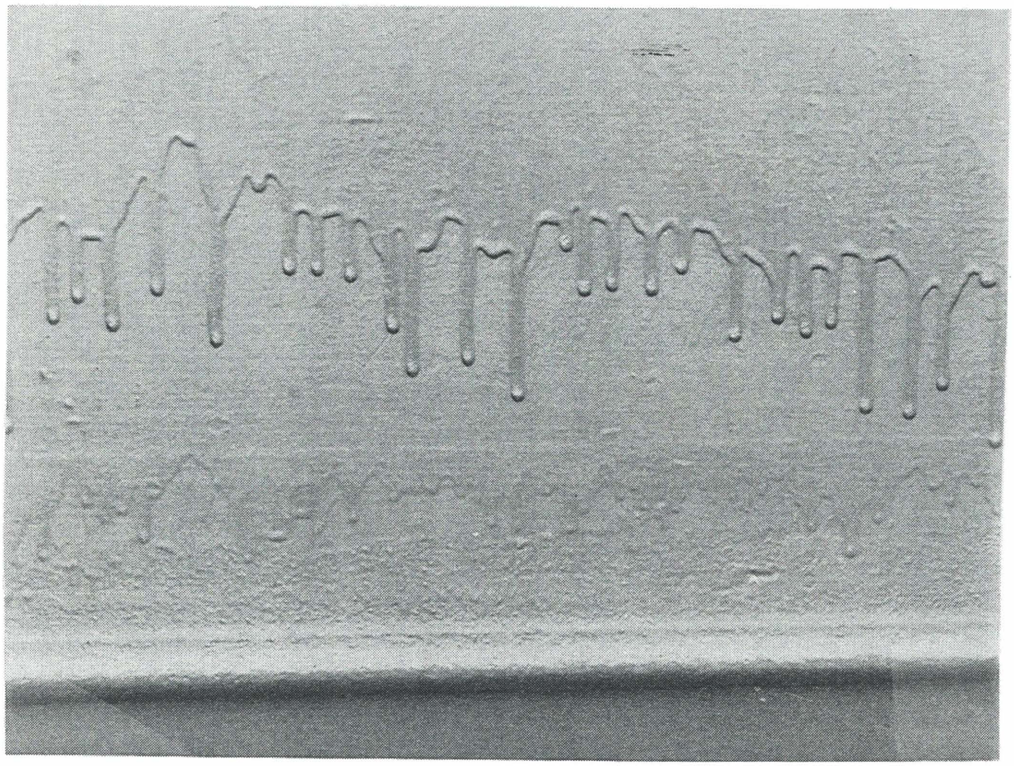

Figure 6. Bridge 5 - Top Coat of Rust Grip

Figure 7. Bridge 5 - Center Span During Application

Bridge 7 - Creek County

The longest bridge in the study is 167 m (548 ft) in length with thirteen spans. The three spans in the center of this bridge are located over a railroad track. Like the bridge in LeFlore County, frequent train arrivals made painting these spans somewhat difficult. A representative from Burlington Northern Railroad was on site while paint operations were taking place on this section of the bridge to keep workers abreast of train schedules and make sure that operations ran as smoothly as possible.

One of the objectives of this evaluation was to compare the performance of coatings placed over steel beams using different methods of cleaning. More specifically, coatings placed over beams that were cleaned using the SSPC SP2 and SSPC SP3 cleaning specification. One half of this bridge was to be cleaned using the SP2 standard, the other the SP3 standard. Unfortunately for the purposes of this evaluation, each beam was cleaned using a combination of these methods.

The average thickness of the existing paint on this bridge ranged from 0 to 0.08 mm (0 to 3 mils). Three different paints were used to overcoat this bridge. The first, a green, zinc spot primer was to be applied to areas where rust was prevalent. This accounted for nearly 80% of the steel. There was not a lot of mill scale on the bridge. The remaining two Wasser coating systems were a silver, intermediate/base coat, and a brown, top coat. They were applied over the entire length of the bridge. When dry, the top coat had a matte finish.

This project took approximately two months to complete. Two spans were completed at a time and each two span section took four days to complete. The spans were cleaned one day, painted with the spot primer the next, then the intermediate and top coats were applied on the last two days before the next section was started.

This bridge had two blast plates, shown in Figure 8, that were removed from the steel beams. There was a lot of rust, debris, and animal nests between the blast plates and the steel beams. The areas were cleaned according to the standards and painted. The blast plates were not replaced.

Workers used scaffolds to reach the steel beams to paint. When painting areas over the railroad tracks, the workers used a Marklift four by four aerial bucket device for convenience. The Marklift was parked on either side of the track so that it would not have to be moved when trains passed.

A joint sealing and patching operation was in progress on top of the bridge deck during the painting of this bridge. Concrete was dropped below the bridge deck and on the dry paint in some spots. It was not completely removed from the beams.

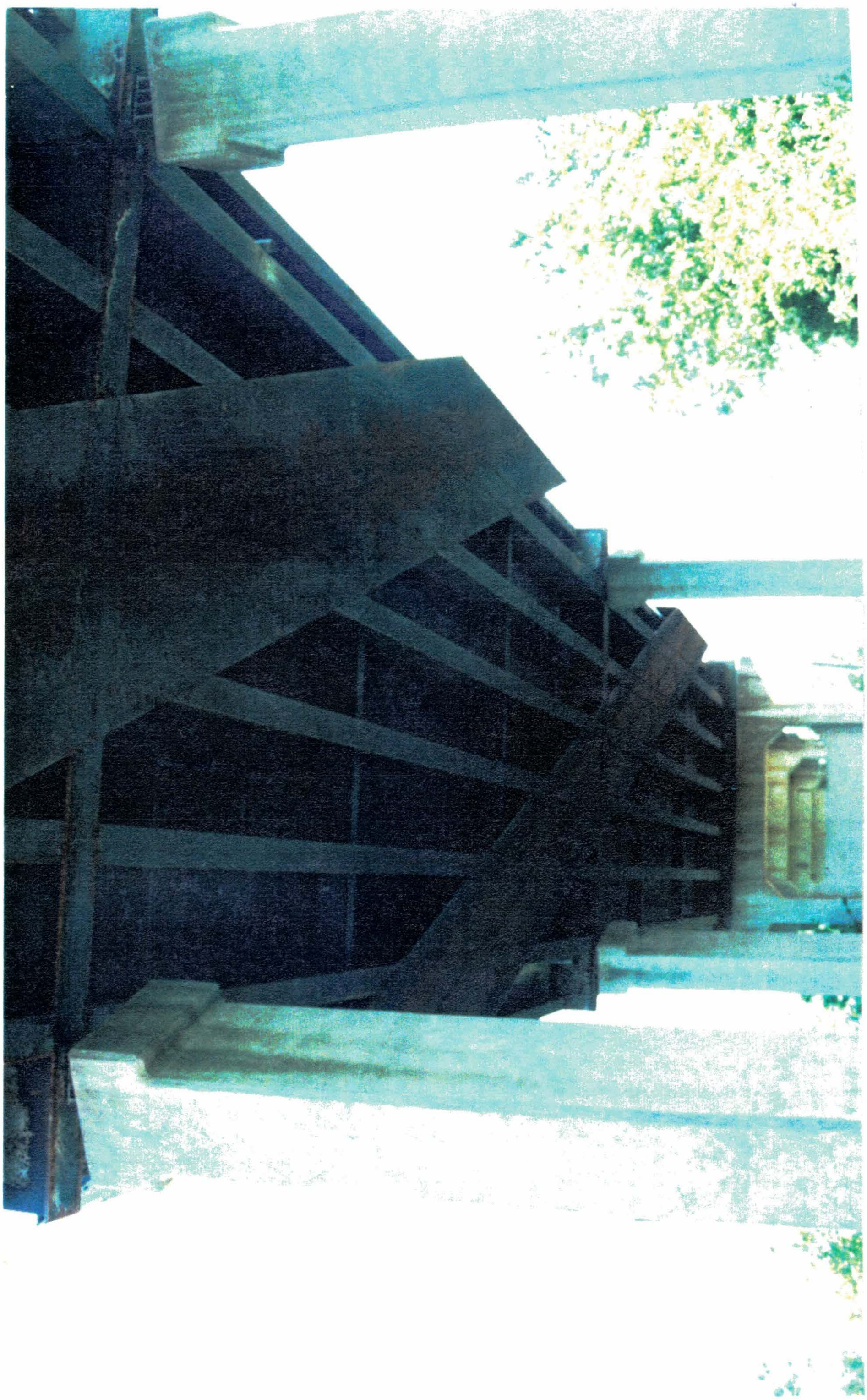

Figure 8. Bridge 7 - Blast Plates

Cost Analysis

One of the primary reasons that DOTs are resorting to overcoating is cost. Financially, some of the most significant changes in overcoating or painting bridge steel have occurred in the cost of paint and disposal of hazardous waste. In this section, a review of the cost to paint each bridge is listed with the primary focus on painting and disposal expenses. Table 6 outlines the key items used in this cost comparison.

The total cost per square meter to overcoat each bridge is listed in column five. These values were calculated by adding the paint and hazardous waste disposal costs together then dividing the result by the average steel area that was painted (column three divided by column four). All costs were estimated using the bid prices submitted by the contractor who was awarded each project.

Table 6. Construction Costs

Bridge	Total Construction Cost (dollars)	Paint and Disposal Cost (dollars)	Approximate Steel Area (square meters)	Paint and Disposal Costs per Square Meter (dollars)
Bridge 1(A)	20,420	11,000	300	37
Bridge 1(B)	25,620	14,100	700	20
Bridge 34(C)	20,096	10,600	360	29
*Bridge 2	33,296	21,650	600	36
Bridge 3	51,170	27,909	520	54
Bridge 4	26,409	25,909	520	50
Bridge 5	43,887	31,038	620	50
Bridge 7	199,004	130,662	2,650	49

* Control Bridge

In this analysis, paint includes the following costs: paint, labor, compatibility testing, and cleaning. Disposal costs include: testing, special handling of hazardous materials (if needed), and disposal. Special handling was not needed on bridges that were not blast cleaned. All additional costs such as joint sealing of the bridge deck, traffic control, special equipment, mobilization and the like, will be lumped under the category "other." The total construction cost will be a combination of the above mentioned categories.

The bar chart in Figure 9 illustrates the total maintenance cost per square meter of steel area for each bridge in this study (from Table 6 column two divided by column four). The average maintenance cost for the seven structures that were to be cleaned using hand and power tools is nearly $65 per square meter ($7 per square foot). The control bridge had an approximate price of $56 per square meter ($5 per square foot).

The pie charts in Figures 10 and 11 illustrate a breakdown of and comparison between the average cost of maintenance for a bridge that is overcoated, and one that is commercially blasted and meets the requirements for containment, treatment, and disposal of hazardous waste.

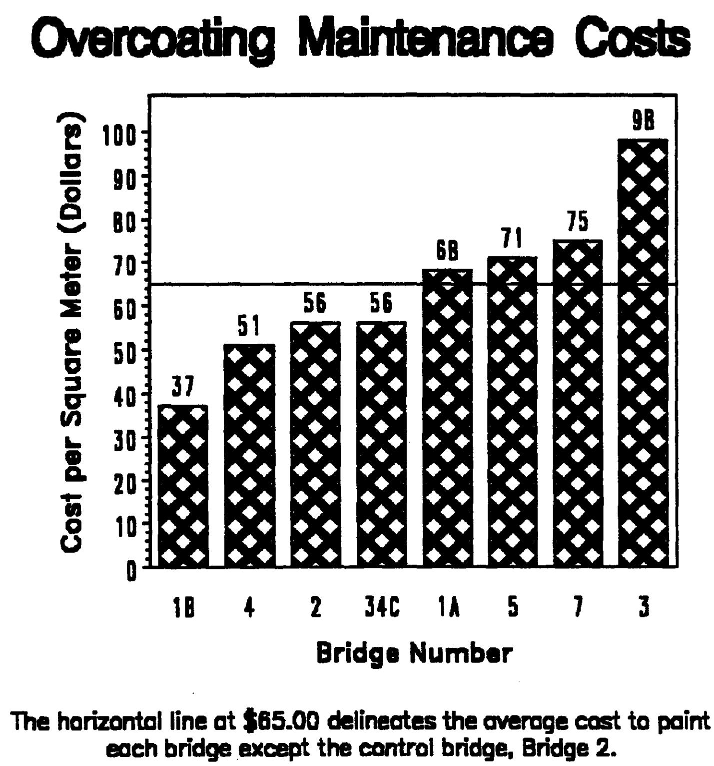

Figure 9. Average Cost of Bridge Painting per Square Meter

For these calculations, a theoretical area of 600 square meters (6500 square feet) was assumed. The average maintenance cost to overcoat a bridge, $65 per square meter, was used to calculate the total cost of maintenance. The cost to paint the control bridge, $56 per square meter, was used to calculate the costs of painting bridges that had hazardous waste disposal.

The percentage of money used in each facet of maintenance is shown in Figure 10. Figure 11 shows the same cost analysis for the control bridge.

From the pie charts, the cost of disposal where there is no hazardous waste comprises 6.3%, roughly $2,500, of the total cost of the painting operation. The cost of disposal for the control bridge makes up more than 11.3%, or $3,748, of the cost to paint the bridge; nearly twice the percentage of funds used for non-hazardous waste.

The percentage of the total cost overcoat bridges with coatings that meet the new specifications and guidelines (59%) is less than the percentage of funds used to paint bridges with coatings that no longer meet the requirements (65%).

When evaluating only the average cost of painting and disposal, there appears to be little difference between the cost to maintain bridges that have been overcoated and painted with "lead-free" paints ($25,205 per 600 square meters) and the cost to maintain bridges that have been treated for non-hazardous material disposal ($25,342 per 600 square meters).

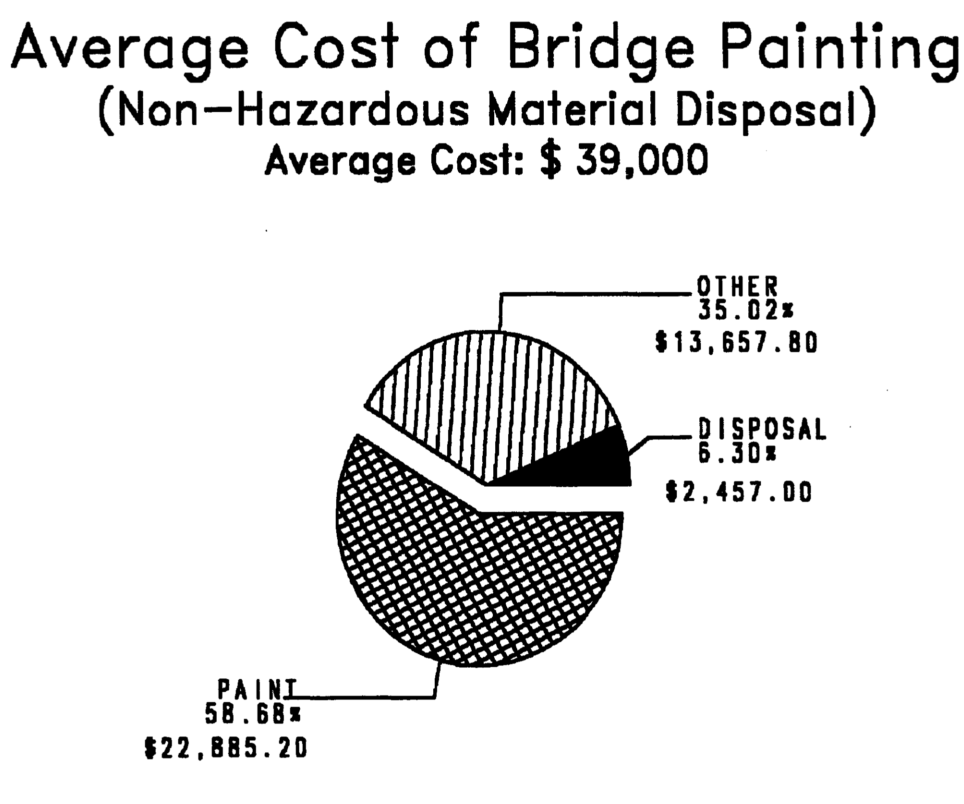

Figure 10. Maintenance Cost without Hazardous Waste Disposal

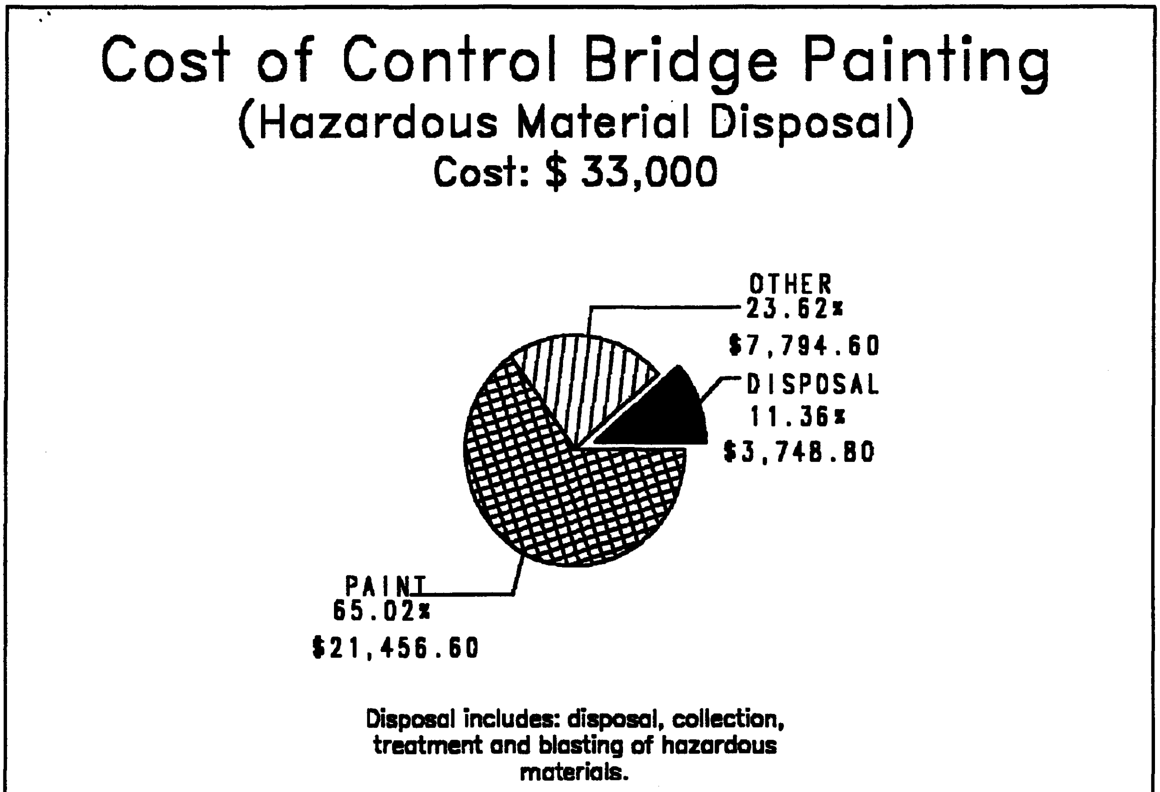

Figure 11. Maintenance Cost with Hazardous Waste Disposal

Discussion of Construction Procedures and Findings

The text presented in this report gave a summary of the application of several different coating systems and cleaning preparation methods to eight bridges. The text also highlighted the costs of lead abatement and containment.

The objectives of this study included a comparison between the performance of coatings placed over SSPC SP2 hand tool cleaned steel to coatings placed over SSPC SP3 power tool cleaned steel. No bridge was cleaned using only one of these cleaning methods. The only bridge that was prepared for painting employing two distinctly different cleaning methods was Bridge 5. The east span of the bridge was cleaned using the SSPC SP1 standard for solvent cleaning and the center and west spans were cleaned using the SSPC SP3 standard for power tool cleaning.

In addition to the bridges not being cleaned according to the guidelines for this evaluation, two bridges were blast cleaned. Bridge 1(A) was cleaned using SSPC SP2, SP3 and SP6 cleaning procedures in certain problem areas. Bridge 1(B) was cleaned entirely using the SP6 standard for cleaning. Bridge 3 in Seminole County was "touched up" to the engineers' specification in other words, it was painted twice.

With all of these different circumstances it will be difficult to make an accurate and equitable evaluation comparing the cleaning methods and paint systems. At this point, any comparison between bridges cleaned using SSPC SP2 and SP3 cleaning standards is not possible. The only bridge that would fit the parameters set for this criterion would be Bridge 5 if the conditions were changed such that a comparison is made between bridges cleaned with the SSPC SP1 and SP3 cleaning methods. Any conclusions drawn or recommendations made at the end of this evaluation with respect to the original objectives of this study must take these discrepancies into account.

It is important to note the costs involved to overcoat the bridges in this evaluation and the expenses incurred when treating and disposing of hazardous waste. As expected, the cost to handle hazardous waste is higher than the cost associated with overcoating. Moreover, when only the cost of paint and disposal are used in each case, hazardous and non-hazardous waste disposal, there is not a significant difference between the construction costs.

Research, Development and Technology Transfer will continue to monitor the bridges named in this study. Each will be evaluated semiannually and the observations will be recorded. A final report will be written at the end of a three year period to compare the performance of each coating using the ASTM D 5065 "Assessing the Condition of Aged Coatings on Steel Surfaces."