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16. ABSTRACT
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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

December 1979

FHWA No. D-5-52
TL No. 657282

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information this final research project report titled:

WATER-BASED COATINGS FOR PROTECTION
OF STEEL STRUCTURES

Study Made by ..... Enviro-Chemical Branch

Under the Supervision of ..... Earl C. Shirley, P.E.

Principal Investigators ..... Raymond Warness and Thomas Shelly

Co-Investigators ..... B. H. Deason, P.E. and C. H. Canright

Report Prepared by ..... Raymond Warness

Very truly yours,

Neal Andersen

NEAL ANDERSEN
Chief, Office of Transportation Laboratory

Attachment

RW:db

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TECHNICAL REPORT STANDARD TITLE PAGE

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Water based coatings, zinc rich primers, paints, coatings, structural steel, corrosion resistance, salt spray tests, accelerated testing, air pollution	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161

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CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quanity	English unit	Multiply by	To get metric equivalent
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) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic yards (yd^3)	3.785 .02832 .7646	litres (l) cubic metres (m^3) 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) feet per second(fps)	.4470 .3048	metres per second (m/s) 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^2)
Force	pounds (lbs) kips (1000 lbs)	4.448 4448	newtons(N) newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds(ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds(ft-lbs) foot-pounds(ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi) pounds per square foot (psf)	6895 47.88	pascals (Pa) pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi $\sqrt{in}$)	1.0988	mega pascals $\sqrt{metre}$ (MPa $\sqrt{m}$)
	pounds per square inch square root inch (psi $\sqrt{in}$)	1.0988	kilo pascals $\sqrt{metre}$ (KPa $\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

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Typical appearance of complete water-based system after salt spray (fog) testing

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INTRODUCTION

The State of California has specified many different solvent-based paint systems through the years for the protection of steel used in highway structures. Typical pigments have been red lead, basic lead silico chromate, zinc chromate, and zinc. Typical vehicles have been alkyd, vinyl, chlorinated rubber and phenoxy resins. In California, at the present time, four types of paint systems are being used for routine painting or repainting of highway structures.

The first is an all vinyl, barrier type system used with good success for over 25 years in coastal environments. The second system consists of a phenoxy type organic zinc-rich primer, vinyl wash intermediate coat and vinyl top coat. This paint system has been specified for use in various exposures for nearly 10 years with good success. The third system, used only in spot blast cleaning and repainting operations, consists of a phenoxy organic zinc-rich primer and vinyl wash intermediate coat followed by an alkyd type finish paint. This system has been successful in mild environments, although some lifting problems of the old paint have been experienced because of the active solvents in the zinc primer. The fourth system, used exclusively for painting toll bridges in the San Francisco Bay area consists of a phenoxy type organic zinc-rich primer, vinyl wash intermediate coat and chlorinated rubber aluminum top coat. This system has been in use for over seven years with good success.

Although the paint systems currently specified have generally performed well and caused few application problems during the years they have been in use, a number of developments indicated that there was a need to investigate the use of water-based

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coatings for painting structural steel. Some of the developments considered were:

1. The limited availability and increasing cost of solvents.

2. Safety aspects of water as compared to solvents.

3. Labor costs.

4. New regulations and laws controlling the use of various materials commonly used in manufacturing paint.

The original plan for this project was first to evaluate the use of water-based coatings applied over an organic zinc-rich primer, and then evaluate complete water-based systems, primers and top coats. No consideration was given at that time to limiting the quantity of solvent in the water-based coatings nor was there any concern over the quantity of solvent in the organic zinc-rich primer.

In June 1977, the California Air Resources Board proposed a model rule to local air quality control districts that would strictly limit the quantity of volatile organic material contained in a coating applied to any structure. This rule, as proposed, would prohibit the use of the organic zinc-rich primer and even some of the water-based paints that were being manufactured because of high organic volatile content. At the present time, most local air quality districts in California have already adopted the proposed rule, with a few minor changes, and it became effective September 2, 1979. A few exemptions for paints such as primers and industrial maintenance finishes are permitted until September 2, 1982. A copy of a typical rule for regulating solvents in architectural coatings appears in Appendix A.

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All laboratory formulated water-based primers and most top coats investigated in this project, with the exception of those noted in Table X, comply with 1982 California air quality requirements.

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

A. Water-based paints applied over organic zinc-rich primer

1. ASTM B117-73 Salt Spray (Fog) tests
2. ASTM B2247-68 100% Relative Humidity tests
3. Outdoor exposure at Sacramento
4. Aluminum water-based top coat development

B. Primer and top coat water-based systems

1. Water-based primers
   a. ASTM B117-73 Salt Spray (Fog) tests
   b. Formula variations
   c. Outdoor exposure tests at the Golden Gate Bridge
2. Water-based top coats
3. Complete water-based systems, primer and top coat.

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CONCLUSIONS

Accelerated exposure tests indicate that some water-based acrylic emulsion paints can be used successfully as a top coat over a phenoxy organic zinc-rich primer. The use of a vinyl wash intermediate coat between the zinc primer and the top coat improved the performance of the water-based top coat in most cases.

Similar accelerated tests made on complete water-based systems showed that some of the coatings evaluated performed equal to or better than an alkyd solvent-based system, when the water-based top coats were applied over a water-based primer which had shown good performance in all the accelerated tests.

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IMPLEMENTATION

Implementation of research on coatings usually begins on a small-scale experimental basis to gain additional information. Accordingly, the experimental aluminum pigmented water-based finish paint, formula PWB 23 already has been used to topcoat 75,000-100,000 square feet of surface area on toll bridges in the San Francisco Bay area. An improved version of the experimental aluminum pigmented water-based (formula PWB 94) has been purchased for additional full-scale test application. A small amount (100 gallons) of an experimental water-based primer, formula PWB 35, based on Spencer Kellog Formula 031226-50-1A also has been purchased for use as a primer under the aluminum water-based paint. Two additional highway structures at different locations in the state have been scheduled for painting with the water-based primer, formula PWB 35 and aluminum finish paint, formula PWB 94. A highway structure, in yet another location in the state, has been scheduled to be painted with formula PWB 31 and PWB 32 (Union Carbide LP-3743) primer and top coat systems.

Experience gained during the small-scale experimental implementation of the water-based coatings has revealed, for one reason or another, variable coating performance. For this reason, anyone contemplating trial batches of the systems described in this report should contact Caltrans or the raw material manufacturer for information on improvements made and/or problems encountered.

Implementation will continue using various experimental water-based systems to paint highway structures in the state. When sufficient data have been obtained from laboratory tests and full-scale field applications, specifications for the water-based systems having satisfactory performance will be included in Caltrans' Standard Specifications handbook.

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TEST RESULTS

Water-Based Paint Used Over An Organic Zinc-Rich Primer

To obtain an evaluation of the performance of the various coatings in a reasonable period of time, it was necessary to use accelerated test methods. ASTM B117-73, Salt Spray (Fog) test, was used for much of this accelerated testing because of its wide use in evaluating protective coatings. Other tests used were ASTM D2247-68, coated metal specimens at 100% relative humidity, and outdoor exposure on racks at the Golden Gate Bridge in San Francisco and on the rooftop of the Transportation Laboratory in Sacramento.

The performance of water-based paint when applied as a top coat over California State Specification 8010-61J-36, organic zinc-rich primer, was investigated. The zinc primer used in the study is currently specified for use on some steel structures in California, and is a single package, phenoxy resin vehicle, solvent-based, air dry coating. The compositional formula of the primer is shown in Appendix B. The water-based top coats investigated used acrylic emulsion vehicles. Some were supplied by paint manufacturers as proprietary products. The majority were made in the laboratory using formulations recommended by the various raw material suppliers.

Table I lists the top coats that were investigated. The performance of these top coats was evaluated by applying them to steel test panels conforming to ASTM D609 Type 1-B and prepared in the following manner:

1. Abrasive blast to 1-1.5 mil surface profile.

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TABLE I

Water-Based Paints Investigated as Top Coats Over Organic Zinc-Rich Primer (1)

Sample #	Manufacturer	Resin Type	Color
S901	Sherwin Williams	Modified Acrylic	Aluminum
S917	RPM	Acrylic Type	Green
S985	Napko	Acrylic Type	White
S1088	Union Carbide	Acrylic Ucar 4358	White
PWB 1	TransLab	Acrylic Rhoplex E990	White
PWB 3	"	" " AC507	Green
PWB 6	"	" " MV9	Green
PWB 7	"	" " "	Aluminum
PWB 8	"	" " "	Tan
PWB 9	"	" " WL81	White
PWB 10	"	" " "	Aluminum
PWB 12	"	" " "	Tan
PWB 13	"	" " "	Medium Blue
PWB 14	"	" " MV9	Tan
PWB 16	"	Acrylic Ucar 4358	Tan
PWB 17	"	Acrylic Rhoplex MV9	White

(1) California State Specification 9010-61J-36

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2. Apply two coats of 8010-61J-36 zinc-rich primer, 3-4 mil total dry film thickness.

3. Apply vinyl wash primer, California State Specification 8010-61J-27 to some of the zinc primed panels to evaluate the effect of a tie coat. The compositional formula of the wash primer is shown in Appendix B.

4. Apply various water-based top coats in two applications, one day apart, to a total dry film thickness of 3 mils.

5. Air dry at approximately 75°F and 50% relative humidity for a minimum of 7 days before testing.

The prepared test panels were then subjected to various test conditions and the resulting performance evaluated.

Table II lists the coatings subjected to Salt Spray (Fog), and the evaluation of the performance of the paint after testing. Table III lists the paint subjected to 100% humidity and the evaluation of the coatings after testing. Table IV lists the coatings subjected to outdoor exposure at 45° South in Sacramento and the evaluation after more than two years. Photographs showing the appearance of some of the coatings after exposure to Salt Spray (Fog) are included in Figure I. The coatings on the bottom portion of the test panels were solvent stripped so the condition of the steel under the coatings could be examined.

The evaluation of the coatings listed in Tables II, III and IV is in reference to the top coats only. As was expected, the organic zinc-rich primer performed satisfactorily and there were no failures due to rust or corrosion even though areas

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TABLE II

ASTM B117-73 SALT SPRAY (FOG) TEST
WATER-BASED TOP COATS OVER ORGANIC ZINC-RICH PRIMER (1)

Sample Number	Description	Wash Primer (2)	Total Hours	Blistering
S901	Aluminum Acrylic	No	468	None, white stains
S917	Green Acrylic	No	1338	None, white stains
S985	White Acrylic	No	602	8 D
S1088	White Acrylic	No	602	8 MD
PWB 6	Green Acrylic	No	1432	8 D, white stains
PWB 7	Aluminum Acrylic	No	1432	6 D, white stains
PWB 7	Aluminum Acrylic	Yes	1432	None
PWB 8	Tan Acrylic	No	1432	8 D, white stains
PWB 8	Tan Acrylic	Yes	1432	None
PWB 10	Aluminum Acrylic	No	800	6 D
PWB 12	Tan Acrylic	Yes	800	None
PWB 13	Blue Acrylic	Yes	800	None
PWB 23	Aluminum Acrylic	No	800	6 M

Blister rating made according to ASTM D714-56 with numbers representing size, letters representing frequency.

8 = smallest size visible to unaided eye, smaller numbers progressively larger size.

D = Dense MD = Medium Dense M = Medium

(1) California State Specification 8010-61J-36

(2) California State Specification 8010-61J-27

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TABLE III

ASTM D2247-68 COATED METAL SPECIMENS AT 100% RELATIVE HUMIDITY
WATER-BASED TOP COATS OVER ORGANIC ZINC-RICH PRIMER (1)

Sample Number	Description	Wash Primer (2)	Total Hours	Blistering
S901	Aluminum Acrylic	No	24	6 MD
S917	Green Acrylic	No	24	7-8 D
S985	White Acrylic	No	24	5 D
S1088	White Acrylic	No	24	6-7 D
PWB 6	Green Acrylic	No	24	3-4 D
PWB 7	Aluminum Acrylic	No	24	7 M
PWB 7	Aluminum Acrylic	Yes	24	None
PWB 7	Aluminum Acrylic	Yes	720	None
PWB 8	Tan Acrylic	No	24	4-5 D
PWB 8	Tan Acrylic	Yes	24	None
PWB 8	Tan Acrylic	Yes	144	8 F

Blister rating made accoring to ASTM D714-56 with numbers representing size, letters representing frequency.

8 = smallest size visible to unaided eye; smaller numbers progressively larger size.

D = Dense MD = Medium Dense M = Medium

(1) California State Specification 8010-61J-36

(2) California State Specification 8010-61J-27

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TABLE IV

OUTDOOR EXPOSURE AT SACRAMENTO, CALIFORNIA
WATER-BASED TOP COATS OVER ORGANIC ZINC-RICH PRIMER (1)

Sample Number	Description	Wash Primer (2)	Performance		
			Blistering	Gloss 60°	
			2 Years	Initial	2 Years
PWB 7	Aluminum Acrylic	Yes	None	50	30
PWB 8	Tan Acrylic	Yes	None	6	2
PWB 10	Aluminum Acrylic	Yes	None	30	20
PWB 12	Tan Acrylic	Yes	None	20	2
PWB 13	Blue Acrylic	Yes	None	45	10
PWB 14	Tan Acrylic	Yes	None	8	2
PWB 16	Tan Acrylic	Yes	None	14	5
PWB 17	White Acrylic	Yes	None	45	25

Blister rating made according to ASTM D714-56
60° specular gloss made according to ASTM D523-67

(1) California State Specification 8010-61J-36
(2) California State Specification 8010-61J-27

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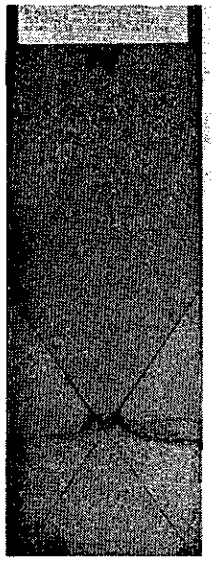
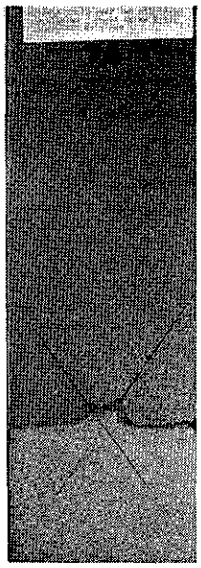
FIGURE I

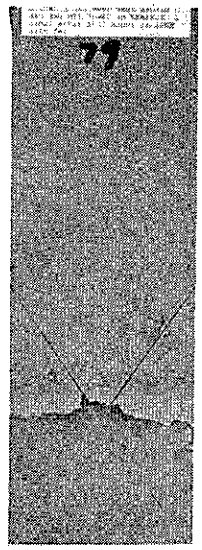
Typical Appearance of Water-Based Top Coats Applied Over Organic Zinc After Salt Spray (Fog) Testing



PWB 8A
Tan Color Top Coat
1432 Hours



PWB 6
Green Color Top Coat
1432 Hours



PWB 7
Aluminum Color Top Coat
1432 Hours

All formulations based on Rhoplex MV-9 acrylic emulsion

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on the painted test panels were scribed to bare steel before testing. The only film irregularities noted on the test panels were due to blisters and white deposits occurring on some top coats subjected to accelerated exposure tests. In every case, when the wash primer was used as an intermediate coat between the zinc primer and the water-based paint, no blistering or white deposits developed on the top coats. Because the wash primer appeared to improve the performance of the water-based top coat, it was used in preparing all panels for outdoor exposure. After more than two years exposure in Sacramento, the test panels are still in good condition. The only noticeable change is in the gloss which has decreased in varying degrees as noted.

Additional larger scale experimental applications using the aluminum pigmented water-based formulation PWB 23 (Appendix B) have been made since, both in Sacramento and on toll bridges in the San Francisco Bay area. In some cases the intermediate coat of vinyl wash primer was not used. These applications were over organic zinc-rich primer and other previously applied coatings such as chlorinated rubber aluminum, phenolic aluminum, vinyl aluminum and alkyd paints. At this time, none of these applications, with or without wash primer, have exhibited the blistering and white deposits observed in the accelerated tests. It is possible that the surface defects noted in accelerated tests, when wash primer is not used, occur only under accelerated test conditions and not in actual outdoor exposures. These defects may become apparent with extended exposure, however.

The preliminary full-scale test applications were sufficiently successful that additional larger test applications were made using the experimental aluminum water-based formulation, PWB 23

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(Appendix B). Since this was a simple formulation containing only three ingredients - acrylic emulsion (MV-9), aluminum paste, and water - the painters mixed all the paint as required at the job site, working from 55 gallon drums of emulsion and 200 pound drums of paste. The total area ultimately painted using this formula and mixing technique was 75,000-100,000 square feet. Most of the paint was applied as a top coat over old but sound surfaces previously coated with a phenolic aluminum paint. During these applications, which took place over a two year period, only one significant problem was encountered. This was poor film formation resulting from application at approximately 10°F lower than the recommended temperature of 55°F. This top coat was subsequently removed and recoated during warmer weather with no problems.

Because of concern over the low temperature performance of formulation PWB 23, laboratory tests were conducted to further determine some temperature characteristics of the coating. Minimum film formation temperatures according to ASTM D2354-68 were determined on the MV9 acrylic emulsion, the water-based aluminum paint, PWB 23, and the same aluminum paint modified with two levels of Texanol, a coalescing agent. A graph showing differences in the minimum film forming temperature is shown in Figure II. Salt Spray (Fog) tests and 100% humidity tests were also made on formula PWB 23 using leafing and nonleafing aluminum paste with and without modification with Texanol. These results are shown in Table V.

Inasmuch as the Texanol additive not only lowered the minimum film forming temperature, but also improved the blister resistance in both Salt Spray (Fog) and 100% humidity tests, a new formula was written using 5% Texanol by weight based on the total solids of the MV9 acrylic emulsion. This formula,

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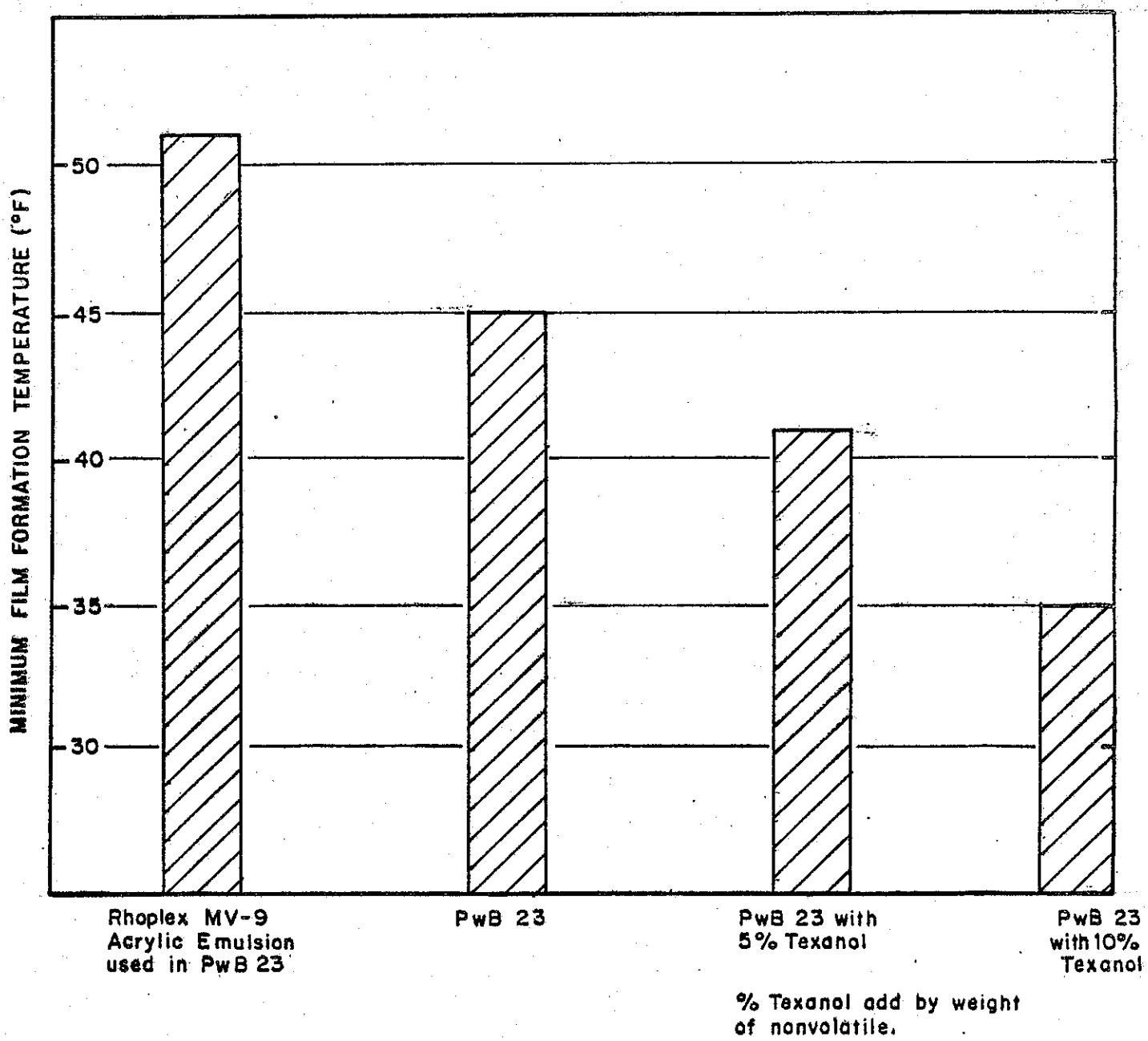

ASTM D 2354-68 MINIMUM FILM FORMATION TEMPERATURE OF PwB 23 WITH TEXANOL ADDITION

FIGURE II

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TABLE V

ASTM D2247-68 COATED METAL SPECIMENS AT 100% RELATIVE HUMIDITY TEST
EVALUATING BLISTERING OF FORMULA PWB 23 WITH TEXANOL ADDED

Time	PWB 23 Leafing Grade Aluminum Paste Alcoa 830	PWB 23 Leafing + Texanol 10%*	PWB 23 Nonleafing Aluminum Paste Alcoa 825	PWB 23 Nonleafing + 10% Texanol*
3 hrs	7(few)	10	4(dense)	6(dense)
6 hrs	4(few)	10	3(dense)	5(very dense)
23 hrs	3(few)	10	3(very dense)	4(very dense)
29 hrs	3(few)	9(few)	3(very dense)	4(very dense)
48 hrs	2-3(few)	9(medium)	2(very dense)	4(very dense)
120 hrs(end)	2(few)	8(medium)	2(very dense)	4(very dense)

ASTM B117-73 SALT SPRAY (FOG) TEST
EVALUATING BLISTERING OF FORMULA PWB 23 WITH TEXANOL ADDED

24 hrs	3(medium)	4(medium	9(few)	10
144 hrs	1(medium)	2(medium)	7(medium)	8(few)
192 hrs	1(very dense) (terminated)	1(dense) (terminated)	6(very dense)	7(few)
264 hrs			4(very dense) (terminated)	6(few)
360 hrs				5(medium)
504 hrs(end)				4(dense) (terminated)

*Texanol added by weight based on MV9 total solids.

Blister rating made according to ASTM D714-56 with numbers representing size, letters representing frequency.

8 = smallest size visible to the unaided eye; smaller numbers progressively larger size.

D = Dense MD = Medium Dense M = Medium

Paint was applied in two coats to unprimed ASTM D609 Type IB steel panels.

Total dry film thickness 3 mil.

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PWB 94, not only included the coalescent additive and two types of aluminum paste, leafing and nonleafing for ease in two coat application, but also packaging requirements, so the paint could be purchased from a paint manufacturer in 2-compartment cans large enough to contain five gallons of paint when the two parts were mixed.

At the present time, 750 gallons of PWB 94 leafing type and 500 gallons of PWB 94 nonleafing type have been purchased from a paint manufacturer and are being applied as a finish coat on bridges in the San Francisco area with good success. Another 3,000 gallons of leafing type and 2,000 gallons of nonleafing type have been ordered. If this water-based coating continues to have satisfactory application properties and proves to have adequate long term durability, it is anticipated that the solvent types of aluminum paint will be replaced with this water-based aluminum coating.

Complete Water-Based Systems

The second objective in the project was to develop a complete water-based system, primer and top coat, for application to steel surfaces that would be equal to or better than a solvent-based alkyd resin vehicle paint system. The alkyd paint system that is referred to consists of two coats of Federal Specification TT-P-615, basic lead silico chromate primer with two top coats of Federal Specification TT-E-489 gloss enamel. A photograph of the typical appearance of an alkyd system after Salt Spray (Fog) exposure is shown in Figure III. The water-based paint system to be developed was originally intended for use on steel highway structures located in mild exposures such as interior valleys and desert areas of the state. However, after the new air quality rules were introduced, it became

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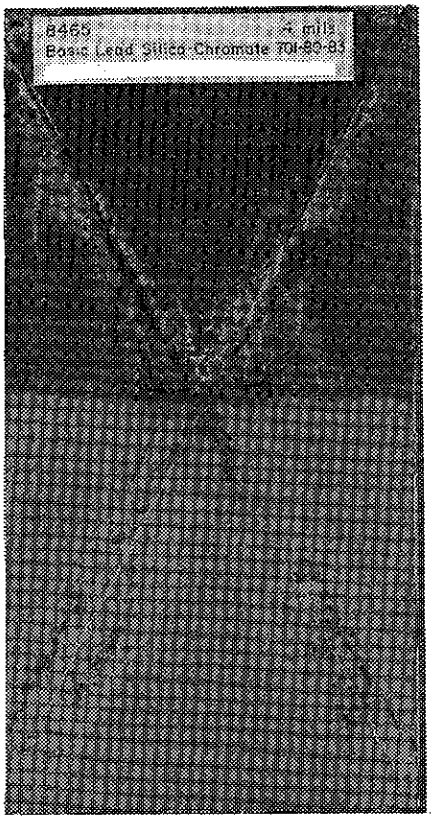
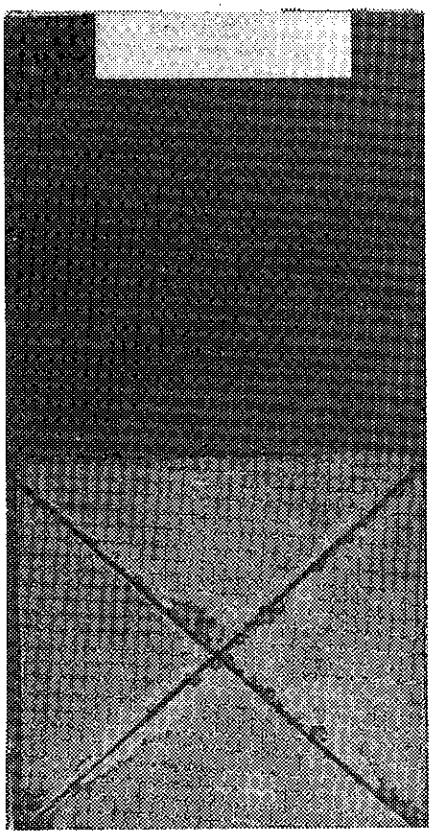
FIGURE III

Typical Appearance of Solvent-Based Alkyd Paint After Salt Spray (Fog) Testing





500 Hour Exposure
2 Coats Basic Lead Silico Chromate Primer Corresponding to TT-P-615 Type II

750 Hour Exposure
2 Coats TT-P-615 Primer With 2 Coats TT-E-489 Gloss Top Coat

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obvious that these water-based paints eventually would find wider application than originally planned.

Inasmuch as some water-based top coats were investigated during the first part of the project, it seemed logical to consider them as prospects for top coats in the second part of the project and to place primary emphasis on developing and evaluating water-based primers.

Water-based primers

Table VI includes a listing of the various emulsions and inhibitive pigments used in primer formulations that were evaluated during this part of the project. While most of the primers were made according to formulas recommended by the various raw material suppliers, some of the laboratory formulations involved direct, single ingredient substitutions of materials so performance comparisons could be made. In these cases the formulations may not have been optimized, possibly resulting in a sacrifice of the overall performance. The primers were all applied in two coats, one day apart, to freshly abrasive blasted steel panels conforming to ASTM D609 with a surface profile of 1-1 1/2 mils. Additional evaluations were made using the same type of steel panel but with matte (30-65 mu) and ground (15-25 mu) surface textures. In these tests all primers performed consistently better when applied to the smoother steel as opposed to the rough abrasive blasted surface. However, since all steel surfaces in full scale painting projects are specified to have not less than a 1 mil surface profile, it seemed more representative for the test evaluations to be based on the rough abrasive blasted surfaces.

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TABLE VI

ASTM B117-73 SALT SPRAY (FOG) TESTING OF VARIOUS WATER-BASED PRIMERS

Primer Number	Paint or Resin Supplier	Resin Type	Inhibitive Pigments	Dry Film Thickness mils	ASTM B117-73 Salt Spray (Fog) Performance		
					Rust ASTM D610-68	Blistering ASTM D714-56	
PB 142	Rohm Haas	Acrylic MV-1	Basic Lead Silico Chromate	3-4	#6 Surface Rust Rust Under Primer	#6M Blisters	468 Hours
PWB 26	Rohm Haas	Acrylic MV-9	Zinc Dust	3	#5 Surface Rust Rust Under Primer	#7D Blisters	817 Hours
PWB 29	Rohm Haas	Acrylic E1423	Zinc Oxide	4	#6 Surface Rust Rust Under Primer	#6D Blisters	330 Hours
PWB 31	Union Carbide	Styrene Acrylic 4341	Barium Meta Borate	4-5	#4 Surface Rust Rust Under Primer	#7D Blisters	330 Hours
PWB 35	Spencer Kellog	Styrene Acrylic X820	Zinc Yellow Zinc Phosphate	4-5	Scribe Rust Only	No Blisters	+3000 Hours
S1217 C	Devoe	Epoxy	Zinc Molybdate	4	Scribe Rust Rust Under Primer	#5M Blisters	800 Hours
S1308	Spencer Kellog	Styrene Acrylic X820	Zinc Phospho Oxide	4	Scribe Rust Under Film Rust At Scribe Only	No Blisters	300 Hours
S1378	Rohm Haas	Acrylic MV-9	Zinc Oxide Barium Meta Borate	5-6	#5 Surface Rust Rust Under Primer	#6M Blisters	700 Hours
S1406	Rohm Haas	Acrylic MC-76	Portland Cement	4-8	#5 Surface Rust	#5D Blisters	1000 Hours
PWB 49	Spencer Kellog	Styrene Acrylic X820	Barium Meta Borate	6-7	#8 Surface Rust Some Rust Under Primer	#6F Blisters	780 Hours
PWB 50	Spencer Kellog	Styrene Acrylic X820	Calcium Boro Silicate	5	#4 Surface Rust Rust Under Primer	#6M Blisters	1000 Hours
PWB 58	Rohm Haas	Acrylic MV-9	Micaceous Iron Oxide	4-5	#6 Surface Rust Rust Under Primer	#4M Blisters	250 Hours
PWB 59	IMC	Styrene Urethane Acrylic 200S-X	Calcium Boro Silicate	-	Paint System Incompatibility No Tests Made		
S1472 A-P	PVO	Alkyd Emulsion	Barium Meta Borate	9-10	#8 Surface Rust Rust Under Primer	No Blisters	500 Hours

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As shown by the salt spray performance of the various primers listed in Table VI, only one emulsion and pigment system, PWB 35, provided good corrosion protection with less than 1/16" underfilm rust at the scribe line and no surface rust or blistering of the film. This primer coating withstood over 3,000 hours in Salt Spray (Fog) exposure with the same good performance whereas most other water-based primer systems began to fail within 100 to 500 hours exposure. Typical photographs are shown in Figures IV and V. Similar performance characteristics were exhibited when the same primers were applied to ASTM D609 steel panels and exposed to 100% humidity. PWB 35 was the only primer evaluated to resist blistering, rusting, or significant softening of the film for over 500 hours. Some of the primers evaluated began to fail after only three hours of testing.

Encouraged by the performance of primer PWB 35, additional work was done to evaluate this formulation by varying some of the many ingredients. Table VII lists the pigment and additive variables and resulting Salt Spray (Fog) performance after 600 hours. Photographs are shown in Figure VI. As the Salt Spray (Fog) tests show, if all the materials are present in the formulation as listed, or if comparable materials are substituted, good performance is obtained. Subsequent tests appear to indicate that the zinc yellow and calcium carbonate may be the most important pigment ingredients in the formula.

Considering the information gained from testing the preceding formulas, another series of tests were planned. This group of tests would use the basic formula PWB 35, modified by using different emulsions in the primer, keeping all other materials unchanged. Table VIII lists the emulsions used and the effect they have on the Salt Spray (Fog) performance of the primer.

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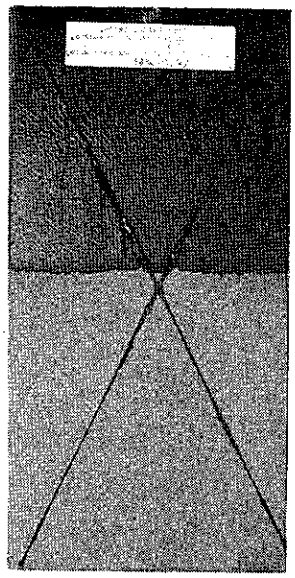
FIGURE IV

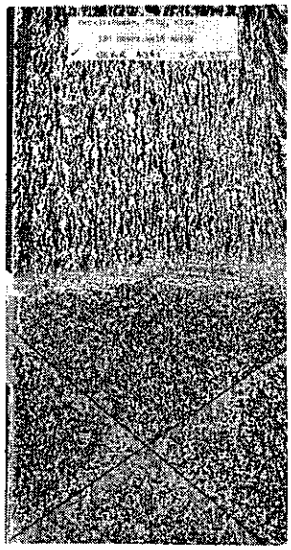
Typical Appearance of Various Water-Based Primers Formulated According to Manufacturer's Recommendations After Salt Spray (Fog) Testing

Rohm Haas 271C
3-4 mil 468 Hours



Spencer Kellog
031226-50-1-A (PWB 35)
5.5-6.5 mil 1400 Hours

Rohm Haas ESA-0148
5-6 mil 330 Hours



Union Carbide Ucar 3743
4-5 mil 330 Hours

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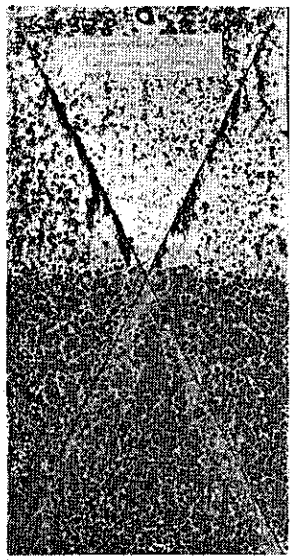
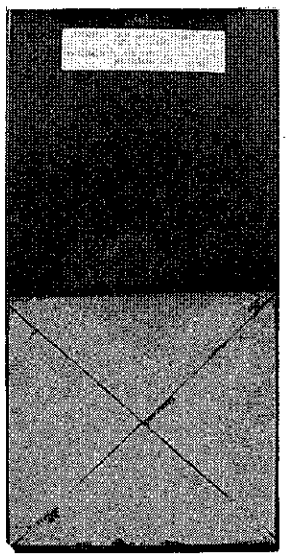
FIGURE V

Typical Appearance of Various Water-Based Primers Formulated According to Manufacturer's Recommendations After Salt Spray (Fog) Testing

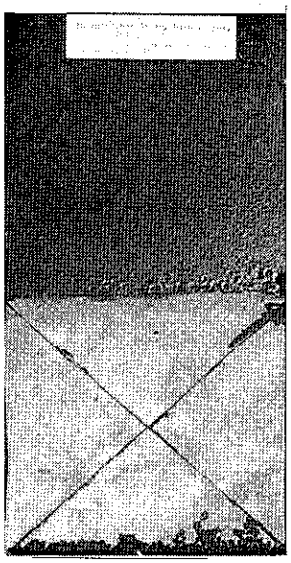
Rohm Haas FL-2153-1
4 mil 330 Hours



Rohm Haas PO-9-16
5-6 mil 700 Hours



Spencer Kellog 46-3
5 mil 380 Hours



Spencer Kellog 94-1
6.5-7 mil 780 Hours

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TABLE VII

ASTM B117-73 SALT SPRAY (FOG) TEST SHOWING THE EFFECT VARIOUS PIGMENT AND ADDITIVE SUBSTITUTIONS HAVE ON A PWB 35 FORMULA

Formula	Substitution Made in PWB 35	ASTM B117, Salt Spray (Fog) 600 Hours
PWB 35	No substitution	No surface rust or blisters
PWB 27C	NXZ Antifoam in place of Nopco NDW	Few blisters
PWB 27E	No RR 555 Interface modifier	Slight surface rust, few blisters
PWB 27F	Zinc yellow omitted	Medium surface rust and numerous blisters
PWB 27G	Zinc phosphate omitted	No surface rust, few blisters
PWB 34	Barium metaborate substituted for calcium carbonate	Moderate Surface rust and blisters
PWB 36	Barium metaborate substituted for zinc yellow	Medium surface rust and blisters
PWB 37	Titanium dioxide substituted for zinc yellow	Medium surface rust and numerous blisters
PWB 38	Davis Co J-0852 zinc phosphate used	No surface rust or blisters
PWB 39	25% of the red oxide replaced with TiO_2	No surface rust or blisters
PWB 40	Gammasperse 645 calcium carbonate used	No surface rust or blisters

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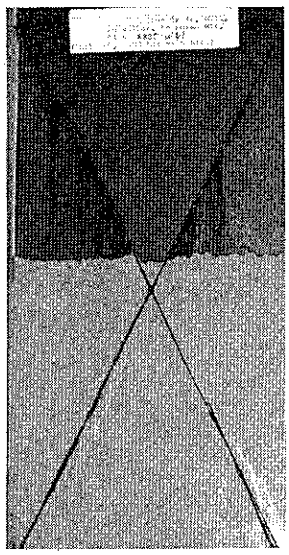
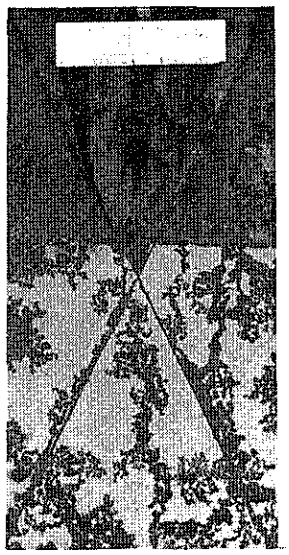
FIGURE VI

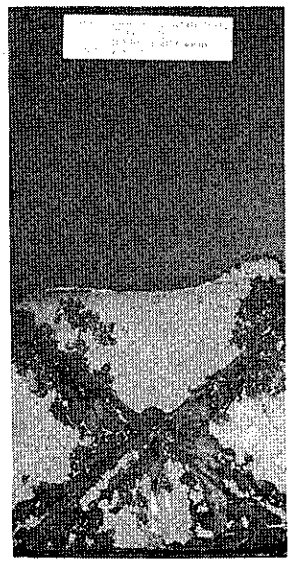
Typical Appearance of Formula PWB 35 Substituting Various Pigments After Salt Spray (Fog) Testing



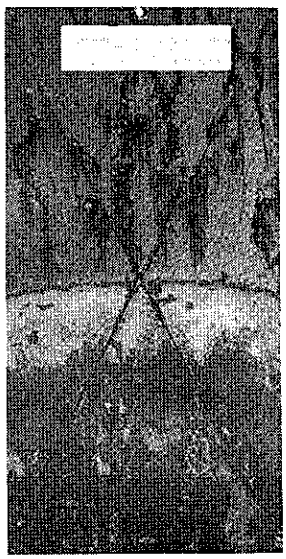
0.15#/gal Zinc Yellow
4539D
1400 Hours



1.0#/gal Busan 11M-1
No Zinc Yellow
650 Hours



1.5#/gal Nalzin SC-1
No Zinc Yellow
780 Hours



1.0#/gal Halox CW2230
No Zinc Yellow
1000 Hours

2 coats, 4.5-5 mil total dry film thickness, on all panels.
Bottom part of panels solvent stripped after exposure.

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TABLE VIII

ASTM B117-73 SALT SPRAY (FOG) TEST SHOWING THE EFFECT VARIOUS EMULSION SUBSTITUTIONS HAVE ON FORMULA PWB 35

PWB 35	None	3000 hours No blisters #9 underfilm corrosion #7 scribe rust(1/16" undercutting)
PWB 43	UCAR 4341	1100 hours #3 medium blisters #2 underfilm corrosion(33%) #6 scribe(1/8" undercutting)
PWB 45	RHOPLEX MV-23	975 hours #6 medium dense blisters #4 underfilm corrosion(10%) #5 scribe(3/16")
PWB 56	AQUAMAC 200S-X	Some stability problem in formula Paint solidified during manufacture No salt spray data

Blister rating made according to ASTM D714-56

Rust rating made according to ASTM D610-68

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Photographs are shown in Figure VII. The results of these last two groups of accelerated tests indicated that all the materials must be present in formula PWB 35, including the Arolon X820 emulsion, to provide good performance. Some later work with this formula also indicates that a minimum pH of 8.2 is necessary for optimum corrosion resistance.

Realizing the limitations of accelerated tests, another set of test panels were prepared in the same manner as the panels in the Salt Spray (Fog) tests. These panels were placed at a test site at the Golden Gate Bridge for actual outdoor exposure evaluation in a marine environment, a photograph of the test site is shown in Figure VIII. Table IX lists the various panels under test and the performance after up to one year of exposure. While the outdoor exposure time for the most part is short, the performance corresponds with that obtained in the accelerated tests.

In order to more fully investigate the performance of some of the primers that were evaluated by laboratory accelerated tests and outdoor exposure, full-scale field applications are being planned at various locations in the state.

Water-based top coats

As previously discussed, it seemed logical to consider some top coats already evaluated in the first part of the project as good candidates to be investigated in the second part of the project. The coatings evaluated were applied to steel panels conforming to ASTM D609, Type 1-B in two coats, one day apart, and allowed to dry one week at room temperature before testing. The panels were then exposed to Salt Spray (Fog) and 100% humidity and evaluated for rusting and blisters. Table X lists those top coats that were evaluated in this part of the project.

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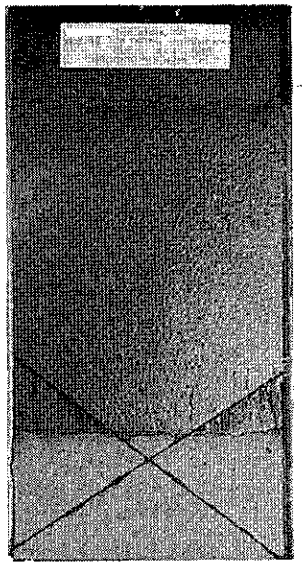
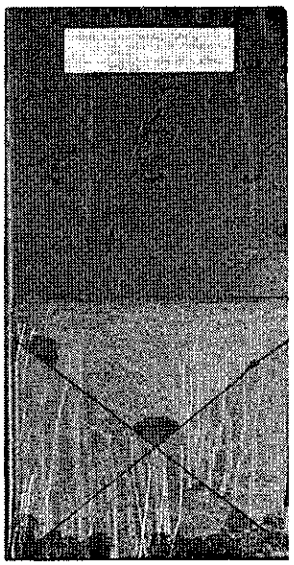
FIGURE VII

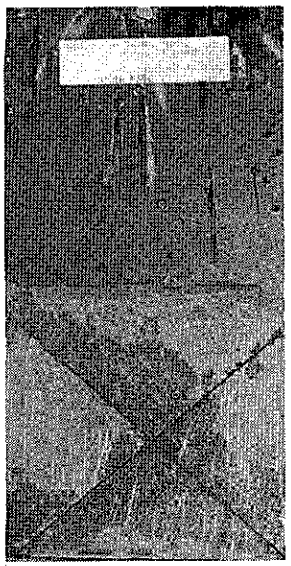
Typical Appearance of Formula PWB 35 Substituting Various Emulsions After Salt Spray (Fog) Testing



Arolon X820
3000 Hours



MV-23
975 Hours



Ucar 4341
1100 Hours

Coatings applied 5.5-6 mil dry film in 2 coats.
Bottom part of panel solvent stripped after exposure.

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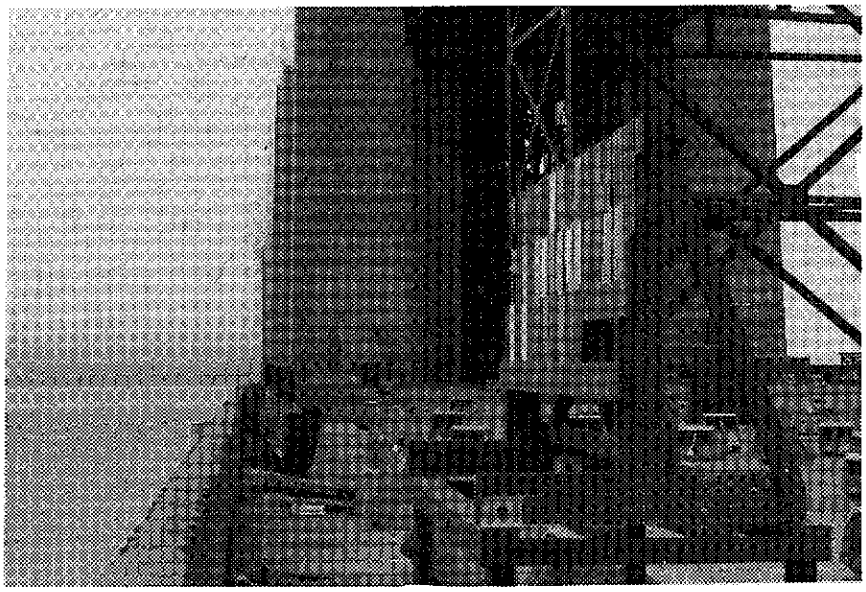
FIGURE VIII

Test Exposure Site at the
Golden Gate Bridge in San Francisco



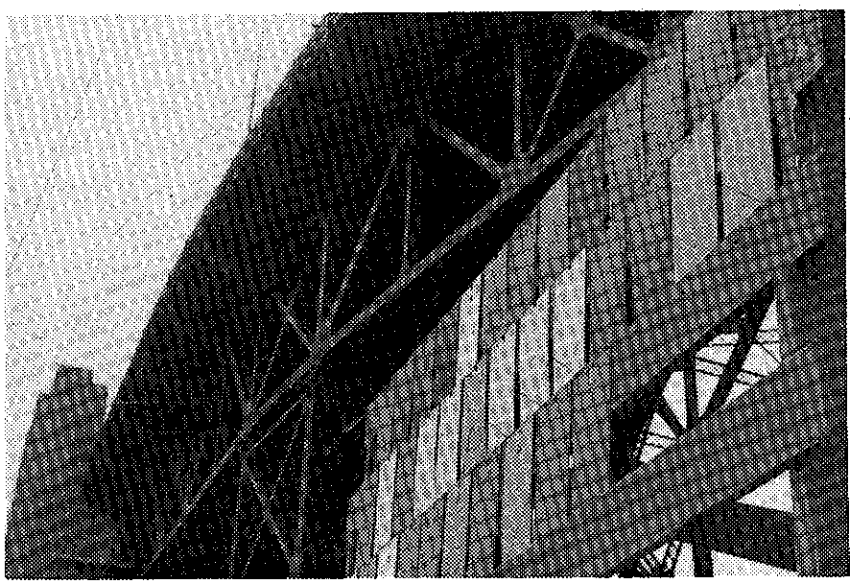


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TABLE IX

EXPOSURE TESTS ON WATER-BASED PRIMERS AT THE GOLDEN GATE BRIDGE IN SAN FRANCISCO

Primer Number	Resin	Inhibitive Pigments	Performance
PWB 27	Arolon X820	Zinc Yellow, $CaCO_3$, Zinc Phosphate	#7M blisters and rust along scribe only
PWB 35	Arolon X820	Zinc Yellow, $CaCO_3$, Zinc Phosphate	Rust in scribe only
PWB 43	Ucar 4341	Zinc Yellow, $CaCO_3$, Zinc Phosphate	#9F blisters and rust along scribe only
PWB 44	Rhoplex MV23	Zinc Yellow, $CaCO_3$, Zinc Oxide	#8M blisters and rust along scribe, #7 surface rust
PWB 46	Rhoplex MV23	Zinc Phosphate, $CaCO_3$, Zinc Oxide	#8M blisters and rust along scribe, #8 surface rust
PWB 49	Arolon X820	Barium Meta Borate, $CaCO_3$	#8F blisters and rust along scribe only
PWB 50	Arolon X820	Zinc Yellow, Calcium Boro Silicate	#7M blisters and rust along scribe only
PWB 55	Arolon X820	Zinc Phospho Oxide, $CaCO_3$	#9M blisters and rust along scribe only
PWB 57	Arolon X820	Zinc Yellow, Micaceous Iron Oxide	Rust in scribe only
PWB 58	Rhoplex MV9	Zinc Oxide, Micaceous Iron Oxide	#8F blisters and rust along scribe, #8 surface rust
PWB 60	Arolon X820	Calcium Boro Silicate, $CaCO_3$	#8M blisters and rust along scribe only
S1406A	Rhoplex MC76	Portland Cement, $CaCO_3$	#7M blisters and rust along scribe, #7 surface rust
S1406B	Rhoplex MC76	Portland Cement, Aluminum Silicate	#7D blisters and rust along scribe, #6 surface rust

All test panels have been in place for 3 months except PWB 27 which has been in place one year.

Rust was present in scribed lines on all test panels.

Blisters on all test panels occurred only next to scribe lines.

Blister rating made according to ASTM D714-56.

Rust rating made according to ASTM D610-68.

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TABLE X

WATER-BASED PAINTS INVESTIGATED AS TOP COATS OVER WATER-BASED PRIMERS

Sample or Formula Number	Resin Type	Manufacturer	Supplier	Color
S1088	Acrylic 4358	Union Carbide	Union Carbide	White
PWB 9*	Acrylic WL81	Rohm Haas	Lab Made	Medium Blue
S1217	Acrylic Emulsion	Proprietary	Devoe	Medium Blue
PWB 23	Acrylic MV9	Rohm Haas	Lab Made	Aluminum
PWB 24*	Kelsol, 3906 Water Dispersible Alkyd	Spencer Kellog	Lab Made	White
PWB 25*	Kelsol, 3907 Water Dispersible Alkyd	Spencer Kellog	Lab Made	White
PWB 32	Styrene Acrylic 4341	Union Carbide	Lab Made	Green
PWB 33	Acrylic MV9	Rohm Haas	Lab Made	Medium Blue
PWB 44	Acrylic MV9	Rohm Haas	Lab Made	White Tint Base
PWB 51	Acrylic MV9	Rohm Haas	Lab Made	Tan
PWB 52	Acrylic MV9	Rohm Haas	Lab Made	Brown
PWB 62	Acrylic MV9	Rohm Haas	Lab Made	Light Blue
PWB 63	Acrylic 503	Union Carbide	Lab Made	White
PWB 94	Acrylic MV9	Rohm Haas	Lab Made	Aluminum
S1379A	Alkyd 580 Modified Styrene Acrylic X820	Spencer Kellog	Spencer Kellog	Green
S1379B	Alkyd 580 Modified Styrene Acrylic X820	Spencer Kellog	Spencer Kellog	Yellow
S1388*	Water Dispersible Alkyd	Spray Lat	Caltrans Equip. Shop	Orange
S1399*	Chemacoil 950 High Solids Alkyd	IMC	IMC	White
S1472A-T	Alqua 189-18 Alkyd Emulsion	PVO	PVO	White

*Will not meet 1982 Air Quality Rule as formulated.

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In general, all of the top coats in this series, except for the two water dispersible alkyds, exhibited blistering to various degrees in both the Salt Spray (Fog) and 100% humidity. Photographs are shown in Figure IX. The water dispersible alkyds tested will not comply with 1982 air quality rules. Most of the coatings also showed signs of rust on the surface of the coating, again with the exception of the water dispersible alkyds. Inasmuch as the overall performance of the water-based top coats was so poor when applied to bare steel, this test was considered too severe for most top coats evaluated at this time. It is probably useful only for relative comparisons at best.

Some of the top coats were additionally evaluated by applying them to ASTM D1733-63 aluminum panels and exposing them to light and water cycling according to ASTM G53-77. All of the top coats performed well in this test with no significant change in the paint film.

Complete water-based systems - primer and top coat

The performance of the complete water-based paint systems as evaluated by accelerated laboratory tests and outdoor exposure at the Golden Gate Bridge shows that the overall performance of the system is dependent upon the performance of the primer.

Most of the top coats evaluated, when applied over Formulation PWB 35, performed well with performance superior to that of a conventional solvent-based alkyd system. Other systems did not perform as well, with little or no increase in performance of the whole system as compared to the performance of the primer alone. Table XI lists the complete systems and Figure X shows photographs of some complete water-based systems after exposure to ASTM B117 Salt Spray (Fog).

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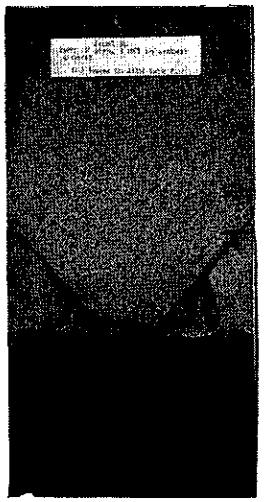
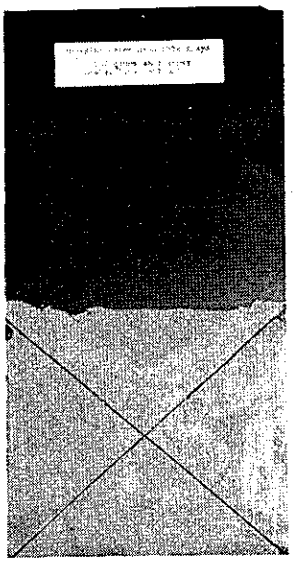
FIGURE IX

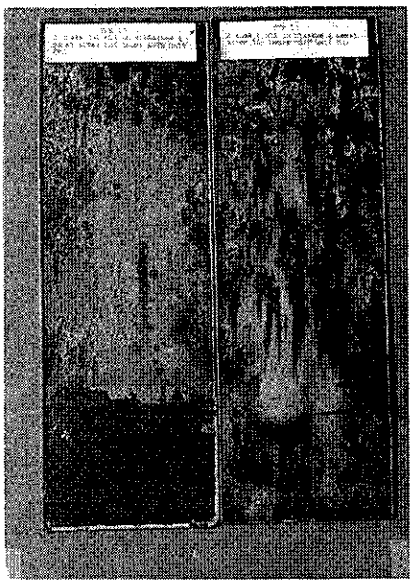
Typical Appearance of Water-Based Top Coats Applied to Unprimed Steel After Salt Spray (Fog) Testing



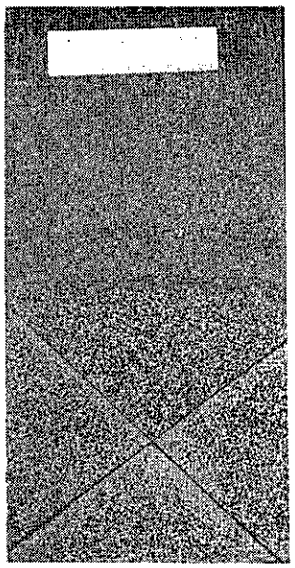
MV9 Acrylic Emulsion
602 Hours



Proprietary Water Dispersible Alkyd
S1388
780 Hours



WL81 Acrylic Emulsion
165 Hours



Ucar 4341 Styrene Acrylic Emulsion
330 Hours

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TABLE XI

COMPLETE WATER-BASED SYSTEMS INVESTIGATED

Primer		Topcoat		Performance	
Resin	Inhibitive Pigment	Resin	Color	ASTM B117 Salt Spray	Golden Gate Bridge
Arolon X820	Zinc Yellow, $CaCO_3$ Zinc Phosphate	Rhoplex MV9	Aluminum	1000 hr Scribe rust only	1 year Blisters and rust at scribe only
Devoe Proprietary	Zinc Dust	Proprietary Acrylic	Blue	Rust and blisters	Rust and blisters
Arolon X820	Zinc Yellow, $CaCO_3$ Zinc Phosphate	Rhoplex MV9	Blue	Scribe rust only	3 month Scribe rust only
Rhoplex MV23	Zinc Oxide, $CaCO_3$	Rhoplex MV9	Blue	-	Blisters and rust scribe only
Rhoplex MV23	Zinc Oxide, $CaCO_3$	Ucar 4341	Green	Rust and blisters	-
Ucar 4341	Busan	Ucar 4341	Green	Rust and blisters	Scribe rust only
Arolon X820	Zinc Yellow, $CaCO_3$ Zinc Phosphate	Arolon X820/580	Green	Scribe rust only	-
Arolon X820	Zinc Yellow, $CaCO_3$ Zinc Phosphate	Alqua 189-18	White	Scribe rust, few surface blisters	-
Napko Epoxy	Proprietary	Napko Acrylic	White	Surface blisters	-
Napko Proprietary	Zinc Dust	Napko Acrylic	White	Trace scribe rust	-

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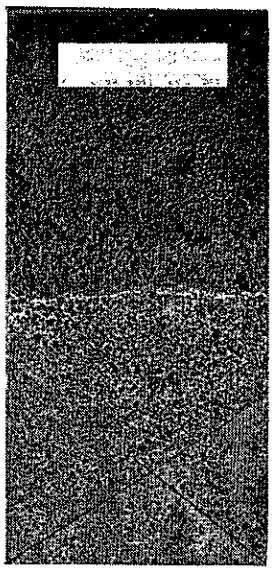
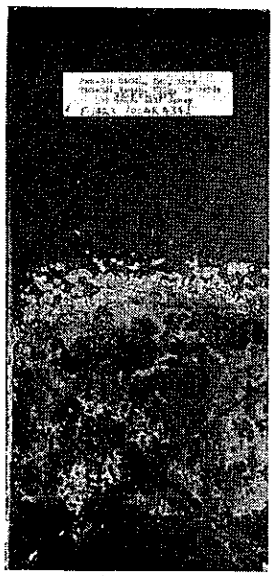
FIGURE X

Typical Appearance of Complete Water-Based System After Salt Spray (Fog) Testing

Top Coat Applied Over Primer With Poor Performance

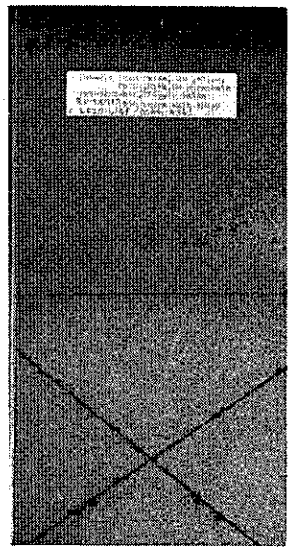


1100 Hours
7.5 mil Total Dry Film
PWB 31 Primer
PWB 32 Top Coat

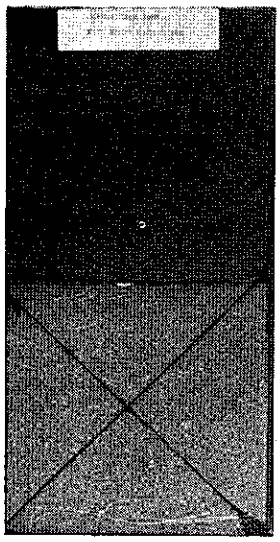


330 Hours
7.5-8.5 mil Total Dry Film
PWB 30 Primer
PWB 32 Top Coat

Top Coat Applied Over Primer With Good Performance



1110 Hours
7.5-8.5 mil Total Dry Film
PWB 27B Primer
PWB 32 Top Coat



1075 Hours
10-10.5 mil Total Dry Film
PWB 35 Primer
PWB 61A-3 Top Coat

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Inasmuch as accelerated laboratory tests do not always correspond to what actually occurs in full-scale field applications, plans are being made to evaluate several of the water-base systems in full-scale tests at various locations in the state.

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Trademark References

Aquamac	IMC Corporation
Aroplaz, Arolon	Spencer Kellog
Busan	Buckman Laboratories, Inc.
Cellosize, Carbitol, Ucar	Union Carbide Corporation
Dowicil	Dow Chemical
Gammasperse	Georgia Marble
Hydropaste	Aluminum Company of America
NDW, NXZ	Nopco Chemical Division
R & R 551	Ross and Rowe, Inc.
Rhoplex, Tamol, Triton	Rohm and Haas Company
R4098	Pfizer Pigments
Snowflake	Thompson Weinmann Company, Inc.
Texanol	Eastman Chemical Products, Inc.

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APPENDIX A

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BAY AREA AIR POLLUTION CONTROL DISTRICT

REGULATION 9

ADOPTED MARCH 1, 1978

RULE FOR ARCHITECTURAL COATINGS

1. 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, to mobile homes, to pavements, or to curbs.

b. Bituminous Coatings Materials

Black or brownish materials, soluble in carbon disulfide, consisting mainly of hydrocarbons and which are obtained from natural deposits, or as residues from the distillation of crude petroleum oils, or of low grades of coal.

c. Fire Retardant Coatings

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

d. Graphic Arts Coatings

Coatings which are marketed solely for application to indoor and outdoor signs and include lettering enamels, poster colors and bulletin colors.

e. Industrial Maintenance Finishes

High performance coatings which are formulated for the purpose of heavy abrasion, water immersion, chemical, corrosion, temperature, electrical or solvent resistance.

f. Metallic Pigmented Paints

Non-bituminous coatings which are formulated with metallic pigment.

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g. Opaque Stains

All stains that are not classified as semitransparent stains.

h. Primers

Coatings which are intended to be applied to a surface to provide a firm bond between the substrate and subsequent coats.

i. Sealers

Coatings which are intended for use on porous substrates to protect the substrate, to prevent subsequent coatings from being absorbed by the substrate, or to prevent harm to subsequent coatings by materials in the substrate.

j. Semitransparent Stains

Coatings which are formulated to change the color of a surface but not conceal the surface.

k. Tile-like Glaze Coatings

Coatings which are formulated to provide a tough, extra-durable coating system, which are applied as a continuous (seamless) high-build film and which cure to a hard glaze finish.

l. Undercoaters

Coatings which are designed to provide a smooth surface for subsequent coats.

m. Varnishes, Lacquers, and Shellacs

Coatings which contain resins and binders but not opaque pigments and which are specifically formulated to form a transparent or translucent solid protective film.

n. Waterproofing Coating

Coatings which are formulated for the sole purpose of preventing penetration of the substrate by water. These coatings include, but are not limited to, bituminous roof and resilient type coatings.

o. Wood Preservatives

Coatings which are formulated for the purpose of protecting exposed wood from decay and insect attack. These coatings perform their function by penetrating into the wood.

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p. Mastic Coatings

Weatherproofing coatings which are formulated to cover holes, minor cracks, and conceal surface irregularities, and which are applied in thicknesses of at least 15 mils.

q. Multi-colored Coatings

Coatings which exhibit more than one color when applied and which are packaged in a single container and applied in a single coat.

2. No person shall sell, offer for sale, or apply:

a. Any architectural coating manufactured after September 2, 1979. which contains more than 250 grams of volatile organic material per liter of coating as applied, excluding water, except that interior coatings shall not contain more than 350 grams of volatile organic material as applied, excluding water.

b. Any architectural coating manufactured after September 2, 1980. which contains more than 250 grams of volatile material per liter of coating as applied, excluding water.

c. Any surface coating manufactured after September 2, 1979, which is recommended for use as a bituminous pavement sealer unless it is an emulsion-type coating.

3. The provisions of Section 2 of this rule shall not apply to architectural coatings sold in this district for shipment outside of this district or for shipment to other manufacturers for repackaging.

4. The provisions of Section 2 of this rule shall not apply to coatings manufactured prior to September 2, 1980 by a Small Business.

a. A "Small Business" for the purposes of this rule means any business which in 1976 sold less than 500,000 gallons of paints and coatings.

(i) A business shall not qualify for this exemption if it would not be considered a Small Business, as defined in Subsection (1) of Section 1896 of Title 2 of the California Administrative Code.

(ii) A business shall not qualify for this exemption if its total annual sales volume of paints and coatings which would otherwise be subject to this rule exceeds by more than 10% the business's total sales volume of such coatings in calendar year 1976.

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b. To qualify for a Small Business exemption, a company requesting such exemption shall file a request in writing with the Air Pollution Control Officer. The company shall provide the Air Pollution Control Officer any necessary information including, but not limited to: (i) total volume (in gallons) of paints and coatings sold in 1976; (ii) the number of persons employed by the company; (iii) the gross sales receipts (in dollars) for 1976; and (iv) total annual sales volume of paints and coatings in 1976 and any subsequent year which would otherwise be subject to this rule. Other information necessary to document that the business is not an affiliate of another business concern which would not be considered a Small Business for the purposes of this rule shall also be provided to the Air Pollution Control Officer.

The Air Pollution Control Officer after considering information submitted by the business concern shall determine whether such concern qualifies as a Small Business as defined in Subsection a. of this section and shall inform the business concern of this determination in writing.

5. The provisions of this rule shall not apply to the following coatings manufactured prior to September 2, 1982:

a. Architectural coatings supplied in containers having capacities of one liter or less;

b. Traffic coatings applied to public streets and highways; however, this exemption shall not extend to traffic coatings applied to other surfaces, including, but not limited to curbs, berms, driveways and parking lots.

c. Architectural coatings recommended by the manufacturer for use solely as a:

1) varnish, lacquer, or shellac
2) semitransparent stain
3) opaque stain on bare redwood, cedar, mahogany, and douglas fir
4) primer, sealer, or undercoater
5) wood preservative
6) fire retardant coating
7) tile-like glaze coating
8) waterproofing coating, except bituminous pavement sealers
9) industrial maintenance finish
10) metallic pigmented
11) swimming pool coating
12) graphic arts coatings
13) mastic coatings
14) multi-colored coatings

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6. 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. The manufacturers of such coatings shall file with the Air Pollution Control Officer and the Executive Officer of the California Air Resources Board prior to September 2, 1979 an explanation of each code.

7. Labeling of Coatings

a. If anywhere on the coating container, on any sticker or label affixed thereto, or in any 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 Section 5 of this rule, then the exemption provided for in said Section 5 shall not apply to that coating.

b. In any instance where more than one of the standards set forth in Section 2 of this rule may be applicable, the most restrictive standard shall apply.

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APPENDIX B

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STATE OF CALIFORNIA

Specification 8010-61J-36

Paint Primer; Zinc-Rich Organic Vehicle Type

Composition:

Pigment Ingredients
(62.3 Percent of Composition Weight, Minimum)

		Parts by Weight of Pigment Type I, Red Tint
Zinc Dust	TT-P-460, Type I, *1	95.0 min.
Red Iron Oxide, *2		1.5 max.
Zinc Oxide	TT-P-463, Type I, Grades A or B	----
Thixotropes and Additives		3.5 max.

Vehicle Ingredients
(37.7 Percent of Composition Weight, Maximum)

		Parts by Weight of Vehicle
Polyaryl Ether, *3		19.0
Ethylene Glycol Monoethyl Ether Acetate	MIL-E-7125	66.8
Toluene	TT-T-548	14.2

*1 Except the metallic zinc content shall be 95 percent by weight, minimum.

*2 Fe_2O_3 98.5% minimum; oil absorption, 21; fineness through 325 mesh screen, 99% minimum; and specific gravity, 5.15.

*3 A polyhydroxy polyalkaryl polyether of the following properties:

Specific gravity	1.18
Viscosity of 40% solids in methyl ethyl ketone, Brookfield rvf, 20 rpm No. 5 spindle	5,500 to 7,700 cps
Reduced viscosity (0.2 g/100 ml. dimethylformamide)	0.4 to 0.6
Ultimate tensile strength	9,000 to 9,500 psi
Ultimate tensile elongation	50 to 100%
Softening temperature	212°F
Bulking value	0.102 gal. per lb.

The average particle size of the pigment shall not exceed 9 microns as determined by the Fisher Sub-Sieve Sizer. The Red Iron Oxide must first be ground into a portion of the vehicle to provide a Hegmen grind sufficient to produce the specified color of the finished paint.

The necessary additives to prevent gas formation in the containers during storage shall be incorporated into the formulated paint.

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Pre-Treatment, Vinyl Wash Primer (State Specification 8010-61J-27).—

Classification:

This specification covers a wash primer formulated specifically for application prior to painting clean aluminum, galvanized surfaces or surfaces previously coated with an organic or inorganic zinc-rich primer. It is also used on blast cleaned steel when specified and is mandatory as an undercoat under vinyl paint systems.

Composition:

Resin Component

	Specifications	*Pounds per 80 gallons of Resin Component*
Polyvinyl-butyral resin [1]		56
Zinc Chromate (insoluble type) [2]		54
Magnesium-silicate	(Type A or B MIL-M-15173)	8
Lampblack	(TT-P-350)	0.6
Butyl Alcohol, normal	(TT-B-846)	125
Ethyl Alcohol	(Grade III of O-E-760) [3]	380

Acid Component

		Pounds per 20 gallons of Acid Component
Phosphoric Acid, 85%	(Class 1 of O-O-670)	28
Water		25 max.
Ethyl Alcohol	(Grade III of O-E-760) [3]	102

[1] The polyvinyl partial butyral resin shall contain only polyvinyl butyral, polyvinyl alcohol and polyvinyl acetate in the molecule, and shall have the following properties:

Polyvinyl alcohol, percent by weight	19.0–22.0
Polyvinyl acetate, percent by weight	1.0 max.
Inherent viscosity, ASTM Designation: D 1243	0.87–0.95
Specific gravity	1.10–1.14
Heating loss, 45 minutes at 105° C., percent by we'ght	3.0 max.
Ash, percent by weight	0.1 max.

[2] The zinc chromate shall be of an insoluble type, showing an analysis 16 to 19 percent CrO_3, and 67 to 72 percent ZnO, and not more than one percent water soluble salts.

[3] Isopropyyl alcohol (99 percent) may be substituted in part for ethyl alcohol on an equal volume basis. The isopropyl alcohol shall have a specific gravity of 0.785 to 0.790 and a distillation range not greater than 1.5° C., and this range shall include 82.3° C.

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Experimental Water Base Aluminum Finish Paint

*Formula PWB 23

Alcoa Hydropaste 830 Aluminum Paste	2 pounds
Rohm and Haas MV9 Acrylic Emulsion	1 gallon
Tap Water	1 pint

Mixing Procedure:

Add one pint of tap water to two pounds of Alcoa Hydropaste 830, mix well. Slowly stir in Rohm and Haas MV9 emulsion. Mix well, avoid incorporating air into paint. Strain paint through a double layer of cheesecloth prior to using. The paint should be mixed fresh each day, do not store mixed paint for over 16 hours. Dispose of unused mixed paint in unsealed containers.

Application:

The mixed paint shall be applied in not less than two coats, to a total dry film thickness of at least 3 mil. Allow a minimum of two hours between coats. 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 55°F.

Preparation:

Surfaces to be painted should be cleaned of dirt, grease, loose chalky paint or other foreign material. Rusty or previously unpainted areas should be blast-cleaned and primed with State Specification 8010-61J-36, Zinc Rich Primer, organic vehicle type.

An application of vinyl wash primer State Specification 8010-61J-27 is presently recommended for use as a tie cost between the zinc rich primer and the finish coats.

Clean up:

Use tap water for clean up. Acetone or other suitable solvent may be used to remove dried paint from spray guns.

*See comments in section on "Implementation", page 5.

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Experimental Water Base Aluminum Finish Paint

*Formula PWB 94

Pigment Ingredients

Leafing Type: Hydro Paste Aluminum No. 830, Alcoa
Nonleafing Type: Hydro Paste Aluminum No. 825, Alcoa

The aluminum paste of the specified type shall be packaged in quantity sufficient to provide 2.0 lb. of paste/gallon of vehicle.

Vehicle Ingredients	% by Weight
Acrylic Emulsion MV9, Rohm Haas	97.8
Texanol Alcohol Ester, Eastman	2.2

The container for the vehicle must be lined if necessary to prevent attack by the vehicle. The lining must not come off the inside of the container as skins.

PACKAGING

The paint shall be furnished in a 6 gallon 2-compartment container, meeting Interstate Commerce shipping standards; one compartment for the vehicle and one for the aluminum paste. The total volume of the unmixed pigment and vehicle in the container shall be 5 gallons.

Mixing Procedure

Add 1/2 gallon of potable water to the compartment containing the Hydropaste Aluminum pigment, mix to a smooth, lump free consistency. Slowly stir in the acrylic emulsion. Mix well, avoid incorporating air into paint. Strain paint through a double layer of cheesecloth prior to using. The paint shall be mixed fresh each day, do not store mixed paint for over 16 hours. Dispose of unused mixed paint in unsealed containers.

Application

The mixed paint shall be applied in not less than two coats, to a total dry film thickness of at least 3 mil. Allow a minimum of 12 hours between coats. 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.

Clean Up

Use tap water for clean up. Acetone or other suitable solvent may be used to remove dried paint from spray guns.

*See comments in section on "Implementation", page 5.

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*RED IRON OXIDE-CHROMATE PRIMER (FORMULA 031226-50-1A) (PWB 35)

Description:

This specification covers a ready-mixed, water-based 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 sequence:

Component		By weight (lbs.)	By volume (gals.)
Mix at low speed:			
Water		135.0	16.21
Tamol 731	(1)	17.0	1.93
Tritan CF-10	(1)	3.0	0.34
Nopco NDW	(2)	2.0	0.27
Ethylene Glycol		28.0	3.02
Dowicil 75	(3)	0.6	0.05
R & R 551	(4)	2.0	0.24
Grind under high shear 15-20 minutes:			
Red Oxide R-4098	(5)	90.0	2.10
Zinc Yellow Y539D	(6)	15.0	0.52
Zinc Phosphate 317	(7)	30.0	1.14
Mica 325	(8)	33.0	1.41
Snoflake	(9)	200.0	8.87
HEC CP-4400	(10)	1.25-1.35	0.11
Under low speed - let down paste slowly:			
Nopco NDW	(2)	1.0	0.13
AROLON X820-W49	(11)	504.0	57.27
Ammonia		7.0	0.93
Butyl Carbitol	(10) } blend	6.0	0.76
Butyl Carbitol Acetate	(10) } blend	6.0	0.74
AROPLAZ 1271 } blend	(11)	25.6	3.07
Triton CF-10 } blend	(1)	1.4	0.16
	Totals	1107.8	99.27

*See comments in Section on "Implementation", page 5.

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Characteristics:

Pigment/Binder Ratio	1.35
Pounds Per Gallon	11.16
% Non-Volatile (Weight)	58.3
% Non-Volatile (Volume - Concentration)	32
% Non-Volatile (Volume)	44.4
pH	8.5-9.0
Viscosity, K.U.	72-75
60°/20° Gloss	Flat
Grind, Hegman	5

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(1) Rohm & Haas
(2) Diamond Shamrock
(3) Dow Chemical
(4) Ross & Row, Inc.
(5) Pfizer
(6) DuPont
(7) Reichard, Coulston, Inc.
(8) English Mica
(9) Thompson Weinman
(10) Union Carbide
(11) Ashland

Note: A light red color primer can be manufactured from Formula #031226-50-1A by replacing up to 75% of the Iron Oxide With the same weight of Titanium Dioxide, ASTM D 476 Type III or IV and an oil absorption of approximately 20 as determined by ASTM D 281.

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UCAR LP-3743 Primer (PWB 31)

Ingredients	Pounds	Gallons
Water	240.0	28.7
Cellosize QP-4400	3.0	0.3
Dispersant (1)	8.0	0.8
Wetting Agent (2)	5.0	0.6
Ethylene Glycol	20.0	2.2
Defoamer (3)	5.0	0.6
Mica, 325 mesh W.G.	35.0	1.5
Titanium Dioxide, rutile (4)	200.0	5.7
"Busan" 11M-1 (5)	100.0	3.6
Alkyd (100% solids) (6)	45.0	5.3
Cobalt Drier (6% Co)	1.0	0.16
Zirco Drier (6% Zr)	1.0	0.14
UCAR Vehicle 4341 (46% solids)	420.0	50.0
Totals	1073.0	100.0

Suppliers

(1) Dispersant - "Busperse" 55 (Buckman Laboratories); "Tamol" 850 (Rohm & Haas)
(2) Wetting Agent - "Igepal" Ca-630 (GAF); "Triton X-100 (Rohm & Haas)
(3) Defoamer - "Bubble Breaker" 748 (Witco Chemical)
(4) "Ti-Pure" R-960 (E.I.DuPont)
(5) "Busan" 11M-1 (Buckman Laboratories)
(6) "Varkyd" 515-100 (McClosky Varnish Co.), Aroplaz 1271 (Ashland Oil)

Procedure

Charge water and at low speed on a high shear dissolver sift in CELLOSIZE QP-4400 and mix 5 minutes. Add next 7 ingredients and mix under high shear for 20 minutes. Reduce speed and add the UCAR Vehicle 4341. Mix for 5 minutes and add the premixed alkyd and driers.

Physical Characteristics

	Minimum	Maximum
Weight per Gallon (lbs.)	10.5	11.0
Stormer Viscosity, Krebs Units	70	80
Total Solids by Weight, %	54.1	----
Total Solids by Volume, %	38.6	----

*See comments in section on "Implementation", page 5.

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