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Low-Solvent Primer and Finish Coats for Use on Steel Structures

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This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

A number of low solvent coatings designed for application to structural steel were evaluated in the laboratory. Coatings determined to provide the best performance from laboratory studies were water-borne primers based on a styrene acrylic emulsion and water-borne finish coats based on a 100% acrylic emulsion.

The water-borne coatings developed in this project were applied to over seventy-five steel highway structures at various locations in California. In most cases the water-borne coatings that were applied are providing satisfactory performance. Application of the water-borne coatings is not recommended at temperatures below 50°F or if the relative humidity exceeds 75%. Additional limits may be required for surface temperature of steel. New low-solvent coatings are currently being evaluated that will comply with air quality regulations and may not be as limited by weather conditions.

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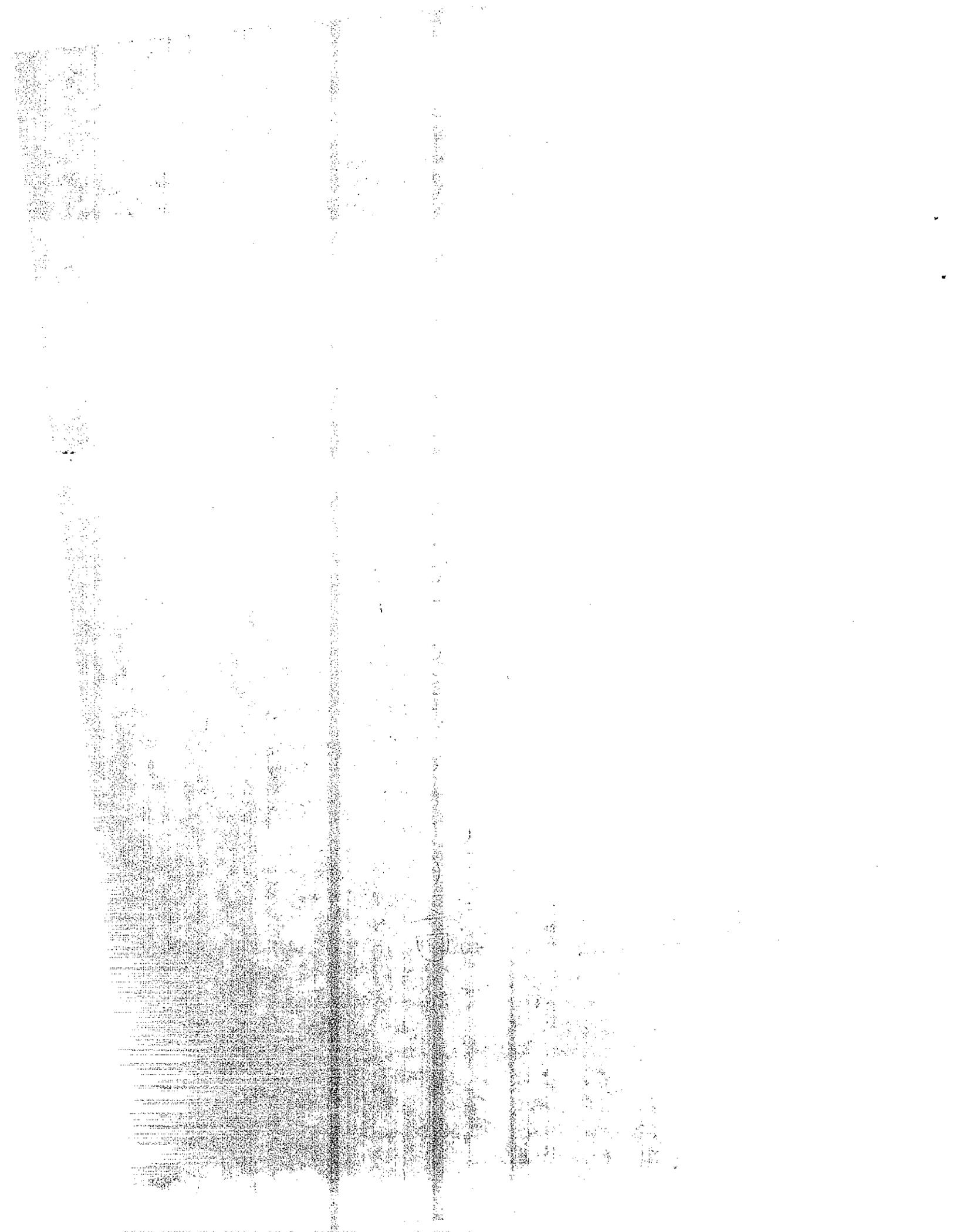
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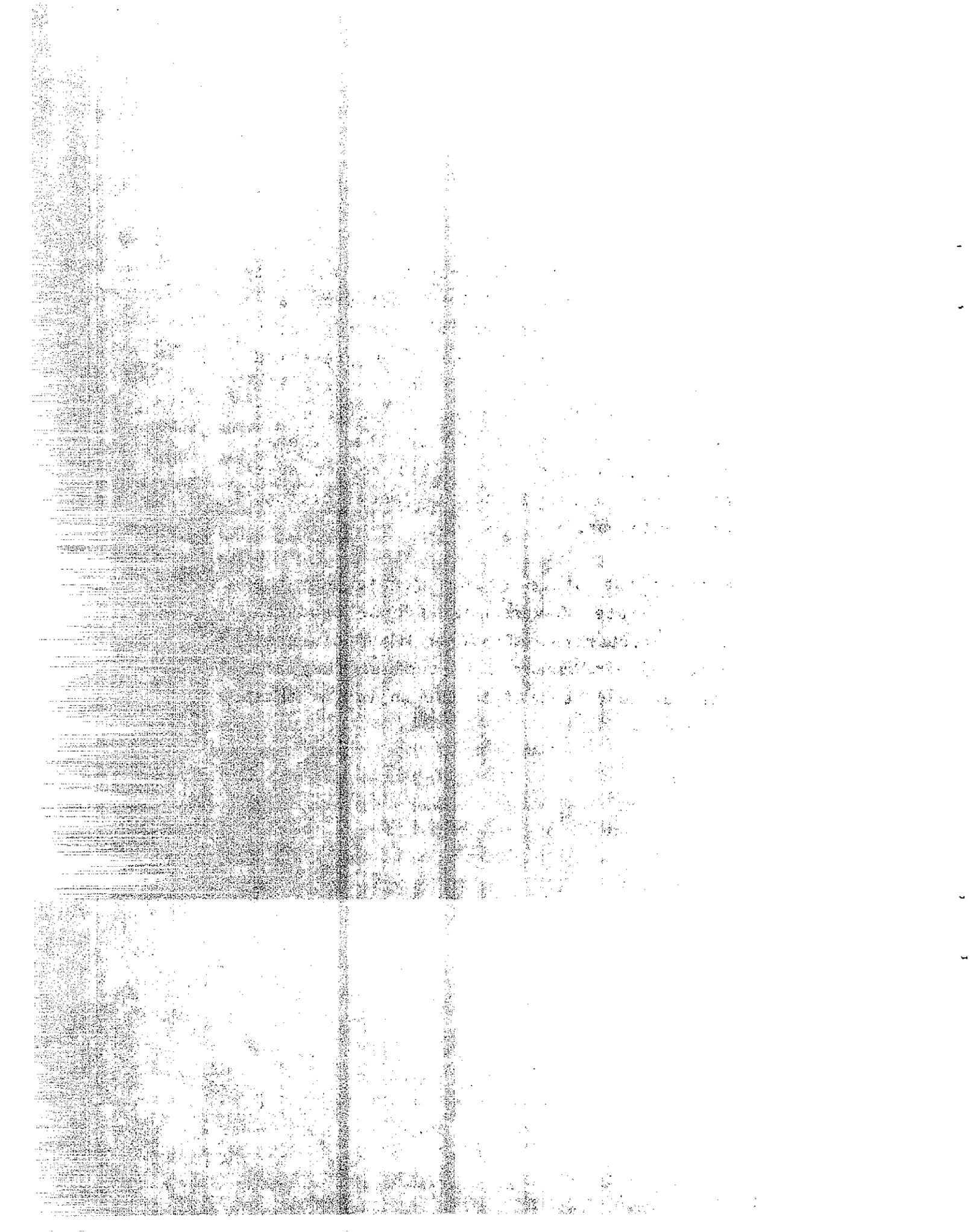
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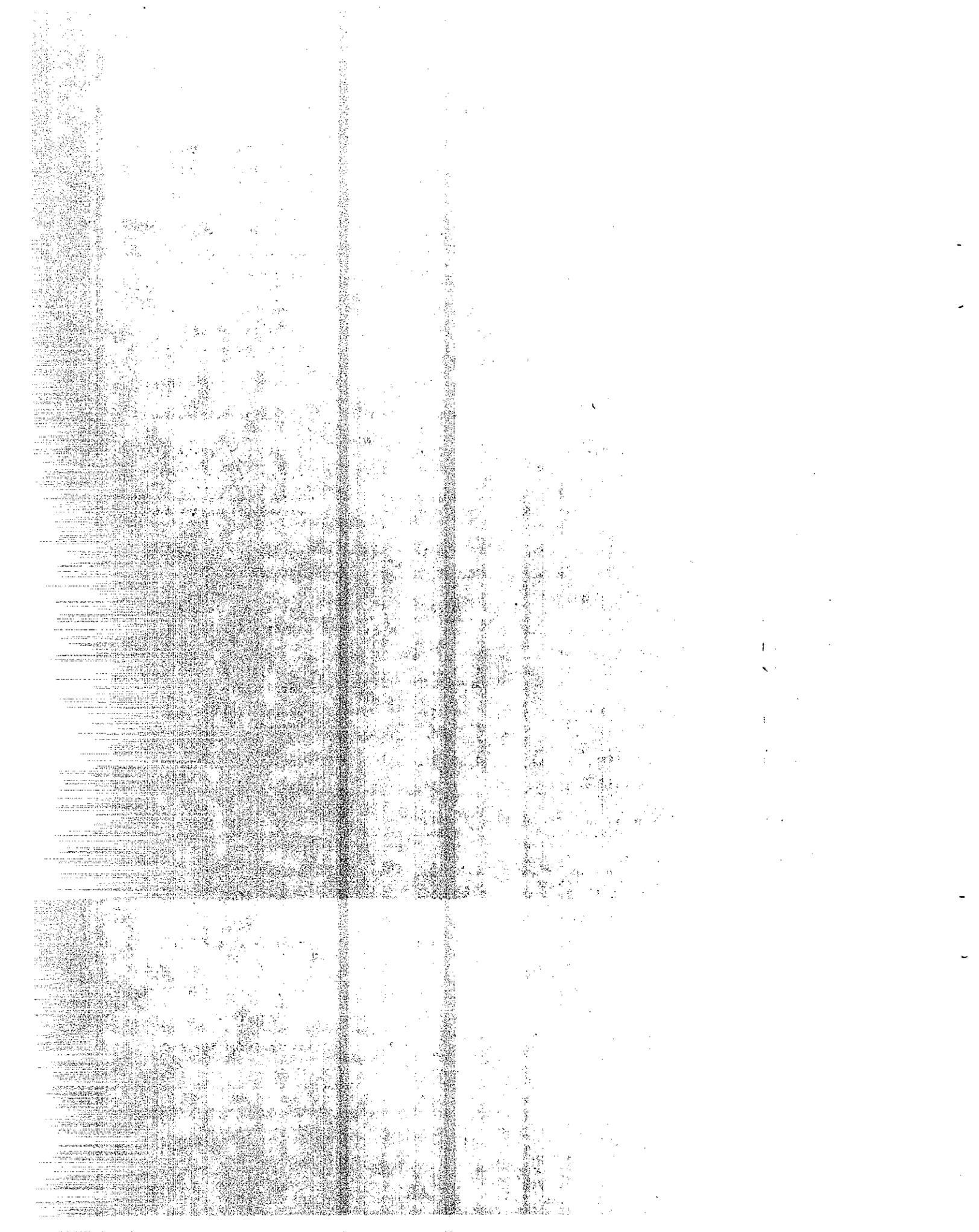
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CONVERSION FACTORS

English to Metric System (SI) of Measurement

<u>Quantity</u>	<u>English unit</u>	<u>Multiply by</u>	<u>To get metric equivalent</u>
Length	inches (in) or (")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft) or (')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in ²)	6.432 x 10 ⁻⁴	square metres (m ²)
	square feet (ft ²)	.09290	square metres (m ²)
	acres	.4047	hectares (ha)
Volume	gallons (gal)	3.785	litres (l)
	cubic feet (ft ³)	.02832	cubic metres (m ³)
	cubic yards (yd ³)	.7646	cubic metres (m ³)
Volume/Time (Flow)	cubic feet per second (ft ³ /s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph)	.4470	metres per second (m/s)
	feet per second (fps)	.3048	metres per second (m/s)
Acceleration	feet per second squared (ft/s ²)	.3048	metres per second squared (m/s ²)
	acceleration due to force of gravity (G)	9.807	metres per second squared (m/s ²)
Weight Density	pounds per cubic (lb/ft ³)	16.02	kilograms per cubic metre (kg/m ³)
Force	pounds (lbs)	4.448	newtons (N)
	kips (1000 lbs)	4448	newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb)	1.356	joules (J)
	foot-kips (ft-k)	1356	joules (J)
Bending Moment or Torque	inch-pounds (ft-lbs)	.1130	newton-metres (Nm)
	foot-pounds (ft-lbs)	1.356	newton-metres (Nm)
Pressure	pounds per square inch (psi)	6895	pascals (Pa)
	pounds per square foot (psf)	47.88	pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi √in)	1.0988	mega pascals √metre (MPa √m)
	pounds per square inch square root inch (psi √in)	1.0988	kilo pascals √metre (KPa √m)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{t_F - 32}{1.8} = t_C$	degrees celsius (°C)



ACKNOWLEDGEMENTS

The investigators would like to thank the raw material suppliers for their cooperation in providing technical information and samples of materials used in this project.

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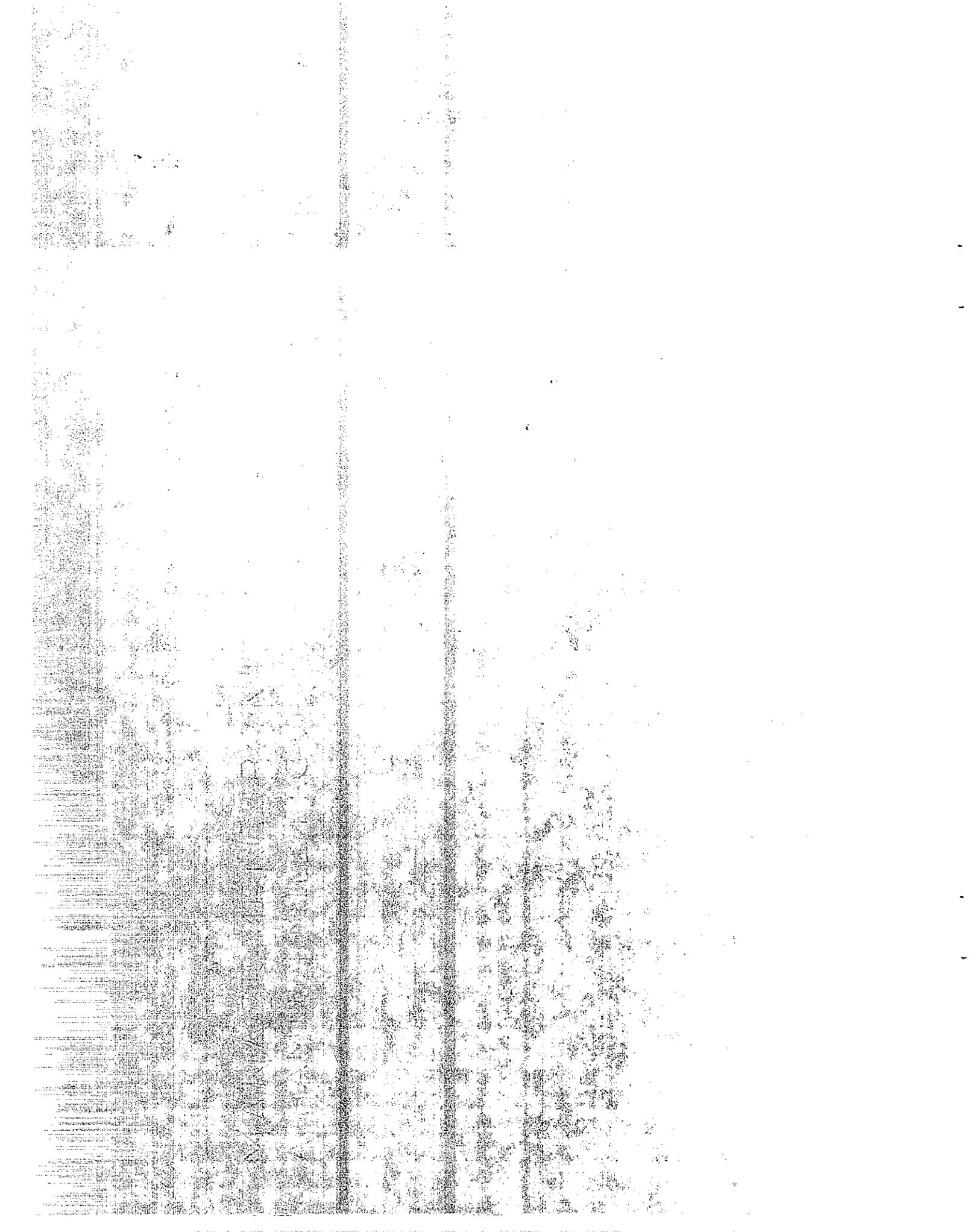
Dale Perry of Caltrans Structures Construction who made the final inspection of all full-scale structures painted during this project.

Special acknowledgement must be given to Normand Moore, Bud Deason, Clyde Canright, and Frank Pacholl from Caltrans Structures Maintenance because without their cooperation full-scale implementation of the coatings developed in this project would have been significantly delayed.



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INTRODUCTION

Over the last thirty-five years California has specified a number of different coating systems for the protection of steel in bridges and other structures in the state highway system. Prior to 1949 the standard paint system was a red lead-linseed oil primer with a graphite-linseed oil finish coat. In the next thirty years, between 1949 and 1979, a comprehensive testing program was pursued in which a variety of coatings were evaluated in an effort to utilize coating systems with the best performance(1). The following list describes general types of paint and coating systems investigated over that thirty year period.

1. Quick-dry red lead primer
2. Basic lead silico-chromate primer
3. Zinc chromate primer
4. Phenolic varnish primers and finish coats
5. Two component epoxy primer and finish coats
6. Vinyl primers and finish coats
7. Alkyd finish coats
8. Zinc and aluminum metalizing systems
9. Chlorinated rubber primer and finish coats
10. Self-cure and post-cure inorganic zinc primers
11. Organic zinc primers.

Before the Federal Clean Air Act of 1970, few restrictions had to be considered when specifying or formulating coatings used for painting steel highway structures. Implementation of this law, however, required that states develop plans to control concentrations of various materials in the air, including hydrocarbons and photochemical oxidants from solvents contained in paints and coatings. To comply with

the Clean Air Act, Los Angeles County adopted a number of regulations governing air pollutants. One of the regulations, designated as Rule 66, controlled quantities and types of solvents contained in paints and coatings and only permitted the uncontrolled use of "non-photochemically reactive" types (supposedly did not contribute reactive hydrocarbons to promote smog formation).

Other air pollution control districts in California soon followed with regulations similar to Rule 66. As a result, most coatings specified for painting highway structures had to be reformulated and new specifications developed to meet the limits permitted by Rule 66.

After several years experience using coatings that complied with regulations based upon "non-photochemically reactive" solvents, the Environmental Protection Agency (EPA) provided new classifications for solvents which in effect stated there were few, if any, non-photochemically reactive solvents. A comprehensive study of the problem regarding organic solvents was subsequently made by the California Air Resources Board (CARB)(2). Conclusions from the study stated that if emissions from all solvent sources were not regulated by about the year 1980, emissions from solvents in California would equal the emissions from motor vehicles.

Model regulations were soon prepared to control solvent emissions from most paint and coatings that were manufactured and applied in California. The original regulation, which was scheduled to become effective September 2, 1979, restricted the total quantity of volatile organic material contained in a paint or coating to two hundred fifty grams

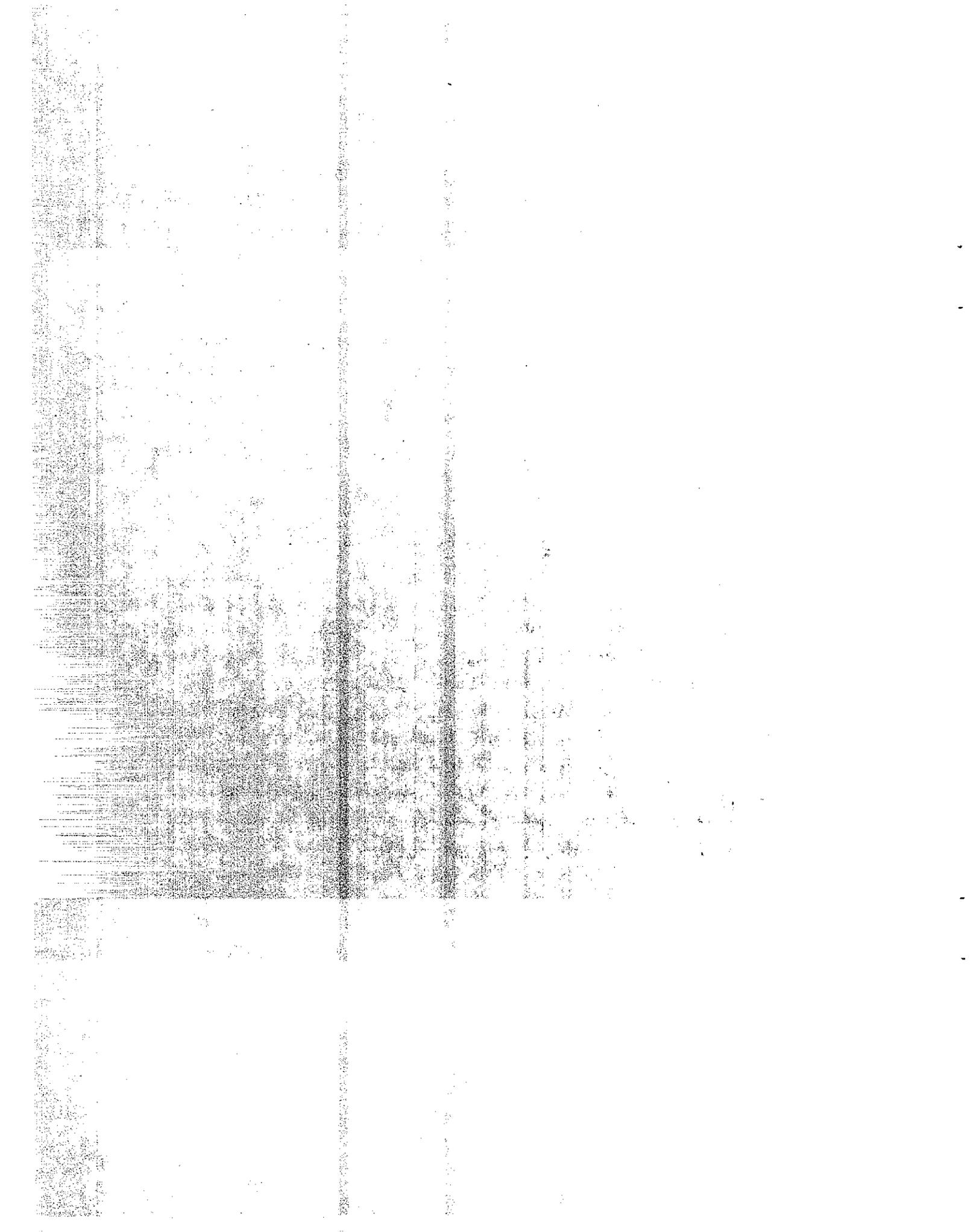
per liter of material as applied, excluding water. A copy of this regulation is included in Appendix A. A few temporary exemptions were permitted, but by September 1, 1982, most coatings had to conform to the regulation. Additional extensions were recently granted, but it is expected that eventually all coatings must comply with the original regulation.

As a result of the impending CARB rule controlling organic solvents, it was necessary to initiate a project to evaluate and develop new paint and coating systems that would not only comply with the CARB Rule but provide coatings with the best possible performance within the restrictions of the regulation.

A description of the work covered in this report is outlined as follows:

- I. Laboratory Evaluation
 - A. Proprietary Coatings
 - B. Raw Material Manufacturer Coatings
 - C. Laboratory Formulations

- II. Full-Scale Structure Work
 - A. Paint Manufacturing to Specification
 - B. State Maintenance Force Application
 - C. Private Contractor Application



CONCLUSIONS

Low-solvent primers and finish coats that conform to proposed air quality regulations and provide satisfactory performance when applied to steel highway structures are currently available.

The types of coatings found to provide the best protection as determined by laboratory tests were water-borne primers formulated using a styrene-acrylic emulsion, and water-borne finish coats formulated using a 100% acrylic emulsion.

The water-borne coatings selected for full-scale evaluation in this project were found to have application requirements similar to most conventional coatings such as; adequate dry film thickness, sufficient dry time between coats, good workmanship, good surface preparation, good inspection, and good painting conditions. The painting conditions, however, did appear to be more critical for water-borne coatings than for conventional solvent-borne paint systems.

Applications of the water-borne coatings during periods of low temperature and high humidity have resulted in some early coating failure. Other coating failures have been attributed to inadequate paint film thickness, application of paint to surfaces below the minimum film formation temperature, excessive dry time of paint due to slow evaporation of water from the paint film, and condensation forming on the coating before it has had time to dry.

The coatings evaluated and developed during this project should by no means be thought of as the ultimate in low-solvent coatings, but merely considered the beginning of a new generation of coatings utilizing available technology, materials, and ideas.

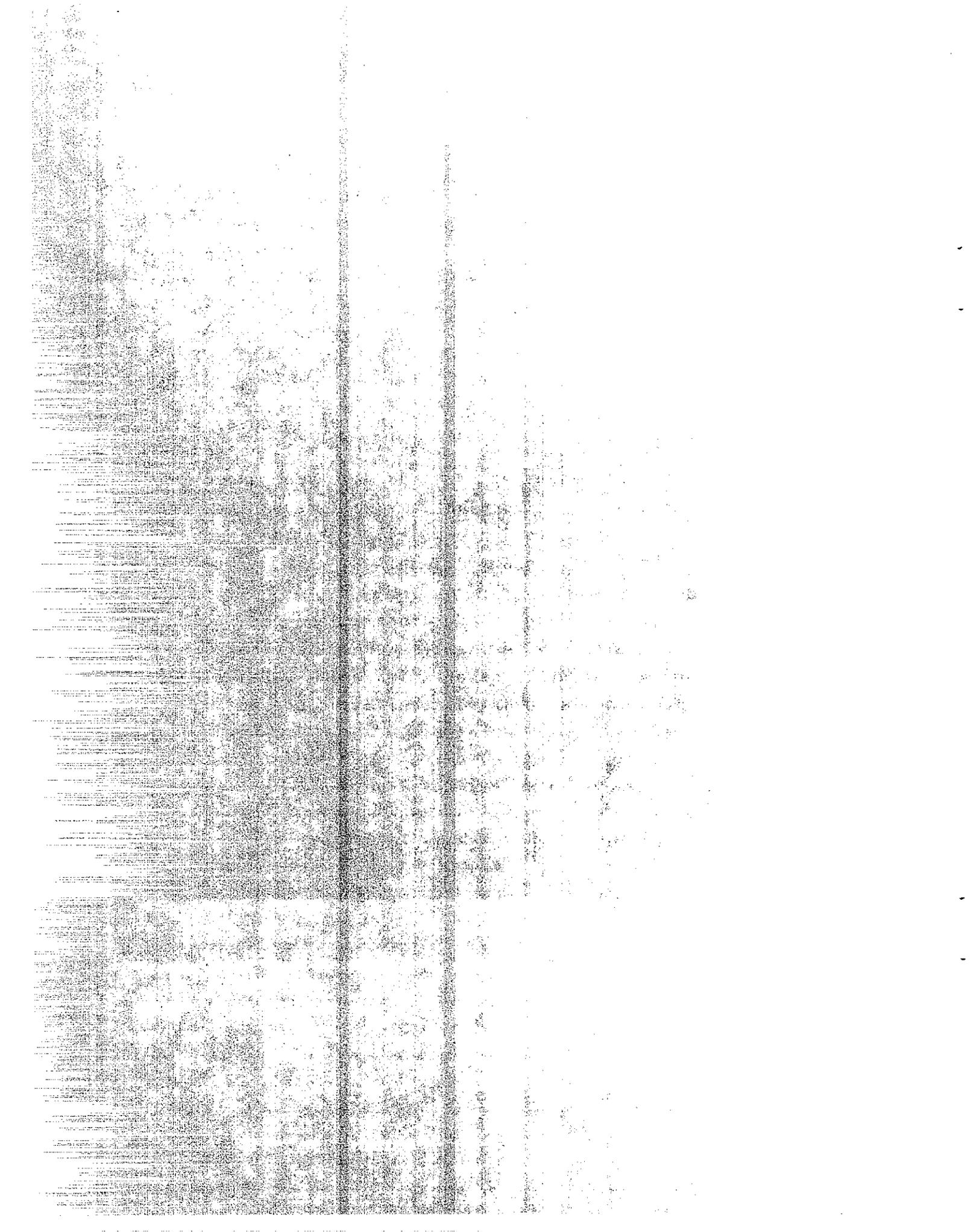
IMPLEMENTATION

Compositional paint formulations and specifications have been developed and are included in the Standard Special Provisions to the California Department of Transportation Standard Specifications. Coatings based on these formulations and specifications are routinely being used by state maintenance forces and private painting contractors for highway painting projects at various locations in California.

At the present time, over seventy-five steel highway structures with a total area of more than eight million square feet have been painted using coatings developed under this project. Structures included in this work range from small rural two lane bridges to large multilane bridges such as the San Francisco-Oakland Bay Bridge.

Other agencies, including the California Department of Parks and Recreation, United States Forest Service, Louisiana Department of Transportation and several cities in California have also painted steel structures using coatings developed in this project.

Some coatings developed in this project are to be included in the Steel Structures Painting Council study "Performance of Alternate Coatings in the Environment (PACE)."



TEST RESULTS

Work on this project included laboratory evaluation and development of low-solvent coatings for steel structures and full-scale application of selected coatings to a significant number of highway structures: Laboratory research work and full-scale painting projects were in progress concurrently throughout much of this project because of the short time before implementation of the regulations. For the purpose of this report, however, each segment of the work will be discussed independently.

Copies of current water-borne paint formulations developed in this project and presently being used to paint highway structures in California are shown in Appendix B. Primer formulations PWB 135 and PWB 137 represent the most recent development in the continuing effort to optimize water-borne coatings for steel structures. These primers are essentially the same as primers PWB 80 and PWB 81 except for the substitution of diethylene glycol monomethyl ether for ethylene glycol on an equal weight basis. This change provides earlier water resistance and results in slightly better performance as compared to formulas PWB 80 and PWB 81 shown in Appendix C.

LABORATORY EVALUATION AND DEVELOPMENT OF COATINGS

The American Society for Testing and Materials (ASTM) standard test procedures were the primary methods used for laboratory coating evaluation. Although the limitations of accelerated performance tests are well recognized, other, more acceptable procedures for predicting the performance of coatings in a limited time were not available. The following ASTM methods were used for most of the comparative laboratory evaluation of coatings in this project.

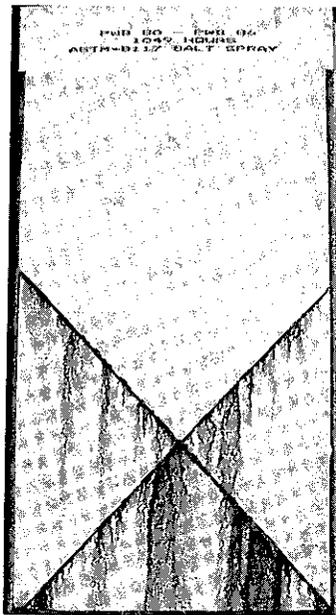
ASTM B117-73 Salt Spray (Fog) Testing
ASTM D2247-68 Testing of Coated Metal Specimens at
100% Relative Humidity
ASTM G53-77 Fluorescent UV-Condensation Exposure of
Nonmetallic Materials

Additional testing was performed on selected coatings by exposing laboratory prepared panels on test racks located at the Transportation Laboratory (TransLab) in Sacramento and the Golden Gate Bridge in San Francisco, California. In most cases, the performance of the coatings exposed at the Golden Gate Bridge test site compared favorably with the performance achieved in salt spray tests. None of the coatings evaluated at the test site in Sacramento exhibited surface rust or blisters after nearly four years exposure. Appendix C contains information on the performance of various coatings exposed in the salt spray and at the Golden Gate Bridge. Photographs of some test panels after exposure are shown in Figures I and II.

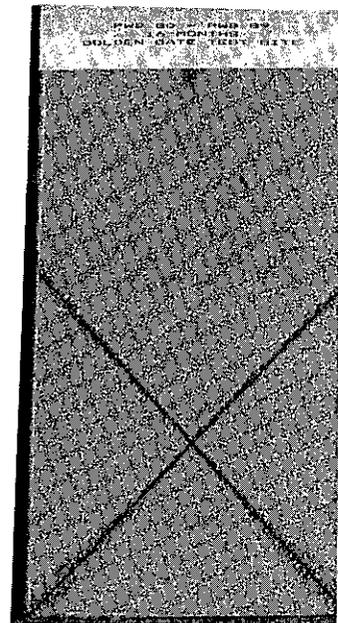
In order to minimize variations in performance tests, the procedures for test panel preparation, coating application and subsequent accelerated testing were closely controlled. Steel test panels corresponding to ASTM D609-73 Type I-Method B¹ were used for all 100% humidity, salt spray, and outdoor exposure tests. Panels used for 100% humidity and salt spray tests where primers were not applied were prepared according to ASTM D609-73 Method D-Solvent Wiping just prior to application of the first coat of paint. Panels used in the salt spray tests for evaluating primers and complete coating systems were abrasive blast cleaned to near white metal (Steel Structures Painting Council (SSPC) Specification No. 10)(3) the same day the first coat of primer was applied. The abrasive used for blast cleaning was a copper slag² which produced a one to two mil surface

1) Type R, Q Panel Company, Cleveland, Ohio

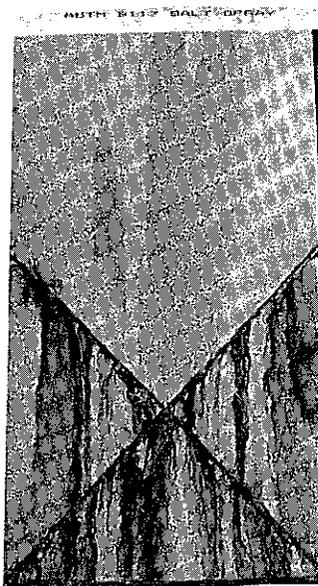
2) Kleen Blast #35, Kleen Blast Division, Leisure Investment Co., Hayward, California



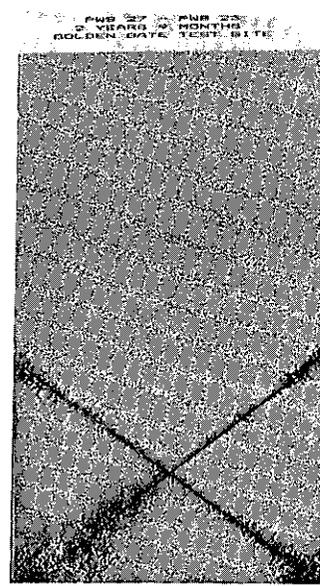
1049 Hours
ASTM B117 Salt Spray



1 year 4 months
Golden Gate Bridge Site



1930 Hours
ASTM B117 Salt Spray

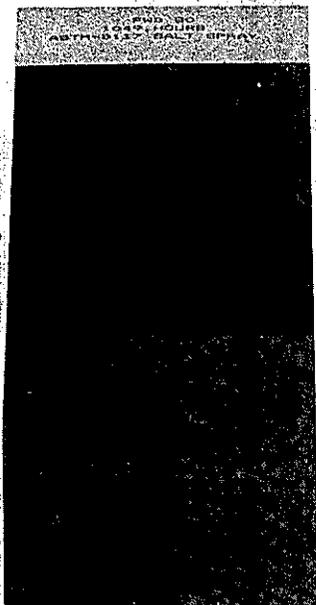


2 years 9 months
Golden Gage Bridge Site

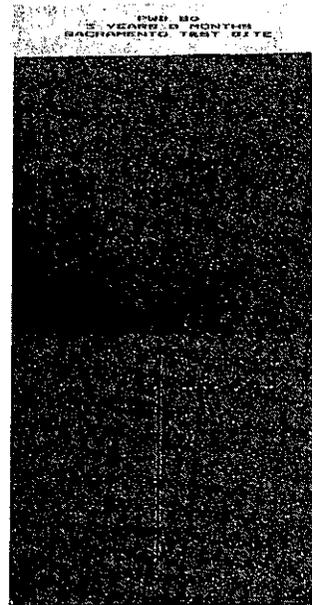
Test panels shown are complete paint systems, two primer and two finish coats, with a total dry film thickness of 7-8 mils.

Figure I

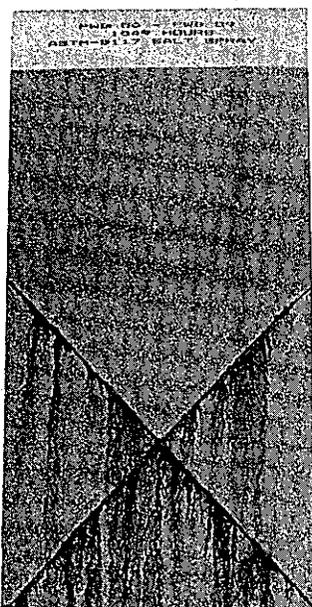
Appearance of Test Panels After Salt Spray and Outdoor Exposure



Primer only, 4 mil DFT
1049 Hours
ASTM B117 Salt Spray



Primer only, 4 mil DFT
3 years 8 months
Sacramento Test Site



Full System 7 mil DFT
1049 Hours
ASTM B117 Salt Spray



Full System 7 mil DFT
3 years 8 months
Sacramento Test Site

Figure II

Appearance of Test Panels After Salt Spray and Outdoor Exposure

profile on the steel surface. The surface roughness was measured with a magnetic roughness gauge and a surface profile comparator.

Alodine treated aluminum test panels¹ were used to evaluate the performance of coatings tested in the UV-condensation tests.

All coatings were applied to the previously prepared test panels using conventional air atomized spray equipment. A minimum drying time of one day at laboratory conditions, typically 77°F and 50% relative humidity, was allowed between coats. An additional period of at least seven days drying time was permitted after the final coat of paint was applied before testing was started. A diagram outlining the panel preparation is shown in Figure III.

The accelerated weathering tests were conducted according to the applicable ASTM procedure. All testing was continuous except for the addition, removal, and evaluation of samples. The specific testing cycle used in the ASTM G-53 UV-condensation test was four hours UV at 60°C alternating with four hours condensation at 40°C.

The coated panels were examined periodically during the testing period. Performance ratings were made at those times and final ratings at the end of each test. The following ASTM methods were used to rate the performance of each coating tested.

1) Type AL, Q Panel Co., Cleveland Ohio

DIAGRAM OF TEST PANEL PREPARATION

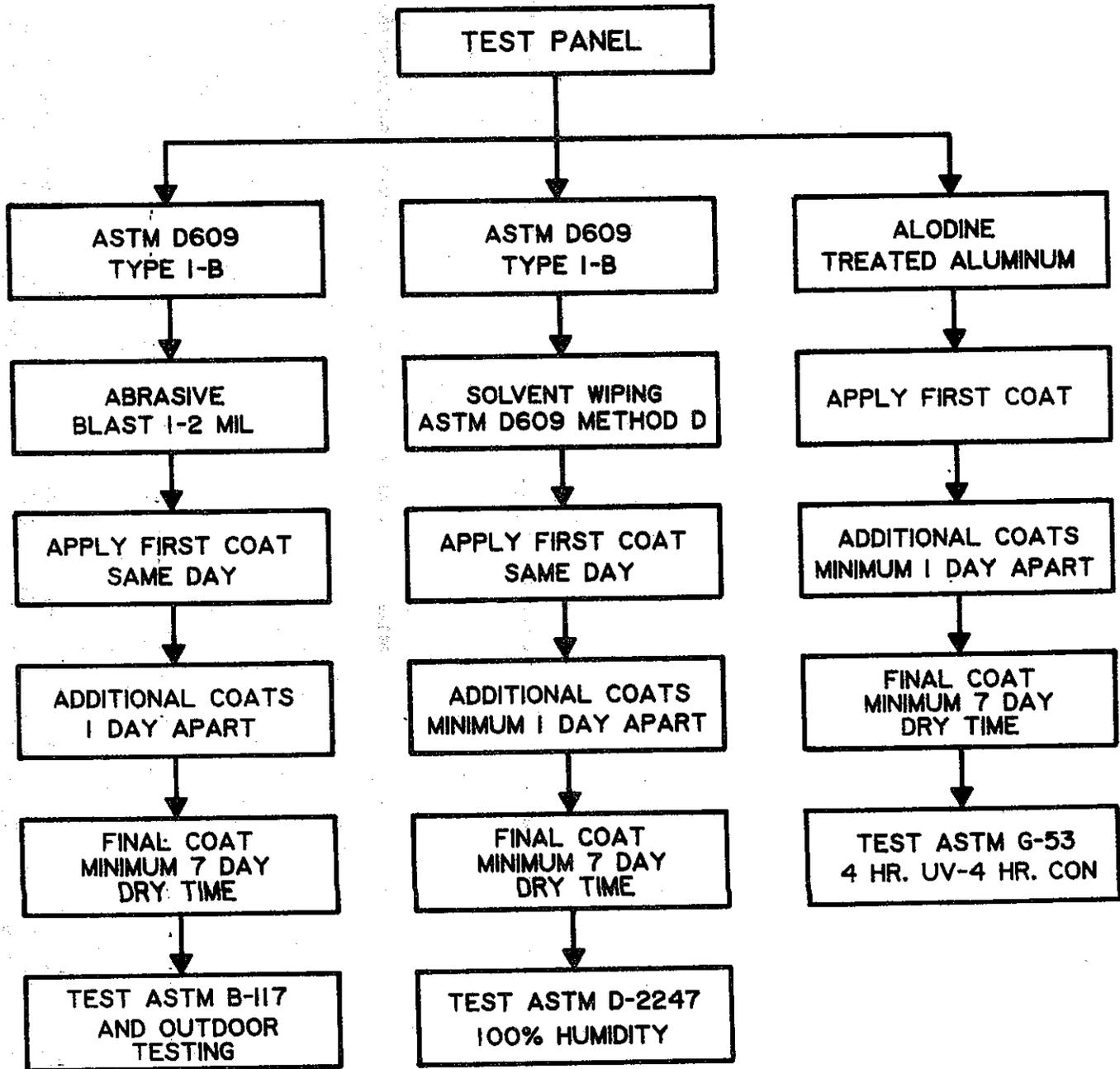


FIGURE III

ASTM D610-68 Evaluating Degree of Rusting on Painted
Steel Surface

ASTM D714-56 Evaluating Degree of Blistering of
Paints

ASTM D1654-79a Evaluation of Painted or Coated
Specimens Subjected to Corrosive
Environments

Evaluation of Proprietary Coatings

At the start of this project, significant contributions were expected from proprietary paint manufacturers. The initial response was not encouraging. Most manufacturers simply stated, "We are working on new coatings and may possibly have some to submit in the future." As the project continued, little additional interest was shown by the paint manufacturers, and consequently, only a small number of proprietary coatings were evaluated. Table I lists the coatings submitted and tested. This limited response from paint manufacturers was possibly due to insufficient time available for industry to develop coatings that would provide satisfactory performance and meet the following requirements:

1. The coating must comply with proposed air quality regulations for California.
2. The coating must be designed for application to both blast cleaned steel and previously painted steel.
3. The coating must not contain lead pigments.

TABLE I
 PROPRIETARY LOW-SOLVENT COATINGS EVALUATED

<u>Laboratory Identification Number</u>	<u>Manufacturer</u>	<u>Coating Description</u>	<u>Types of Coating</u>
S 1373	Triangle Paint Co.	Water-Borne Emulsion	Primer
S 1388	SprayLat Corp.	Water Dispersable Alkyd	Primer and Finish
S 1401	Carboline	High Solids Epoxy	Primer and Finish
S 1425	Sea Group Inc.	High Solids Urethane	Primer and Finish
S 1600	Rustoleum Corp.	Water-Borne Emulsion	Primer and Finish
S 1620	American Chemical Corp.	Water Dispersable Alkyd	Finish
S 1755	Mobil Chemical Co.	High Solids Epoxy	Primer and Finish
S 1761	Burke Paint Co.	Water-Borne Emulsion	Primer and Finish
S 1771	American Chemical Co.	Water-Borne Emulsion	Primer and Finish
S 1772	Valvoline Chemical Co.	Water-Borne Wax	Primer and Finish
S 1825	Burke Paint Co.	Water-Borne Emulsion	Primer and Finish
S 1826	Triangle Paint Co.	Water Dispersable Silicone Alkyd	Finish
S 1827	Preco Industries	Water-Borne Epoxy	Finish
S 1880	Ameron Coatings	High Solids Epoxy	Primer and Finish
S 1926	Hemple Marine Paints	Water-Borne Emulsion	Primer and Finish
S 1933	Debco Coatings	Water-Borne Emulsion	Primer and Finish
S 1944	Thoro Products	Water-Borne Emulsion	Primer

4. The coating should have proof of its effectiveness as evidenced by past performance on structural steel.

Since so few proprietary coatings were submitted by proprietary paint manufacturers, and those that were submitted either did not meet the established requirements or did not demonstrate satisfactory performance in accelerated laboratory tests, full-scale applications of low-solvent proprietary coatings were not made in this project. Photographs of some proprietary coatings after ASTM B117 Salt Spray (Fog) Testing are shown in Figure IV.

Raw Material Supplier Coatings

Manufacturers of raw materials for the coating industry were immediately interested in becoming involved with a project to develop low-solvent coatings for structural steel. Requirements for raw materials manufacturers were the same as previously established for proprietary paint manufacturers, with one exception; coatings could be new developments and proof of coating effectiveness was not required. This exception could have been responsible for much of the difference in interest shown between the paint manufacturers and raw material suppliers.

In order to expedite laboratory evaluation of the coating formulations submitted by the raw material manufacturers, one quart samples of each paint were requested to be supplied along with the compositional formulation.

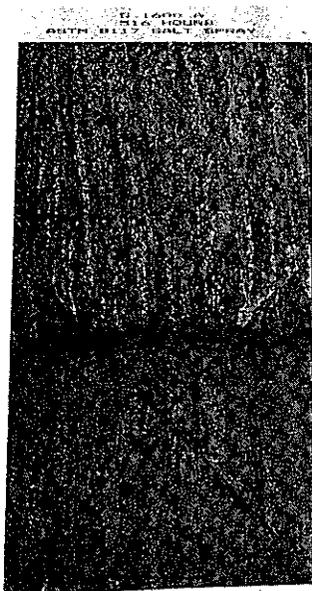
Table II lists some of the coating samples supplied by various raw material manufacturers for this project. The performance of coatings evaluated in the laboratory varied



Primer only, 4 mil DFT
531 Hours



Full System, 6 mil DFT
531 hours



*Primer only, 4 mil DFT
516 Hours



*Full System, 7 mil DFT
1070 Hours

* Bottom part of panel solvent stripped after testing.

Figure IV

Appearance of Proprietary Coatings After
ASTM B117 Salt Spray Testing

TABLE II
RAW MATERIAL MANUFACTURER LOW-SOLVENT COATINGS EVALUATED

<u>Laboratory Identification Number</u>	<u>Manufacturer</u>	<u>Coating Description</u>	<u>Types of Coating</u>
S 1378	Rohm and Haas	Water-Borne Emulsion	Primer and Finish
S 1379	Spencer Kellogg	Water-Borne Emulsion	Primer and Finish
S 1399	IMC Corp.	High Solids Alkyd	Primer and Finish
S 1407	Rohm and Haas	Polymer Modified Cement	Primer
S 1472	PVO International	Alkyd Emulsion	Primer and Finish
S 1518	Rohm and Haas	Water-Borne Emulsion	Primer and Finish
S 1567	Rohm and Haas	Water-Borne Emulsion	Finish
S 1585	Buckman Laboratories	Water-Borne Emulsion	Primer
S 1586	Union Carbide Corp.	Water-Borne Emulsion	Finish
S 1619	Spencer Kellogg	Water Dispersable Alkyd	Finish
S 1623	Henkle Corp.	Water Reducible Epoxy	Primer and Finish
S 1624	Henkle Corp.	High Solids Epoxy	Finish
S 1654	Rohm and Haas	Water Reducible Epoxy	Primer and Finish
S 1668	Spencer Kellogg	Water Dispersable Alkyd	Primer and Finish
S 1693	NL Chemicals	Water-Borne Emulsion	Primer
S 1714	Reichhold Chemicals	Water-Borne Emulsion	Primer and Finish

TABLE II (Con't.)

RAW MATERIAL MANUFACTURER LOW-SOLVENT COATINGS EVALUATED

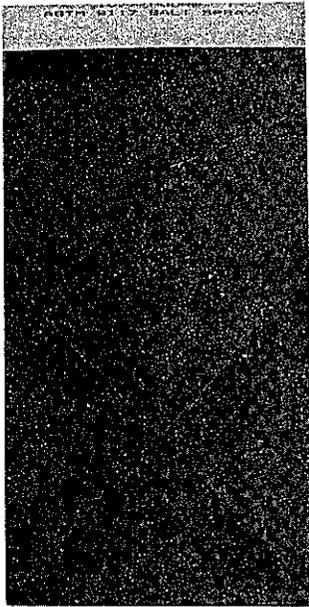
<u>Laboratory Identification Number</u>	<u>Manufacturer</u>	<u>Coating Description</u>	<u>Types of Coating</u>
S 1717	Union Carbide Corp.	Water-Borne Emulsion	Finish
S 1727	Rohm and Haas	Water-Borne Emulsion	Primer
S 1760	Reichhold Chemicals	Water-Borne Emulsion	Primer and Finish
S 1824	ICI Americas Inc.	Water-Borne Emulsion	Primer
S 1835	Union Carbide Corp.	High Solids Phenolic	Primer
S 1853	NL Chemicals	Water-Borne Emulsion	Primer
S 1858	Halox Pigments	Water-Borne Emulsion	Primer
S 1876	Union Carbide Corp.	High Solids Phenolic	Primer
S 1885	ICI Americas Inc.	Water-Borne Emulsion	Primer
S 1901	Rohm and Haas	Water-Borne Emulsion	Primer and Finish
S 1946	ICI Americas Inc.	Water-Borne Emulsion	Finish
S 1974	Spencer Kellogg	Water-Borne Emulsion	Primer
S 1976	NL Chemicals	Water-Borne Emulsion	Primer

to a great extent. Some coatings were apparently well formulated and exhibited good performance while others rated only fair or poor. A few coatings were so unstable or poorly formulated that evaluations could not be made because of pigment settlement, coating gelation, or resin incompatibility.

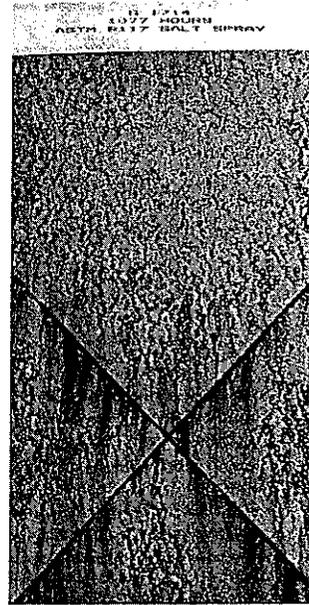
In many cases, the performance of coatings tested in salt spray (fog) did not correspond with the manufacturer's prediction. Early failures were common with significant rust and blisters forming on the surface of coated test panels within 300 hours. Photographs of some test panels after ASTM B117 Salt Spray (Fog) Testing are shown in Figure V. A reason for the poorer-than-expected performance of some coatings was attributed to differences in preparation of the test panels. Most manufacturer's tests had been made on smooth, unblasted steel panels as opposed to the rough surface on the abrasive blast cleaned steel panels used in this project. A previous study(4) concluded that the performance of water-borne coatings was unrealistically good when applied to smooth, unblasted steel.

A few of the coatings did perform well enough in laboratory tests to warrant application to full-scale projects. These were subsequently applied to various structures by either maintenance forces or painting contractors. Table III lists information about these coatings. After up to five years of exposure, the full-scale applications are performing as well as the laboratory tests had predicted.

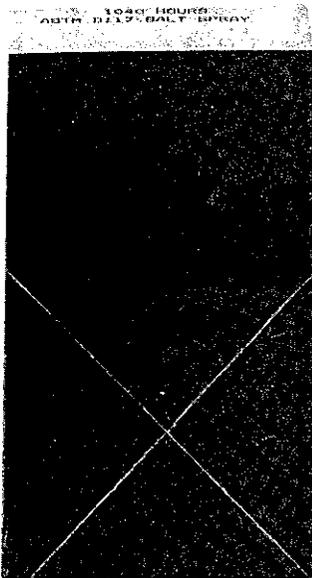
Raw material manufacturers have continued to be very active in submitting samples and formulations utilizing recently



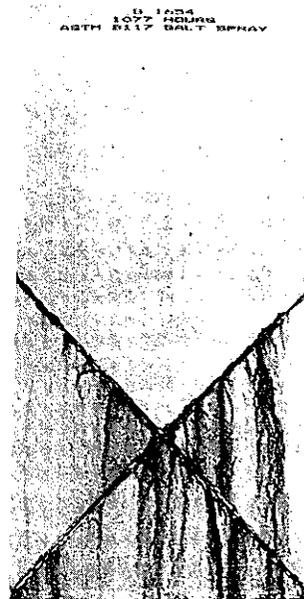
Primer only, 4 mil DFT
1077 Hours



Full System, 7 mil DFT
1077 hours



Primer only, 4 mil DFT
1040 Hours



Full System, 5 mil DFT
1077 Hours

Figure V

Appearance of Raw Material Manufacturer's Coatings
After ASTM B117 Salt Spray Testing

TABLE III

FULL-SCALE APPLICATION OF RAW MATERIAL
MANUFACTURER'S PRIMER FORMULATIONS

<u>Manufacturer</u>	<u>Formula Number</u>	<u>Vehicle</u>	<u>Inhibitive Pigment</u>	<u>Applica- tion By</u>	<u>Location</u>
Spencer Kellogg	031226-1-A	Arolon 820	Zinc Phosphate Zinc Yellow	State Forces	San Francisco
Spencer Kellogg	031226-1-A	Arolon 820	Zinc Phosphate Zinc Yellow	Paint Contractor	Colfax
Spencer Kellogg	031226-1-A	Arolon 820	Zinc Phosphate Zinc Yellow	Paint Contractor	Tehachapi
Union Carbide	LP-3743	UCAR 4341	Barium Meta Borate	Paint Contractor	Livingston
ICI Americas	DA-4498-152-1	Haloflex 202	Zinc Phosphate	State Forces	San Francisco
ICI Americas	DA-4498-152-1	Haloflex 202	Zinc Phosphate	Paint Contractor	San Jose
ICI Americas	DA-4498-205-1	Haloflex 202	Zinc Phosphate	Paint Contractor	San Jose
Union Carbide	PP-3906	Phenolic Resin, Tung Oil	Zinc Phosphate	State Forces	San Francisco

developed products. At the time this report was being prepared, two new primers developed by different manufacturers were being applied in full-scale test applications to bridges in the San Francisco Bay area.

The work performed in this part of the project provided the foundation for all subsequent laboratory and full-scale work. Raw material manufacturers for the coating industry deserve recognition for significant contributions to this project.

Laboratory Formulations and Evaluations

Information gained from raw material manufacturers provided the basis for all laboratory formulations developed in this project. Initially, laboratory formulations only duplicated those previously submitted by raw material manufacturers. Paint formulations were duplicated so that Trans-Lab personnel could become knowledgeable in laboratory-scale production of water-borne coatings, uncover possible processing problems which could complicate full-scale production of the coating, and verify the performance of coating formulations in an additional series of accelerated tests.

It soon became apparent that duplicating existing formulations had been the best way to proceed because problems with laboratory-scale production of paint immediately occurred. Although laboratory personnel were experienced in making various solvent-borne coatings, it was obvious that most water-borne maintenance coatings required special techniques to produce satisfactory coatings. In order to achieve adequate pigment dispersion without excessive heat build-up, dispersion speed, mixing vessels and impeller size were critical.

The apparently simple process of adding various ingredients was also important. Introduction of materials at the wrong time, too rapidly, or in the wrong sequence resulted in a sandy or gelled mass which could not be converted into a usable paint. As personnel became more familiar with water-borne paint technology, early laboratory-scale production problems were all but eliminated. The experience gained in this part of the project proved to be invaluable for full-scale production of the coatings in commercial paint factories.

After laboratory personnel had become experienced in duplicating the raw material suppliers' formulations, significant effort was then directed toward thoroughly investigating those formulations which had been identified by accelerated tests as having the best performance. During the early part of the project, primer formulations based on two styrene acrylic emulsions, Arolon 820 manufactured by Spencer Kellogg and UCAR 4341 manufactured by Union Carbide, provided the best overall performance of primers applied to abrasive blasted steel.

The early selection of finish coat formulations proved to be somewhat more complicated than primers, because finish coat performance is dependent upon the surface to which it is applied. The application of finish coats to unprimed steel resulted in generally poor performance, and when applied over a primer the performance was dependent upon the primer to which applied. The selection of finish coat formulations in the early part of the project ultimately was based on overall performance in all of the accelerated tests. Formulations of finish coats that were selected for additional development work were those based on an acrylic

emulsion, Rhoplex MV-9 manufactured by Rohm and Haas, and the same styrene acrylic emulsion, UCAR 4341, used in the primer formulation.

Unfortunately, a short time after the laboratory investigation began, Union Carbide discontinued manufacturing UCAR 4341. A recommended replacement, UCAR 4426, failed to provide a coating with acceptable stability or performance. As a result, most of the laboratory work in this project was done with primer formulations based on Aroclon 820 and finish coats based on Rhoplex MV-9.

Laboratory work continued with considerable effort directed toward determining the effect various formula ingredients had on the performance of selected primer and finish coats. This work was considered important for several reasons. First, because most formulations were developed by manufacturers whose laboratories were located on the east coast of the United States, many materials listed in the formula were either not readily available or were more expensive than alternative materials available on the west coast.

A second reason was that the originator of the coating formulation typically made reference to only one or two sources of brand name products for each ingredient. Our goal was to provide a compositional formulation which would reference ASTM, chemical or physical characteristics for each of the ingredients in the formula wherever it was possible.

A third reason was to determine how critical a specific material was to the performance of the coating, and what effect the substitution of an alternative material would have on the performance. Table IV lists ingredient variations investigated in primer formulation PWB 135 which is shown in Appendix B.

Table IV

Materials Evaluated in PMB 135 Primer Formulation

Dispersant/ Stabilizer #/100 Gallons	Talmo 731 11,14,15,16,27,20,	Colloids III 17	Colloids III M 17	Nopcosperse 44 9
Surfactant #/100 Gallons	Trilon CF 10 1.4,2.8,3.4,4.4,5.4	Ross & Rowe 551 0, 2	Yelkin TS 2	
Defoamer #/100 Gallons	Nopco NDW 0.5,1.0,1.5,2.0, 3.0,3.7,4.8	Foamaster 6 3.0	Drew L477 3.0	
Pigments #/100 Gallons	Iron Oxide Pfizer R3098 22.5,45,90,100	Iron Oxide Pfizer R1599 50, 100	Iron Oxide Pfizer 2899 100, 90, 50	Iron Oxide Pfizer R05097 90, 40
Pigments #/100 Gallons	Calcium Carbonate Snow Flake 80,95,100,115,125,135, 150,165,175,200	Calcium Carbonate Gammasperse 6451 200	Calcium Carbonate Vicron 15-15 55, 75, 200	MICA ASTM D607 Type A 0, 33, 36, 40
Pigments #/100 Gallons	Titanium Dioxide ASTM D476 Type III, IV 22.5, 50, 67.5	Zinc Phosphate Reichard Coulston 317 0, 30, 35, 40, 43	Zinc Phosphate Davis J0852 30, 40	Zinc Phosphate Nichen #7 40
Pigments #/100 Gallons	Zinc Yellow ASTM D478 Type I 0,1.0,5.0,10,15	Zinc Oxide ASTM D79 French, Dry 18, 20, 25	Calcium Barium Phosphosilicate Halox BW-191 100	Zinc Phospho- silicate Halox ZX-III 100
Pigments #/100 Gallons	Zinc Phospho Oxide Walzin SC-1 50, 80, 150	Zinc Phospho Oxide Walzin 2 80, 100	Barium Metaborate Busan II-MI 40, 50, 80, 100	Barium Metaborate Butrol 22 50
Pigments #/100 Gallons	Magnesium Chromate Nichen #5 5	Calcium Metasilicate Wollastonite 50		Organic Zinc Salt Sicorin RZ 20
Thickeners #/100 Gallons	Cellulose QP4400 0.5,0.8,1.0,1.5,2.0	Natrosol 250HR 0.5,0.8,1.0,1.5,2.0	Rhosolate I 1.0,2.0,2.5,3.5, 4.0,4.5,6.0	Methocel J 12MS 1, 2
ATKyd Resin #/100 Gallons	Aropiaz 1271 0, 26	Aiqua 189-18 26	Varkyd 515-100 26	
Solvents #/100 Gallons	Ethylene Glycol 28	Butyl Carbitol 5, 6	Butyl Carbitol Acetate 5, 6	Methyl Carbitol 6
				Texanol 12

In most cases the materials listed above were evaluated in the basic PMB 135 Formula shown in Appendix B by changing only one ingredient or quantity at a time. The quantities shown represent pounds of materials used in 100 gallons of finished paint.

As a result of work in this part of the project, it was concluded that most pigments and solvents can be identified by ASTM designation or chemical and physical characteristics with few problems. Other materials such as defoamers and thickeners may be substituted in some cases with similar types of other brand name products. The ingredient found to be most critical to the performance of the coating was the emulsion, closely followed by dispersants and surfactants.

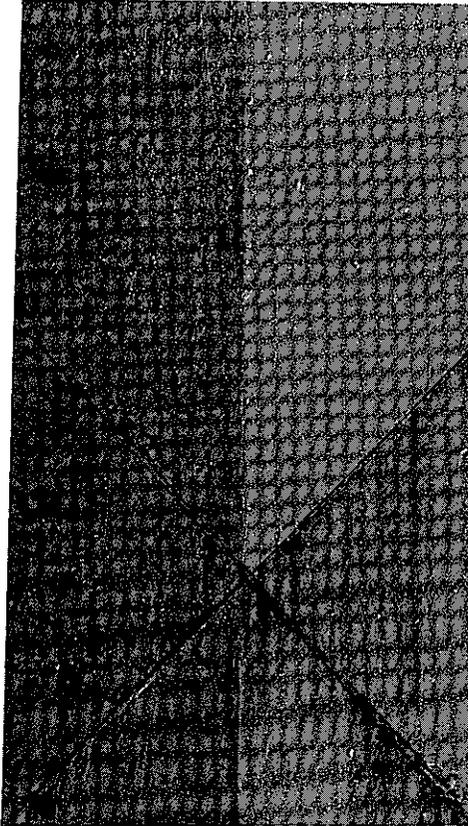
Laboratory studies also indicated that the performance of a specific coating formulation could vary depending upon the use of different production batches of emulsion from a single supplier. The performance variations appeared to be more noticeable in pilot plant batches of emulsion as compared to full-scale production batches. The use of materials other than those specifically called for in the formulation usually caused an overall decrease in performance.

Additional laboratory studies were also made to determine the effect of temperature, humidity, surface preparation, and film thickness on the performance of the coatings when evaluated by accelerated tests. A photograph showing the effect film thickness had on the performance of a primer is shown in Figure VI. As a result of these studies the following conclusions were made:

1. Water-borne coatings should not be applied at a temperature below 50°F or above 75% relative humidity.
2. Water-borne coatings should not be applied to surfaces below the minimum film formation temperature (MFT) of the coating.

ONE COAT
PRIMER
1-2 mil

ONE COAT
PRIMER
3-4 mil



One Coat
Primer
1-2 mil

One Coat
Primer
3-4 mil

After 1116 Hours ASTM B117 Salt Spray Testing

Figure VI

Effect of Film Thickness on Primer Performance

3. Commercial blast cleaning, SSPC No. 6(3) provides satisfactory surface preparation.
4. Water-borne primers should be applied in two coats to a minimum dry film thickness of four mils. Water-borne finish coats should also be applied in two coats to a minimum dry film thickness of three mils.

Laboratory work has continued to investigate additional materials for use in both primers and finish coats. Recently two primers, one based on a vinyl acrylic emulsion, Haloflex 202 manufactured by ICI Americas, and the other based on a phenolic resin, UCAR CK 2500 manufactured by Union Carbide, have exhibited good performance in accelerated tests. Preliminary laboratory work is currently being conducted into formula variations for these coatings. Original formulas for these primers, DA 4498-152-11 and PP 3906 respectively, are shown in Appendix B. Although the phenolic resin primer formulation as shown slightly exceeds the 250 grams of solvent per liter permitted by the CARB regulation, a minor reformulation is planned that will reduce the solvent level to 250 grams per liter or less.

FULL-SCALE WORK

Paint Manufacturing

The first step in full-scale application of low-solvent coatings developed in this project was to locate paint manufacturers willing to supply the specified primers and finish paints. While a number of paint manufacturers in California were familiar with state specifications for solvent-borne coatings, none had experience manufacturing the exact water-borne coatings which were being ordered. Several industrial paint manufacturers nonetheless were interested in making the water-borne coatings and accepted orders for the paint. Delays in production of the initial batches of paint were common because some ingredients were not normally stocked and had to be specially ordered, and others were obtainable only from the east coast suppliers.

The paint manufacturers were very cooperative and permitted personnel from the TransLab to be present during the paint manufacture. This proved to be an advantage for all concerned because TransLab personnel were able to witness scale-up of previous laboratory work and provide the manufacturer with knowledge gained in laboratory formulation.

However, a number of problems still occurred during the manufacture of the initial batches of paint. The following list describes common problems experienced in full-scale production.

1. Use of incorrect material due to wrong coding number by paint manufacturer.

2. Use of incorrect material due to misreading of code number by production worker.
3. Inadequate manufacturing instructions in formulation for unknowledgeable operator.
4. Poor sizing of disperser blade to mixing vessel.
5. Excessive disperser blade speed, resulting in ineffective pigment dispersion and heat buildup.
6. Exceeding maximum temperature recommended during paint manufacture.
7. Incorrect order of addition of ingredients.
8. Poor pigment dispersion resulting from selection of hard-to-disperse materials.
9. Viscosity problems resulting from manufacturers inexperience with cellulosic thickeners.
10. Unauthorized substitution for specified materials.

As manufacturers gained experience with the formulations for specified water-borne coatings, these problems have essentially been eliminated. At present, the primary problems that occasionally occur result from poor quality control during production of the coatings in the factory.

To date (January 1985), eleven different paint companies have manufactured water-borne coatings to Caltrans specifications and several other companies have shown interest by

submitting competitive bids in response to purchase orders. Table V lists those paint companies that have manufactured water-borne or low-solvent coatings developed in this project.

State Maintenance Force Application of Water-Borne Coatings

The initial application of water-borne coatings by state maintenance forces occurred during the latter part of 1976, on bridges in the San Francisco area. At that time, the work consisted of applying a water-borne aluminum finish coat to surfaces that had been primed with a solvent-borne organic zinc primer and vinyl wash primer tie coat, and to previously painted surfaces still in good condition.

The water-borne aluminum finish coat applied in those first operations was very unsophisticated. Painters essentially made the paint at the job site working from fifty-five-gallon barrels of Rhoplex MV9 acrylic emulsion and two-hundred-pound drums of Alcoa Hydropaste 830 aluminum paste. The only directions given to the painters at that time were to thoroughly mix one pint of water with two pounds of aluminum paste, then slowly stir in one gallon of acrylic emulsion and mix well; the paint was then ready for application. The success achieved with this exceedingly simple coating was very encouraging and, while a number of formulation refinements have been made, the basic ingredients are still the same.

The first of several changes made in the specification was in respect to packaging of the coating so it could be purchased from paint companies in easier-to-handle quantities.

TABLE V

COMPANIES MANUFACTURING
WATER-BORNE COATINGS TO
STATE SPECIFICATIONS

Koppers Co. Inc., Los Angeles, CA
Valspar Corp. (Mobil Chemical Co), Azusa, CA
Sinclair Paint Co., Los Angeles, CA
Frazee Paint Co., San Diego, CA
Universal Protective Coatings, San Rafael, CA
Frank Dunne Paint Co., Oakland, CA
Davlin Paint Co., Berkeley, CA
Triangle Paint Co., San Leandro, CA
Dunn-Edwards Paint Co., Los Angeles, CA
Ellis Paint Co., Los Angeles, CA
Decratrend Paint Co., Los Angeles, CA
Paint and Coating Corp., Los Angeles, CA

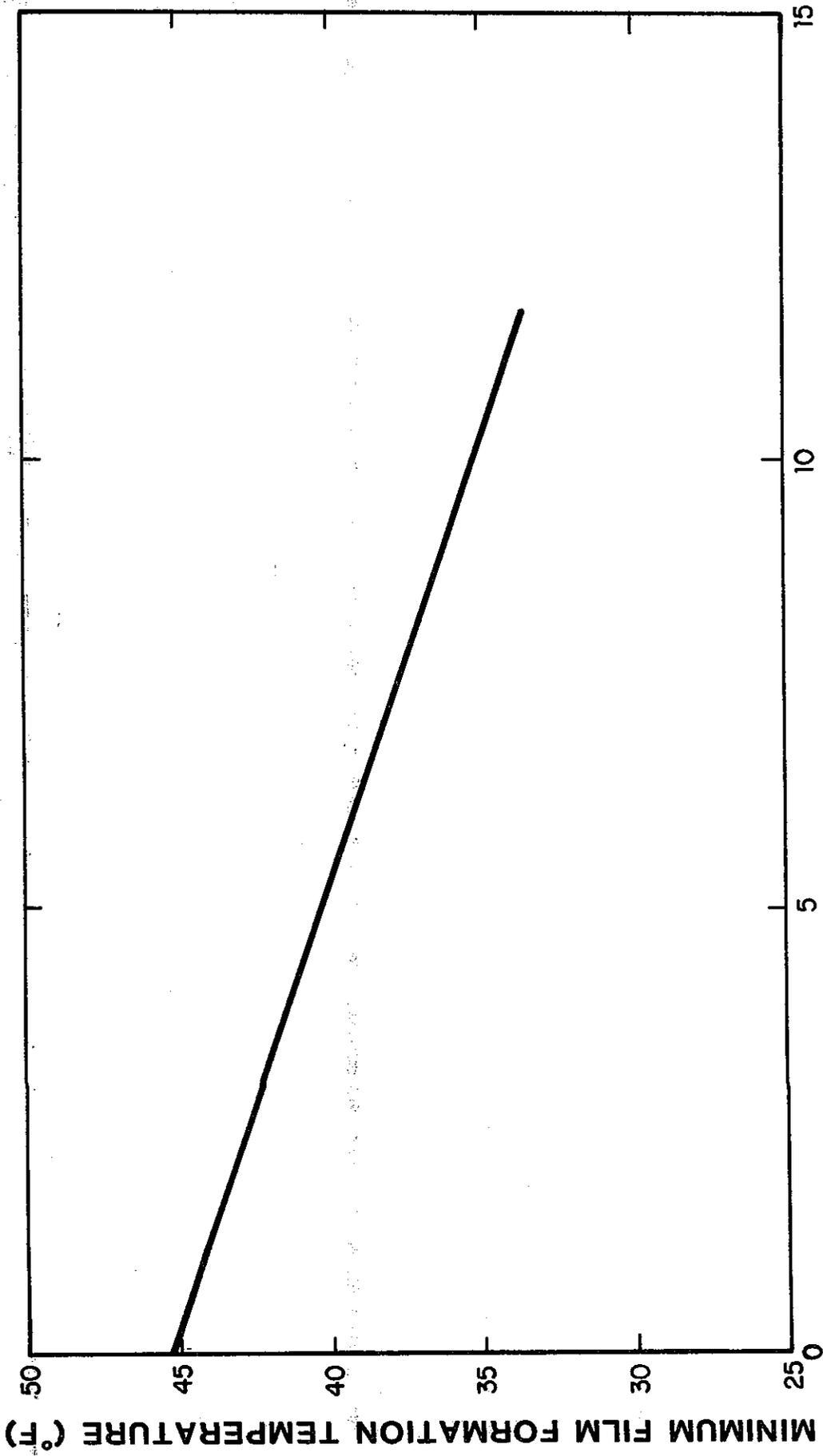
The vehicle was put in five-gallon cans and the corresponding quantity of aluminum paste in separate one-gallon cans. For ease of pigment dispersion the required quantity of water is still stirred into the aluminum paste prior to addition of the vehicle.

Modifications to the formulation have also been made to permit application of the coating at most temperatures experienced in the San Francisco area. Problems were encountered during the first winter when the original water-borne aluminum paint was applied near 40°F. This resulted in significant coating failure because the film cracked, lost adhesion and was partially blown off by the wind. This was determined to be due to application at temperatures below the MFT of the coating.

Figure VII shows the effect a coalescent solvent has on the ASTM D2354 Film Formation Temperature. Current formulations now require a specific level of coalescent to be contained in the coating. Additional formula modifications have improved application characteristics.

Figure VIII shows the effect a cellulosic thickener has on the viscosity of the coating. Other materials such as defoamers and preservatives have been included in the formulation to control foam caused by air incorporated during mixing and to insure adequate storage life of the coating. The current water-borne aluminum finish coat, formulation PWB 132, is shown in Appendix B.

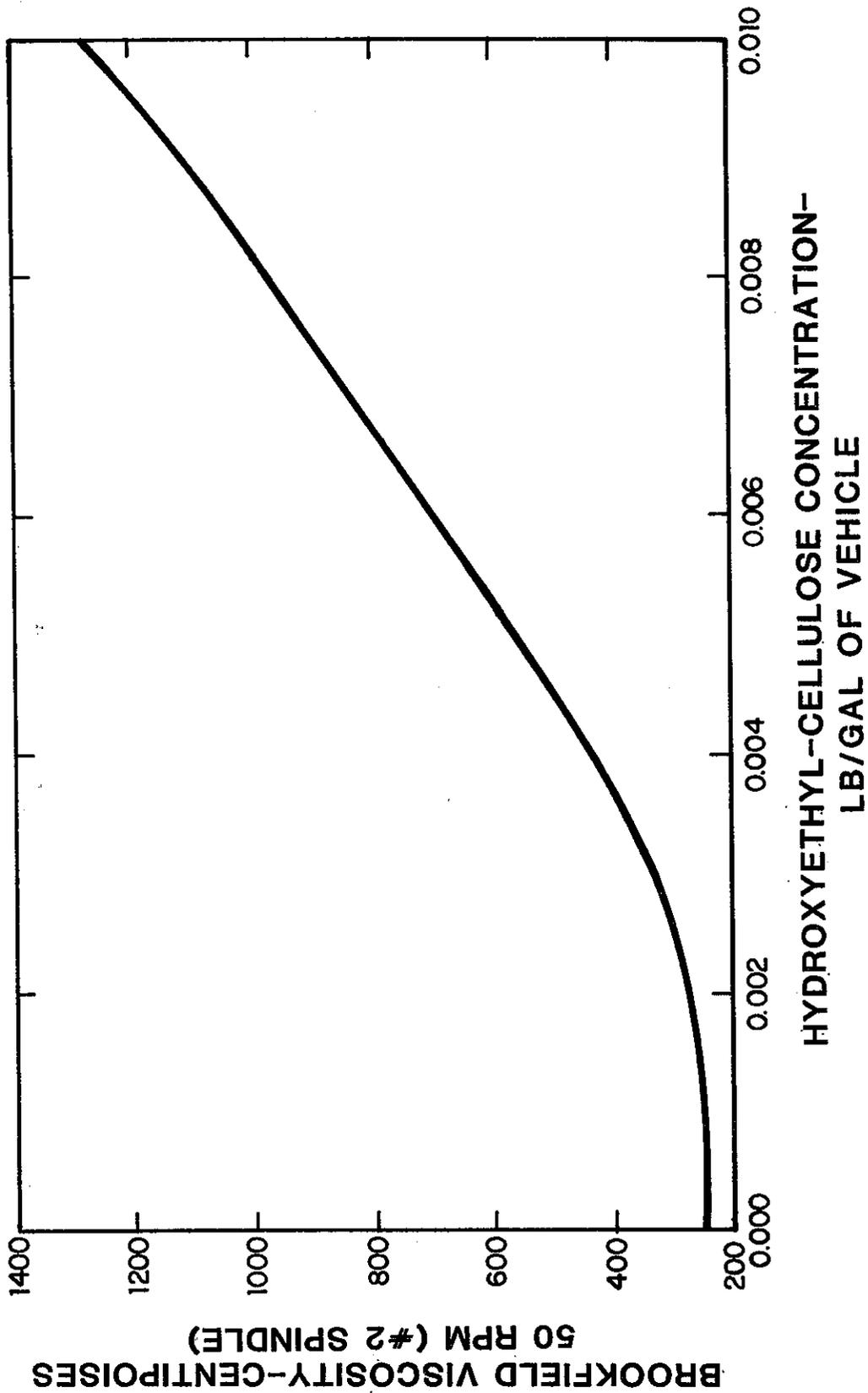
Application of a complete water-borne paint system consisting of primers and finish coats first occurred during mid-1979. The primer used in this work was one based on



% TEXANOL ADDED BY WEIGHT OF VEHICLE NON-VOLATILE

ASTM D-2354 MINIMUM FILM FORMATION TEMPERATURE
OF WATER-BORNE ALUMINUM FINISH PAINT

FIGURE VII



VISCOSITY PROFILE OF WATER-BORNE ALUMINUM FINISH

FIGURE VIII

Arolon 820 styrene acrylic emulsion which had previously exhibited good performance in accelerated laboratory tests. Performance of this primer in the initial application was encouraging and additional larger-scale application soon followed. During the last five years, formula modifications have been made in an effort to improve manufacturing, application and performance characteristics of this primer. The current formulation for the water-borne primer which is being used for most work by state maintenance forces is shown in Appendix B as Formula PWB 135.

While the majority of painting by state maintenance forces has been done on bridges in the San Francisco area, significant work has also been done by maintenance forces on bridges in northern California near Ft. Bragg and in the Los Angeles and San Diego areas of southern California. The same type primer has been used for nearly all maintenance work, but depending upon location of the structure, various colored acrylic water-borne finish coats have been used. Formulations for these finish coats are shown in Appendix B.

Surface preparation prior to application of the water-borne coatings has varied considerably in maintenance work and has included Near-White Blast Cleaning, SSPC No. 10(3), Commercial Blast Cleaning, SSPC No. 6(3), Hand Tool Cleaning, SSPC No. 2(3), steam cleaning, and high pressure water washing. Water-borne paint has also been successfully applied over existing coating systems which include lead and zinc primers, phenolic, vinyl, and chlorinated rubber aluminum finish coats.

The method of paint application by maintenance forces has varied considerably. Most paints were applied by conventional air atomized pressure pot spray equipment; airless spray equipment is not currently used by state maintenance forces. A significant quantity of water-borne coatings has also been applied by brush and roller.

Since the coatings were initially designed for spray application, achieving adequate dry film thickness with brush and roller application has been a common problem. Experience has shown that, typically, one-half the desired dry film thickness is attained by most painters using brushes and rollers to apply water-borne coatings developed in this project. At present, work is under way to improve brush and roller application characteristics of these coatings. Encouraging results have already been obtained. Replacing a portion of the cellulosic thickener with rheological modifier QR708 manufactured by Rohm and Haas appears to help prevent overbrushing and overrolling of the coatings.

The minimum dry film thickness that is acceptable for each coat of primer is two mils, and for each finish coat one and one-half mils. The resulting dry film thickness of a typical water-borne paint system over blast cleaned steel would be four mils of primer applied in two coats followed by three mils of finish applied in two coats. One-day minimum dry time is recommended between coats.

Over five million square feet of steel on highway structures has been painted by state maintenance forces using water-borne paint since use of these coatings was initiated in 1976. In general, the water-borne coatings have performed well; however, certain areas appear to present some

problems. The most significant problem has been incomplete film formation caused by application of water-borne coatings during cold, damp weather when evaporation of water from the coating is extremely slow. Another problem has been thin film application resulting from overbrushing and overrolling. An additional problem has resulted from paint application over hand-cleaned surfaces. The residual rust is solubilized by water in the paint and the dissolved rust then stains the surface of the newly applied coating giving the appearance of coating failure. Application of water-borne paint over rust, as with most coatings, is not an acceptable practice. Thus, this reaction with water-borne coatings should be considered as evidence of inadequate cleaning prior to painting rather than a coating failure.

Work has continued on the evaluation and development of coatings which are less sensitive to application conditions and procedures. At the present time, a new water-borne vinyl acrylic coating and a new high solids solvent-borne coating are being applied to several structures by maintenance forces. Early results from limited application of these coatings has been good and an additional two thousand gallons of each type coating is being purchased.

Private Contractor Application of Water-Borne Coatings

Contract painting operations represent approximately one-third of the total maintenance painting on more than a thousand steel highway structures throughout California. Private painting contractors are chosen to do the work as a result of submitting the lowest price in a competitive

bidding process. When performing the work, the contractors are required to use a specified coating system and comply with all preparation and application requirements specified in the contract documents. A state inspector is assigned to monitor the application and all coatings are tested for compliance prior to application.

In 1979, because of impending air quality regulations, it was considered necessary to begin phasing new paint systems into contract maintenance painting operations so that by the 1982 implementation date, the change to coatings meeting air quality regulations would be complete. Of the fourteen structures scheduled for contract painting during the 1979 painting year, three were selected to be painted with water-borne coating systems. Coating systems used on the painting contracts were those which had been evaluated in laboratory accelerated tests and shown good performance. One of the coatings systems was also currently being used by state maintenance forces.

Work on the first structure proceeded on schedule during June and July 1979. This structure was completely abrasive blast-cleaned to Near-White Metal, SSPC No. 10(3), and four mils of water-borne primer were applied in two coats. The primer used in this work was based on an early version of the current PWB 135 primer formula shown in Appendix B. The first coat of primer was required to be applied on the same day that blast cleaning was performed. Three mils of water-borne aluminum finish paint based on an early version of Formula PWB 132, shown in Appendix B, were then applied in two coats. No problems were encountered on this water-borne paint project and a recent inspection of the structure, after over five years service, revealed the coating system to still be in good condition.

The second structure scheduled for painting that year was to be completely steam cleaned, then abrasive spot blast-cleaned to Near-White Metal, SSPC No. 10(3), where rust was visible. The blast-cleaned areas were then primed with two coats of water-borne primer, Formula LP-3743, based on UCAR 4341 styrene acrylic emulsion, to a minimum dry film of four mils. The entire structure was then painted with two coats, four mils dry film thickness, of a green water-borne finish paint based on the same emulsion used in the primer.

Work on the second structure was delayed and did not start until the fall of 1979. Much of the cleaning and painting was conducted under favorable weather conditions; however, the weather deteriorated considerably during the latter part of the job when rain, fog and low temperatures were common.

The contract contained provisions which specified that paint work be suspended at temperatures below 50°F and relative humidity greater than 75%. Work continued whenever conditions permitted and much of the paint on the last few spans was applied at or near the minimum conditions. Drying time of the coatings significantly increased under these marginal conditions and flash rusting occurred on some of the areas where primers were applied to blast-cleaned steel. Painting of the structure was completed during December 1979.

Recent inspection of the structure, nearly five years after painting, has shown the overall performance of the water-borne coating system to be good. However, those areas

painted during marginal weather conditions are exhibiting spot rust stains and some localized repaint work may be needed within the next five years.

The third structure painted during the first year was completely cleaned by abrasive blasting to Near-White Metal, SSPC No. 10(3). The paint system and film thickness for the coatings were the same as specified for the first water-borne paint application earlier that year.

Contract paint work was also delayed on this project and did not start until the fall of 1979. Weather conditions during most of this project were poor with periods of rain and cold wind. Snow was even observed on the surrounding mountains one morning. Work continued as weather conditions permitted with most painting performed near the specified minimum of 50°F. The temperature usually dropped significantly below 50°F soon after sundown and on many days painting continued until sundown.

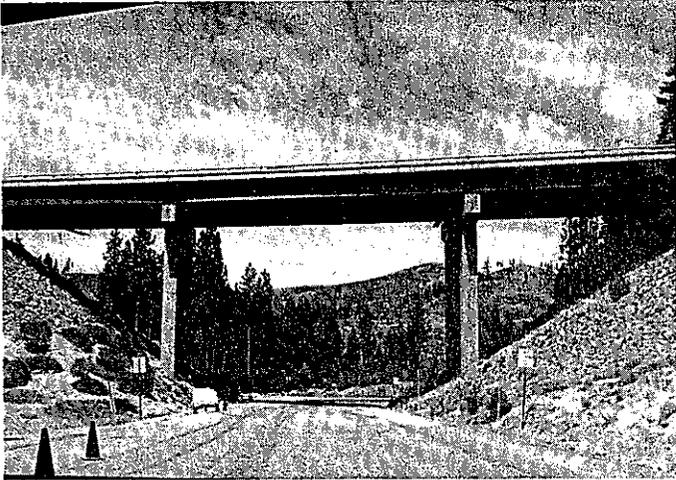
At the present time, after nearly five years, this paint system is still performing well. Some minor rust stains are occurring at various locations but there is no indication of general breakdown in the system.

Because of the success water-borne coatings had the first year, despite the weather problems, an increased number of structures were scheduled to be painted with water-borne coatings during the 1980 painting year. In the 1980 painting year, nearly half of the structures scheduled for contract painting were specified to be painted with water-borne coatings. Minor modifications were made to the formulations between painting years so that application

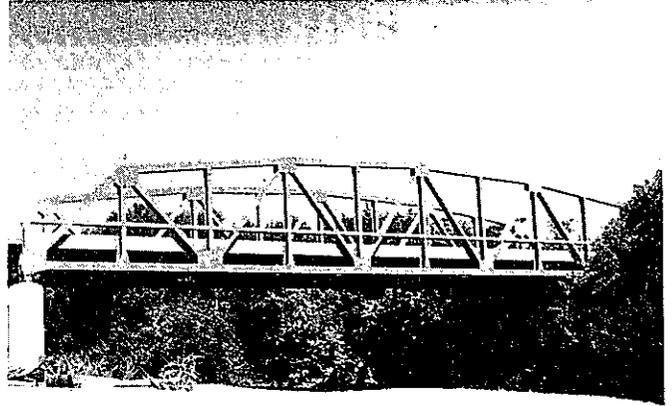
characteristics were improved. The work with water-borne coatings progressed smoothly in the 1980 painting year with few problems noted.

In the following years, an increasing percentage of highway structures scheduled for painting have been painted with water-borne coatings. In the 1983 painting year, all structures scheduled for cleaning and painting by contract were painted with water-borne coatings. At the present time, more than seventy-five structures, at various locations in the state, have been spot painted or 100% painted with water-borne coatings. This has resulted in over two and one-half million square feet of steel on highway structures painted with water-borne paint by private paint contractors in the last five years. Figure IX shows a map of California indicating the location of various structures painted with water-borne coatings during that period. Photographs of some typical structures are shown in Figures X and XI.

Recent inspection of the paint systems on the structures painted with water-borne coatings show that, in general, the paints are performing well. In cases where coating failures have occurred, the breakdown has not developed over the entire structure but is limited to specific areas. The cause of most coating failures that have been observed cannot be attributed solely to the fact water-borne coatings were used. Figure XII shows photographs of coating failure due to application at temperatures significantly below 50°F. Following is a list of some problems associated with coating failure on various structures:



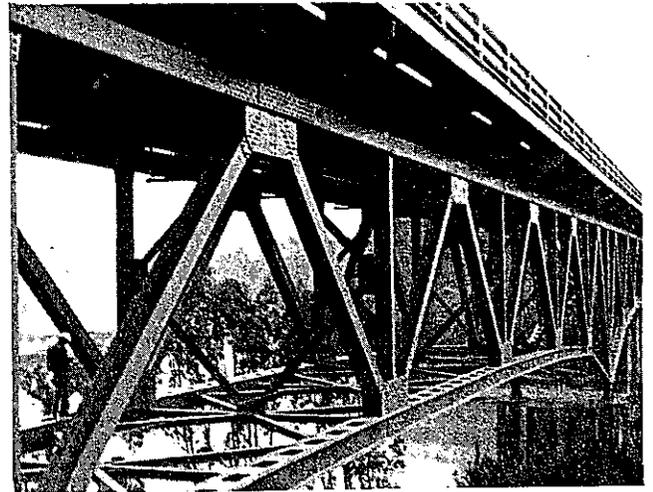
Mountains



Near Coastal



Coastal



Coastal

Figure X

Typical Structures Painted With
Water-Borne Coatings

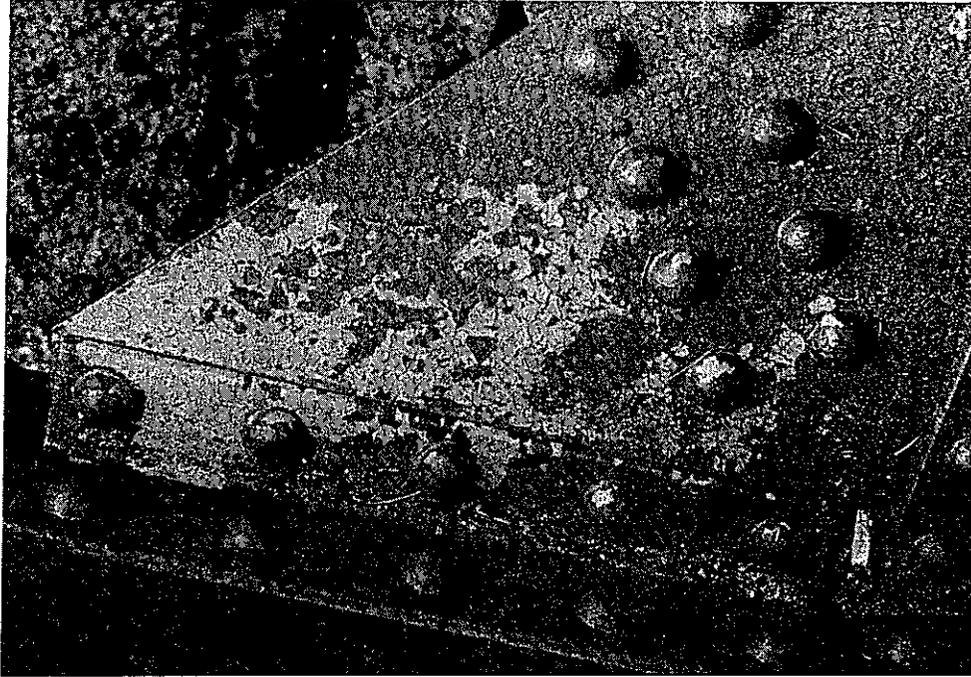


Northern California

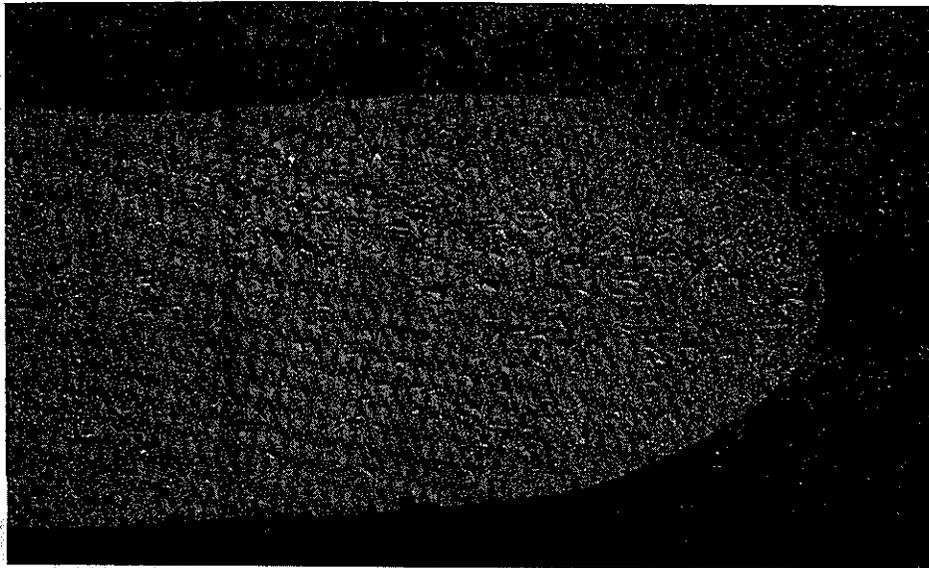


Southern California

Figure XI
Typical Structures Painted With
Water-Borne Coatings



Job Site Finish Coat Failure



*Laboratory Induced Finish Coat Failure

*6 mil wet film draw down of finish coat on previously primed steel test panel. Finish coat then dried at constant 35°F.

Figure XII

Finish Coat Failure Caused By Low Temperature

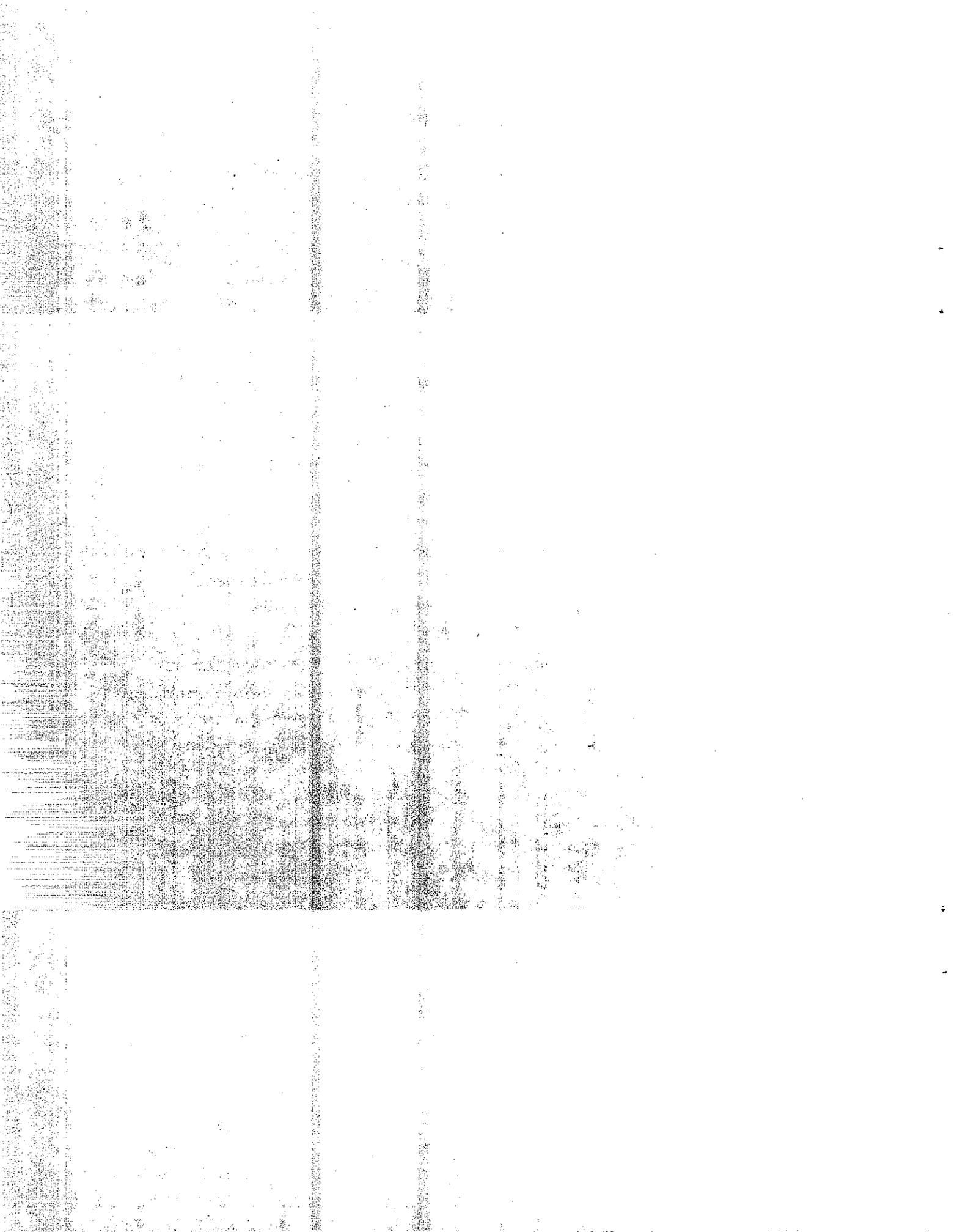
1. Inadequate film thickness of primer to steel.
2. Inadequate film thickness all coats.
3. Inadequate blast cleaning prior to painting.
4. Long delay in application of succeeding coats of paint after the first coat of primer.
5. Uneven application of paint resulting in excessively thick or thin areas.
6. Application under marginal weather conditions.
7. Painting over sand left from blast cleaning operations.
8. Applying paint to steel surfaces colder than 50°F.
9. Application and drying of coating at temperature or relative humidity exceeding specified limits.

In an effort to prevent many of these problems from occurring on future bridge painting projects, specifications are being revised so bridge painting operations are more closely controlled. A paint inspector training program is to be developed so inspectors will be more knowledgeable about what they are required to do. Additional restrictions on the type of painting equipment have already been instituted. Airless spray is no longer permitted. Many of the problems noted in the past have been the result of uneven application of paint due to the uncontrolled high volume output of airless spray equipment.

Caltrans plans to remain active in the evaluation and development of new low-solvent coatings for contract application to highway structures. Technological advances have been dramatic during the last five years and future developments will most certainly lead to additional coatings that will comply with stricter environmental controls, and provide coatings that surpass the performance demonstrated by current water-borne coatings.

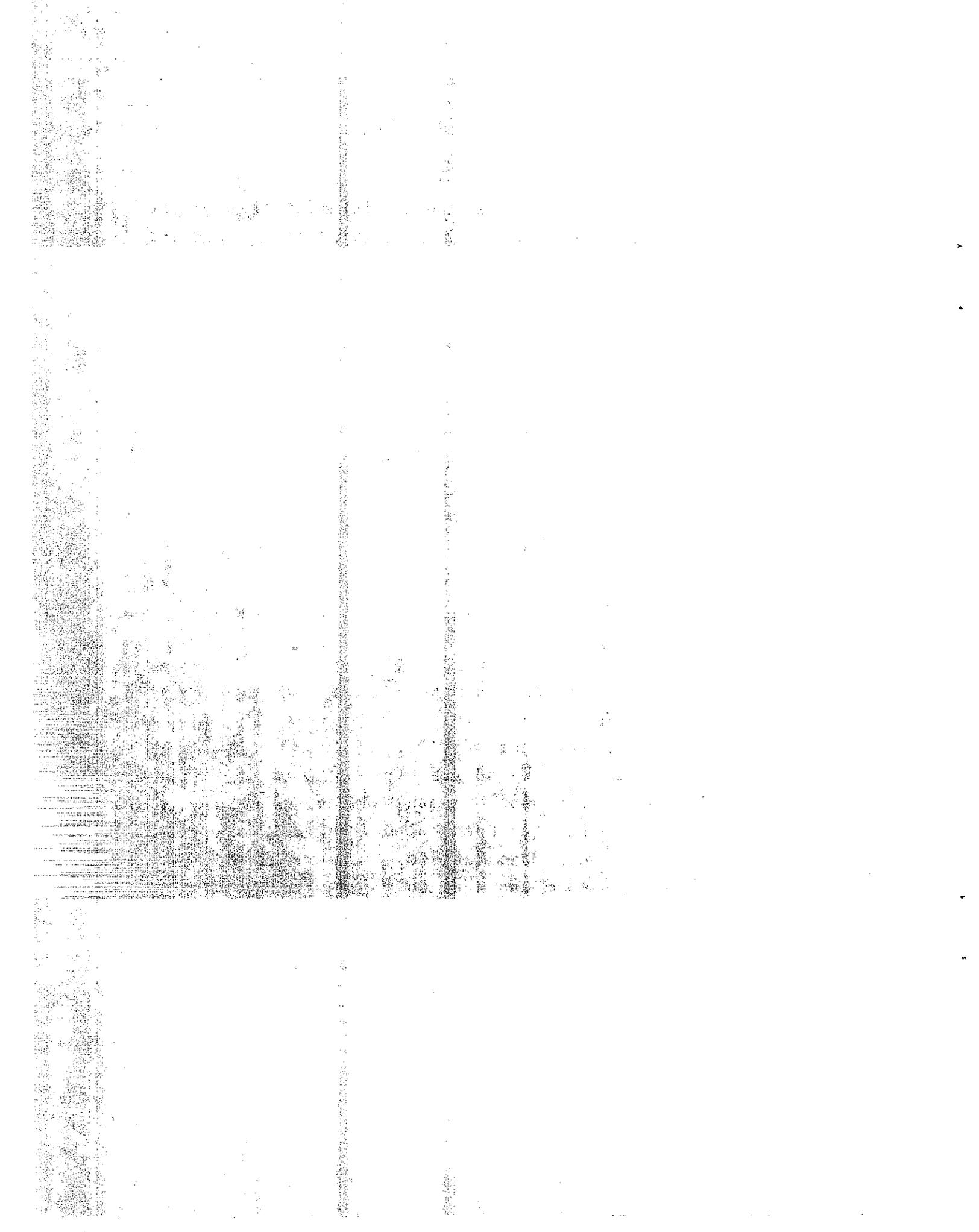
LITERATURE REFERENCES

1. Evaluation of Coatings on Coastal Steel Bridges 16 Year Period, Interim Report; Herbert A. Rooney and Albert L. Woods, State of California, Department of Public Works, Division of Highways, Materials and Research Department, January 1969, Research Project No. 645135.
2. Consideration of Model Organic Solvent Rule Applicable to Architectural Coatings, prepared by the staff of the Industrial Strategy Development Section, State of California Air Resources Board, presented at the Air Resources Board meeting, June 29, 1977, Agenda Item 77-14-4.
3. Steel Structures Painting Manual Volume 2, Systems and Specifications Third Edition 1982, Steel Structures Painting Council, John Keane, Executive Editor.
4. Water-Based Coatings for Protection of Steel Structures, Raymond Warness, State of California, Department of Transportation, Division of Construction, Office of Transportation Laboratory, December 1979, Report No. FHWA/CA/TL-79/24.



TRADEMARK REFERENCES

Alqua	PVO International Inc.
Arolon	Spencer Kellogg Division of Textron Inc.
Aroplaz	Spencer Kellogg Division of Textron Inc.
Busan	Buckman Laboratories
Butrol	Buckman Laboratories
Carbitol	Union Carbide Corp.
Cellosize	Union Carbide Corp.
Chemacoil	IMC Corp.
Drew	Drew Chemical
Foamaster	Diamond Shamrock
Gammasperse	Georgia Marble
Haloflex	ICI Americas
Halox	Halox Pigments
Methocel	Dow Chemical
Miox	Reichard Coulston
Nalzin	NL Chemicals
Natrosol	Hercules Inc.
Nichem	Nichem Inc.
Nopco	Diamond Shamrock
Rheolate	NL Industries
Rhoplex	Rohm and Haas Co.
Sicorin	Basf Wyandotte Corp.
Snowflake	Thompson Weinman and Co.
Texanol	Eastman Chemical Co.
Tamol	Rohm and Haas Co.
Triton	Rohm and Haas Co.
UCAR	Union Carbide Corp.
Varkyd	McCloskey Varnish Co.
Vicron	Pfizer Minerals and Pigments
Yelkin	Ross and Row Inc.



APPENDIX A

MANAGEMENT
A HANDBOOK FOR
MANAGEMENT PRACTITIONERS

Proposed Model Rule For The
Application of Architectural Coatings

I. Definitions

a) Architectural Coatings

For the purpose of this rule, an architectural coating is defined as any coating applied to stationary structures and their appurtenances, mobile homes, pavements, or curbs.

b) Fire Retardant Coatings

Architectural coatings which are designed to retard fires and under accepted methods of tests, will significantly: (a) reduce the rate of flame spread on the surface of a material to which it has been applied, or (b) resist ignition when exposed to high temperatures or (c) insulate a substrate to which it has been applied and prolong the time required to reach its ignition temperature.

c) Industrial Maintenance Finishes

Those coatings specifically formulated for the purpose of metal corrosion protection.

d) Metallic Pigmented Paints

Non-bituminous coatings formulated with significant amounts of metallic pigment.

e) Opaque Stains

All stains not classified as semitransparent stains.

f) Primers

The first coat applied to a surface intended to provide a firm bond to the substrate for subsequent coats.

Consideration of Model Organic
Solvent Rule Applicable to
Architectural Coatings

c) Sealers

Coatings intended for use on porous substrates to prevent subsequent coatings from being absorbed by the substrate, and to protect the substrate from water.

h) Semitransparent Stains

A penetrating composition that changes the color of a surface but does not conceal the surface.

i) Tile-like Glaze Coatings

Coatings applied by conventional means and intended to produce vitreous (tile-like) finishes on relatively rough masonry or other cementitious walls and ceilings.

j) Undercoaters

Soft easily sanded coatings designed to provide a very smooth surface for subsequent coats.

k) Varnishes, Lacquers, and Shellacs

Coatings containing resins and binders but not pigments and specifically formulated to form a transparent or translucent solid protective film.

l) Wood Preservatives

Those coatings specifically formulated for the purpose of protecting exposed wood from decay and insect attack and which do so by penetrating into the wood.

2. No person shall sell, offer for sale, or apply any architectural coating manufactured after July 1, 1978 which:
 - a. contains more than 250 grams of volatile organic material per liter of coating as applied, excluding water, except as provided in subsection b and c of this section.
 - b. contains more than 350 grams of volatile organic material per liter of coating as applied, excluding water, and is recommended solely for use on interior surfaces. After July 1, 1980 interior coatings may not contain more than 250 grams of volatile organic material per liter of coating as applied, excluding water.
 - c. contains more than 50 grams of volatile organic material per liter of coating as applied, excluding water, and is recommended for use as a bituminous pavement sealer or bituminous reflective roof coating.

3. Until July 1, 1982, the provisions of this rule shall not apply to:
 - a. architectural coatings supplied in containers having capacities of one liter or less;
 - b. reflective roof coatings supplied in containers having capacities of 20 liters or less;
 - c. traffic coatings applied to public streets and highways, excluding curbs and berms.

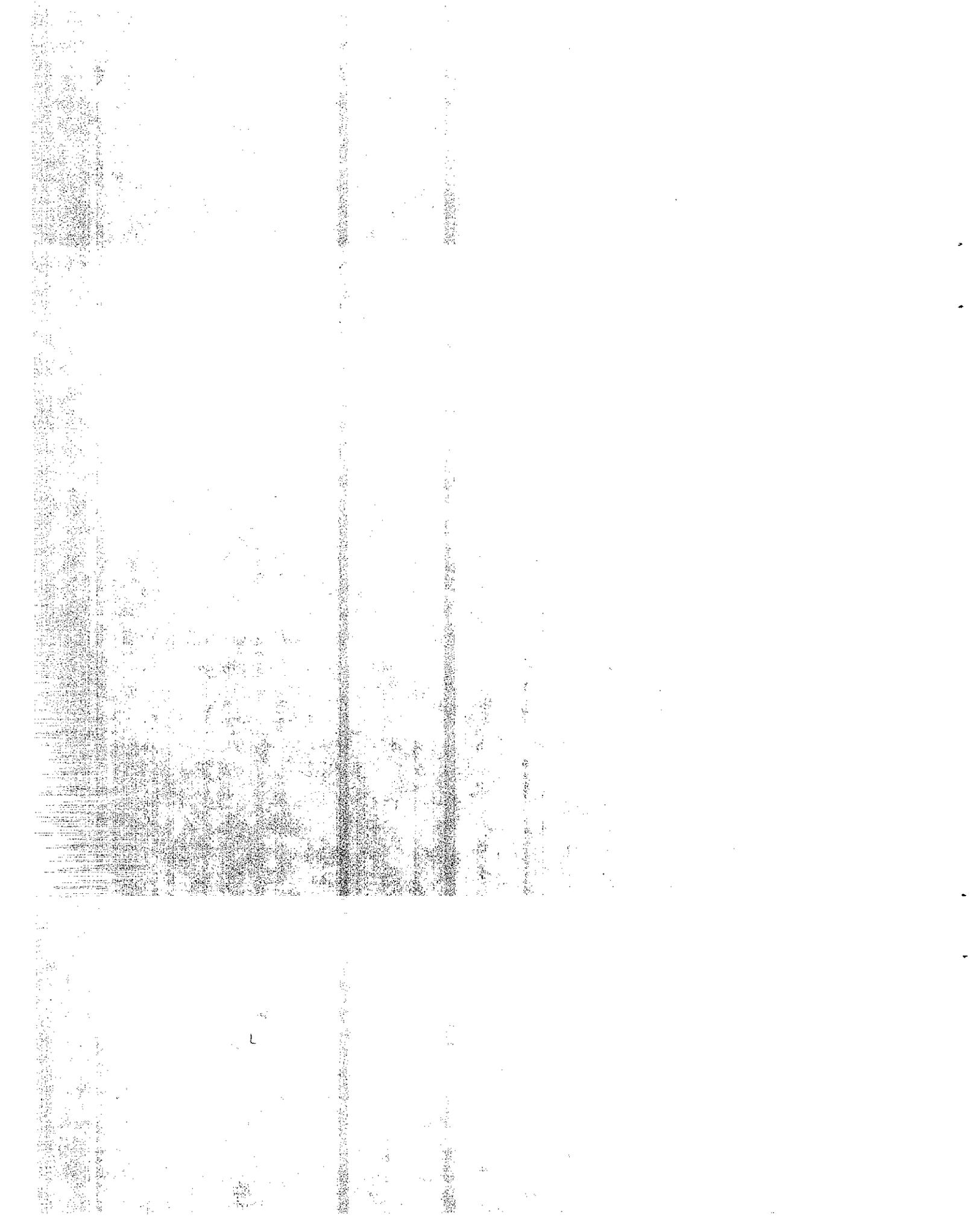
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- d. architectural coatings recommended and used solely as a:
- 1) varnish, lacquer, or shellac
 - 2) semitransparent stain
 - 3) opaque stain on bare redwood, cedar, and mahogany
 - 4) primer, sealer, or undercoater
 - 5) wood preservative
 - 6) fire retardant coating
 - 7) tile-like glaze coating
 - 8) waterproofing coating
 - 9) industrial maintenance finish
 - 10) metallic pigmented coating
 - 11) swimming pool coating
- e. if anywhere on the coating container, label, or in sales or advertising literature, any indication is given that the coating may be used or is suitable for use for any purpose other than those specifically provided for in subsection d of this section, then the provisions of Section 2 shall apply.

4. Identification of Coatings

Containers for all coatings subject to Section 2 shall display the date of manufacture of the contents or a code indicating the dates of manufacture. An explanation of each code shall be filed with the Air Pollution Control Officer and the Executive Officer of the California Air Resources Board prior to July 1, 1978.

APPENDIX B



SECTION 8-2. (BLANK)
SECTION 8-3. PAINT

8-3. _____ RED PRIMER PAINT - WATER-BORNE (FORMULA PWB-135).--

Description.--This specification covers a ready-mixed, water-borne paint formulated for use on blast cleaned steel surfaces exposed to the air.

This coating is intended for spray application. Limited application can be made by brushing or rolling.

Composition.--Paint shall be mixed in the following proportions and sequence:

Component		Pounds/100 gallons
Mix at low speed:		
Water		96.0
Dispersant/Stabilizer	(1)	17.0
Surfactant	(2)	3.0
Defoamer	(3)	2.0
Diethylene Glycol		
Monomethyl Ether		28.0
Preservative	(4)	0.6

Hold back part of water initially to get good grind viscosity.

Grind under high shear to achieve specified grind.

Do not exceed 100°F during this operation, add remainder of water after grind is achieved.

Red Iron Oxide	(5)	90.0
Zinc Phosphate	(6)	40.0
Mica-ASTM D 607 Type A		33.0
Calcium Carbonate	(7)	200.0
Zinc Yellow-ASTM D 478 Type 1		5.0

Add premixed water and cellulose and mix at slower speed until moderately thickened before proceeding with letdown.

Hydroxyethyl Cellulose (8)]	1.5-2.5
Water]	25.0

Under low speed - let down paste slowly:

Styrene acrylic emulsion	(9)	510.0
Defoamer	(3)	1.0
Diethylene glycol monobutyl ether]	6.0
Diethylene glycol monobutyl ether acetate]	6.0
Alkyd, 100% solids (10)]	25.6
Surfactant (2)]	1.4
Water]	21.0
Ammonia 28%]	6.0

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Characteristics:

Weight per gallon, pounds	11.1-11.3
Pigment by weight of paint, percent	32-34
Nonvolatiles by weight of paint, percent	57.8-59.8
Nonvolatile vehicle, by weight, percent	37.5-39.5
Nonvolatiles by volume of paint, percent	44-46
Fineness of grind, Hegman	3-5
Viscosity, KU	69-75
pH	8.5-9.0
Drying time at 77°F, 50% RH, 5 mil wet film	
Set to touch, hours	1 max.
Dry through, hours	4 max.

- (1) Tamol 731 (Rohm Haas)
- (2) Triton CF-10 (Rohm Haas)
- (3) Foamaster G (Diamond Shamrock)
- (4) Dovicil 75 (Dow Chemical)
- (5) Synthetic iron oxide, spheroidal particle shape, Fe_2O_3 98% minimum, oil absorption* 20+3, specific gravity 5.2 ± 0.1 , 99.9% passing 325 mesh screen. Water soluble matter 0.15% maximum, easy dispersable type recommended.
- (6) Essentially $Zn_3(PO_4)_2 \cdot 2H_2O$, specific gravity 3.4 ± 0.1 , oil absorption* 20+3, average particle size less than 10 microns
Water soluble matter 0.2% maximum.
- (7) 98% minimum $CaCO_3$, having an average particle size of 5 microns or less, a maximum particle size of 25 microns and containing no less than 80% particle size of less than 10 microns. Oil absorption* shall be less than 22.
- (8) Cellosize QP4400 (Union Carbide) or Natrosol 250 MR or 250 MBR (Hercules)
- (9) Aroclon 820-W-49 (Spencer Kellog)
- (10) Aroplaz 1271 (Spencer Kellog)

*Oil absorption values determined according to ASTM D 281

SECTION 8-2. (BLANK)
SECTION 8-3. PAINT

8-3. PINK PRIMER PAINT - WATER-BORNE (FORMULA PWB-137).--

Description.--This specification covers a ready-mixed, water-borne paint formulated for use on blast cleaned steel surfaces exposed to the air.

This coating is intended for spray application. Limited application can be made by brushing or rolling.

Composition.--Paint shall be mixed in the following proportions and sequence:

Component	Pounds/100 Gallons
• Mix at low speed:	
Water	96.0
Dispersant/Stabilizer (1)	17.0
Surfactant (2)	3.0
Defoamer (3)	2.0
Diethylene Glycol	
Monomethyl Ether	28.0
Preservative (4)	0.6

Hold back part of water initially to get good grind viscosity.

Grind under high shear to achieve specified grind.

Do not exceed 100°F during this operation, add remainder of water after grind is achieved.

Red Iron Oxide (5)	40.0
Titanium Dioxide-ASTM D 476(6)	50.0
Zinc Phosphate (7)	40.0
Mica -ASTM D 607 Type A	33.0
Calcium Carbonate (8)	200.0
Zinc Yellow-ASTM D 478 Type I	5.0

Add premixed water and cellulose and mix at slower speed until moderately thickened before proceeding with letdown.

Hydroxyethyl Cellulose(9)	1.5-2.5
water	25.0

Under low speed - let down paste slowly:

Styrene acrylic emulsion (10)	510.0
Defoamer (3)	1.0
Diethylene glycol monobutyl ether	
] Premix	6.0
Diethylene glycol monobutyl ether acetate	
] Premix	6.0
Alkyd, 100% solids (11)	25.6
Surfactant (2)	1.4
Water	21.0
Ammonia 28%	6.0

Characteristics:

Weight per gallon, pounds	11.1-11.3
Pigment by weight of paint, percent	32-34
Nonvolatiles by weight of paint, percent	57.8-59.8
Nonvolatile vehicle, by weight, percent	37.5-39.5
Nonvolatiles by volume of paint, percent	44-46
Fineness of grind, Hegman	3-5
Viscosity, KU	69-75
pH	8.5-9.0
Drying time at 77°F, 50% RH, 5 mil wet film	
Set to touch, hours	1 max.
Dry through, hours	4 max.

- (1) Tamol 731 (Rohm Haas)
- (2) Triton CF-10 (Rohm Haas)
- (3) Foamaster G (Diamond Shamrock)
- (4) Dowicil 75 (Dow Chemical)
- (5) Synthetic iron oxide, spheroidal particle shape, Fe₂O₃ 98% minimum, oil absorption* 20+3, specific gravity 5.2± 0.1, 99.9% passing 325 mesh screen. Water soluble matter 0.15% maximum, easy dispersable type recommended.
- (6) Type III or IV - Oil absorption* 19+2
- (7) Essentially Zn₃(PO₄)₂·2H₂O, specific gravity 3.4±0.1, oil absorption* 20+3, average particle size less than 10 microns. Water soluble matter 0.2% maximum.
- (8) 98% minimum CaCO₃, having an average particle size of 5 microns or less, a maximum particle size of 25 microns and containing no less than 80% particle size of less than 10 microns. Oil absorption* shall be less than 22.
- (9) Cellosize QP4400 (Union Carbide) or Natrosol 250 MR or 250 MBR (Hercules)
- (10) Aroclon 820-W-49 (Spencer Kellog)
- (11) Aroplaz 1271 (Spencer Kellog)

*Oil absorption values determined according to ASTM D 281.

8-3. LIGHT GREEN FINISH PAINT - WATER-BORNE (FORMULA PWB-82 REVISED).--

Description.--This specification covers a ready-mixed, water-borne paint formulated for use as a finish coat on properly prepared metal surfaces.

This coating is intended for spray application. Limited application may be made by brushing or rolling.

Composition.--Paint shall be mixed in the following proportions and sequence:

Component	Pounds/100 Gallons
Mix at low speed:	
Water	70
Dispersant (1)	17
Surfactant (2)	2.4
Defoamer (3)	1.2
Ethylene Glycol-ASTM D 2693	30

Grind under high shear to achieve specified grind.
Do not exceed 110°F during this operation.

Calcium Carbonate (4)	50
Chromium Oxide Green (5)	150
Zinc Oxide (6)	6
Titanium Dioxide (7)	50
Hydroxyethyl Cellulose (8)	1.3-2.0
Water	19

] Premix

Let down paste slowly:

Acrylic Emulsion (9)	620
2,2,4-Trimethylpentanediol-1,3-Monoiso Butyrate	28
Defoamer (3)	1.2
Preservative (10)	2
Ammonium Hydroxide (28%)	5-6

Characteristics:

Weight per gallon, pounds	10.4-10.6
Pigment by weight of paint, percent	23.3-25.3
Nonvolatiles by weight of paint, percent	51.1-53.1
Nonvolatile vehicle, by weight, percent	35.7-37.7
Nonvolatiles by volume of paint, percent	38-40
Fineness of grind, Hegman	6 min.
Viscosity, KU	67-72
PH	9.0-9.5
Drying time at 77°F, 50% RH 4 mil wet film	
Set to touch, hours	1 max.
Dry through, hours	4 max.

- (1) Tamol 165 (Rohm Haas)
- (2) Triton CF-10 (Rohm Haas)
- (3) Foamaster G (Diamond Shamrock)
- (4) 98% minimum CaCO₃, having an average particle size of 5 microns or less, a maximum particle size of 25 microns and containing no less than 80% particle size

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of less than 10 microns. Oil absorption* shall be less than 22.

- (5) 99% minimum Cr_2O_3 , $\pm 99.9\%$ passing a 325 mesh screen, with an average particle size of less than 1 micron, oil absorption* 20 ± 2 , water soluble matter 0.2% maximum.
- (6) ASTM D 79, French process, dry
- (7) ASTM D 476 Type IV, oil absorption* 19 ± 2 .
- (8) Cellosize QP 4400 (Union Carbide) or Natrosol 250 MR or 250 MSR (Hercules)
- (9) Rhoplex MV9 (Rohm Haas)
- (10) Skane M-8 (Rohm Haas)

*Oil absorption values determined according to ASTM D 281.

8-3. GREEN FINISH PAINT - WATER-BORNE (FORMULA PWB-83
REVISED).--

Description.--This specification covers a ready-mixed, water-borne paint formulated for use as a finish coat on properly prepared metal surfaces.

This coating is intended for spray application. Limited application may be made by brushing or rolling.

Composition.--Paint shall be mixed in the following proportions and sequence:

Component	Pounds/100 Gallons
-----------	--------------------

Mix at low speed:

Water		55
Dispersant	(1)	15
Surfactant	(2)	1
Defoamer	(3)	1.2
Ethylene Glycol-ASTM D 2693		30

Grind under high shear to achieve specified grind.
Do not exceed 110°F during this operation.

Calcium Carbonate	(4)	50
Chromium Oxide Green	(5)	150
Zinc Oxide	(6)	6
Phthalocyanine green dispersion	(7)	40
Hydroxyethyl Cellulose	(8)	1.3-2.0
Water	Premix	19

Let down paste slowly:

Acrylic Emulsion	(9)	620
2,2,4-Trimethylpentanediol-1,3-Monoiso Butyrate		28
Defoamer	(3)	1.2
Preservative	(10)	2
Ammonium Hydroxide (28%)		5-6

Characteristics:

Weight per gallon, pounds	10.1-10.3
Pigment by weight of paint, percent	20.6-22.6
Nonvolatiles by weight of paint, percent	49.0-51.0
Nonvolatile vehicle, by weight, percent	35.7-37.7
Nonvolatiles by volume of paint, percent	38-40
Fineness of grind, Hegman	6 min.
Viscosity, KU	67-72
pH	9.0-9.5
Drying time at 77°F, 50% RH, 4 mil wet film	

Set to touch, hours	1 max.
Dry through, hours	4 max.

Color to closely match Color Chip 72 (On file at the Transportation Laboratory)

(1) Tamol 165 (Rohm Haas)

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- (1) Tamol 165 (Rohm Haas)
- (2) Triton CF-10 (Rohm Haas)
- (3) Foamaster G (Diamond Shamrock)
- (4) 98% minimum CaCO_3 , having an average particle size of 5 microns or less, a maximum particle size of 25 microns and containing no less than 80% particle size of less than 10 microns. Oil absorption* shall be less than 22.
- (5) 99% minimum Cr_2O_3 , +99.9% passing a 325 mesh screen, with an average particle size of less than 1 micron, oil absorption* 20+2, water soluble matter 0.2% maximum.
- (6) ASTM D 79, French process, dry
- (7) SUP-R-CONC L 6-41-L-401 (Hilton-Davis)
- (8) Cellosize QP 4400 (Union Carbide) or Natrosol 250 MR or 250 MBR (Hercules)
- (9) Rhoplex MV9 (Rohm Haas)
- (10) Skane M-8 (Rohm Haas)

*Oil absorption values determined according to ASTM D 281.

8-3. WHITE TINTABLE FINISH PAINT - WATER-BORNE (FORMULA PWB-86 REVISED).--

Description.--This specification covers a ready-mixed, water-borne paint formulated for use as finish coats on properly prepared metal surfaces.

This coating is intended for spray application. Limited application may be made by brushing or rolling.

Composition.--Paint shall be mixed in the following proportions and sequence:

Component	Pounds/100 gallons
-----------	--------------------

Mix at low speed:

Water		63
Dispersant	(1)	17
Surfactant	(2)	2.4
Defoamer	(3)	1.2
Ethylene Glycol-ASTM D 2693		30

Hold back part of water initially to get good grind viscosity.

Grind under high shear to achieve specified grind.

Do not exceed 100°F during this operation, add remainder of water after grind is achieved.

Calcium Carbonate	(4)	50
Zinc Oxide	(5)	6
Titanium Dioxide	(6)	200
Hydroxyethyl Cellulose	(7) 	1.3-2.0
Water	Premix	19

Let down paste slowly:

Acrylic Emulsion	(8)	620
2,2,4-Trimethylpentanediol-1,3-Monoiso Butyrate		28
Defoamer	(3)	1.2
Preservative	(9)	2
Ammonium Hydroxide (28%)		5-6

When color paints are specified, light-fast, alkali-resistant, compatible, dry color pigments shall be substituted for the titanium dioxide pigment on an equal volume basis.

Light-fast, alkali-resistant, compatible, pigment dispersions may also be used but are limited to a maximum of 5 pounds per 100 gallons of paint to achieve the specified color.

Characteristics:

Weight per gallon, pounds	10.4-10.6
Pigment by weight of paint, percent	23.5-25.5
Nonvolatiles by weight of paint, percent	51.4-53.4

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Nonvolatile vehicle, by weight, percent	36.0-38.0
Nonvolatiles by volume of paint, percent	39-41
Fineness of grind, Hegman	6 min.
Viscosity, KU	67-72
pH	9.0-9.5
Drying time at 77°F, 50% RH, 4 mil wet film	
Set to touch, hours	1 max.
Dry through, hours	4 max.

- (1) Tamol 165 (Rohm Haas)
- (2) Triton CF-10 (Rohm Haas)
- (3) Foamaster G (Diamond Shamrock)
- (4) 98% minimum CaCO₃, having an average particle size of 5 microns or less, a maximum particle size of 25 microns and containing no less than 80% particle size of less than 10 microns. Oil absorption* shall be less than 22.
- (5) ASTM D 79, French process, dry
- (6) ASTM D 476 Type IV, oil absorption* 19+2.
- (7) Natrosol 250 MR or 250 MBR (Hercules) or Cellosize QP 4400 (Union Carbide)
- (8) Rhoplex MV9 (Rohm Haas)
- (9) Skane M-8 (Rohm Haas)

*Oil absorption values determined according to ASTM D 281

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8-3. FLAT GRAY FINISH PAINT - WATER-BORNE (FORMULA PWB-87 REVISD).--

This specification covers a pre-mixed, water-borne paint formulated for use as a finish coat on properly prepared metal surfaces.

This coating is intended for spray application. Limited application may be made by brushing or rolling.

Composition.--Paint shall be mixed in the following sequence:

Component	Pounds/100 gallons
-----------	--------------------

Mix at low speed:

Water		54
Dispersant	(1)	17
Surfactant	(2)	2.4
Defoamer	(3)	1.2
Ethylene Glycol-ASTM D 2693		30

Grind under high shear to achieve specified grind, do not exceed 100°F. during this operation.

Calcium Carbonate	(4)	50
Zinc Oxide	(5)	6
Titanium Dioxide	(6)	150
Lamp Black Dispersion	(7)	0.5-1.0
Diatomaceous Silica	(8)	50
Hydroxyethyl Cellulose	(9)	1.3-2.0
Water	Premix	19

Let down paste slowly:

Acrylic Emulsion	(10)	620
2,2,4-Trimethylpentanediol- 1,3-Monoiso Butyrate		28
Defoamer	(3)	1.2
Preservative	(11)	2
Ammonium Hydroxide (28%)		5-6

Characteristics:

Weight per gallon, pounds	10.4
Pigment by weight of paint, percent	24.7
Nonvolatiles by weight of paint, percent	52.9
Nonvolatiles by volume of paint, percent	41
Fineness of grind, Hegman	5 min.
Viscosity, KU	67-72
pH	9.0-9.5
Drying time at 77°F, 50% RH, 4 mil wet film	
Set to touch, hours	1
Dry through, hours	4

Color to closely match Color Chip 36495 of Federal Standard 595a.

- (1) Tamol 165 (Rohm Haas)
- (2) Triton CF-10 (Rohm Haas)
- (3) Foamaster G (Diamond Shamrock)
- (4) 98% minimum CaCO_3 , having an average particle size of 5 microns or less, a maximum particle size of 25 microns and containing no less than 80% particle size of less than 10 microns. Oil absorption* shall be less than 22.
- (5) ASTM D 79, French process, dry
- (6) ASTM D 476 Type III or IV, *oil absorption 19+2.
- (7) Aurasperse W-7717 (Harshaw) or equivalent.
- (8) Celite 499 (Johns-Manville)
- (9) Cellosize QP 4400 (Union Carbide) or Natrosol 250 MR or 250 MBR (HERCULES)
- (10) Rhoplex MV9 (Rohm Haas)
- (11) Skane M-8 (Rohm Haas)

*Oil absorption values determined according to ASTM D 281

8-3. LIGHT TAN FINISH PAINT - WATER-BORNE (FORMULA PWB-88 REVISED).--

Description.--This specification covers a ready-mixed, water-borne paint formulated for use as finish coats on properly prepared metal surfaces.

This coating is intended for spray application. Limited application may be made by brushing or rolling.

Composition.--Paint shall be mixed in the following proportions and sequence:

Component	Pounds/100 gallons
-----------	--------------------

Mix at low speed:

Water		40
Dispersant	(1)	17
Surfactant	(2)	2.4
Defoamer	(3)	1.2
Ethylene Glycol-ASTM D 2693		39

Grind under high shear to achieve specified grind, do not exceed 110°F.

Calcium Carbonate	(4)	90
Yellow Iron Oxide	(5)	50
Titanium Dioxide	(6)	70
Zinc Oxide	(7)	6

Let down paste slowly:

Acrylic Emulsion	(8)	620
2,2,4-Trimethylpentanediol-1,3-Monoisobutyrate		28
Defoamer	(3)	1.2
Preservative	(9)	2
Ammonium Hydroxide (20%)		5-6
Thickener	(10) 	8-12
Water	Premix	35

Characteristics:

Weight per gallon, pounds	10.1-10.3
Pigment by weight of paint, percent	20.2-22.2
Nonvolatiles by weight of paint, percent	49.2-51.2
Nonvolatile vehicle, by weight, percent	35.7-37.7
Nonvolatiles by volume of paint, percent	37-39
Fineness of grind, Hegman	6 min.
Viscosity, KU	67-72
pH	9.0-9.5
Drying time at 77°F, 50% RH, 4 mil wet film	
Set to touch, hours	1 max.
Dry through, hours	4 max.

Color to closely match Color Chip 81 (On file at the Transportation Laboratory)

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- (1) Tamol 165 (Rohm Haas)
- (2) Triton CF-10 (Rohm Haas)
- (3) Foamaster G (Diamond Shamrock)
- (4) 98% minimum CaCO_3 , having an average particle size of 5 microns or less, a maximum particle size of 25 microns and containing no less than 80% particle size of less than 10 microns. Oil absorption* shall be less than 22.
- (5) Synthetic iron oxide containing a minimum 99% as $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ (a minimum of 86% calculated as Fe_2O_3 .) 99.9% passing a 325 mesh screen, with an average particle size of 15 microns or less.
- (6) ASTM D 476 Type IV, oil absorption* 19±2.
- (7) ASTM D 79, French process, dry
- (8) Rhoplex MV9 (Rohm Haas)
- (9) Skane M-8 (Rohm Haas)
- (10) Rheolate I (NL Industries)

*Oil absorption values determined according to ASTM D 281

8-3. TAN FINISH PAINT - WATER-BORNE (FORMULA PWB-89
REVISED).--

Description.--This specification covers a ready-mixed, water-borne paint formulated for use as finish coats on properly prepared metal surfaces.

This coating is intended for spray application. Limited application may be made by brushing or rolling.

Composition.--Paint shall be mixed in the following proportions and sequence:

Component	Pounds/100 gallons
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Mix at low speed:

Water		55
Dispersant	(1)	17
Surfactant	(2)	2.4
Defoamer	(3)	1.2
Ethylene Glycol-ASTM D 2693		39

Grind under high shear to achieve specified grind, do not exceed 110°F.

Calcium Carbonate	(4)	90
Yellow Iron Oxide	(5)	80
Titanium Dioxide	(6)	40
Zinc Oxide	(7)	6

Let down paste slowly:

Acrylic Emulsion	(8)	620
2,2,4-Trimethylpentanediol-1,3-Monociso Butyrate		28
Defoamer	(3)	1.2
Preservative	(9)	2
Ammonium Hydroxide (28%)		5-6
Thickener	(10)	8-12
Water	Premix	20

Characteristics:

Weight per gallon, pounds	10.1-10.3
Pigment by weight of paint, percent	20.2-22.2
Nonvolatiles by weight of paint, percent	49.2-51.2
Nonvolatile vehicle, by weight, percent	35.7-37.7
Nonvolatiles by volume of paint, percent	37-39
Fineness of grind, Hegman	6/min.
Viscosity, KU	67-72
pH	9.0-9.5
Drying time at 77°F, 50% RH, 4 mil wet film	
Set to touch, hours	1 max.
Dry through, hours	4 max.

Color to closely match Color Chip 86 (On file at the Transportation Laboratory)

7-2-84

- (1) Tamol 165 (Rohm Haas)
- (2) Triton CF-10 (Rohm Haas)
- (3) Foamaster G (Diamond Shamrock)
- (4) 98% minimum CaCO_3 , having an average particle size of 5 microns or less, a maximum particle size of less than 10 microns. Oil absorption* shall be less than 22.
- (5) Synthetic iron oxide containing a minimum 99% as $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$ (a minimum of 86% calculated as Fe_2O_3 .) 99.9% passing a 325 mesh screen, with an average particle size of 15 microns or less.
- (6) ASTM D 476 Type IV, oil absorption* 19±2.
- (7) ASTM D 79, French process, dry
- (8) Rhoplex MV9 (Rohm Haas)
- (9) Skane M-8 (Rohm Haas)
- (10) Rheolate I (NL Industries)

*Oil absorption values determined according to ASTM D 281

Aluminum Finish Paint - Water Base
Formula PWB 132

COMPOSITION

The Paint shall be supplied with 1.5 pounds of the specified aluminum paste to one gallon of vehicle.

PIGMENT INGREDIENTS

Leafling Type: Hydro Paste Aluminum No. 830, Alcoa

Characteristics of Pigment:

Non-volatiles by weight of pigment, percent 72 min.

VEHICLE INGREDIENTS

	<u>% by Weight</u>
Acrylic Emulsion (1)	95.37
2,2,4-Trimethyl pentanediol-1,3-monosio butyrate	2.15
Water	2.25
Thickner (2) } Premix	0.08-0.13
Preservative (3)	0.02
Defoamer (4)	0.10

Characteristics of Vehicle:

Weight per gallon, pounds	8.6-8.8
Non-volatiles by weight of vehicle, percent	42.5-44.5
Viscosity, centipoises, Brookfield RVT #3 spindle at 50 rpm	800-1000
pH	9.0-9.6
Minimum Film Formation Temperature, °F	44-45

- (1) Rhoplex MV-9 (Rohm and Haas)
- (2) Cellosize QP4400 (Union Carbide), or
Natrosol 250 MR (Hercules)
- (3) Proxel CRL (ICI Americas)
- (4) Troykyd 999, (Troy Chemical) or
Foamaster G (Diamond Shamrock)

Characteristics of Mixed Paint:

Non-volatiles by volume of mixed paint, percent	36-38
Drying time at 77°F, 50% RH, 4 mil wet film	
Set to touch, hours	-1/2 max.
Dry hard, hours	-1 max.

PACKAGING

The paint shall be packaged in two separate containers comprising one unit, one a 5 gallon container with 4 gallons of vehicle, and the other a one gallon container with 6 pounds of the specified aluminum paste. The paste and vehicle shall be furnished in separate, new, round containers and shall have standard full open head with bails. All material shall be packaged in suitable containers and have compatible gaskets to prevent any reaction between the container and the contents. The containers shall have removable lids, be of such type that they will not be attacked by the contents, and also comply with the U.S. Department of Transportation or I.C.C. Regulations as applicable.

The label on each container must be marked with the mixing procedure and a warning not to store paint that has been mixed.

MIXING PROCEDURE

Add 1/2 gallon of potable water to the aluminum paste, mix to a smooth, lump free consistency, Slowly stir in the vehicle. Mix well, avoid incorporating air into paint. Strain paint through a double layer of cheesecloth prior to using. The paint must be mixed fresh each day, do not store mixed paint. Dispose of unused mixed paint in unsealed containers.

APPLICATION

The mixed paint shall be applied to a total dry film thickness of at least 1.5 mil. Conventional air spray is recommended, however, brush application may be used. Paint should not be applied when the ambient temperature is above 100°F or below 50°F, or when the relative humidity exceeds 75 percent.

CLEAN UP

Use tap water for clean up. 10% ammonia, acetone, or other suitable solvent may be used to remove dried paint from spray guns and other equipment.

(Use only when specifically requested by Structures Maintenance
Paint Section.)

Mtl. P10.5
7-2-84

SECTION 8-2. (BLANK)
SECTION 8-3. PAINT

8-3. RED PRIMER PAINT - WATER-BORNE (FORMULA
DA-4498-152-1).--

Description.--This specification covers a ready-mixed, water-borne paint formulated for use on blast cleaned steel surfaces exposed to the air.

This coating is intended for spray application. Limited application can be made by brushing or rolling.

Composition.--Paint shall be mixed in the following proportions and sequence:

Component		Pounds/100 gallons
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Mix at low speed:

Water		163.8
Defoamer	(1)	2.3
Thickener] Premix	4.7
Water		9.3
Hydroxypropyl methylcellulose (3) (2.5% solution in water, pH adjusted to 8.5-9.0)		47.0
Surfactant (30% in water)(4)		10.5

Hold back part of water initially to get good grind viscosity.

Grind under high shear to achieve specified grind.

Do not exceed 100°F during this operation, add remainder of water after grind is achieved.

Zinc Phosphate	(5)	65.5
Magnesium Silicate	(6)	212.9
Red Iron Oxide	(7)	31.6

Reduce speed and slowly add stabilized latex. Stabilize latex by first adjusting to pH 4 with 28% ammonium hydroxide, then blend with surfactant.

Vinyl acrylic latex	(8)	587.3
Surfactant (30% in water)(4)		23.4

Mix thoroughly, then add coalescent

Coalescent	(9)	11.7
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7-2-84

Characteristics:

Weight per gallon, pounds	11.6-11.8
Pigment by weight of paint, percent	25.5-27.0
Nonvolatiles by weight of paint, percent	56.5-58.0
Nonvolatiles by volume of paint, percent	40.0-41.5
Fineness of grind, Hegman	4-5
pH	4.0-4.5
Consistency, Krieb-Stormer, shearing rate 200 RPM, Grams	700 max.
Equivalent K.U.	125 max.
Cone and plate viscosity, shearing rate 10,000 sec ⁻¹ , Poise	0.5 max.

- (1) Colloid 642 (Colloids Inc.)
- (2) QR-708 (Rohm and Haas)
- (3) Methocel J12MS (Dow Chemical)
- (4) Pluronic F-87 (BASF Wyandotte)
- (5) Zinc Phosphate 317 (Reichard-Coulston)
- (6) Beaverwhite 325 (Cyprus International Minerals Co.)
- (7) Red Iron Oxide RC 1475 (Reichard-Coulston)
- (8) Haloflex 202 (ICI Americas Inc.)
- (9) 2,2,4 - Trimethylpentanediol-1,3-monoisobutyrate

Paint shall be packaged in polypropylene or high density polyethylene pails and lids.

STATE OF CALIFORNIA

Specification

Red Primer, High Solids Phenolic Type
(Formula PP-3906)

Descriptions:

This specification covers a red, ready-mixed, air drying, high solids, corrosion resistant, phenolic resin/tung oil primer. This coating is intended for spray application to blast cleaned steel surfaces exposed to the air. Limited application can be made by brushing or rolling.

Composition:

	PIGMENT	Pounds/100 gallons
Magnesium Silicate	(1*)	194
Zinc Phosphate	(2*)	171
Iron Oxide	(3*)	194
Silica	(4*)	3
	VEHICLE	
Phenolic Resin/Tung oil varnish	(5*)	500
Aliphatic thinner TT-T-291F, Type I		82
n-Butanol ASTM D304		3
Zirconium Drier ASTM D600, Class A	6%	4.7
Cobalt Drier ASTM D600, Class B	6%	2.4
Calcium Drier ASTM D600, Class B	5%	1.8
Anti-skinning Agent, oxime type		4.7

Characteristics:

Weight per gallon, pounds, ASTM D1475	11.6-11.8
Pigment by weight of paint, percent, ASTM D2371	47-49
Nonvolatile content, percent, ASTM D2369, Procedure B	79.5-81.5
Fineness of grind, Hegman ASTM D1210	4-5
Consistency, Krebs Units, ASTM D562	78-84
Drying time at 77°F, 50% RH, 3 mil wet film, ASTM D1640	
Set to touch, hours	2.5 max.
Through dry, hours	8 max.

- (1) Magnesium Silicate, platey shape, specific gravity 2.7 ± 0.1 , *oil absorption, pH $8.8 \pm .3$, Hegman fineness $+6.0$, 100% passing 325 mesh screen, CaO content 0.5% maximum, water soluble matter 1.0% maximum.
- (2) Essentially $Zn_3(PO_4)_2 \cdot 2H_2O$, specific gravity $3.2 \pm .1$, *oil absorption 22 ± 3 , average particle size less than 10 microns, water soluble matter 0.2% maximum.

- (3) Synthetic iron oxide, spheroidal particle shape, Fe_2O_3 98% minimum, *oil absorption 18 ± 2 , specific gravity 5.2 ± 0.1 , 99.9% passing 325 mesh screen, water soluble matter 0.15% maximum.
- (4) Precipitated hydrophobic silica, surface area, N_2 B.E.T. $120 \pm 15 \text{ m}^2/\text{g}$, mean particle diameter 3 microns, drying loss at 150°C 1-2%, ignition loss (2 hours at 1000°C) 5-6%, SiO_2 content 98% minimum based on substance ignited for two hours at 1000°C .
- (5) Phenolic resin/tung oil varnish shall be a 75% non-volatile solution composed of the following:

	<u>Lbs</u>
Union Carbide CK-2500 Resin	125
Aliphatic thinner TT-T-291F, Type II	106
n-Butanol ASTM D304	19
Tung oil ASTM D-12	250

Dissolve CK-2500 in butanol and aliphatic thinner. Add tung oil slowly while stirring.

*Oil absorption values determined according to ASTM D281.

APPENDIX C

PROPERTY
PRODUCT

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EXPOSURE EVALUATIONS OF WATERBORNE COATINGS

ASTM B117
Salt Spray

Test Site At
Golden Gate Bridge

Test Panel	Description	Performance	Time, Hours	Performance	Time, Years
PWB 57 Primer	Aroclon 820, Zinc Yellow, Miox 316	8 rust 8 few blisters	780	10 rust 10 blisters	2-1/2
PWB 50 Primer	Aroclon 820 Halox CW 2230	3-4 rust 4 dense blisters	1000	7 rust 9 few blisters	2-1/2
S 1406 Primer	Rhoplex MC-76 Cement, CaCO ₃	5 rust 7 med. dense blisters	750	3-4 rust 5-6 dense	2
PWB 60 Primer	Chemacoil 100 Halox CW 2230	2 rust 5 medium blisters	350	6 rust 7 medium blisters	2
S 1406 Primer	Rhoplex MC-76 Cement, ASP 400	5 rust 5 dense blisters	750	2 rust 4-6 dense blisters	2
PWB 27B Primer	Aroclon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	9 rust	1000	8-9 rust	2-1/2
PWB 94 Topcoat	Waterborne Aluminum	8 few blisters		1 few blisters	
S 1309 Primer	Aroclon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	6 rust	1100	8 rust	3-1/4
PWB 23 Topcoat	Waterborne Aluminum	5 few blisters		10 blisters	
PWB 27 Primer	Aroclon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	10 rust 10 blisters	1000	10 rust 10 blisters	3-1/4
S 1309 Primer	Aroclon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	9 rust 7-9 medium blisters	1100	8 rust 7-8 few blisters	3-1/4
PWB 33 Primer	Aroclon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	9 rust	1400	9 rust	2-1/2
PWB 41, 35 Topcoats	Rhoplex MV9 Blue finish	6 medium blisters		10 blisters	

Test Panel	Description	Performance	Time, Hours	Performance	Time, Years
PWB 29 Primer	Rhoplex MV 23 Zinc oxide	6 rust 6 dense blisters	330	10 rust	2-1/2
PWB 33 Topcoat	Rhoplex MV 9 Blue finish	Primer only		10 blisters	
PWB 44 Primer	Rhoplex MV 23 Zno, zinc yellow	4 rust 2-3 medium blisters	665	4 rust 7 dense blisters	2
PWB 49 Primer	Aroclon 820 Busan 11 M-1	6 rust 6 med. dense blisters	780	10 rust 10 blisters	2-1/2
PWB 35, 41 Primers	Aroclon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	9 rust	1400	8 rust	2-1/2
PWB 48D Topcoat	Rhoplex MV 9 White finish	6 medium blisters		10 blisters	
PWB 31 Primer	UCAR 4341 Busan 11 M-1	4 rust	980	10 rust	2-1/2
PWB 32 Topcoat	UCAR 4341 Green finish	7 dense blisters		8 medium blisters	
PWB 58 Primer	Rhoplex MV 9 Htox 316	6 rust 4-8 medium blisters	250	5-6 rust 7-8 dense blisters	1
S 1388 Finish	H.D. Alkyd Proprietary Orange finish	10 rust 10 blisters	780	10 rust 8 few blisters	2-1/2
PWB 46 Primer	Rhoplex MV 23 Zn ₃ (PO ₄) ₂	3 rust 7 dense blisters	480	9 rust 6-8 dense blisters	2-1/2
PWB 41 Primer	Aroclon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	9 rust 6 medium blisters	1400	10 rust 8 few blisters	2-1/2
PWB 43 Primer	UCAR 4341 Zinc yellow, Zn ₃ (PO ₄) ₂	6 rust 2-3 medium blisters	1086	9 rust 10 blisters	2-1/2
PWB 55 Primer	Aroclon 820 Halzin SC-1	9 rust 10 blisters	780	9 rust 10 blisters	2-1/2

Test Panel	Description	Performance	Time, Hours	Performance	Time, Years
PWB 80, 81 Primers	Arolon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	9 rust 7 few med. blisters	1049	9 rust 7 medium blisters	1/2
PWB 80, 81 Primers	Arolon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	10 rust	1049	10 rust	1/2
PWB 88, 89 Topcoats	Rhoplex MV 9 Tan finish	10 blisters		10 blisters	
PWB 80, 81 Primers	Arolon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	10 rust	3071	10 rust	1/2
PWB 82, 83 Topcoats	Rhoplex MV 9 Green finish	6 few blisters		10 blisters	
PWB 80, 81 Primers	Arolon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	10 rust	1049	10 rust	1/2
PWB 86, 87 Topcoats	Rhoplex MV 9 Grey finish	10 blisters		10 blisters	
PWB 80, 81 Primers	Arolon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	10 rust	1930	10 rust	1/2
PWB 87, 103 Topcoats	Rhoplex MV 9 Aluminum finish	10 blisters		10 blisters	
PWB 80, 81 Primers	Arolon 820 Zinc yellow, Zn ₃ (PO ₄) ₂	10 rust	3071	10 rust	1/2
PWB 110, 111 Topcoats	Rhoplex MV 9 Blue finish	6 few blisters		10 blisters	

Performance ratings made according to ASTM D610 for rust and ASTM D714 for blistering.

All test panel prepared by abrasive blasting prior to painting.

All primers applied in two coats 4 mil minimum dry film thickness.

All top coats applied in two coats 3 mil minimum dry film thickness.

PWB designation indicates California Transportation Laboratory Formulation

S designation indicates paint submitted already made up by a proprietary or raw material supplier.

