EVALUATION OF WATER-BASED INORGANIC ZINC PAINT SYSTEMS

FINAL REPORT

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ABSTRACT

This research project was conducted in order to find good quality water-based inorganic zinc paint systems and to develop good techniques for field application. However, based upon laboratory evaluation of 12 different paint systems, it was concluded that the development of water-based zinc paint systems has not been sufficiently advanced to the point of full-scale field application. In fact, it was the opinion of this researcher that due to the laboratory results, no paint system involved in the testing program warranted a field test.

The laboratory evaluation using several different generic types of topcoats enabled a recommendation to be made as to what appeared to be the most compatible systems of those undergoing tests. Two systems, each consisting of the water-based inorganic zinc silicate primer and the epoxy polyamide topcoat, had the best relative compatibility between coats after being exposed to a salt fog atmosphere for 4 weeks.

INTRODUCTION

Solvents found in most of the presently used paint systems are petroleum products which are currently subject to shortages and price increases. In addition, environmentalists are becoming increasingly concerned over the use of solvent based paints. Due to these circumstances, this research project was initiated in order to determine specifications for a water-based inorganic zinc paint system and to develop good techniques for field applications.

As a result of laboratory evaluation of 12 different water-based paint systems, manufactured by four different paint companies, no system was found to be suitable as a bridge coating. Due to the lack of a high-quality system being found among those tested in the laboratory, the field evaluation, including development of application techniques, was cancelled.

METHODOLOGY

Water-based inorganic zinc paint systems of the generic types listed in Table 1 were evaluated in the laboratory. Each system consisted of a primer and either one or two topcoats. The coats of paint for each system were applied to steel panels at the dry film thicknesses listed in Table 2. These panels were then subjected to a salt fog exposure for 4 weeks in accordance with LDH Designation: TR 1011, found in the appendix. Upon completion of this test, the coatings were evaluated.

The topcoats of all the systems evaluated were applied to weatherometer panels and subjected to exposure in a carbon arc weatherometer for 1500 hours. This test method was also described in LDH Designation: TR 1011.

It should be noted that, although the systems evaluated in this project were referred to as water-based, a few of the paints were reported to contain a small amount of organic solvent to aid in dispersion of the pigment.

TABLE 1

Water-Based Systems Evaluated
(Generic Types)

PAINT SYSTEM	GENERIC TYPE OF PRIMER	GENERIC TYPE OF FIRST TOPCOAT	GENERIC TYPE OF SECOND TOPCOAT
A-1	Inorganic Zinc Ammonium Silicate	Bisphenol-A Epoxy	
A-2	Inorganic Zinc Ammonium Silicate	Bisphenol-A Epoxy	Alkyd
A-3	Inorganic Zinc Ammonium Silicate	Acrylic Latex	
A-4	Inorganic Zinc Ammonium Silicate	Epoxy Ester	Acrylic Latex
A-5	Inorganic Zinc Ammonium Silicate	Bisphenol-A Epoxy	Acrylic Latex
A-6	Inorganic Zinc Ammonium Silicate	Acrylic Latex	
A-7	Inorganic Zinc Ammonium Silicate	Lithium Silicate	
B-1	Inorganic Zinc Alkali Silicate	Acrylic Latex	
B-2	Inorganic Zinc Potassium Silicate	Acrylic Latex	
C-1	Inorganic Zinc Sodium Silicate	Acrylic Latex	
C-2	Inorganic Zinc Sodium Silicate	Epoxy Polyamide	
D-1	Inorganic Zinc Potassium Silicate	Epoxy Polyamide	

TABLE 2

Thickness of Applied Coatings

PAINT SYSTEM	AVG. THICKNESS OF PRIMER (MILS)	AVG. THICKNESS OF FIRST TOPCOAT (MILS)	AVG. THICKNESS OF SECOND TOPCOAT (MILS)
A-1	3.00	6.00	
A-2	3.50	4.75	4.00
A-3	2.75	7.00	
A-4	3.00	3.75	3.00
A-5	2.25	4.00	3.00
A-6	2.75	6.25	
A-7	2.75	3.25	
B-1	5.50	4.00	
B-2	5.75	4.50	
C-1	4.00	3.75	
C-2	3.75	4.25	
D-1	2.00	5.25	

RESULTS

All topcoats of the water-based systems under evaluation had good results after being exposed in the weatherometer for 1500 hours. However, as can be seen in Table 3, most of the systems which were applied to steel panels and exposed to a salt fog atmosphere for four weeks showed varying degrees of blistering. The values reported in this table are based upon the photographic reference standards found in ASTM Designation: D-714, "Standard Method of Evaluating Degree of Blistering of Paints."

TABLE 3

CONDITION OF PAINT COATINGS AFTER 4 WEEKS EXPOSURE IN THE SALT FOG CABINET

PAINT SYSTEM	FREQUENCY OF BLISTERS	ASTM BLISTER SIZE NUMBER	OTHER SIGNS OF FAILURE
A-1	Dense	6	
A-2	Medium Dense	8	
A-3	Few	2	
A-4	---------	-----	Complete delamination between topcoats
A-5	---------	-----	Complete delamination between topcoats
A-6	Medium	4	
A-7	None	10	Binder in topcoat appeared to degrade
B-1*	Dense	6	Complete delamination between topcoats
B-2	Medium	4	Slight checking. Topcoat remained water sensitive
C-1	Medium Dense	6	
C-2	Medium	8	
D-1	Medium	8	Slight undercutting present

*This system was not exposed in the salt fog cabinet due to premature delamination.

DISCUSSION OF RESULTS

Based upon the results of the evaluation of systems A-3, A-4, A-5, A-6, B-2 and C-1, it appeared that acrylic latex was not compatible with either an epoxy or an inorganic zinc silicate primer. Complete delamination between the epoxy and the acrylic latex of systems A-4 and A-5 occurred after 4 weeks of salt fog exposure. The other systems mentioned had varying degrees of blistering between the inorganic zinc silicate primer and the acrylic latex topcoat which occurred after salt fog exposure. System B-1 also showed the same incompatibility prior to salt fog exposure.

There was a slight incompatibility between the inorganic zinc silicate primer and the bisphenol-A epoxy, as can be seen in the results of systems A-1 and A-2. However, as noted in systems C-2 and D-1, a relatively good compatibility existed between the inorganic zinc silicate primer and the epoxy polyamide topcoat. After salt fog exposure of these two systems, the blisters which formed were size No. 8 occurring at a medium frequency.

System A-7 was unlike the others in composition. The water-based inorganic zinc silicate primer was coated with a water-borne silicate topcoat. The compatibility of these two paints was very good. However, the binder of the topcoat showed degradation after 4 weeks of salt fog exposure resulting in an obvious failure.

CONCLUSIONS

1. None of the water-based inorganic zinc systems evaluated were found to be suitable for large scale field use as a bridge coating. Failures of coatings after 4 weeks of salt fog exposure were due to blistering, delamination and what appeared to be a degradation of the binder in the topcoat.

2. Use of an acrylic latex coating was found to cause blistering or delamination when coated over either an inorganic zinc silicate primer or an epoxy intermediate coat.

3. Use of a bisphenol-A epoxy over an inorganic zinc silicate primer also resulted in slight blistering after 4 weeks of salt fog exposure.

4. The systems consisting of an inorganic zinc silicate primer and a polyamide epoxy topocat had the best relative compatibility of coats although a few small blisters were found to be present.

RECOMMENDATIONS

Of the 12 water-based systems which were laboratory evaluated, none were found suitable as a satisfactory coating. It is therefore recommended that the field evaluation not be implemented at this time.

It has also been determined that the paint manufacturers should continue their research in order to develop a high-quality water-based inorganic zinc paint system.

APPENDIX

Method of Test for

ACCELERATED EXPOSURE FOR ZINC PRIMERS AND RESPECTIVE TOPCOATS

LDH Designation : TR 1011 - 74

Scope

1. The objective of this method of test is to subject zinc primers and the appropriate topcoats to accelerated exposure for the purpose of qualifying the complete system for the Qualified Products List. Each manufacturer that submits a zinc paint for approval must submit a complete system -- primer and topcoat -- to be tested and approved because there shall be no intermixing of primer and topcoat from various manufacturers.

Apparatus

2. The apparatus shall consist of the following:

(a) Salt Spray Cabinet capable of maintaining 135 ± 8 F (57 ± 4 C) inside temperature, 15 ± 3 psi (103 ± 20 kN/m^2) atomization pressure, and a cam that gives 8 hours heating and 16 hours non-heating.

(b) Sunshine Carbon Arc Atlas Weatherometer (triple arc continuous) capable of maintaining 145 ± 9 F (63 ± 5 C) black panel temperature, 18 minutes of 20 ± 3 psi (138 ± 20 kN/m^2) water spray, for each 102 minutes of ultraviolet light.

Procedure

3. (a) Salt Fog Exposure

Reference ASTM B 117. Three steel panels, A - 36, approx 4 by 8 by 0.13 in.(102 by 203 by 3.3 mm) shall be sandblasted to a SSPC - 10 or SSPC - 5 near white or white blast. The coating will be applied at a dry film thickness of 0.003 in. (0.08 mm) minimum for organic zinc primer and 0.003 in. to 0.005 in. (0.08 mm - 0.13 mm) dry film thickness for inorganic zinc primer. The topcoats will be applied at 0.003 in. (0.08 mm) minimum dry film thickness over organic zinc and 0.005 in. (0.13 mm) minimum dry film thickness over inorganic zinc. The panels will have a diagonal scribe 1/8 in. ± 1/16 in. (3.2 ± 1.6 mm) wide. The coated panels will be placed in the salt fog cabinet for a period of four weeks for organic zinc coating and four weeks for inorganic coating, at a salt concentration of 18% salt by weight and a temperature of 135 ± 8 F (57 ±4 C).

(b) Weatherometer Exposure

Reference ASTM D 609. Two steel panels approx 3 by 9 by 0.03 in. (76 by 229 by 0.8 mm) will be coated as prescribed below and shall remain in the weatherometer for a period of 1500 ± 48 hours. The weatherometer will be operated at a black panel temperature of 145 ± 9 F (63 ± 5 C) with an intermittent water spray lasting 18 minutes at 20 ± 3 psi (138 ± 20 kN/m^2) for each 102 minutes of continuous ultraviolet light. The relative humidity shall be maintained at 85 ± 5%.

The coating thickness applied to weatherometer panels shall be the same as those specified for preparing panels for (a) Salt Fog Exposure above. Only the topcoat (no primer) shall be applied when preparing panels for weatherometer exposure.

Report

4. The report of the salt fog exposure and weatherometer exposure is subjective and is reported as satisfactory or unsatisfactory for the specified number of hours exposure. When evaluating the test results, the following properties shall be observed and the applicable ASTM designations used as guidelines in determining whether or not the tested system is satisfactory or unsatisfactory:

PROPERTY	AMOUNT ALLOWED	ASTM REFERENCES
BLISTERING	NONE	D 714
CHALKING	SLIGHT	D 659
CHECKING	NONE	D 660
CRACKING	NONE	D 661
DELAMINATION	NONE	
DISCOLORATION	SLIGHT	
RUSTING	NONE	D 610
UNDERCUTTING	NONE	

Normal testing time is approx 18 weeks.