ARIZONA DEPARTMENT OF TRANSPORTATION

REPORT NUMBER: FHWA/AZ-86/275

EVALUATION OF NON-LEAD PAINT SYSTEMS

STATE OF THE ART

Final Report

Prepared by:
Gary L. Tinklenberg
Corrosion Control Consultants and Labs
1104 Third Avenue
Lake Odessa, Michigan 48849

March 1987

Prepared for:
Arizona Department of Transportation
206 South 17th Avenue
Phoenix, Arizona 85007
in cooperation with
U.S. Department of Transportation
Federal Highway Administration

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Arizona Department of Transportation or the Federal Highways Administration. This report does not constitute a standard, specification, or regulation. Trade or manufacturer's names which may appear herein are cited only because they are considered essential to the objectives of the report. The U. S. Government and the State of Arizona do not endorse products or manufacturers.

TECHNICAL REPORT DOCUMENTATION PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
FHWA-AZ87-275		

4. TITLE AND SUBTITLE	5. REPORT DATE
EVALUATION OF NON-LEAD PAINT SYSTEMS STATE OF THE ART	March 1987
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Gary L. Tinklenberg	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Corrosion Control Consultants and Labs Inc. 1104 Third Avenue Lake Odessa, Michigan 48849	10. WORK UNIT NO.
	11. CONTRACT OR GRANT NO. HPR-PL-1(31)ITEM275
12. SPONSORING AGENCY NAME AND ADDRESS Arizona Department of Transportation 206 South 17th Avenue Phoenix, Arizona 85007	13. TYPE OF REPORT & PERIOD COVERED Final Report 9,86 - 2,87
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

In cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

A review of ADOT painting specifications is presented with comments on a section by section basis where appropriate. ADOT is not only concerned with new structures, but with the removal of lead-based paints from existing structures; therefore, the removal of existing paints is discussed per Arizona conditions. A review of possible substitutes for lead-based paints with comments addressing surface preparation, number of coats, type of paint, inspection, alternates, availability, advantages, and disadvantages is documented. A cost comparison of various paint systems was performed. Recommendations are made for the following items: type of bridge paint specification, type of evaluation, procedure, application specification improvements, suggested method to generate an initial qualified products list, method to maintain painting procedures and products, paint types for new structures, paint types for existing structures, concrete painting, and traffic paint.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
paint systems, non-lead, lead-based paints, removal, paint specifications, silica sand, sandblasting, inspection	Document is available to the U.S. public through the National Technical Information Springfield, Virginia 22161

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	59	

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The following report was written for the Arizona Department of Transportation at the request of the Arizona Transportation Research Center. The purpose of this project was to review ADOT's paint and painting specifications in regard to current practice and prepare an analysis for the same. Recommendations are presented to aid ADOT in achieving a better specification for paints and painting of structural steel.

This report contains five items along with the respective references:

I. Specification Review

   A. Lead Specifications

      1. Application Specifications
      2. Material Specifications

   B. Preformed Marking Specifications

   C. Permanent Marking Specifications

   D. Concrete Painting Specifications

II. Removal of Lead-Based Paints

III. Review of Substitutes For Lead-Based Paints

IV. Cost Comparison of Various Systems

   Tables I, II, III

V. Performance Evaluations For Traffic Paints

VI. Recommendations

In early January of 1987 we visited the Arizona Department of Transportation for two days. On the first day, we conducted a one-day seminar on the topic of Non-Lead Bridge Paints. The second day encompassed two meetings: one to discuss the I-10 and I-17 Interchange problem and the other to review a draft of this report. During this visit many of the conditions peculiar to Arizona were highlighted and taken into account in the recommendation section of this report.

SECTION I. SPECIFICATION REVIEW

The specifications provided for review were the following:

I. 1982 Standard Specifications

A. Section 610 - Painting
B. Section 1002 - Paint
C. Section 701 - Maintenance and Protection of Traffic

II. 1985 Supplemental Specification

A. Section 610 - Painting
B. Section 705 - Preformed Pavement Marking Pages 162 thru 166

III. Draft Specifications

A. Section 610 - Painting (dated 8/4/86)
B. Section 1002- Paint (dated 8/4/86)
C. Section 708 - Permanent Pavement Markings (dated 9/26/86)

These specifications will be reviewed by topics in the following order:

1. Painting (Section 610)
2. Paint (Section 1002)
3. Preformed Pavement Markings (Section 705)
4. Permanent Pavement Markings (Section 708)

No attempt will be made to comment on Section 701, since this is outside our area of expertise. We assumed this was included for information purposes.

I. STANDARD SPECIFICATION

The Arizona Department of Transportation (ADOT) as of August, 1986, no longer uses lead-based paints on structures. There is value however in reviewing the lead-based paints specifications. These are the systems that are on many current structures; thus the review will help in understanding the existing conditions. Additionally, the review will assist in understanding the methods used by ADOT to specify and administer painting contracts.

A. Painting - section 610 (1982)

The standard specifications are for the application of a lead-based paint. In view of existing E.P.A. laws, it is doubtful that either the fabricator or the field paint applicator is in compliance with current requirements. The general requirements include blood-lead testing for all workers who remove or apply lead-based paints. Also, lead analysis on all spent material must be performed. **If the spent material has a higher rating than 5 PPM leachable, it must be treated as a hazardous waste.** (This creates a very expensive disposal problem.) Obviously Arizona has not experienced many of the same problems that are occurring in other States since they too have stopped using lead-based paints. (More information on leaded paints is contained in the next section.)

The following is a section-by-section review. (Only those sections with comments are listed.)

1) Section 610-3.02A

The coating of galvanized surfaces, especially in a chloride environment, can greatly extend the service life of the system.

2) Section 610-3.02B

Currently there are numerous health problems associated with the use of silica sand. There are lawsuits[1] which involve not only the painting contractor and the sand supplier but also the specifier. We recommend against the use of silica sand.

The description of the blast-cleaned surface is one of a white metal blast (SSPC-SP-5). This is a very expensive procedure and usually not done in the United State in conjunction with an alkyd paint system. In fact, it is done only with the highest of paint technologies in very aggressive atmospheres. We recommend that the requirements be lowered to a near-white blast (SSPC-SP-10). The necessity of an anchor pattern is well documented. However, too much of a good thing is very harmful. We recommend an upper limit of 2 or 2.5 mils.

3) Section 610-1.05

More definition on dry film thickness measurements and gauge calibrations are needed. We recommend that an SSPC document be referenced. (See the dry film thickness measurement section of the sample specification.)

The determination of excessive dry film thickness is a time-dependent phenomenon. As specified, without a time limit, all one has to do is wait. Therefore for practical reasons we would doubt that this requirement accomplishes anything in the field.

4) Section 610-1.05B

This section makes no mention of what to do on faying surfaces. The coefficient of friction is greatly reduced with the application of many paints.

The removal of linseed oil is difficult in the field; therefore, if linseed oil has been applied, it is highly probable that it will remain on the surface of a structure to be welded. The effects on structural welds due to this are so dramatic that many agencies specify against putting anything on an area to be welded.

II. SUPPLEMENTAL SPECIFICATION

A. Painting - Section 610 (1985)

This specification is identical to the Standard (I.) through Section 6.02. Section 6.03 contains only a minor change in the paragraph on mixing. This addition is not adequate to insure proper dispersion of the zinc in the applied film. All zinc-containing paints should be mixed just prior to application.

Significant changes occur in Section 610-1.05.

1) Section 610-1.05A.

Since the first field coat cannot be applied within 24 hours, preparation of the shop coat is required. This is an expensive operation since it is very labor intensive. Great care and caution is required to insure uniform preparation or early delamination failures can be expected. In practice brush blasting is extremely difficult to do uniformly on a bridge structure. The strict time to recoating will also present problems in the field. These stringent application requirements have led to great reductions in the use of this type of system for highway use.

The specification requires the application of a wash primer when required. We received nothing from ADOT which indicated why it would be required on a freshly blasted surface. Therefore we do not understand this requirement.

2) Section 610-1.05B.

The problem of the coating of faying surfaces is not addressed. One of the greatest reducers of the coefficient of friction is phenolics. It is worse than an alkyd.

There is no mention regarding the filler material for small cracks. This repair method also causes problems in the surface preparation procedure of the shop coat.

III. DRAFT SPECIFICATIONS

A. Painting - Section 610 (dated 8/4/86)

There are only minor changes between these and the supplemental specifications. Therefore, the comments that pertain to the supplements also pertain to this specification.

I. STANDARD SPECIFICATIONS

B. Paint - 1002 (1982)

The red lead paint specification is typical of various highway painting specifications. It has remained essentially unchanged since 1950. The blue lead, second coat is also vintage 1950. Since the development of these two specifications there have been two families of coatings. The first, basic lead silico chromate types, also contained lead but were not as hazardous as red or blue lead and showed some improvements in durability. The second is the present generation of current technology systems (developed since World War II). These usually contain resins of a completely different type from the long-used alkyd or oil types.

In general, the performance of any lead-based systems currently can be duplicated with no-lead, no-chromate systems that are formulated with alkyd resins. Therefore with all the current environmental problems associated with lead and chromate, the use of such systems is no longer justifiable. (Additional problems are incurred when these coatings are removed. These will be discussed in the section on the elimination of lead-based systems.)

The zinc-dust/zinc-oxide primer as specified, can be one of three types that are contained in TT-P-641. The specification makes no mention of which type to use. This being the case, it is difficult to comment except in general terms. Very few States (Arizona is the only we have first-hand knowledge of) use this type of paint as a standard primer. Most are using various forms of zinc-rich paints which are substantially different from this type. There are major difficulties in recoating this system if type III is used.

III. DRAFT SPECIFICATION

B. Paint - Section 1002 (dated 8/4/86)

This specification has many of the same weaknesses as the Standard. The removal of lead only to substitute another heavy metal, chromate, is no improvement. Chromates are less soluble than lead but more toxic (smaller amounts can cause problems). This can easily be seen in comparing the OSHA exposure limits.

Lead - 50 Micrograms / m^3

Chromate - .1 micrograms / m^3

II. SUPPLEMENTAL SPECIFICATION

B. This specification is typical of most agencies. The problem with the specifications is that the results of non-compliance are not well understood. Therefore we would recommend the use of a 180 day replacement guarantee. This may also reduce the number of tests that are required.

III. DRAFT SPECIFICATIONS

C.Permanent Pavement Markings - Section 708 (dated 9/26/86)

The removal of lead from traffic paint is not nearly so advanced as the removal from maintenance paints. The main reason for this is simply that the traffic paint industry works on very low margins, therefore there is little money for research and development. Certain companies are making an attempt to remove lead, with Sherwin-Williams providing the leadership. The problem is that if everyone were to switch to a non-lead, yellow pigment, the industry could not produce enough yellow given its current production capacity.

Another problem of replacing lead in traffic paints is much more difficult to solve due to the lack of color-stable yellow pigments. There has been only one State to remove the lead from yellow paint, and that is Virginia. In discussions with them, it was obvious that the problem with the yellow pigmented paints is not that of putting lead into the environment through use, but it is the problem of disposal of left-over amounts in the bottoms of drums. There are other States that are considering changes (Florida, Missouri, Kansas) or possibly are in the process of changing; but no results are available as yet.

In discussions with technical services from Prismo (a large traffic paint manufacturer) it was pointed out that there are a number of problems in removing lead.

1) The current price for lead-based yellow pigments is about $.50/lb. At the current specified level this is about $.50/gallon. The replacement pigments are from $5.00-$9.00/lb. for good quality (lightfast) and imports from West Germany. Thus if even 1/4 of the current levels are used and the system formulated to equal light-fastness, there would still be a ten-fold increase in pigment cost.

2) Formulation - The replacement pigments are so fluffy that the only extender that works is $CaCO_3$ due to its low oil absorption characteristics. Calcium carbonates are not the best extenders from a durability viewpoint.

For these reasons the industry is not producing good (e.g., an equal) substitutes for lead-based yellows. Since fading appears to be the major problem, they should not be used without extensive evaluation.

The change-over to no-lead systems should not be a difficult one. Experimental non-lead systems can be obtained from paint manufacturers. These could be evaluated (see evaluation section) and in a matter of 18 to 24 months, non-lead systems could be in use. It should be noted, however, that indications are that non-lead systems are more expensive than leaded systems.

The draft specification dated 9/26/86 that was sent to us for review is typical of a chlorinated rubber formula specification. Outside of usually being more expensive than performance specifications, it is a good specification. There are, however, a few items that need to be addressed:

1) Section 708-2.01B1.

There is a 3 missing in the percentage of magnesium silicate. It reads 6.0-38.0 and should be 36.0-38.0.

2) Section 708-2E2.

The use of the word "excessive" could be a problem. What it excessive depends on your bias. We would recommend a quantitative measurement based on your past experience.

3) Section 708-2.01.E.4.

For quality control testing purposes a 12 month stability test is impractical. If this is considered important we recommend accelerated procedures. (ASTM-D-1309)

4) Section 708-2.02A.

The term "essentially free" lacks definition. We would recommend the use of a maximum percentage of imperfects be allowed.

5) Section 708-3.02.

The wet-mil thickness requirement should add "without beads".

In preparing this report we discussed the chlorinated rubber paint system with States that use performance

specifications, formula specification with both alkyd and chlorinated rubber paints. The results of those discussions are as follows:

1) In general most who use performance specifications do not use chlorinated rubber paints although most (if not all) said they outlasted the alkyd types. However the extra cost was difficult to justify.

The approximate cost for

a) Alkyd systems - performance $3.50-$4.00/gal.

b) Chlorinated rubber systems $5.50/gal.

2) Performance Specification resulted in lower paint costs (about $1.00/gallon).

3) The Arizona specification (similar to the Wyoming and the New Jersey Type IV) is a good chlorinated rubber system.

4) The major complaints with chlorinated rubber paints were difficulty of application and long dry times.

5) Water Based systems are doing better than anticipated and if compared to chlorinated rubber systems are very competitive. (They are not competitive with alkyds however.)

D. Concrete Painting Specifications

The concrete painting specifications supplied to us by ADOT appear to be written around a specific product. Thus, although it may not look like proprietary specifications, in effect it is.

There are a number of types of coatings that work well on concrete that are eliminated by using this specification. The problem is, however, that there is very little data upon which a performance specification can be based. This is also true for the supplied formula specifications. We can find nothing to substantiate that the specified levels are the optimums from an ADOT viewpoint.

For this reason it is not appropriate for us to comment on the supplied concrete painting system. The system should be evaluated against other coatings for concrete and against established performance criteria. (See the Recommendation, Section 9.)

PAINTING SPECIFICATIONS

The evolution of our current bridge painting specification was a slow process. One must appreciate the complexities of specifications development (e.g., the many factors that affect the wording in specifications and the type of specifications that were necessary).

When developing a painting specification, especially in the highway industry, there is some background information that must be kept in mind throughout the process. This is:

1) Painting specifications are used and interpreted by people who are not corrosion control experts.

2) Many times things are criticized simply because they are more complicated or initially more expensive than what was done in the past. This often occurs with no long term cost analysis.

3) People resist change. The idea in the old saying, "If it works don't change it," is well established.

4) There is little or no tolerance for failure in field experimental systems.

Many times throughout the development of specifications changes were necessary for one of these reasons.

A specification must be understandable both to the inspector and the contractor and it must be enforceable both in the field and in the courts. If either of these conditions is not met the specification should be revised. We have had to revise our specification on a yearly basis, which not only takes a great deal of time but also generates a certain amount of confusion and criticism from contractors. Any changes that are made must be supported and evaluated on their own merit; but one cannot forget or disregard the harmful side effects of changing specifications. We are hopeful that any more changes will be minor.

The following are two specifications for the total shop painting method and a field painting specification. The field painting is based on a commercial blast. We have encountered too many problems that are related to a brush-off blast. It is important to note that by definition a commercial blast (SP-6)

removes all paint. This important requirement is often overlooked. Therefore, if one of these specifications is used, the mandatory attendance of all bidders is strongly urged. This usually eliminates many potential problems.

TYPICAL SPECIFICATION

Not To Be Used For Direct Substitution

If used in its entirety or any portion, it should be reviewed by

CORROSION CONTROL CONSULTANTS AND LABS, INC.
1104 Third Avenue
Lake Odessa, Michigan 48849
Telephone (616) 374-8185

SUPPLEMENTAL SPECIFICATION FOR COMPLETE SHOP COATING OF STRUCTURAL STEEL AND FIELD REPAIR OF DAMAGED COATING

5/86

A. Description - This specification covers the shop cleaning and the shop application of a complete coating system on new structural steel. This work is included in the work of furnishing and fabricating structural steel. This specification also covers the field cleaning and repair of surfaces damaged in shipping, handling, and erecting the structural steel. This work is incidental to the cost of erection.

The coating system shall consist of a coat of zinc-rich primer, a coat of high-build epoxy, and a urethane protective coat.

Terminology used herein is in accordance with the definitions used in Volume 2, Systems and Specifications, of the SSPC Steel Structures Painting Manual (1982 Edition).

B. Materials:

1. Coating System - The Contractor shall select a complete coating system from one of the approved coating systems listed in the attached Qualified Products List (QPL). The Contractor shall supply the Engineer with the product data sheets before any coating is done. The product data sheets shall indicate the mixing and thinning directions, the recommended spray nozzles and pressures, the minimum drying time for shop applied coats, and the recommended procedures for coating galvanized bearings, bolts, nuts, and washers.

2. Color Requirements -

3. Chrome Plating - Hanger pins shall be completely hard chrome plated to a minimum thickness of 3 mils. The surface finish on the chromed pins shall be less than 20 micro inches root mean square (rms) on the bearing surface and less than 125 micro inches root

mean square (rms) on the ends.

4. Zinc Coatings - Position dowels and anchor bolts, including nuts and washers, shall be hot-dip galvanized in accordance with ASTM A153. Galvanized nuts shall be tapped oversize in accordance with the requirements of ASTM A563 and shall meet the requirements of Supplementary Requirement S1 of ASTM A563, Lubricant and Test for Coated Nuts. Excess hot-dip galvanizing on threaded portions shall be removed by centrifuging or air blasting immediately upon withdrawal; flame chasing is prohibited.

All portions of bearings not welded to the beam or girder and other structural members and parts required to be zinc coated shall be galvanized in accordance with ASTM A123. Fabricated bearing components shall be blast cleaned to remove all mill scale prior to galvanizing.

C. Provisions For Inspection - The Contractor shall furnish and erect scaffolding meeting the approval of the Engineer to permit inspection of the steel prior to and after coating.

Rubber rollers, or other protective devices meeting the approval of the Engineer, shall be used on scaffold fastenings. Metal rollers or clamps and other types of fastenings which will mar or damage freshly coated surfaces shall not be used.

D. Preparation For Shop Coating - All areas of oil and grease on surfaces to be coated shall be cleaned with clean petroleum solvents and then all the surfaces to be coated shall be blast cleaned to a near-white finish in accordance with SSPC-SP 10 (page 47, Volume 2).

All fins, tears, slivers, and burred or sharp edges that are present on any steel member, or that appear during the blasting operation, shall be removed by grinding and the area reblasted to give a 1 to 2-mil surface profile.

Scaling hammers may be used to remove heavy scale but heavier type chipping hammers which would excessively scar the metal shall not be used.

Abrasives used for blast cleaning shall be either clean dry sand, steel shot, mineral grit, or manufactured grit and shall have a gradation such that the abrasive will produce a uniform profile of 1 to 2 mils, as measured with Testex Replica Tape.

All abrasive and paint residue shall be removed from steel surfaces with a good commercial grade vacuum cleaner equipped with a brush-type cleaning tool, or by double blowing. If the double blowing method is used, the top surfaces of all structural steel, including top and bottom flanges, longitudinal stiffeners, splice plates, hangers, etc., shall be vacuumed after the double blowing operations are completed. The steel shall then be kept dust free and primed within 8 hours after blast cleaning.

Care shall be taken to protect freshly coated surfaces from

subsequent blast cleaning operations. Blast-damaged primed surfaces shall be thoroughly wire brushed or if visible rust occurs, reblasted to a near-white condition. The wire brushed or blast cleaned surfaces shall be vacuumed and reprimed.

All areas where field welding is required, except the areas where the stud shear connectors will be welded to the top flange, shall be masked prior to shop coating. Areas where stud shear connectors will be welded to the top flange shall be masked after the primer coat has been applied, but before the topcoat is applied.

E. Mixing The Coating - The coating shall be mixed with a high shear mixer (such as a Jiffy Mixer), in accordance with the producer's directions, to a smooth, lump-free consistency. Paddle mixers or paint shakers are not allowed. Mixing shall be done, as far as possible, in the original containers and shall be continued until all of the metallic powder or pigment is in suspension.

Care shall be taken to ensure that all of the coating solids that may have settled to the bottom of the container are thoroughly dispersed. The coating shall then be strained through a screen having openings no larger than those specified for a No. 5o sieve in ASTM E 11. After straining, the mixed primer shall be kept under continuous agitation up to and during the time of application.

F. Thinning The Coating - In general the coatings are supplied for normal use without thinning. If it is necessary to thin the coating for proper application in cool weather or to obtain better coverage of the urethane topcoat, the thinning shall be done in accordance with the manufacturer's recommendations.

G. Conditions For Coating - The coating shall be applied only when the following conditions have been met:

1. Temperature - The temperature of the air and the steel shall be above 50 F but shall not be so hot as to cause blistering of the coating. The surface temperature shall be at least 5 F higher than the dew point.

2. Humidity - The coating shall not be applied when the relative humidity is greater than 90 percent. A minimum of 50 percent is required during the curing time of the inorganic type primers.

H. Applying The Coating - After the surface to be coated has been cleaned and approved by the Engineer, the primer shall be applied so as to produce a uniform even coating bonded with the metal. Succeeding coats shall be applied when approved by the Engineer. The minimum curing time between coats is listed in the

attached Qualified Products List. Depending on site conditions, additional time may be required for proper curing before topcoating. It is the applicator's responsibility to determine if the coating has cured sufficiently for proper topcoating.

The coating shall be applied with the spray nozzles and pressures recommended by the producer of the coating system, so as to attain the film thicknesses specified. Surfaces to be coated include faying (contact) surfaces of bolted field splices. The dry film thickness of the primer coat on the bolted friction splices on the main members and on the top of top flanges where the stud shear connectors are to be welded, shall not be less than 1 mil nor greater than 2.5 mils. The faying surfaces of bolted field splices and the top of top flanges where the stud shear connectors are to be welded shall be masked during subsequent coating operations. In the areas of field bolted connections (including the outside surface of splice plates) the outside surfaces shall be primed (minimum 2.5 mils) only. On all other areas, the minimum dry film thickness for the primer coat shall be 2.5 mils, the epoxy coat and the urethane protective coat shall be sufficient to provide a uniform appearance but in no case less than 3.5 and 1.0 mils respectively. The dry film thickness will be determined by the use of a magnetic dry film thickness gauge. The gauge shall be calibrated on the blasted steel with plastic shims approximately the same thickness as the minimum dry film thickness. A Tooke film thickness gauge may be used to verify the coating thickness when requested by the Engineer. If the Tooke gauge shows the primer coat to be less than the specified minimum thickness, the total coating system will be rejected even if the total dry film thickness exceeds the 6-mil minimum for a 2-coat system or exceeds the 7.0-mil minimum for a 3-coat system.

All bolted shop connections shall be removed prior to the blasting and coating of the girders or beams. The parts shall be blasted separately and primed, then reassembled and the bolts fully torqued.

All galvanized components, including galvanized nuts, bolts, and washers, shall be solvent cleaned, given a tie coat, and then coated with the epoxy topcoat. Any galvanized surface on the outside of the fascia beam shall be given a urethane protective coat in addition to the epoxy topcoat.

If the application of the coating at the required thickness in one coat produces runs, bubbles, or sags, the coating shall be applied in multiple passes of the spray gun, the passes separated by several minutes. Where excessive coating thickness produces "mud-cracking," such coating shall be scraped back to soundly bonded coating and the area recoated to the required thickness.

In areas of deficient primer thickness, the areas shall be thoroughly cleaned with power washing equipment, as necessary to remove all dirt; the areas shall then be wire brushed, vacuumed, and recoated.

All coating shall be done in a neat and workmanlike manner as described in SSPC PA 1, producing a uniform, even coating

which is bonded to the underlying surface.

Erection marks, for the field identification of members, and weight marks shall be transferred or preserved.

All metal coated with impure, unsatisfactory, or unauthorized coating material, or coated in an unworkmanlike or objectionable manner, shall be thoroughly cleaned and recoated or otherwise corrected as directed by the Engineer.

All dry spray shall be removed, by sanding if necessary, prior to the application of the topcoat.

Material shall not be loaded for shipment until the shop coating has adequately cured and been inspected. The components will be stamped "Recommended For Use" only after the loading has been completed and approved.

I. Handling Steel - Extreme care shall be exercised in handling the steel in the shop, during shipping, during erection, and during subsequent construction of the structure. The steel shall be insulated from the binding chains by softeners approved by the Engineer. Hooks and slings used to hoist steel shall be padded. Diaphragms and similar pieces shall be spaced in such a way that no rubbing will occur during shipment that may damaged the coatings. The steel shall be stored on pallets at the job site, or by other means approved by the Engineer, so that it does not rest on the dirt or so that components do not fall or rest on each other. All shipping and job site storage details shall be presented to the Engineer at the pre-fabrication meeting and they must be approved prior to shipping the steel.

J. Field Repair - The Contractor shall provide means and a time mutually agreed to for inspecting the structural steel in accordance with the requirements specified herein under "C. Provisions For Inspection."

All field repairs shall be made in strict accordance with the coating supplier's recommendations and shall be approved by the Engineer. All coatings applied to repair areas shall be applied using recommended spray equipment only. The coating supplier's recommendations are to be supplied to the field personnel by the fabricator of the steel. Such field repairs shall include the application of a complete 3-coat system; e.g., on rusted areas: the zinc-rich primer, the epoxy intermediate coat, and the urethane topcoat; on non-rusted areas (where the primer is at least equal to the minimum required dry film thickness) and on galvanizing: the tie coat, the epoxy intermediate coat, and the urethane topcoat.

Surfaces which will be inaccessible for coating after erection shall be repaired and/or recoated prior to erection.

When the erection work has been completed, including all connections and the straightening of any bent metal, the steel shall be prepared for repairs. All adhering scale, dirt, grease, form oil, or other foreign matter shall be removed by appropriate means and any rusted or uncoated areas blast cleaned to a near-white finish in accordance with SSPC SP 10. All abrasive and

paint residue shall be removed from steel surfaces by vacuuming or by double blowing, except that if the double blowing method is used, the top surfaces of all structural steel, including top and bottom flange, splice plates, hangers, etc. c., shall be vacuumed after the double blowing operations are completed. The coating surrounding the blasted area shall be thoroughly wire brushed, vacuumed, and the area recoated with the same coating system used in the shop. When sprayinig a blasted area or an area of insufficient primer thickness, the surrounding area will get covered with primer. Prior to the application of the intermediate coat, the area around the area where the primer has been repaired shall be adequately rubbed to remove the primer from the epoxy or urethane. The requirements specified herein for provisions for inspection, mixing the coating, thinning the coating, temperature and humidity requirements for coating, and applying the coatings, shall govern the application of the coating to the repaired areas. The requirements for the dry film thickness of the repair coats are the same as for the shop coats. Proper curing conditions will be required between the application of the coatings. Minimum curing times for each product of the system are listed on the Qualified Products List. No more than 60 calendar days will be permitted between coats. If this limit is exceeded, all newly coated surfaces shall be hand sanded prior to the next coat.

Galvanized nuts, bolts, and washers shall be coated in accordance with the recommendations of the manufacturer of the coating system. This procedure shall include the removal of any residuals on the surface and the application of a tie coat prior to application of the field coats. This tie coat may be brushed.

Any temporary attachments or supports for scaffolding or forms shall not damage the coating system. (In particular, on the fascias where bracing is used, sufficient size support pads must be used.) Any damage that occurs from such devices shall be repaired by the above procedure.

K. Protection Of The Work - Pedestrian, vehicular, and other traffic upon or underneath the structure shall be protected. All portions of the structures (superstructure, substructure, slope protection, and appurtenances) shall be protected against splatter, splashes, and smirches of coating or coating materials by means of protective covering suitable for the purpose. Similar protections shall be afforded any appurtenances that could be damaged by blast cleaning operations. The Contractor shall be responsible for any damage caused by his operations to vehicles, persons, or property.

Whenever the intended purposes of the protective devices are not being accomplished, work shall be suspended until corrections are made. In addition, any abrasive material and debris deposited on the pavement, shoulders, or slope paving in the working area shall be removed before those areas are reopened to traffic.

L. Stenciling Requirement - At the completion of the shop coating, the completion date (month and year) shall be stenciled on the inside of the fascia beams, at the locations designated by the Engineer, in 4-inch numbers; for example: 6/86. The paint used for this marking shall be the same as the topcoat except the color shall be black.

M. Measurement And Payment - The completed work of Structural Steel, Furnishing and Fabricating (of the type specified) includes furnishing, fabricating, and cleaning the structural steel; furnishing and applying the complete shop applied coating system including the stenciling and the field repair of the coating system.

TYPICAL SPECIFICATION

Not To Be Used For Direct Substitution

If used in its entirety or any portion, it should be reviewed by
CORROSION CONTROL CONSULTANTS AND LABS, INC.
1104 Third Avenue
Lake Odessa, Michigan 48849
Telephone (616) 374-8185

SUPPLEMENTAL SPECIFICATION FOR CLEANING AND COATING EXISTING A-588 STEEL STRUCTURES AND OTHER STEEL STRUCTURES WITH HEAVY CORROSION

05-12-86

A. Description - This work shall consist of the complete blast cleaning and coating of the metal surfaces of existing A-588 steel structures and other steel structures with heavy corrosion, including downspouts and all brackets. If any portion of the deck is to be removed, then the top of all the exposed top flanges shall also be blast cleaned and prime coated according to this specification. Utility conduits shall also be cleaned and coated according to this specification but shall be done only when called for on the plans. This work excludes hand railings and chain link fence enclosures.

Terminology used herein is in accordance with the definitions used in Volukme 2, Systems and Specifications of the SSPC Steel Structures Painting Manual (1982 Edition).

B. Coating Ssystem - The Contractor shall select a complete coating system from one of the approved coating systems listed in the attached Qualified Products List (QPL).

The Contractor shall supply the Engineer with the product data sheets before any coating is done. The product data sheets shall indicate the mixing and thinning directions, and the recommended spray nozzles and pressures.

C. Color Requirements -

D. Cleaning of Structures - All areas of oil and grease on surfaces to be coated shall be cleaned with clean petroleum solvents and then all the surfaces to be coated shall be blast cleaned to a commercial finish as defined in SSPC-SP 6. See SSPC Visual Standards. (See Note 1).

All fins, tears, slivers, and burred or sharp edges that are present on any steel member, or that appear during the blasting operation, shall be removed by grinding and the area reblasted to give a 1 to 2-mil surface profile. Scaling hammers may be used to remove heavy scale but heavier type chipping hammers which

would excessively scar the metal shall not be used.

Abrasives used for blast cleaning shall be either clean dry sand, steel shot, mineral grit, or manufactured grit and shall have a gradation such that the abrasive will produce a uniform profile of 1 to 2 mils, as measured with Testex Replica Tape. Due to surface roughness from corrosion, this method will not work on A-588 structures; Thus for each lot of abrasive, the Contractor shall supply an unblasted piece of steel at least one foot square and 1/4 inch thick and blast it on site with their standard procedures. The inspector will determine the profile on this piece.

All abrasive and paint residue shall be removed from steel surfaces with a good commercial grade vacuum cleaner equipped with a brush-type cleaning tool, or by double blowing. If the double blowing method is used, the exposed top surfaces of all structural steel, including flanges, longitudinal stiffeners, splice plates, hangers, etc., shall be vacuumed after the double blowing operations are completed. The steel shall then be kept dust free and primed within 8 hours after blast cleaning.

Care shall be taken to protect freshly coated surfaces, bridge bearing components, hand railings, galvanized fence enclosures, all appurtenances, and any adjacent concrete from blast cleaning operations. These areas shall be protected from blasting operations by masking. Blast damaged primed surfaces shall be thoroughly wire brushed or if visible rust occurs, be reblasted to a near-white condition. The wire brushed or blast cleaned surfaces shall be vacuumed and reprimed.

For structures with piers, a minimum of 5 feet on each side of the piers shall be blast cleaned on the same day and primed as a unit to prevent damage to previously primed surfaces.

E. Mixing the Coating - The coating shall be mixed with a high shear mixer (such as Jiffy Mixer) in accordance with the manufacturer's directions, to a smooth, lump-free consistency. Paddle mixers or paint shakers are not allowed. Mixing shall be done, as far as possible, in the original containers and shall be continued until all of the metallic powder or pigment is in suspension.

Care shall be taken to ensure that all of the coating solids that may have settled to the bottom of the container are thoroughly dispersed. The coating shall then be strained through a screen having openings no larger than those specified for a No.50 sieve in ASTM F 11. After straining, the mixed primer shall be kept under continuous agitation up to and during the time of application.

F. Thinning the Coating - In general the coatings are supplied for normal use without thinning. If it is necessary to thin the coating for proper application in cool weather or to obtain better coverage of the urethane topcoat, the thinning shall be done in accordance with the manufacturer's recommendations.

G. Conditions for Coating - Coating shall be applied only when the following conditions have been met:

1. Temperature - The temperature of the air and the steel shall be above 50 F for coatings other than the topcoat. For the urethane topcoat, the temperature of the air and steel shall be above 40 F. Coatings shall not be applied if the temperature is high enough to cause blistering. The surface temperature shall be at least 5 F higher than the dew point.
2. Humidity - The coating shall not be applied when the relative humidity is greater than 90 percent nor when a combination of temperature and humidity conditions are such that moisture condenses on the surface being coated.

H. Coating of Structures - After the surface to be coated has been cleaned and approved by the Engineer, the coatings shall be applied with the spray nozzles and pressures recommended by the producer of the coating system, so as to attain the film thickness specified. The minimum dry film thickness for the primer shall be three (3) mils; the intermediate coat and the urethane topcoat shall be sufficient to provide complete coverage and a uniform appearance (See Note 2). In no case shall the intermediate coat be less than three and one half (3.5) mils nor the topcoat less than one (1) mil. The dry film thickness will be determined by use of a magnetic film thickness gauge. The gauge shall be calibrated on the blasted steel with plastic shims approximately the same thickness as the minimum dry film thickness. A Tooke Film Thickness Gage may be used to verify the coating thickness when requested by the Engineer (See Note 3). If the Tooke Gage shows the primer coat to be less than the specified minimum thickness, the total coating system will be rejected even if the total dry film thickness exceeds the minimum.

If the application of coating at the required thickness in one pass produces runs, bubbles, or sags, the coating shall be applied in multiple passes of the spray gun, the passes separated by several minutes. Where excessive coating thickness produces "mud-cracking," such coating shall be scraped back to soundly bonded coating and the area recoated to the required thickness.

All dry spray shall be removed, by sanding if necessary. In areas of deficient primer thickness, the areas shall be thoroughly cleaned with power washing equipment, as necessary to remove all dirt; the areas shall then be wire brushed, vacuumed and recoated.

Proper curing conditions will be required between the application of all coats. Minimum curing times for each product of the system are listed on the Qualified Products List.

After the steel is primed, it shall be vacuumed again before

subsequent coating. If for any reason this vacuuming does not remove all the accumulated dust and/or dirt, or if more than three weeks has elapsed since the steel was primed, or if in the opinion of the Engineer the surface is unfit for topcoating, the surface shall be scrubbed with a mild detergent solution (any commercial laundry detergent) and thoroughly rinsed with water and allowed to dry for 24 hours before the surface is coated.

All metal coated with impure, unsatisfactory, or unauthorized coating material, or coated in an unworkmanlike or objectionable manner, shall be thoroughly cleaned and recoated or otherwise corrected as directed by the Engineer.

I. Provisions for Field Inspection - The Contractor shall furnish and erect scaffolding meeting the approval of the Engineer to permit inspection of the steel prior to and after coating.

Rubber rollers, or other protective devices meeting the approval of the Engineer, shall be used on scaffold fastenings. Metal rollers or clamps and other types fastenings which will mar or damage freshly coated surfaces shall not be used.

J. Protection of the Work - Pedestrian, vehicular, and other traffic upon or underneath the structure shall be protected. All portions of the structures (superstructure, substructure, slope protection, and appurtenances) shall be protected against splatter, splashes, and smirches of coating or coating material by means of protective covering suitable for the purpose. Similar protection shall be afforded any appurtenances that could be damaged by blast cleaning operations. The Contractor shall be responsible for any damage caused by his operations to vehicles, persons or property.

During blast cleaning operations, the Contractor shall make provisions for protection of existing traffic from any hazards resulting from the blast cleaning operations. These provisions shall include a type of barrier system which would protect against direct blasting of vehicles or pedestrians, eliminate abrasive materials and debris from falling on the traveled portions of the pavement, and prevent the spreading of abrasive materials and debris into an area which would create a traffic hazard.

Whenever the intended purposes of the protective devices are not being accomplished, work shall be suspended until corrections are made. In addition, any abrasive material and debris deposited on the pavement, shoulders, or slope paving in the working area shall be removed before those areas are reopened to traffic.

K. Stenciling Requirement - At the completion of the coating, the completion date (month and year) shall be stenciled on the structure in 4-inch numbers; for example: 6/86. The paint used for this marking shall be the same as the topcoat except that the color shall be black.

The numbers shall be stenciled on the inside of each facia beam at the approaching traffic end of the structure. The two required markings shall be located at least 10 feet from the abutment. If these locations are not applicable to the structure, the locations of the two markings will be designated by the Engineer.

L. Measurement and Payment - The completed work as measured for CLEANING AND COATING EXISTING A-588 STEEL STRUCTURES AND OTHER STEEL STRUCTURES WITH HEAVY CORROSION will be paid for at the contract unit prices for the following contract items (pay items).

Pay Item	Pay Unit
Cleaning Existing Steel Structure,(Structure No.)	Lump Sum
Coating Existing Steel Structure, (Structure No.)	Lump Sum

Stenciling is considered a part of the work of Coating Existing Steel Structure, (Structure Number) and will not be paid for separately.

The following notes are listed only to be a help to the bidder in determining the bid. They are not contract provisions, but point out some of the not so obvious problems which have been encountered during blasting and coating of weathered A-588 Steel and heavily corroded structural steel.

Note 1. In many areas, especially under joints, the steel is heavily pitted. The complete removal of the last remaining trace of visible rust products is practically impossible. This being the case the definition of a commercial blast cannot be achieved. To solve this problem in these areas the appearance of a commercial blast is required, i.e., when compared to the visual standard the surface shall look the same. Even this is difficult but it does allow for very very small rust deposits at the base of a pit.

Note 2. Once again the pitting in the blasted surface causes a problem. The dry film thickness of the primer varies greatly, typically between 3 and 12 mils. The specification calls for a minimum of 3 mils; to achieve this much more paint than normal is required in a pitted area. The inspector is instructed to look for the low areas.

There are some spray techniques and equipment that greatly affect the amount of urethane that is required for complete coverage and a uniform appearance. These include the application technique of both the primer and the intermediate coat.

Note 3. All dry film thickness gauges shall be calibrated on a relatively smooth section of the blasted web, not in a heavily pitted area.

Qualified Product List
Systems Listed in Alphabetical Order by Producer
Use: Coating of Existing Steel Structures
Type 4

Producer / Products	Minimum Dry Film Thickness Mils*	Coats Represented By: Color	Min.Time Between Coats Hrs.	Coats
Ameron Protective Coatings Division Dimetcoat 68A 48 Amercoat 383HS 24 Amercoat 450GL	B. Marshall 4.0 Same 3.5 313-886-5555 1.0			1st Tinted 2nd White 3rd **
201 North Berry Street Brea, CA 92621				
Carboline Carboline 658 48 Carboline 190FD 24 Carboline 134	PCA, Inc. 4.0 6315 E. 7 Mile, Suite 200 3.5 Detroit, MI 48234 1.0 313-891-2060			1st Tinted 2nd White 3rd **
320 Hanley Industrial Ct. St. Louis, MO 63144				
Devoe-Napko Zinc Prime 115 48 Chemfast Epoxy 24	Same 4.0 502-897-9861 3.5			1st Tinted 2nd 547 White
P.O. Box 7600 Louisville, KY 40207 Prufthane	1.0	**		3rd 369
Hempel Marine Paints, Inc. Hempadur Zinc 1535 P.O. Box 3279 Hempadur Hi-Build 4520 Wallington, NJ 07057 Hempathane 5528	Robert Coy 4.0 Same 3.5 201-939-9411 1.0	Tinted White **	48 24	1st 2nd 3rd
P.P.G. Industries Aquapon Zinc Rich 9933 Lawler Ave. Aquapon 97-3 Lansing, MI 48917	John Felice 4.0 3928 West Saginaw 3.5 3rd	Tinted White	48 24	1st 2nd Suite 260 Pitthane

Acrylic Urethane Skokie, IL 60077	1.0 517-323-9144	**
Porter Paint Company Zinc Lock 308 48 400 South 13 Street 43 24 Louisville, KY 40201 Hythane 502-588-9200	Pontiac Paint Company 4.0 1310 West Wide Track Dr. 3.5 Pontiac, MI 48058 1.0	1st Tinted 2nd MCR White 3rd **
Sherwin Williams Zinc Clad 7 48 Tile Clad II Enamel 24 Alphatic Polyurethane	Tim Lathrop 4.0 1137 Haco Drive 3.5 Lansing, MI 48912 1.0 517-482-5587	1st Tinted 2nd White 3rd **
Tnemec Company, Inc 90-94 Tneme-Zinc 48 North Kansas City, Series 66 Epoxoline 24 Missouri 64116 Series 72 Endura Shield II	Mich Protective Coatings 4.0 Brad Brown 3.5 P.O. Box 39287 1.0 Detroit, MI 48239 313-538-7878	1st Tinted 2nd White 3rd **
Valspar Corporation MZ-4 48 901 N. Greenwood Ave. Val-Chem 89 Epoxy 24 Kankakee, Ill 60901 Series Urethane	Bill Slabinski 4.0 1401 Severn Street 3.5 Baltimore, MD 21230 1.0 ** 800-638-7756	1st Tinted 2nd White 3rd 40

* The intermediate coat and the urethane topcoat shall be of sufficient dry film thickness to completely cover the prime coat and the intermediate coat respectively and produce a uniform color and appearance.

**** The color number for the urethane topcoat shall match the color number shown on page 1 of this specification.**

SECTION II. REMOVAL OF LEAD-BASED PAINTS

In the last 5 years a number of states (including Virginia, North Carolina, Maryland, New Jersey, Massachusetts, California, and Michigan) have had difficulties in removing lead-based paints from existing structures. This problem has become so important that in Virginia, South Carolina, and Michigan major research efforts are taking place. Some states, Virginia and South Carolina, have had problems with the disposal of the spent material which has been declared a hazardous waste under federal laws. Unfortunately the type of products ADOT uses would probably also have this problem. Other states, Massachusetts and Michigan, have had problems with the public health divisions of state and local government agencies. The problem here is the lead that is carried to the surrounding environment[2] (a public health concern) and the exposure[3] of the workers to dangerous levels of lead (an occupational safety concern). It is obvious that this problem will not just go away. The health concerns are based on thorough medical research and should not simply be ignored as another bureaucratic scare. (For example; before any damage is detectable two-thirds of the kidney function can be lost due to exposure of low levels of lead over the years).

The best study available which deals with this problem is NCHRP Report #265, "Removal Of Lead-Based Bridge Paints." (This study is too lengthy to place in an appendix.) The report describes the various solutions to the problem, analyzes the costs of each solution, and predicts the probability of success of each solution. It is well written and will easily convince anyone of the dangers. We urge you to make a copy available to all those involved in handling lead-based paints, especially the foremen.

SECTION III: REVIEW POSSIBLE SUBSTITUTES FOR LEAD-BASED PAINTS

This task as outlined by Arizona Department of Transportation would involve the writing of a book. This in fact is what the NCHRP (National Cooperative Highway Research Program) has done. They are publishing a book entitled Bridge Painting Synopsis. This book will be available in 1987. It was written by Clive Hare, reviewed and approved by an NCHRP committee (of which Gary Tinklenberg was a member). This work is the most comprehensive publication on bridge painting of which we are aware.

The scope of this type of work is well beyond the financial constraints of our current project. Therefore we will perform the review on a few typical systems, not on all available substitutes.

The following systems will be reviewed:

I. For new work:

A. Total Shop Painting

B. Shop Prime Field Topcoat

II. For existing structures:

C. An inorganic zinc-rich system

D. An organic zinc-rich system

E. An alkyd no-lead, no-chromate system

F. A one-component urethane system

G. An epoxy system that meets low VOC requirements

H. An epoxy mastic system

A painting system consists of a number of elements, not simply the paint. Different systems require different levels of surface preparation, number of coats, levels of inspection, and levels of maintenance. A brief discussion for each selected system, its various components, and the reasons for each component follows.

SYSTEM A TOTAL SHOP PAINTING

Components

Surface Preparation	- commercial blast
Number of Coats	- two
Type of Paint	
- Primer	- urethane
- Topcoat	- urethane
Inspection	- mandatory, but due to easy accessibility, not difficult
Alternates	- epoxy primer could also be used
Availability	- currently this concept is new to many fabricators but it is gaining popularity
Advantages	- lowest cost (see cost comparison in Table I) - very little field inspection - primer is well protected from elements; e.g., not even exposed during construction - very easy to inspect in shop
Disadvantages	- unfamiliar to many agencies and fabricators - requires trained inspectors

Discussion: The benefits of this system are described in two articles published in major journals[4,5].

SYSTEM B SHOP PRIME FIELD TOPCOAT

Components

Surface Preparation	- commercial blast
Number of Coats	- three
Type of Paint	
- Primer	- alkyd
- Intermediate	- alkyd
- Topcoat	- silicone alkyd
Inspection	- difficult; requires detailed inspection of primer after erection of structure
Alternates	- could use organic zinc-rich primer
Availability	- readily available
Advantages	- similar to current system, therefore people are accustomed to it
Disadvantages	- many disputes on repair of primer (or cleaning of primer) - primer can be difficult to clean - primer easily contaminated - can have adhesion problems with intermediate coats

Discussion: The Michigan Department of Transportation attempted to use a similar system in Michigan for four years, but the problems in the field were so pronounced that the system was discontinued.

SYSTEM C AN INORGANIC ZINC-RICH

Components

Surface Preparation	- near-white blast
Number of Coats	- two or three
Type of Paint	
- Primer	- inorganic zinc-rich
- Intermediate	- epoxy
- Topcoat	- urethane
Inspection	- mandatory and sophisticated
Alternates	- could use a vinyl topcoat but chalking is a problem
Availability	- readily available
Advantages	- outstanding corrosion performance (if applied correctly) - good appearance - low cost per service year in a corrosive environment
Disadvantages	- requires excellent inspection - requires skilled application - requires moisture to cure (except for high-ratio silicate types) - durability very sensitive to primer thickness - sensitive to poor surface preparation

Discussion: This system was also used for four years in Michigan. The disadvantages grew to the point where it became necessary to discontinue use of this system in 1985.

SYSTEM D AN ORGANIC ZINC-RICH

Components

Surface Preparation	- near-white blast
Number of Coats	- three
Type of Paint	
- Primer	- epoxy zinc-rich
- Intermediate	- epoxy
- Topcoat	- urethane
Inspection	- mandatory; detailed on primer. - extremely easy on intermediate and topcoat
Alternates	- could substitute a commercial blast
Availability	- readily available from many suppliers
Advantages	- good durability in corrosive environments - easy to inspect intermediate and topcoat - tolerates less than ideal conditions and inspections - good appearance
Disadvantages	- requires skilled applicator - requires detailed inspection of primer dry film thickness - overspray problems

Discussion: This system is the system currently in use in Michigan. It (or something similar) is used by a number of other States with a great deal of success. Our experience indicates that there are smaller practical differences in cost than appear to be present in theoretical projections between a near-white blast and a commercial blast.

In the field it is necessary to get contractors to reblast small areas that were done early in the day and have rusted back. Additionally we have found a much greater inspection variability with a commercial blast than a near-white blast. For these reasons we recommend a near-white blast. We urge use of the product that tolerates a lack of specification compliance. This, if nothing else, is cheap insurance.

SYSTEM E AN ALKYD NO-LEAD, NO-CHROMATE

Components

Surface Preparation	- touch up rusted areas; power wash remainder of structure
Number of Coats	- one
Type of Paint - Topcoat	- silicone alkyd
Inspection	- easy but performance is still dependent on good inspection
Alternates	- none
Availability	- readily available; best availability of formula specifications of all systems
Advantages	- easy to apply - easy to inspect - very familiar to industry - readily brushable - will isolate lead from environment
Disadvantages	- poor tolerance of salt and environmental temperature extremes - does not eliminate lead; only isolates it from environment

Discussion: This type of system would be very familiar to ADOT personnel with experience in applying and maintaining the lead-based system previously used. Therefore a change to this type of paint could be made with minimal inconvenience.

SYSTEM F A ONE-COMPONENT URETHANE (MOISTURE CURE)

Components

Surface Preparation	- commercial blast
Number of Coats	- two
Type of Paint	
- Primer	- moisture cure urethane
- Topcoat	- aliphatic urethane
Inspection	- easy
Alternates	- some companies prefer an epoxy intermediate
Availability	- various paint companies manufacture these types of paints, however the resin for the primer is basically available only from one supplier
Advantages	- tolerates poor surface preparation - good appearance
Disadvantages	- time between coats is critical

Discussion: This system was used on four structures in Michigan. All four had major topcoat delamination problems within two years. The use of this system has been discontinued in Michigan. We would not recommend this system until (and unless) the sensitivities of recoat interval (time, temperature and humidity) have been greatly reduced.

SYSTEM G AN EPOXY SYSTEM (LOW VOC)

Components

Surface Preparation	- near-white blast
Number of Coats	- two or three
Type of Paint	
- Primer	- high-solid epoxy
- Intermediate	-
- Topcoat	- high-solid urethane
Inspection	- easy
Alternate	- none
Availability	- limited, only a few suppliers offer this type of system (many have products in the development phase)
Advantages	- low VOC; e.g., meets E.P.A. solvent emission requirement - easy to work with
Disadvantages	- no long term proven performance - difficult to apply in thin films therefore high paint usage - could have compatibility problem with existing paints; thus would require more than normal amount of preliminary testing

Discussion: These are a new generation of coatings brought about by the E.P.A. restrictions on the emission of volatile organic compounds (VOC). They have been on the market only a short while. Little independent test data is available.

SYSTEM H AN EPOXY MASTIC

Components

Surface Preparation	- commercial blast
Number of Coats	- two or three
Type of Paint	
- Primer	- epoxy mastic
- Topcoat	- urethane
Inspection	- easy
Alternates	- none
Availability	- readily available
Advantages	- easy to apply - tolerates poor surface preparation
Disadvantages	- many suppliers claim one coat is all that is necessary and blasting is not necessary

Discussion: The claims for this type of system are not well supported among government agencies. Ohio DOT tried for a number of years to get by with one coat only to give up due to the numerous immediate rust failures. One-coat application is simply too sensitive to applicator skill and inspection (or lack of it). This being the case, two coats are usually used. Since good long-term appearance is necessary, these must be topcoated with a urethane. The use of the two coats is recommended.

SECTION IV. COST COMPARISON OF THE VARIOUS SYSTEMS

To calculate costs for any paint system is difficult since the costs are to a great extent dependent on the structure to be painted, the make-up of the local market and the cost the local market is willing to bear. For this reason the best one can do is to 1), compare the systems on an individual structure or market, or 2), make some assumption and compare one system to another. Since we are not experienced in the Arizona market and we are dealing with systems that for the most part are new to the Arizona market, the second method is the method that will be used.

Three methods for estimating cost and, as such, the value of the system will be used.

I. A comparison of costs based on 1981 Steel Structures Painting Council information.

II. A comparison based on the information supplied in the soon-to-be-published NCHRP Bridge Painting Synthesis.

III. A comparison based on the costs supplied by the NCHRP but the length of useful life modified based on our experience and a visit to the Phoenix area.

A brief discussion of each follows.

The SSPC-Based Method

Table II is based on information contained in "Good Painting Practice" published by the Steel Structures Painting Council in 1982. This Table should be used only for comparison purposes since all systems should be adjusted by inflation. (Since it will be a constant, it was not necesesary to incorporate it into the Table; all systems would be affected equally.) The life predictions are very short in this reference since they are based on the time to a given level of rust on test panels, not the typical maintenance painting cycle used by most agencies. However, the costs on a relative basis are still helpful.

Table III is based on the information that was supplied by the NCHRP (National Cooperative Highway Research Program) in a synthesis on Bridge Painting. This price information is much more current and the length of useful life is based on a maintenance painting cycle. These are the most accurate cost projections of which we are aware.

The last two columns of Table III contain comparative predicted life and cost estimates based on our experience. The values listed in the NCHRP study assume that the job was properly done. The problem with this assumption is that there are such great differences in the various systems' ability to tolerate mistakes. The probability of getting the job done properly on a State-wide basis has been factored into the predicted useful life.

As one can see from Table I the comparisons are all in general agreement in ranking the various systems. It is clear that the best systems are not always the cheapest on an initial cost basis. If further projections are made comparing the net present value of the options, the total shop system is an even bigger bargain. The differences in the field painting cost are closer together with some of the long-term systems losing some of their cost advantage. No attempt was made to do a net present value analysis however, since most State agencies do not function on a financial basis that involves a cost for money. The method also does not take into account public inconvenience during painting operations or the value of a bridge that "looks good" for a long time.

TABLE I

A COMPARISON OF THE VARIOUS COSTING METHODS

In the Table below the "best" system (lowest cost per service year) was given a '1' rating.

SYSTEM TYPE	METHOD SSPC	NCHRP	MODIFIED NCHRP
NEW STEEL			
A. TOTAL SHOP	1	1	1
B. SHOP PRIME/FIELD TOPCOAT	2	2	2
EXISTING STRUCTURES			
C. INORGANIC-FIELD APPLIED	5	5	6
D. ORGANIC-FIELD APPLIED	6	6	5
E. NO-LEAD ALKYD	1	1	1
F. MOISTURE CURE URETHANE	4	2	2
G. LOW VOC EPOXY	3	4	4
H. EPOXY MASTIC	2	3	3

TABLE II COST COMPARISON USING 1981 SSPC DATA

System	Use	Surface Prep	Paint	Labor	Total	Increase due to working above ground[1]	Predicted Service Life[10]	Cost per Service Year/SqFt
A	New	.26	.17	.36	.79[2]	.82[3]	8	.1025
B	New	.26	.17	.48	.91	1.21	7	.173
C	Existing[7]		.27	.65	1.77	2.35	12	.196
D	Existing[7]		.28	.65	1.78	2.37	12	.198
E[4]	Existing[8]	.20[9]	.10	.26	.56	.74	7	.106
F[4]	Existing[8]	.20[9]	.12	.34	.66	.88	5[5]	.176
G[4]	Existing[8]	.20[9]	.44	.38	1.02	1.36	8[6]	.17
H[4]	Existing[9]	.20[9]	.20	.38	.78	1.04	8	.13

1 Since the manuals list a range of 25% to 50%, 33 was used. (It is assumed ADOT has more simple structures than complex; therefore the skew.)

2 Includes touch-up.

3 The increase in cost was added only to the field operations.

4 These paint systems are not in the SSPC Manual. We used a similar system for paint costs and adjusted based on experience.

(TABLE II, COST COMPARISON, continued)

5 Much higher (8) if attention is paid to recoat interval, but (5) based on field experience.

6 Estimate.

7 Eliminates lead on the structure.

8 Encapsulates lead; only isolates it from environment.

9 Power wash surface (0.10/sq.ft.); hand tool clean only rusted areas (0.10/sq.ft.)

10 All values for existing structures that do not remove the lead (Systems E-H) are estimates based on the life of the system on new steel.

TABLE III COST COMPARISON USING 1987 NCHRP DATA

System	Surface Prep	Paint	Labor	Total	Total with increase due to above grnd	Predicted Service Life NCHRP	Cost/sq.ft. per service year NCHRP	Predicted Life based on personal experience *	Cost based on personal experience
A	.30	.23	.44	.97[3]	1	35	0.028	35	0.028
B	.30	.21	.46	.97[3]	1	30	0.032	30	0.032
C	1.32	.32	.79	2.43	1	40	0.0608	30	0.081
D	1.32	.37	.66	2.35	1	35	0.0671	40	0.05875
E	.15	.10	.25	.50	1	20	0.025	25	0.02
F	.15	.226	.40	.78	1	20	0.039	25	0.0312
G	.15	.30[2]	.40	.85	1	20[4]	0.0425	25	0.034
H	.15	.24	.40	.79	1	20	0.0395	25	0.0316

* And Arizona environment

1 Already taken into account in basic cost data.

2 Estimate

3 Includes touch-up

4 Estimate; this system is not listed in the report.

SECTION V. PERFORMANCE EVALUATIONS FOR TRAFFIC PAINTS

The main reason to consider establishing a performance specification is to reduce overall costs. If only one dollar per gallon could be saved, this would amount to over a quarter of a million dollars a year in savings. Even after subtracting the cost of the testing program ($50,000 to $100,000 depending on the test parameters selected), there are still substantial savings.

The only realistic way to evaluate traffic stripes is to place them on a highway side by side and measure the degradations with time. There are a number of variables that should be considered.

1. The different types of pavement - The same paint may perform much differently on concrete or bituminous surfaces.

2. Different environments - particularly those where snow plowing occurs.

3. Both daytime and nighttime appearance.

These variables are usually addressed by using two test zones each with bituminous and concrete pavement. The stripes are placed transverse to the traffic flow. This practice, although well used, has its drawbacks; however, since the test period is shortened, the advantages outweigh the disadvantages. The stripes are then evaluated by observers or with an instrument to measure retroreflectivity (nighttime visibility).

The performance method is being promoted by the Federal Highway Administration[6]. If the concept of regional evaluation laboratories gains support, this would be the most cost-effective way to specify traffic paints by performance.

Without a great deal more information on the current status of traffic marking in Arizona, no recommendations other than performance testing can be made.

SECTION VI. RECOMMENDATIONS

The recommendations are based on a review of the ADOT supplied information and a visit to the Phoenix area in January of 1987. There are ten specific recommendations for ADOT to consider. These are:

1. Type of bridge paint specification.
2. Type of evaluation procedure.
3. Application Specification Improvements.
4. Suggested method to generate an initial Qualified Products List.
5. Suggested method to maintain a Qualified Products List.
6. Method to maintain painting procedures and products.
7. Paint types for new structures.
8. Paint types for existing structures.
9. Concrete painting.
10. Traffic Paint.

These sections will be further subdivided, where appropriate in the following manner:

A. Summary of Recommendation.

B. Pertinent Background Information.

C. Alternatives.

D. Choice of and reasons for a specific alternative.

Section 1. Bridge Painting Specification Type

Recommendations

Adopt a performance type of product selection.

Background

The Department uses a formula type specification. A detailed explanation, including advantages and disadvantages is contained in a report written by the Michigan DOT[7].

Alternatives

- Maintain the current system.
- Change to performance system.

Reasons for recommendations

- Formula specifications require more development time than available at ADOT.
- There are a number of evaluation labs that can maintain the system for ADOT at very little cost, if any, to ADOT. (See recommendation 5.)
- Given the current staffing at ADOT it will be difficult (if not impossible) to properly maintain and technically service a formula specification.
- FHWA is in favor of performance specifications.
- Performance specifications tend to stay abreast (or lag only slightly) with technology.

Section 2. Type of Evaluation Procedure

Recommendation

An accelerated method with high priority given to ultra-violet and cyclic testing.

Background

The work to establish the method has already been done in other States.

Alternatives

"Real World" testing; e.g., exposing panels in a test area or on a bridge.

Reasons For Recommendations

- Corrosion is not a major problem in Arizona thus the most important tests are those that have the greatest effect on appearance.

- In the "real world", the time to evaluate the appearance changes in high quality paints is too long. (This is not to say that, as an on-going evaluation, panels should not be exposed by ADOT and evaluated on a routine basis. We would encourage this; however, not as an initial test to be accepted by ADOT.)

Section 3. Application Specifications

Recommendations

Rewrite the current specifications to better reflect current technology and eliminate loop-holes and easily misunderstood wording.

Background

The current procedural portions of the specifications have not been updated for quite some time. Additionally, the current specifications have been written for a slow-drying alkyd system.

Alternatives

None. If the paint system has already been revamped by removal of lead from the system, the procedures that so heavily depend on the properties of an alkyd system must also be changed.

Reasons for Recommendations

We would further suggest that ADOT issue a contract to conduct a training program and rewrite or review the paint application specification. Since this sounds like a self-serving recommendation we did not include it as a formal recommendation.

Section 4. Method To Generate An Initial Qualified Products List

Recommendations

Hire an independent lab to generate the initial list.

Background

ADOT does not use performance specifications.

Alternatives

Perform the testing with ADOT equipment and personnel.

Have the manufacturer do initial testing.

Reasons for Recommendations

- ADOT does not have a background in performance testing, although it could be developed. In conjunction with recommendation 5, we do not feel the in-house expertise and experience will be cost effective.

- This is a major procedural change for ADOT. This being the case, it is appropriate for ADOT to bear the initial cost of the change.

- It will give ADOT a good initial database.

- It results in a high degree of flexibility since standard can be adopted after the database is generated. If the manufacturer is to do all the initial testing, he should be given expected performance requirement prior to his commitment to spend the funds for the required tests (could be done, but difficult).

Section 5. Method to Maintain Qualified Products List

Recommendation

Require new suppliers to have their products evaluated by an independent lab according to ADOT procedures and have the independent lab submit the test results to ADOT. (These new products could also be types not on the initial list.)

Alternatives

ADOT will perform (or pay for) the evaluations.

Reasons for Recommendations

- State government agencies all too often become the testing labs for small paint companies. This will mandate a high level of confidence in a product before a product is tested.
- State government agencies are continually "harassed" with "the solution to all their problems" type products. This procedure will eliminate this hassle.
- There are a number of competent evaluation labs. ADOT certification of the lab is worth considering, however.
- The ADOT cost of maintaining this system is minimized.
- By allowing generic types not on the initial list, a good new system will have a chance of being approved.

Section 6. Method to Maintain Procedures, Practices and Qualified Products List

Recommendation

Set up an interdepartmental committee to administer the program. The committee should meet approximately twice a year and have two members from the following divisions:

- Maintenance
- Construction
- Design
- Materials
- Research

It is further recommended that this committee be staffed with middle management personnel, those most familiar with or responsible for the painting of structures (not the head of each division). This committee should be responsible to a high level of management.

Background

Our experience indicates that those who have to implement the policies have the most interest in how the policies are arrived at. In many departments the painting of structures is simply too trivial a problem to warrant a large amount of time from high level managers.

Alternatives

Continue with the current system.

Reasons for Recommendations

- This method promotes a mutual understanding of each division's problems; therefore relationships between departments usually improve.
- This system allows those that are active in the actual work (those with the highest level of interest) to have input into the decisions that will affect their jobs.
- This system has been used in Michigan for three years with a great deal of success.
- The system is independent of one or two key individuals.

Section 7. Paint Types for New Structures

Recommendations

The initial systems tested for new structures should be only ones which :

- use at least an SSPC surface preparation standard;
- use an epoxy or urethane primer (not moisture cure urethane;
- use an aliphatic or acrylic urethane topcoat.

Background

There are many different types of paint products available. Allowing companies to submit any generic system may result in far too many systems to practically evaluate. (The resulting high cost must also be considered.)

There has been work done by other agencies that can be used to select those generic classifications which are best suited to the problems with coating found in Arizona. Arizona does not have a corrosion problem. Thus the most important characteristic of a coating system is long term durability of a good appearance.

Alternatives

Let the manufacturers of various systems choose the best products for Arizona.

Reasons for Recommendations

- The best interests of ADOT and the best interests of a coating manufacturer could result in different systems.
- It would not only be impractical but also very expensive to test any generic system someone thought would work well.
- Although all urethane systems have some drawbacks, particularly in humid environments, the strong points of this type of system are in line with the conditions found in Arizona and the requirements of ADOT.
- These are relatively easy to apply in the shop, have good resistance to handling damage and are easy to touch up.

(Section 7, continued)

- Blasting will remove mill scale.

- Moisture cure urethane systems to date have had many problems in other agencies.

  Note: Special requirements would be needed in friction connections if this type of system is used.

Section 8. Paint Types for Existing Structures

Recommendations

Use only those systems that are compatible with the existing lead-based paints. An alkyd primer with a silicone alkyd topcoat is suggested.

Background

The problem many States are facing is the disposal of the spent abrasive used in the removal of lead-based paint. Once the abrasive is contaminated with lead-based paint there is a high probability it would be declared a hazardous waste under the current E.P.A. quidelines.

Alternatives

Remove all lead and repaint the structure with different systems.

Let the manufacturers of the various systems choose the test products for the system.

Reasons for Recommendation

- The first alternative is expensive and unnecessary.
- The second has the same problems as those listed under recommendation 7.
- Arizona does not have a corrosion problem thus during the repainting of structures for appearance reasons, the lead could be isolated from the environment under a non-lead paint system.
- The best chances of compatibility are with similar systems.

Section 9. Concrete Painting

Recommendations

Set up approval maintenance and administration procedures for concrete similar to the system recommended for steel.

Background

During the visit to Arizona we had the opportunity to spend some time driving around in the Phoenix area. We noticed a great deal of painted concrete. There were, in fact, a significantly greater number of concrete structures than steel structures.

Alternative

Continue with the status quo.

Reasons for Recommendations

- There is no data to support the position that the current methods optimize the benefit to ADOT.

- There is very little data available on the testing of coatings over concrete.

  Note: Although the format for testing coatings over steel and concrete is similar, some developmental work would be necessary to determine the best procedures for the testing of coatings on concrete.

Section 10. Traffic Paint

Recommendation

Maintain the current system and investigate the possibility of getting involved in a FHWA regional traffic paint testing center.

Background

Arizona has not had a problem with the disposal of barrels which contained lead-based paints.

Alternative

- Maintain the current formula specifications.
- Evaluate traffic paints in-house.

Reasons for Recommendation:

- Formula-specified systems tend to be more expensive in the long run.
- ADOT is satisfied with its current system. Therefore, there is no urgency to change systems. This being the case, a method for change at a low cost is to participate in a regional test program[6].

REFERENCES

1. Journal of Protective Coatings & Linings, Oct., 1985, p.1. Journal of Protective Coatings & Linings, Jan., 1986, pp.5-9.

2. The New England Journal of Medicine, 1982, Vol. 306 No. 11, pp.673-676.

3. Marilyn H. Toby: TRNews, Jan.-Feb., 1984, No. 110, pp.2-4.

4. James D. Culp, Gary Tinklenberg, and Jon Reincke: Civil Engineering, Oct., 1986, pp.42-44.

5. Gary Tinklenberg and James D. Culp: Journal of Protective Coatings & Linings, June, 1984, pp. 26-29.

6. Dennis C. Judyckli and R.J. Betsold: FHWA, 6300 Georgetown Pike, HRT-10, McLean, Virginia 22101-2296, Subject: Pavement Marking Workshops - Quality Control and Testing, Dec 5, 1986.

7. G. L. Tinklenberg: Research Report No.R-1273, Michigan Department of Transportation, Lansing Michigan, July, 1986.