

# Laboratory Evaluation of Commercial Epoxy Coating Systems for Civil Works Applications

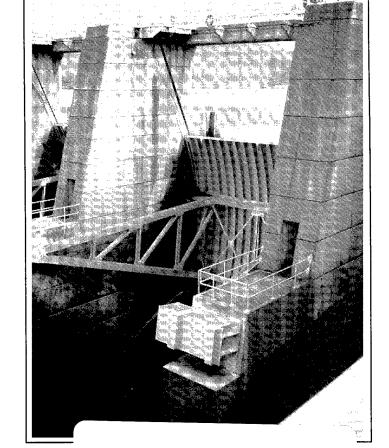
by Timothy D. Race

Provisions of the Clean Air Act Amendments of 1990 will put new restrictions on the use of highsolvent-content paints beginning in 1997. This will require the U.S. Army Corps of Engineers to find alternatives to some coatings now used to protect steel from corrosion in civil works applications. Furthermore, defense acquisition reform will mandate the use of commercially available products in place of most (or all) military paint specifications. To address this new requirement, the U.S. Army Construction Engineering Research Laboratories (USACERL) investigated the performance of several commercially available coating systems to help the Corps develop performance-based criteria documents for purchasing commercial products.

This report documents USACERL's laboratory evaluation of the performance of commercially available zinc-rich epoxy primers and epoxy topcoats. The evaluation comprised salt water immersion, fresh water immersion, and cyclic corrosion weathering tests.

Exposed test panels were evaluated for rusting, blistering, and rust undercutting. The Corpsstandard zinc-rich epoxy primer and epoxy topcoat system was used as an experimental control.

Based on the findings of this investigation, several commercial products are viable alternatives to the Corps-standard system.





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## **Foreword**

This study was conducted for Headquarters, U.S. Army Corps of Engineers under "Civil Works Investigations and Studies"; Work Unit 31205, "Developing High-Performance Coatings." The technical monitors were R. Kinsel and J. Gilson, CECW-EE.

The work was performed by the Materials Science and Technology Division (FL-M) of the Facilities Technology Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL). Dr. Ellen G. Segan is Acting Chief, CECER-FL-M, and Donald F. Fournier is Acting Operations Chief, CECER-FL. The USACERL technical editor was Gordon L. Cohen, Technical Information Team.

COL James T. Scott is Commander of USACERL, and Dr. Michael J. O'Connor is Director.

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## 1 Introduction

#### **Background**

The U.S. Army Corps of Engineers uses epoxy coating systems because their excellent barrier properties provide good long-term protection for steel structures in immersion service. Corrosion protection can be enhanced by priming the steel substrate with a zinc-rich epoxy primer such as E-303d, the Corps' current in-house specification. At the same time, epoxy topcoats enhance the performance of zinc-rich primers by providing impact- and abrasion-resistance, and they act as a barrier to corrosive water, oxygen, and salt. To achieve proper coating performance with zinc-rich epoxy primers, good surface preparation is required. Civil Works Guide Specification CWGS-09940 calls for the use of SSPC-SP-5\*, White Metal Blast Cleaning, for coating systems using primer E-303d. The chemical composition of primer E-303d is described in CWGS-09940, Painting: Hydraulic Structures and Appurtenant Works (1995).

The Corps of Engineers currently uses E-303d as a primer for two types of topcoats:

- MIL-P-24441, Paint, Epoxy-Polyamide
- Steel Structures Painting Council (SSPC) Paint Specification No. 16, Coal Tar Epoxy-Polyamide Black (or Dark Red) Paint (1991).

These coating systems, designated by the Corps as systems 21-A-Z and 6-A-Z, respectively, are used for a variety of applications, including fresh water and salt water immersion, and atmospheric weathering. MIL-P-24441 has an excellent record of corrosion protection in use by the Corps of Engineers and the U.S. Navy. Its performance is often used as a performance benchmark for other coating systems.

One problem with E-303d is that it has a relatively high volatile organic compound (VOC) content—typically 500-600 grams per liter as applied. The U.S. Environmental Protection Agency (EPA) has proposed a national rule that places tighter restrictions on the VOC content of architectural and industrial maintenance coatings (PL 101-549, 104 stat 2399). The VOC content requirement for industrial

<sup>\*</sup> SSPC: Steel Structures Painting Council.

maintenance coatings will likely be restricted to 450 grams per liter, so the Corps will no longer be able to apply E-303d when the national rule is implemented on 1 April 1997. Therefore, a suitable replacement is needed very soon.

Federal acquisition reform will have an impact on what the Corps selects as alternative epoxy coating systems. The revised Federal Acquisition Regulation, or FAR (60 FR 48231–48257) redefines the procurement process for Department of Defense agencies. Part 12 of the revised FAR states a clear preference for the procurement of commercial products and systems. Criteria documents (specifications) for procuring commercial products should not merely be directive, but should be based on performance data. In response to the revised FAR and other defense acquisition reforms, the Corps of Engineers has taken the initiative to eliminate the use of military specifications from all future procurements. This initiative may result in the elimination of topcoat MIL-P-24441 (used in Corps system 21-A-Z). As of this writing, MIL-P-24441 is exempt from the military specification ban, but national trends in procurement reform and environmental protection strongly indicate that the exemption cannot be expected to continue indefinitely. Therefore, it is highly advisable for the Corps to proactively investigate viable commercial alternatives to MIL-P-24441 in preparation for the likely ban on this topcoat.

The U.S. Army Construction Engineering Research Laboratories (USACERL) was tasked to determine whether there are epoxy coating systems now commercially available that conform to the requirements of the proposed national rule on VOC content while meeting the basic performance criteria for primer E-303d and topcoat MIL-P-24441 (Corps system 21-A-Z).

Part of this tasking was to evaluate the suitability of three ASTM-standard short-term laboratory tests for rapidly determining the relative (vice absolute) performance of two or more coating systems. If suitable, such tests may serve as the basis for developing a performance-based specification for commercial paint systems of the generic type investigated here.

## **Objectives**

The primary objective of this investigation was to test the relative performance and potential utility of commercial zinc-rich epoxy primers and topcoats to determine whether the market offers suitable replacements for Corps standard primer/topcoat system 21-A-Z.

The secondary objective was to establish the suitability of three ASTM-standard test methods (salt water immersion, fresh water immersion, and cyclic corrosion) for rapidly evaluating the relative performance of this generic type of coating system.

#### Approach

A list of manufacturers producing low-VOC zinc-rich epoxy primer/epoxy topcoat systems was compiled from an standard coatings industry directory. Sufficient resources were provided to randomly select six coating systems for the commercial product survey.

To accomplish the primary objective of this research, the six selected coating systems were applied to steel test plates. As an experimental control, Corps standard system 21-A-Z also was applied to steel test plates. The test coatings were evaluated using ASTM-standard laboratory methods designed to simulate three exposure environments:

- 120-day fresh water immersion
- 120-day salt water immersion
- 112-day atmospheric weathering.

Test panels were evaluated periodically for degree of rusting, blistering, and rust undercutting. More information about the test procedures is provided in Chapter 2.

To accomplish the secondary objective—evaluating the effectiveness of the three test methods used in this investigation—the methods were evaluated against one criterion: the tests' ability to reliably identify the difference between suitable coatings and unsuitable ones. In this research, early blistering was considered a surrogate indicator of coating unsuitability. The laboratory samples were analyzed statistically to determine correlations (and consistency of results) between coatings and test exposures.

#### Scope

Neither the selection of products for testing nor the results reported here should be interpreted as an endorsement of specific products or manufacturers. The intent of this work was not to qualify or disqualify individual products, but to determine the potential suitability of commercial products as a group.

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This investigation was limited to laboratory testing. Care should be taken not to extrapolate the results of laboratory experiments to actual field performance. Field tests must be conducted to fully validate the utility of any coating technology.

## **Mode of Technology Transfer**

It is recommended that the findings of this research be incorporated into any new Corps of Engineers criteria documents for commercial epoxy coating systems, as developed in accord with the revised FAR.

## 2 Testing Procedures

#### **Test Coating Application**

Six commercial epoxy zinc-rich primer/epoxy topcoat systems were mixed and applied in accordance with the manufacturers' recommendations. Corps of Engineers paint system 21-A-Z was used as an experimental control. System 21-A-Z consists of two coats of E-303d primer and two coats of MIL-P-24441, Formula 152, Type IV, epoxy-polyamide topcoat. Coatings were spray-applied to SP 1 and SP 5 cleaned, hot-rolled commercial grade carbon steel test panels measuring 3 x 9 x 0.125 in.\* Table 1 lists the test and control coatings, and Appendix A lists additional information about the coating manufacturers.

The dry film coating thicknesses of the test and control coatings were measured in accordance with ASTM D 1186, Standard Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Base (1987). The average dry film thicknesses for each coating system are listed in Table 2. Dry film thicknesses for individual test panels can be found in Appendix B, Tables B1–B7.

Table 1. Test and control coatings (with VOC content in grams/liter).

Manufacturer	Primer	Topcoat	VOC Primer/Topcoat (g/l)
Ameron	Amercoat 68HS Zinc	Amercoat 385 Multi- Purpose	288 / 276
Carboline	Carboline 858	Carboline 890	302 / 214
Gavlon Industries	Gavlon 9198-6129 Primer	Gavlon 9888-0008LF	324 / 168
Keeler & Long	Kolor-Poxy 1-11 Solid Zinc Rich Primer No. 7600	Kolor-Poxy 3500 S/P Surfacing Enamel	260 / 72
Poly-Carb	Mark 59.3	Mark 83.3	0 / N/A
Sherwin-Williams	Zinc Clad IV	Kem Cure MW Hi-Build	308 / 340
Corps specification	E-303d	MIL-P-24441 Formula 152, Type IV	500-600 / 340

<sup>\* 1</sup> in. = 2.54 cm

Table 2. Paint dry film thicknesses.

	Dry Film Thickness of System Components (expressed in thousandths of an inch)					
Coating System	Zinc Primer	Epoxy Topcoat	Epoxy Topcoat	Total System		
Ameron	4.8	4.1	4.9	13.8		
Carboline	5.1	6.1	N/A	11.2		
Gavlon	5.3	3.5	5.0	13.8		
Keeler & Long	2.6	10.4	N/A	13.0		
Poly-Carb	5.8	3.3	3.8	12.9		
Sherwin-Williams	5.0	6.1	4.6	15.7		
21-A-Z (control)	1.7	6.5	N/A	8.2		

#### **Selection of Test Methods**

The selected laboratory test methods simulate the expected service environments for epoxy coated-steel. Each is an ASTM-standard methodology shown to produce results that correlate with actual outdoor exposures. Consequently, they are especially useful in quickly ranking a set of coatings.

#### **Salt Water Immersion**

Six test panels of each control and experimental system were immersed for 120 days in synthetic sea water prepared in accordance with Section 7, Salt Solution, of ASTM B 117 Standard Test Method of Salt Spray (Fog) Testing (1990). All test panels were scribed before immersion, exposing an area approximately 1/8 x 2 in. The purpose of the scribing is to simulate coating film defects that inevitably occur due to damage during handling, erection, and service life. Test panels were evaluated after 7, 60, and 120 days for degree of rusting and blistering in accordance with ASTM D 610, Standard Method for Evaluating Degree of Rusting on Painted Surfaces (1989) and ASTM D 714, Standard Test Method for Evaluating Degree of Blistering of Paints (1987). Degree of undercutting was measured after 120 days in accordance with ASTM D 1654, Standard Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments (1992).

#### Fresh Water Immersion

This test employed the same test and evaluation procedures used in the salt water test. The test panels were immersed in aerated tap water.

## **Cyclic Corrosion Weathering**

Six scribed test panels of each control and experimental system were subjected to 16 weeks of cyclic corrosion testing. The test cycle comprised 1 week in an ultraviolet condensation cabinet per ASTM G 53, Standard Practice for Operating Lightand Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials (1991) using UV-A bulbs (4 hours UV at 60 °C, 4 hours condensation at 50 °C), followed by 1 week of hourly cycling through salt spray at 30 °C (4.0 g/L ammonium sulfate, 0.5 g/L sodium chloride) and forced air drying at 40 °C (modified ASTM G 85 Annex A5). The test panels were evaluated for degree of rusting and blistering after 1, 2, 4, 8, 12, and 16 weeks. The degree of undercutting was measured after 16 weeks.

## 3 Results and Discussion

#### Salt Water Immersion

Degree of blistering adjacent to the scribe and rusting were determined for the test and control coatings after 7, 60, and 120 days in salt water immersion. Rust undercutting at the scribe was measured after 120 days. The results are summarized in Table 3. The rust undercutting data have been converted to integer values from 0 to 10, as described in ASTM D 1654. The blistering data are similarly converted by taking the average of the sum of the blister size and the converted blister density. The converted blister density is an integer value from 0 to 10 with very dense blistering equal to zero and no blistering equal to 10. Rust, blister, and undercut values are the averages of six test specimens for each coating system. The composite score, shown in the last column, is the sum of numerical rust, blister, and undercut ratings at 120 days. A composite score of 30 corresponds to no coating degradation. The raw data for the salt water immersion tests are presented in Appendix B.

#### Blistering

Early blistering adjacent to the scribe is a good indicator of poor long-term performance for salt water immersion applications. Blistering not associated with the area near the scribe is less likely to occur, but when it does it indicates more serious performance problems. Most of the commercial epoxy systems showed good resistance to blistering in salt water immersion. However, one of the commercial systems

Table 3. 120-day salt water immersion test results.

Coating System	Rust	Blister	Undercut	Total
Ameron	10	10	10	30.0
Carboline	10	10	10	30.0
Gavlon	10	8.2	1.8	20.0
Keeler & Long	10	2	0	12.0
Poly-Carb	10	. 10	10	30.0
Sherwin-Williams	10	10	10	30.0
21-A-Z (control)	9.7	10	9	28.7

showed some minor blistering not associated with the scribe, and another system exhibited severe blistering over the entire coated surface.

#### Undercutting

The degree of rust undercutting measured at the scribed area is an important measure of long-term coating performance. Four of the commercial epoxy systems had no undercutting, but the two systems that had blistered did show severe undercutting. The control system (21-A-Z) exhibited minor undercutting at the scribe.

#### Surface Rusting

Visible rusting is typically associated with broken blisters, pinholes, and holidays. Only the control system had any visible surface rust. Two of the six test panels had minor pinpoint rusting associated with pinholes in the coating.

#### Composite Scores

The control system (21-A-Z) showed minor degradation after 120-days and had a composite score of 28.7. In a previous investigation of commercial zinc-rich epoxy primers (Race 1996), system 21-A-Z showed no degradation and had a composite score of 30 for 120-days salt water immersion. Of the six epoxy test systems, four had perfect composite scores and two had relatively poor scores. Five of the primers evaluated in this study were also evaluated in Race 1996. Table 4 compares the performance of these materials topcoated with MIL-P-24441 in the previous study against their performance when topcoated with the manufacturer's own commercial

Table 4. Comparison of zinc-rich epoxy performance with commercial vs military specification topcoats in salt water immersion.

Coati	ng System	Rust	Blister	Undercut	Total
	MIL-P-24441	10	10	10	30
Ameron	Commercial	10	10	10	30
	MIL-P-24441	10	10	10	30
Carboline	Commercial	10	10	10	30
-	MIL-P-24441	10	10	10	30
Gavlon	Commercial	10	8.2	1.8	20
	MIL-P-24441	10	10	10	30
Keeler&Long	Commercial	10	2	0	12
	MIL-P-24441	10	10	10	30
Poly-Carb	Commercial	10	10	10	30

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topcoat in this work. Three of the primers had perfect scores both with MIL-P-24441 and their manufacturer's commercial topcoat. Two of the primers showed markedly inferior results with their respective commercial topcoats.

Paint system 21 (MIL-P-24441, Formulas 150 and 152)—an epoxy topcoat system without zinc—was evaluated in another previous study by Race and Boy (1995). In that study, system 21 showed both blistering (4.0) and undercutting (8.5) at the scribe, and a composite score of only 22.5 after 112-days in salt water immersion (Race and Boy 1995). All of the commercial primers as well as Corps standard E-303d improved the performance of system 21 in salt water immersion. However, two of the commercial epoxy systems in the current study exhibited a lower degree of protection—in spite of their zinc-rich primer—than did system 21 without a zinc-rich primer in the 1995 Boy and Race study.

#### Fresh Water Immersion

#### Rusting, Blistering, and Undercutting

Degree of rusting and blistering were determined for the test and control coatings after 7, 60, and 120 days in fresh water immersion. Rust undercutting at the scribe was measured after 120 days. The results are shown in Table 5, and the raw data are presented in Appendix B. The composite score for each test panel is presented in the last column of the table.

#### **Composite Scores**

With the exception of the two coatings that performed poorly in salt water immersion, the commercial epoxy systems performed well in fresh water immersion. Table 6 compares the performance of five primers that were evaluated with both the

Table 5. 120-day fresh water immersion test results.

Coating System	Rust	Blister	Undercut	Total
Ameron	10	10	10	30.0
Carboline	10	10	10	30.0
Gavlon	10	10	4.2	24.2
Keeler & Long	10	2.0	0	12.0
Poly-Carb	10	10	10	30.0
Sherwin-Williams	10	10	10	30.0
21-A-Z (control)	10	10	10	30.0

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Table 6. Comparison of zinc-rich epoxy performance with commercial vs military specification topcoats in fresh water immersion.

Coating Sy	stem	Rust	Blister	Undercut	Total
A	MIL-P-24441	10	10	10	30
Ameron	Commercial	10	10	10	30
O = ul = 1! = =	MIL-P-24441	10	10	10	30
Carboline	Commercial	10	10	10	30
O souls a	MIL-P-24441	10	10	10	30
Gavlon	Commercial	10	10	4.2	24.2
	MIL-P-24441	10	10	10	30
Keeler&Long	Commercial	10	2	0	12
Dalu Oada	MIL-P-24441	10	10	10	30
Poly-Carb	Commercial	10	10	10	30

commercial and military specification topcoats. Again, as in the salt water test, three of the fresh water exposed primers showed the same high level of performance with both topcoats. Furthermore, the same two primers that performed poorly in other tests also showed markedly inferior results with their own commercial topcoats. As in other tests, the two poorly performing primer/topcoat systems did not equal the performance of MIL-P-24441 without a primer; after 112-days system 21 had a perfect composite score of 30 (Race and Boy 1995).

## **Cyclic Corrosion Weathering**

#### Rusting, Blistering, and Undercutting

Test panels were evaluated for rusting and blistering after 1, 2, 4, 8, 12, and 16 weeks. Rust undercutting at the scribe was measured at the completion of the 16 week test. The results are summarized in Table 7. Appendix B contains the raw data for the cyclic corrosion testing.

Five of the six test systems had perfect blister and rust ratings at the completion of the cyclic corrosion test. The control exhibited extensive blistering along the scribe, but no surface rusting. All but one of the coating systems exhibited some degree of undercutting at the scribe. The control system and one of the test systems were undercut severely.

Table 7. 112-day cyclic corrosion test results.

Coating System	Rust	Blister	Undercut	Total
Ameron	10	10	9.8	29.8
Carboline	10	10	8.7	28.7
Gavlon	10	10	6.7	26.7
Keeler & Long	10	4.3	2.0	16.3
Poly-Carb	10	10	9	29.0
Sherwin-Williams	10	10	10	30.0
21-A-Z (control)	10	2.3	2.7	15.0

#### Composite Scores

In Race and Boy (1995), system 21 without a zinc-rich primer showed blistering (3.7) and undercutting (4.3), and achieved a composite score of 18.1. In the current study, all but one of the commercial epoxy systems performed better in cyclic corrosion testing than did system 21 in Race and Boy (1995). Cyclic corrosion testing of the zinc-rich primers topcoated with MIL-P-24441 was also conducted previously. Table 8 compares the results of the previous tests with those from the current study.

## **Analysis of Variance**

Standard deviations were computed for each performance attribute (i.e., rusting, blistering, undercutting, and total), paint system, and test exposure. Table 9 lists these values.

Table 8. Comparison of zinc-rich epoxy performance with commercial vs military specification topcoats in

cyclic corrosion.

Coating System	1	Rust	Blister	Undercut	Total
	MIL-P-24441	10	10	10	30
Ameron	Commercial	10	10	9.8	29.8
	MIL-P-24441	10	10	10	30
Carboline	Commercial	10	10	8.7	28.7
	MIL-P-24441	10	10	9	29.0
Gavlon	Commercial	10	10	6.7	26.7
	MIL-P-24441	10	10	10	30
Keeler&Long	Commercial	10	4.3	2	16.3
	MIL-P-24441	10	10	10	30
Poly-Carb	Commercial	10	10	9	29.0

Table 9.	Standard deviations for sal	t water (SW) .	fresh water (FW)	, and cyclic corrosion (CC) tes	its.
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Coating System	Rust SW / FW / CC	Blister SW / FW / CC	Undercut SW / FW / CC	Total SW / FW / CC
Ameron	0/0/0	0/0/0	0 / 0 / 0.41	0/0/0.41
Carboline	0/0/0	0/0/0	0 / 0 / 1.03	0 / 0 / 1.03
Gavion	0/0/0	2.86 / 0 / 0	0.75 / .41 / .82	2.9 / .41 / .82
Keeler & Long	0/0/0	0 / 0 / 1.75	0.75 / 0 / 1.67	0 / 0 / 3.27
Poly-Carb	0/0/0	0/0/0	0 / 0 / 1.55	0/0/1.55
Sherwin-Williams	0/0/0	0/0/0	0/0/0	0/0/0
21-A-Z (control)	0.52 / 0 / 0	0/0/1.03	0 / 0 / 1.03	0.52 / 0 / 1.26

There is very little variance in the rusting data, primarily because rusting was detected on only one coating system in one test exposure. There is also little variance in the blistering data, again because very few paint systems exhibited any blistering. In general, the more severe the blistering (lower score) the lower the variance. The relatively high blistering variances noted for two samples were coincidental with the onset of blistering, which can vary significantly from panel to panel in its early stages. These differences tend to level out over time. Undercutting was by far the most variable performance attribute measured, especially in the cyclic corrosion test. There also does not appear to be any correlation between degree of undercutting and the magnitude of the standard deviation. In other words, the observed variability in degree of undercutting does not appear to be time-dependent (as appears to be the case for blistering). Significant variability also was noted for the composite (total) scores, especially for the cyclic corrosion test.

## Significance Testing and Rank Order Performance

#### Salt Water Test

The t-test was used to determine the significance of the test results. For salt water immersion there was no observed degradation or variance for the best four coating systems. The observed differences between these products and each of the other materials are significant at the 99.9 percent confidence level. The rank order performance, then, is Ameron = Carboline = Poly-Carb = Sherwin-Williams > 21-A-Z > Gavlon > Keeler&Long. This rank order correlates perfectly with that derived from the composite scores. The 120-day test is not long enough to be able to identify differences between the better products, although poor products are readily identified within this period. A longer exposure period is needed to qualify the performance

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of coatings for use in salt water immersion, but 120 days is considered adequate to determine fitness for purpose.

#### Fresh Water Test

For fresh water immersion, as for salt water immersion, there was no observed degradation or performance variance among the four best coating systems. The observed differences between these products and each of the other materials are significant at the 99.9 percent confidence level. The rank order performance is Ameron = Carboline = Poly-Carb = Sherwin-Williams = 21-A-Z > Gavlon > Keeler&Long. This rank order correlates perfectly with that derived from the composite scores. The 120-day test was not long enough to be able to identify differences between the better products. Poor products are readily identified in 120 days. A longer exposure period is needed to qualify coatings for use in fresh water immersion, but 120 days is considered adequate to determine fitness for purpose.

#### Cyclic Corrosion Test

For the cyclic corrosion test there were no significant differences in the performance of the four highest scoring materials at the 95 percent confidence level. At the 95 percent confidence level the materials are ranked Ameron = Carboline = Poly-Carb = Sherwin-Williams > Gavlon > Keeler&Long > 21-A-Z. At the 70 percent confidence level the rank order comes closer to approximating that given by the composite scores: Sherwin-Williams > Ameron > Poly-Carb = Carboline > Keeler&Long > 21-A-Z. The 112-day test period is adequate to determine the differences between poor and good performing products. The differences between the highest-performing paints are not statistically significant. The data suggest that a minimum composite score of 27 to 28 would be an appropriate acceptance criterion for qualifying coating systems of the type evaluated in this study by these test methods.

## Modes of Degradation and Failure

Early blistering at the scribe in all three exposures correlates well with poor overall performance. Blistered panels also have the lowest (worst) undercutting scores. Undercutting without blistering was observed for one system in salt water, one system in fresh water, and four systems in cyclic corrosion.

## 4 Conclusions and Recommendations

#### **Conclusions on Coatings Systems**

For the fresh and salt water immersion exposures, most commercial systems tested in this study performed well. The top-performing commercial products are equal to or better than the standard Corps coating system 21-A-Z. The better commercial systems perform as well with the commercial topcoats as they do with MIL-P-24441. The better commercial and standard Corps systems should provide similar long-term performance in fresh and salt water immersion applications.

The top commercial systems performed significantly better than system 21-A-Z in the cyclic corrosion test. However, system 21-A-Z performed much worse than in a previous study, achieving a composite score of just 15.0 in the current test as compared to 30.0 in the earlier one. These differences are probably due to the relatively low primer and total system thicknesses applied in this study (1.7 and 8.2 mils, respectively) compared to those in the previous study (3.1 and 11.1 mils, respectively). Batch variations also may have been a factor in the reduced cyclic corrosion resistance of the control samples. MIL-P-24441 is produced by a number of different manufacturers, and significant variations in material quality and composition have been noted by USACERL when conducting quality-control tests for Corps field activities. Nevertheless, it is concluded that the better commercial systems tested in this study are suitable alternatives to Corps system 21-A-Z for atmospheric exposures in corrosive environments.

The four top-performing commercial coating systems exhibited superior performance in all three test exposures. The other two commercial systems performed poorly in all test exposures. The uniformly good results for the four top performers in both immersion and atmospheric exposures is encouraging because most Corps applications for these materials involve structural components that are simultaneously immersed in water and exposed to the atmosphere.

#### **Conclusions on Test Methods**

It is concluded that the test methods and evaluation procedures used in this study are capable of distinguishing between the adequate and inadequate coating systems at or above the 95 percent confidence level. Because fitness for purpose correlates well with the presence or absence of early blistering on test panels, the experimental results support the overall finding that each test method was adequate for determining minimum performance requirements. Poor performers are readily identified or screened out by the test methods. However, it must be noted again that the 120-day immersion tests are not long enough to determine the actual long-term durability of the coating systems in these exposures, nor are they long enough to distinguish between the better-performing products. Laboratory exposures of a year or longer would be useful in identifying differences among the higher-performing products, but, longer exposures are impractical from the standpoint of qualifying coatings based on their performance.

#### **Recommendations**

It is recommended that field tests of the most promising commercial systems (Amercoat, Carboline, Sherwin-Williams, Poly-Carb) be conducted to determine the long-term performance of these products under real-world conditions. Field test applications should include structures exposed to the same exposure conditions simulated in this laboratory test.

It is recommended that, upon field verification of these laboratory tests, the test and evaluation procedures reported here should be used to develop a performance-based criteria document for a commercial zinc-rich epoxy primer/epoxy topcoat system. Such a document should be issued as a commercial item description by the General Services Administration.

## References

- ASTM B 117, Standard Test Method of Salt Spray (Fog) Testing (ASTM, Philadelphia, PA, 1990).
- ASTM D 610, Standard Method for Evaluating Degree of Rusting on Painted Surfaces (ASTM, 1989).
- ASTM D 714, Standard Test Method for Evaluating Degree of Blistering of Paints (ASTM, 1987).
- ASTM D 1186, Standard Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Base (ASTM, 1987).
- ASTM D 1654, Standard Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments (ASTM, 1992).
- ASTM G 53, Standard Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials (ASTM, 1991).
- CWGS-09940, Painting: Hydraulic Structures and Appurtenant Works (Army Engineer Division, Hunstville, AL, 1995).
- Federal Register (FR), vol 60, pp 48231-48257.
- MIL-P-24441, Paint, Epoxy-Polyamide, General Specification for (Naval Sea Systems Command, Alexandria, VA, 1991).
- Public Law (PL) 101-549, 104 stat 2399, sec 183(e) (15 November 1990).
- Race, Timothy D., Laboratory Evaluation of Commercial Epoxy Zinc-Rich Primers for Civil Works Applications, Technical Report (TR) 96/39/ADA306450 (U.S. Army Construction Engineering Research Laboratories [USACERL], February 1996.)
- Race, Timothy D., and Jeffrey H. Boy, Laboratory Evaluation of Fusion-Bonded Epoxy Coatings for Civil Works Applications, TR FM-95/06/ADA291876 (USACERL, January 1995).
- SSPC SP-1, Solvent Cleaning (Steel Structures Painting Council [SSPC], Pittsburgh, PA, 1982).
- SSPC SP-5, White Metal Blast Cleaning (SSPC, 1991).
- SSPC SP-6, Commercial Blast Cleaning (SSPC, 1991).
- SSPC Paint Specification No. 16, Coal Tar Epoxy-Polyamide Black (or Dark Red) Paint (SSPC, 1991).

# Appendix A: Manufacturers of Coatings Tested in This Study

Ameron-Protective Coatings Group 201 N. Berry St. Brea, CA 92622

Carboline Co. 350 Hanley Industrial Court St. Louis, MO 63144

Sherwin-Williams Co. 101 Prospect Ave. NW Cleveland, OH 44115-1075

Gavlon Industries, Inc. 10531 W. Little Yonk Rd. Houston, TX 77041

Keeler & Long, Inc. 856 Echo Lake Rd. Watertown, CT 06795

Poly-Carb, Inc. 33095 Bainbridge Rd. Cleveland, OH 44139

# Appendix B: Raw Data for In-Laboratory Coating Tests

Table B1. Test data for E303d/MIL-P-24441 system (Corps system 21-A-Z).

COATING SYSTEM DATA		1ST COAT	ΑΤ		2ND COAT		38	3RD COAT	
COATING I.D.	Epoxy Z	Epoxy Zinc-Rich Paint	υţ	MIL 2444			N/A		
	E303d E	E303d Epoxy Zinc-Rich Paint	ich Paint						
MANUFACTURER	Referen	Reference Material		Referen	Reference Material				
VOLUME % SOLIDS	See attached	. payor		See attached	rched				
VOC (unthinned)	See attached	payor		See attached	rched				
POT LIFE (unaccelerated)	See attached	payor		See attached	rched				
INDUCTION TIME	See attached	rched		See attached	ched				
DRYING TIME MINIMUM TO RECOAT	See attached	rched		See attached	ched				
RECOMMENDED FILM THICKNESS, DRY	See attached	payor		See attached	peyor				
MIXING RATIOS	₹			See attached	ched				
THINNING, Maximum	MEK Ap	MEK Approx. 15%		See attached	ched				
APPLICATION									. 1911
DATE	2/13/62			5/14/95					
RH	26%			52%					
Temperature	72∘F			75°					
SUBSTRATE CONDITION	SSPC-SP10	10		E303d E	E303d Epoxy Zinc Rich	Rich			
COATING BATCH NUMBERS	Base: 1766	Base: 17682/Cure: 17681/Zn Dust: 3/95	/Zn Dust: 3/95	Not Legible	ple				
THINNING	MEK Ap	MEK Approx. 15%		None					
EQUIPMENT	DEVILBISS MBC	S MBC		Density MBC	MBC				
DRY FILM THICKNESS, MILS	SALT	FRESH	U.V.	SALT	FRESH	U.V.	SALT	FRESH U.	U.V.
SAMPLE NO. 10-1	1.9	9.1	1.5	7.0	7.8	5.5			
SAMPLE NO. 10-2	2.1	1.3	2.0	5.9	4.8	7.0			
SAMPLE NO. 10-3	1.8	1.3	2.1	7.0	9'9	1.7			
SAMPLE NO. 10-4	1.8	1.3	1.8	7.0	5.5	6.3			
SAMPLE NO. 10-5	2.0	1.3	1.5	7.5	4.7	6.5			
SAMPLE NO. 10-6	1.7	1.6	1.9	8.0	6.1	6.1			
SAMPLE TOTALS				SALT	FRESH	U.V.			
SAMPLE 10-1 TOTAL (COATS 1 & 2)				8.9	9.4	7.0			
SAMPLE 10-2 TOTAL (COATS 1 & 2)				8.0	6.1	9.0			8-10 8-10
SAMPLE 10-3 TOTAL (COATS 1 & 2)				8.8	7.9	9.2			
SAMPLE 10-4 TOTAL (COATS 1 & 2)				8.8	6.8	8.			
SAMPLE 10-5 TOTAL (COATS 1 & 2)				9.5	6.0	8.0			
SAMPLE 10-6 IOIAL (COAIS I & 2)				7./	/:/	8.0			

Table B1. Continued.

PANEL EVALUATION - U.V./PROHESIO	JATION - U.V	1./PROHESIC		AY CORPS C	N (U.S. ARMY CORPS OF ENGINEERS							
ASTM D714 DEGREE OF BLISTERING	EGREE OF BI	LISTERING										
						<b>EXPOSURE 1</b>	EXPOSURE TIME (HOURS)	()				
SAMPLE	1	168	Ŕ	336	9	672	15	1344	2	2016	26	2688
NO.	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size
10-1	0	0	1	9	Σ	4	MD	4	MD	4	Ω	2
10-2	0	0	ш	9	Σ	4	MD	4	MD	4	QW	2
10-3	F	4	Σ	4	MD	2	Δ	2	۵	2	۵	2
10-4	0	0	4	4	Σ	2	MD	2	MD	2	٥	2
10-5	. 0	0	0	0	F	9	MD	4	MD	4	О	4
9-01	0	0	0	0	0	0	Σ	9	Σ	9	۵	2
ASTM D610 DEGREE OF RUSTING	EGREE OF R	USTING										
						<b>EXPOSURE 1</b>	EXPOSURE TIME (HOURS)	0				
SAMPLE	)Į	168		336	9	672	31	1344	20	2016	7	2688
NO.	% Rusted	% Rusted Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade	Ľ	% Rusted Rust Grade	<u> </u>	% Rusted Rust Grade
10-1	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	01
10-2	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	10	<0.01%	01
10-3	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
10-4	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	10	<0.01%	01
10-5	<0.01%	01	<0.01%	10	<0.01%	01	<0.01%	10	<0.01%	10	<0.01%	. 10
10-6	<0.01%	10		10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
<b>ASTM D1654</b>	- EVALUATION OF COAT	ON OF COA		ENS SUBJEC	ED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	ROSIVE ENV	RONMENTS					
					UNSCRIBI	UNSCRIBED AREA - EXPOSURE TIME (HOURS)	(POSURE TIN	IE (HOURS)				
SAMPLE	ř	168	8	336	9	72	13	1344	20	2016	26	2688
Ö.	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating
10-1	0	10	0	10	0	10	0	01	0	10	0	10
10-2	0	10	0	10	0	10	0	10	0	10	0	10
10-3	0	0	0	10	0	10	0	10	0	10	0	10
104	0	2	0	10	0	10	0	10	0	10	0	10
10-5	0	10	0	10	0	10	0	10	0	10	0	10
10-6	0	10	0	10	0	10	0	10	0	10	0	10
	MEA	MEAN CREEPAG	GE FROM SCRIBE	SRIBE	COMMENTS	Š						
SAMPLE	EXF	<b>EXPOSURE TIME</b>	IE - 2688 HOURS	URS	All blistering	s is along sc	ribe edges.	All blistering is along scribe edges. No blistering is seen in unscribed areas as of 672 hours.	g is seen in	unscribed a	reas as of 67	2 hours.
NO.	ш	mm	Ra	Rating	Some yello	Some yellowing is noted at 672 hours.	d at 672 ho	Jrs.				
10-1	-/_	7-10		3	Blisters at 1	344 hours ar	e confined	Blisters at 1344 hours are confined to scribe edges.	ges.			
10-2	7-	7-10		3								
10-3	10	10-13		2								
10-4	13	13-16										
10-5	7-	7-10		3								
9-01	9	2-7		4								

Table B1. Continued.

ASTM D714 DEGREE OF BLISTERING SAMPLE NO. Frequency 10-1 0	OPET OF BLIEFFBING		A CTA D714 DECDEE OF BISTDING			
SAMPLE NO.		•				
SAMPLE NO.			EXPOSURE	EXPOSURE TIME (DAYS)		
NO.		7	9	09		120
10-1	Frequency	Size	Frequency	Size	Frequency	Size
	0	0	0	0	0	0
10-2	0	0	0	0	0	0
10-3	0	0	0	0	0	0
10-4	0	0	0	0	0	0
10-5	0	0	0	0	0	0
9-01	0	0	0	0	0	0
ASTM D610 DE	ASTM D610 DEGREE OF RUSTING					1
	-		EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE		7	9			120
Ö.	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
10-1	<0.01%	01	<0.01%	10	<0.01%	10
10-2	<0.01%	01	<0.01%	10	<0.01%	01
10-3	<0.01%	10	<0.01%	10	<0.01%	10
10-4	<0.01%	01	<0.01%	10	<0.01%	01
10-5	<0.01%	01	<0.01%	10	<0.01%	10.
10-6	<0.01%	10	<0.01%	10	<0.01%	10
ASTM D1654 - I	EVALUATION OF CO	<b>DATED SPECIMENS SI</b>	- EVALUATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	SIVE ENVIRONMENTS		
		ח	UNSCRIBED AREAS - EXPOSURE TIME (DAYS)	XPOSURE TIME (DAYS		
SAMPLE		7		90	1	120
NO.	% Failed	Rating	% Failed	Rating	% Failed	Rating
10-1	0	01	0	10	0	10
10-2	0	01	0	10	0	01
10-3	0	01	0	10	0	01
10-4	0	01	0	10	0	10
10-5	0	01	0	10	0	10
9-01	0	10	0	01	0	10
	MEAN CREEPAGE	SE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIME	AE - 120 DAYS				
NO.	mm	Rating	·			
10-1	0	01				
10-2	0	01				
10-3	0	01				
10-4	0	01				
10-5	0	01				
9-01	0	10				

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	ASTM DZ14 DECEC OF BLISTEDING					
<b>VSTM D/ 14 D</b>	EGREE OF BLISTERING					
			EXPOSURE 1	EXPOSURE TIME (DAYS)		
SAMPLE	7		9	90		120
NO.	Frequency	Size	Frequency	Size	Frequency	Size
10-1	0	0	0	0	0	0
10-2	0	0	0	0	0	0
10-3	0	0	0	0	0	0
10-4	0	0	0	0	0	0
10-5	0	0	0	0	0	0
10-6	0	0	0	0	0	0
STM D610 D	ASTM D610 DEGREE OF RUSTING					
			EXPOSURE 1	EXPOSURE TIME (DAYS)		
SAMPLE			9	09		120
Ö	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
10-1	<0.01%	10	<0.01%	01	<0.01%	01
10-2	<0.01%	10	<0.01%	10	<0.01%	10
10-3	<0.01%	10	<0.01%	10	<0.01%	10
10-4	<0.01%	01	<0.01%	01	<0.01%	01
10-5	<0.01%	01	<0.03%	6	%E0'0>	6
10-6	<0.01%	10	<0.03%	6	<0.03%	6
STM D1654	ASTM D1654 - EVALUATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	<b>DATED SPECIMENS</b>	SUBJECTED TO CORI	ROSIVE ENVIRONME		
		In	UNSCRIBED AREAS - EXPOSURE TIME (DAYS)	XPOSURE TIME (DAY	(S)	
SAMPLE	7		9	60		120
NO.	% Failed	Rating	% Failed	Rating	% Failed	Rating
10-1	0	01	0-1	6	0-1	6
10-2	0	10	0-1	6	1-0	6
10-3	0	10	0-1	6	1-0	6
10-4	0	10	0-1	6	0-1	6
10-5	0	10	1-0	6	0-1	6
10-6	0	10	0-1	6	0-1	6
	MEAN CREEPAGE FROM SCRIBE	E FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIME - 120 DAYS	E - 120 DAYS				
NO.	mm	Rating				
10-1	0-0.5	ó				
10-2	0-0.5	6				
10-3	0-0.5	6				
10-4	0-0.5	6				
10-5	0-0.5	6		,		

Table B2. Test data for Americoat epoxy system.

COATING EVETEM DATA		ISTCOAL	JAI		2ND COAT			3RD COAT	
COAIING STSIEM DAIA	V	Amoroat ABHS Jing		Amercoo	Amercoat 385 Multi-Purpose	-Purpose	Amercoa	Amercoat 385 Multi-Purpose	urpos
COALING I.D.	Rich Epoxy Primer	v Primer		Epoxy			Epoxy		
MANIEACTURER	Ameron			Ameron			Ameron		
	70% +/- 3%	عج ا		%8 +/- 3%	%		96% +/- 3%	*	
VOLUME & SOLIDS	2.4 lbs/aal	_		2.3 lbs/gal			2.3 lbs/gal		
VOC (GIIIIIII MOC)	16 hours @ 70°F	Ø 70°F		3 hours @ 70° F	70° F		3 hours @ 70° F	70° F	
NOTO TIME	None			None			None		
DOVING TIME MINIMI IM TO RECOAT	2 hours @ 70 ° F	70 ° F		8 hours @ 70°F	70°F		8 hours @ 70°F	70°F	
RECOMMENDED FILM THICKNESS, DRY	3 mils			4-6 mils			4-6 mils		
MIXING RATIOS	Mix Kit Only	٨		Mix Kit Only	Ąl		Mix Kit Only	Ąį	
THINNING, Maximum	0.5 pint/c	0.5 pint/gal w/Amercoat 65	coat 65	6% per g	w/Amer	coat 101	6% per go	6% per gal w/Amercoat 101 6% per gal w/Amercoat 101	ld d
APPLICATION									
DATE	4/25/95			4/26/95			4/27/95		
15.7 F3	46%			20%			%69		
TEMPERATURE	73°F			75°F			80∘F		
SI BETDATE CONDITION	SSPC SP5			SH89			Amercoat 385	at 385	
COATING BATCH NUMBERS	Base: L502	259/Powder: (	Base: L502259/Powder: G503102/Cure; L411266 Base: N407053/Cure: L502314	6 Base: N407	053/Cure: L5	02314	Bose: BT-NA	Base: BT-N402127/Cure: L502314	502314
HINNING	1/2 pint			None			None		
EQUIPMENT	Devilbiss MBC	MBC		Devilbiss MBC	MBC		Devilbiss MBC	MBC	
DRV FILM THICKNESS. MILS	SALT	FRESH	U.V.	SALT	FRESH	'n.	SALT	FRESH	≥
SAMPLE NO. 1-1	5.6	6.5	4.4	4.1	4.7	4.6	3.6	5.4	4.6
SAMPLE NO 1-2	4.6	4.0	4.2	4.9	4.0	5.4	4.1	5.2	5.4
SAMPLE NO. 1-3	5.1	4.6	3.6	3.9	3.7	4.7	9.0	4.2	4.9
SAMPLE NO. 1-4	5.0	5.7	4.1	2.7	4.3	4.4	6.3	4.6	4.9
SAMPLE NO. 1-5	4.1	6.1	3.9	4.9	2.9	3.1	4.0	5.7	4.9
SAMPLE NO. 1-6	4.7	5.6	3.9	3.7	4.4	3.1	5.2	4.5	2.5
SAMPLE TOTALS				SALT	FRESH	). ).			
SAMPLE 1-1 TOTAL (COATS 1.2 & 3)	_			13.3	16.6	13.6			
SAMPLE 1-2 TOTAL (COATS 1 2 & 3)				13.6	13.2	15.0	_		
SAMPLE 1-3 TOTAL (COATS 1 2 & 3)				15.0	12.5	13.2			
SAMPLE 1-3 LOTAL (COATS 1, 2 & 3)	_			14.0	14.6	13.4			
SAMPLE 1-5 TOTAL (COATS 1, 2 & 3)	<del></del>			13.0	14.7	11.9			
	•								

Table B2. Continued.

PANEL EVAL	UATION - U.	V./PROHESIC	PANEL EVALUATION - U.V./PROHESION (AMERON)	_								
ASTM D714	ASTM D714 DEGREE OF BLISTERING	LISTERING		]								
					1	EXPOSURE TIME (HOURS)	IE (HOURS)					
SAMPLE	1	168	336	92	2/9	2	13	1344	20	2016	3688	88
Ñ.	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size
1-1	0	0	0	0	0	0	0	0	0	0	0	0
1-2	0	0	0	0	0	0	0	0	0	0	0	0
1-3	0	0	0	0	0	0	0	. 0	0	0	0	0
1-4	0	0	0	0	0	0	0	0	0	0	0	0
1-5	0	0	0	0	0	0	0	0	0	0	0	0
1-6	0	0	0	0	0	0	0	0	0	0	0	0
ASTM D610	ASTM D610 DEGREE OF RUSTING	RUSTING										
					3	EXPOSURE TIME (HOURS)	(E (HOURS)					
SAMPLE	_	168	38	336	672	2	13	1344	37	2016	2688	82
NO.	% Rusted	Rust Grade		% Rusted Rust Grade	% Rusted	Rust Grade		· % Rusted   Rust Grade	L	% Rusted Rust Grade	% Rusted Rust Grade	Rust Grade
1-1	<0.1%	01	<0.1%	01	<0.1%	10	<0.01%	٥l	<0.01%	01	<0.01%	10
1-2	<0.1%	10	<0.1%	10	<0.1%	10	<0.01%	10	<0.01%	01	<0.01%	10
1-3	<0.1%	10	<0.1%	10	<0.1%	10	<0.01%	10	<0.01%	10	<0.01%	2
1-4	<0.1%	10	<0.1%	01	<0.1%	10	<0.01%	10	<0.01%	01	<0.01%	0
1-5	<0.1%	10	<0.1%	10	<0.1%	10	<0.01%	10	<0.01%	10	<0.01%	10
<u>1</u> -6	<0.1%	욘	<0.1%	10	<0.1%	10	<0.01%	10	<0.01%	10	<0.01%	10
<b>ASTM D165</b> 4	1 - EVALUATI	ON OF COA	TED SPECIME	NS SUBJECTE	ASTM D1654 - EVALUATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	IVE ENVIROR	IMENTS					
					UNSCRIBE	UNSCRIBED AREA - EXPOSURE TIME (HOURS)	OSURE TIME (	HOURS)				
SAMPLE		168	ж Э	336	672		13	1344	20	2016	2688	æ
Ö.	% Failed	Rafing	% Failed	Rating	% Falled	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating
7	0	10	0	01	0	10	0	0	0	9	0	10
1-2	0	01	0	10	0	10	0	01	0	9	0	10
1-3	0	10	0	10	0	10	0	02	0	10	٩-1	٥
1-4	0	01	0	10	0	10	0	10	0	9	0	0
1-5	0	2	0	10	0	10	0	10	0	10	0	10
1-6	0	10	0	10	0	9	0	10	0	0	0	10
	M	AN CREEPA	MEAN CREEPAGE FROM SCRIBE	RIBE	COMMENTS:							
SAMPLE	ш	XPOSURE TIN	EXPOSURE TIME - 2688 HOURS	IRS								
Ö.		mm	Rai	Rating								
1-1		0		10								
1-2		0		10								
1-3		0		10								
1-4		0		10	٠							
1-5		0.5	_	٥								
1-6		0		10								

Table B2. Continued.

	ASIM D. 14 DEGREE OF BLISTERING		JGI ISOGKJ	EXPOSIDE TIME (DAVS)		
SAMPLE		7	9	60	31	120
Š.	Frequency	Size	Frequency	Size	Frequency	Size
1-1	0	0	0	0	. 0	0
1-2	0	0	0	0	0	0
1-3	0	0	0	0	0	0
1-4	0	0	0	0	0	0
1-5	0	0	0	0	0	0
1-6	0	0	0	0	0	0
STM D610 D	ASTM D610 DEGREE OF RUSTING					
			EXPOSURE	EXPOSURE TIME (DAYS)		
SAMPLE		7	9	09	120	0
Š	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
-	<0.01%	01	<0.01%	10	<0.01%	10
1-2	<0.01%	OL	<0.01%	10	<0.01%	10
1-3	<0.01%	01	<0.01%	10	<0.01%	10
1-4	<0.01%	01	<0.01%	10	<0.01%	10
1-5	<0.01%	10	<0.01%	10	<0.01%	10
1-6	<0.01%	10	<0.01%	10	<0.01%	10
STM D1654	- EVALUATION OF CC	DATED SPECIMENS S	ASTM D1654 - EVALUATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	SIVE ENVIRONMENTS		
			UNSCRIBED AREAS - EXPOSURE TIME (DAYS)	XPOSURE TIME (DAYS)		
SAMPLE		7	9	90	120	Q
Ö.	% Failed	Rating	% Failed	Rating	% Failed	Rating
1-1	0	Ol	0	10	0	10
1-2	0	30	0	10	0	10
1-3	0	10	0	10	0	10
1-4	0	01	0	10	0	01
1-5	0	OL	0	10	0	01
1-6	0	10	0	10	0	10
	MEAN CREEPAG	MEAN CREEPAGE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIN	EXPOSURE TIME - 120 DAYS				
ġ	шш	Rating				
1-1	0	10				
1-2	0	10				
1-3	0	10				
1-4	0	10				
1-5	0	2				

Table B2. Continued.

01110	CHIGHTS BUSINESS OF BUSINESS AND A STATE OF THE PRINCESS AND THE PRINCESS	ď				
31M U/14 U	EGKEE OF PRINERILY					
			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE	7	,	09	0	2	120
ġ	Frequency	Size	Frequency	Size	Frequency	Size
1-1	0	0	0	0	0	0
1-2	0	0	0	0	0	0
1-3	0	0	0	0	0	0
1-4	0	0	0	0	0	0
1-5	0	0	0	0	0	0
9-1	0	0	0	0	0	0
STM D610 D	ASTM D610 DEGREE OF RUSTING					
			EXPOSURE TIME (DAYS)	IIME (DAYS)		
SAMPLE		7	7	99		120
Ö	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
1-1	<0.01%	01	<0.01%	01	<0.01%	10
1-2	<0.01%	01	<0.01%	10	<0.01%	10
1-3	<0.01%	10	<0.01%	10	<0.01%	10
1-4	<0.01%	10	<0.01%	10	<0.01%	10
1-5	<0.01%	10	<0.01%	10	<0.01%	01
9-	<0.01%	01	<0.01%	10	<0.01%	10
STM D1654	- EVALUATION OF C	OATED SPECIMENS	ASTM D1654 - EVALUATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	OSIVE ENVIRONMEN	VTS	
		n	UNSCRIBED AREAS - EXPOSURE TIME (DAYS)	XPOSURE TIME (DAY	S	
SAMPLE		7	9	09		120
Ö.	% Failed	Rating	% Failed	Rating	% Failed	Rating
1-1	0	10	0	10	0	10
1-2	0	10	0	10	0	10
1-3	0	10	0	10	0	10
1-4	0	10	0	10	0	10
1-5	0	10	0	10	0	10
1-6	0	10	0	10	0	10
	MEAN CREEPA(	MEAN CREEPAGE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TII	EXPOSURE TIME - 120 DAYS				
Ö.	шш	Rating				
1-1	0	01				
1-2	0	10				
1-3	0	10				
1-4	0	10				
1-5	0	10				
7 1	c	5				

system.	
arboline epoxy	
est data for C	
Table B3. To	

TEST COATING SPECS (CARBOLINE)								
COATING SYSTEM DATA		IST COAT		2	2ND COAT		3RD COAT	)AT
COATING LD	Carboline 858	e 858		Carboline 890	e 890			
	Primer			High Build Epoxy	d Epoxy			
MANUFACTURER	Carboline	Ф		Carboline	Ф			
VOLUME % SOLIDS	64% +/- 2%	%		75% +/- 2%	%			
VOC (unthinned)	2.52 lbs/gal	Jal		1.78 lbs/gal	Jal			
POT LIFE (unaccelerated)	4 hours @ 72° F	§ 72° F		3 hours @ 75°	) 75° F			
INDUCTION TIME	None Stated	nted		None Stated	rted			
DRYING TIME MINIMUM TO RECOAT	3 hours @ 75° F	) 75° F		8 hours @ 75° F	9 75° F	ļ		
RECOMMENDED FILM THICKNESS, DRY	3 mils	į		7 mils				
MIXING RATIOS	Mix kit only	γlγ		1 part bo	I part base to I part converter	art conv	erter	
THINNING, Maximum	#2			#2				
				- Đ	À			
APPLICATION								
DATE	5/1/95			5/2/95			į	
NH.	26%			%99				
TEMPERATURE	72° F			72° F			}	
SUBSTRATE CONDITION	SSPC SP10	0		Primed				
COATING BATCH NUMBERS	Not Legible	•		Base: 5B7999L	79991			
THINNING	None			#2				
EQUIPMENT	<b>Devilbiss MBC</b>	MBC		Devilbiss MBC	MBC			
DDV EILM THICKNESS MIIS	SALT	FRESH	U.V.	SALT	FRESH	U.V.	SALT   FRESH	н   и.v.
SAMPLE NO 6-1	4.4	5.6	5.2	5.6	9.9	4.4		
SAMPI F NO. 6-2	5.2	0.9	5.0	5.1	5.6	5.0		
SAMPLE NO. 6-3	0.9	2.0	5.0	7.0	4.0	3,6		
SAMPLE NO. 6-4	5.8	0'9	5.0	6.2	7.3	7.0		
SAMPLE NO. 6-5	5.2	4.3	4.0	8.4	8.7	5,3		
SAMPLE NO. 6-6	2.3	4.6	5.0	9.7	5.4	4,6		
SAMPLE TOTALS				SALT	FRESH	U.V.		
SAMPLE 6-1 TOTAL (COATS 1 & 2)				10.0	11.6	9.6		
SAMPLE 6-2 TOTAL (COATS 1 & 2)				10.3	11.6	10.0		
SAMPLE 6-3 TOTAL (COATS 1 & 2)				13.0	9.0	8.6		
SAMPLE 6-4 TOTAL (COATS 1 & 2)				12.0	13.3	12.U		
SAMPLE 6-5 TOTAL (COATS 1 & 2)				0 2	13.0	5.7		
SAMPLE 6-6 TOTAL (COATS   & 2)				200	0.00	2,7		

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PANEL EVALUATION - U.V./PROHESION (CARB	JATION - U.	/./PROHESIC	N (CARBOLI	OLINE)					÷.			
ASTM D714 DEGREE OF BLISTERING	SEGREE OF B	LISTERING			 1							
					Ш	XPOSURE TIM	ME (HOURS)					
SAMPLE		168		336	9	672		1344	50	2016	2688	
Ö	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size
6-1	0	0		0	0	0	0	0	0	0	0	0
6-2	0	0	0	0	0	0	0	0	0	0	0	0
6-3	0	0	0	0	0	0	0	0	0	0	0	0
6-4	0	0	0	0	0	0	0	0	0	0	0	0
6-5	0	0	0	0	0	0	0 .	0	0	0	0	0
9-9	0	0	0	0	0	0	0	0	0	0	0	0
ASTM D610 DEGREE OF RUSTING	DEGREE OF R	USTING										
					Ш	EXPOSURE TIME (HOURS)	ME (HOURS)					
SAMPLE		168		336	9	672	EL.	1344	20	2016	2688	88
Ŋ.	% Rusted	% Rusted Rust Grade	٠٠	Rust Grade	% Rusted	% Rusted Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
6-1	<0.01%	01	<0.01%	01	<0.01%	10	<0.01%	01	<0.01%	01	.<0.01%	10
6-2	<0.01%	01	<0.01%	10	<0.01%	10	%L0'0>	01	<0.01%	01	<0.01%	01
6-3	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	10	<0.01%	10
6-4	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	01	<0.01%	10	<0.01%	10
9-9	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	10	<0.01%	10	<0.01%	10
9-9	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	10	<0.01%	10	<0.01%	10
<b>ASTM D1654</b>	•	ON OF COA	TED SPECIME	<b>EVALUATION OF COATED SPECIMENS SUBJECTED</b>	D TO CORR	TO CORROSIVE ENVIRONMENTS	SONMENTS		8			
			3		UNSCRIBED	UNSCRIBED AREA - EXPOSURE TIME (HOURS	OSURE TIM	E (HOURS)				
SAMPLE		168		336	9	672	13	1344	20	2016	2688	88
NO.	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating
6-1	0	임	0	01	0	01	0	01	0	01	0	01
6-2	0	01	0	01	0	01	0	10	0	10	0	10
6-3	0	01	0	01	0	01	0	10	0	10	0	10
6-4	0	10	0	10	0	01	0	10	0	10	0	10
9-9	0	10	0	01	0	01	0	10	0	10	0	10
9-9		10	0		0	10	0	01	0	10	0	10
	M	MEAN CREEPAGE FROM	<b>IGE FROM S</b>	M SCRIBE	COMMENTS	5:						
SAMPLE	ш	EXPOSURE TIME - 2688		HOURS								
Ö	۲	mm	) 	Rating								
P-1		2		8						:		
6-2	)	0.5		6								
6-3	0	0-0.5		6								
6-4		. 0		10					٠			
9-9		1-2		7								
9-9	0	-0.5		6						,		

Table B3. Continued.

PANEL EVALUATION - FI	JATION - FRESH WATE	RESH WATER IMMERSION (CARBOLINE)	BOLINE)			
ASTM D714 DEGREE OF	EGREE OF BLISTERING					
			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE			09	0	15	120
Š.	Frequency	Size	Frequency	Size	Frequency	Size
6-1	0	0	0	0	0	0
6-2	0	0	0	0	0	0
6-3	0	0	0	0	0	0
6-4	0	0	0	0	0	0
6-5	0	0	0	0	0	0
9-9	0	0	0	0	0	0
ASTM D610 DEGREE OF	DEGREE OF RUSTING					
			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE			09	C	21	120
Ö.	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
6-1	<0.01%	10	<0.01%	10		10
6-2	<0.01%	10	<0.01%	10		10
6-3	<0.01%	10	<0.01%	10	<0.01%	01
6-4	<0.01%	10	<0.01%	10		10
6-5	<0.01%	10	<0.01%	10		10
9-9	<0.01%	01	<0.01%	10		10
ASTM D1654 - EVALUAT	- EVALUATION OF CO	<b>DATED SPECIMENS 5</b>	LUATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	SIVE ENVIRONMENT	S	
			UNSCRIBED AREAS - E	- Exposure time (days)		
SAMPLE			9	0		120
ON	% Failed	Rating	% Failed	Rating	% Failed	Rating
6-1	0	10	0	10	0	10
6-2	0	10	0	10	0	10
6-3	0	10	0	10	0	10
6-4	0	10	0	10	0	10
9-9	0	10	0	10	0	10
9-9	0	10	0	10	0	10
	MEAN CREEPAG	CREEPAGE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIME - 120 DAYS	120 DAYS				
Ñ.	mm	Rating				
6-1	0	10				
6-2	0	10				
6-3	0	10				
6-4	0	10				
9-9	0	10				
9-9	0	10				

Table B3. Continued.

ASTM D714 DEGDEE O	ECDEE OF RISTERING	<u>ن</u>				
2 IX 12 11 12	EGALL OF CHAILMING					
			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE	7		09		-	120
ON	Frequency	Size	Frequency	Size	Frequency	Size
6-1	0	0	0	0	0	0
6-2	0		0	0	0	0
6-3	0	0	0	0	0	0
6-4	0		0	0	0	0
6-5	0		0	0	0	0
9-9	0		0	0	0	0
ASTM D610 DEGREE	EGREE OF RUSTING					
			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE		7		90		120
Ö.	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
6-1	<0.01%	10	%10 <sup>'</sup> 0>	01	<0.01%	10
6-2	<0.01%	01	<0.01%	01	<0.01%	10
6-3	<0.01%	10	<0.01%	01	<0.01%	10
6-4	<0.01%	10	<0.01%	10	<0.01%	01
6-5	<0.01%	01	<0.01%	10	<0.01%	10
l	%10'	10	<0.01%	10	<0.01%	10
654	- EVALUATION	OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	SUBJECTED TO COR	ROSIVE ENVIRONM	l	
		jo	UNSCRIBED AREAS - EXPOSURE TIME (DAYS)	XPOSURE TIME (DA)		
SAMPLE		7	9	09		120
NO.	% Failed	Rating	% Failed	Rating	% Failed	Rating
6-1	0	10	0	10	0	10
6-2	0	10	0	10	0	10
6-3	0	01	0	10	0	10
6-4	0	01	0	10	0	10
6-5	0	01	0	10	0	0
9-9	0	10	0	10	0	10
	MEAN CREEPA	GE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TII	EXPOSURE TIME - 120 DAYS				
ON	mm	Rating				
6-1	0	01				
6-2	0	10				
6-3	0	10				
6-4	0	10				
9-9	0	10				
, ,		CI				

Table B4. Test data for Gavlon epoxy system.

A Property Comments of the Party of the Part		TACOAT	-		2ND COAT	Aī		3RD COAT	
COATING SYSTEM DATA		200			2000	ž		OND OND	
COATING I.D.	Zinc Rich	Zinc Rich Epoxy Primer	er	Epoxy Poly	'amide Prir	Epoxy Polyamide Primer/Topcoat	Epoxy Poly	Epoxy Polyamide Primer/Topcoat	r/Topcoat
	Gaylon 9	Gavlon 9198-6129 Primer	rimer	Gavlon 9	Gavion 9888-0008LF	ш	Gaylon 9	Gavlon 9888-0008LF	
MANUFACTURER	Gavlon In	Gavion Industries, Inc.	ij	Gavlon tr	Gavlon Industries, Inc.	<u>ن</u>	Gavlon Ir	Gavlon Industries, Inc.	
VOLUME % SOLIDS	60.50%			81%			81%		
VOC (unthinned)	2.7 lbs/gal			1.40 lbs/gal	ā		1.40 lbs/gal	٥	ļ
POT LIFE (unaccelerated)	4-6 hours @ 77° F	@ 77° F		4 hours @ 77° F	77° F		4 hours @ 77° F	77° F	
INDUCTION TIME	20 minute	20 minutes @ > or = to 70°F	to 70°F	30 minutes @ 77°	ss @ 77° F		30 minute	30 minutes @ 77° F	
DOVING TIME MINIMUM TO RECOAT	45 minutes @ 77° F	s @ 77° F		4 hours -	4 hours - 7 days @ 77° F	77° F	4 hours -	4 hours - 7 days @ 77° F	L.
RECOMMENDED FILM THICKNESS, DRY	5 mils			5 mils			4 mils		
MIXING RATIOS	1 part ba	se to 1 par	I part base to I part converter	4 parts B	to 1 part /	4 parts B to 1 part A by volume	4 parts B	4 parts B to 1 part A by volume	oy volume
THINNING, Maximum	Gaylon 5130	130		Gavlon 5130	130		Gavlon 5130	130	į
APPLICATION									
DATE	4/29/95			5/1/95			5/2/95		
	26%			26%			29%		
TEMPERATURE	73∘F			72° F			72°F		ļ
SUBSTRATE CONDITION	SSPC SP5			Primed			Primed		
COATING BATCH NUMBERS	Base: 2-5-0	Base: 2-5-02-050/Cure; 2-5-01-020	-5-01-020	Base: 2-5-0	Base: 2-5-04-68/Cure 2-5-04-069	-5-04-069	Base: 2-5-0	Base: 2-5-04-68/Cure 2-5-04-069	24-069
DNINNING	Gavion 5130	130		Gavlon 5130	130		Gavlon 5130	130	
EQUIPMENT	Devilbiss MBC	MBC		Devilbiss MBC	MBC		Devilbiss MBC	MBC	
DRY FILM THICKNESS, MILS	SALT	FRESH	U.V.	SALT	FRESH	U.V.	SALT	FRESH	U.V.
SAMPLE NO. 5-1	5.0	9.9	5.6	4.5	2.7	3.0	9.0	7.2	3.8
SAMPLE NO. 5-2	3.0	5.3	4.6	4.3	1.7	4.0	5.2	7.7	4.6
SAMPLE NO. 5-3	5.2	3.0	5.6	2.1	2.7	4.7	9.0	6.9	3.7
SAMPLE NO. 5-4	4.6	5.6	5.0	4.9	2.4	4.0	5.6	0.9	3.6
SAMPLE NO. 5-5	9.0	6.2	5.6	3.0	4.8	3.4	5.5	3.5	3.6
SAMPLE NO. 5-6	6.0	7.0	5.3	4.0	3.0	3.2	4.5	3.6	3.8
SAMPLE TOTALS				SALT	FRESH	U.V.			
SAMPLE 5-1 TOTAL (COATS 1, 2 & 3)	<b>-</b>			15.5	16.5	12.4			
SAMPLE 5-2 TOTAL (COATS 1, 2 & 3)				12.5	14.7	13.2	Т		
SAMPLE 5-3 TOTAL (COATS 1.2 & 3)	•			13.3	12.6	14.0			
SAMPLE 5-4 TOTAL (COATS 1, 2 & 3)				15.1	14.0	12.7	<del>"</del> T		
SAMPLE 5-5 TOTAL (COATS 1, 2 & 3)				14.5	14.5	12.6	<del>- 1</del>		
				14.5	13.6	12.1			

Table B4. Continued.

PANEL EVALL	PANEL EVALUATION - U.V./PROHESION (GAVLON)	./PROHESION	V (GAVLON)									
ASTM D714 C	ASTM D714 DEGREE OF BLISTERING	ISTERING	-								:	
						EXPOSURE TIME (HOURS)	ME (HOURS)					
SAMPLE	٦	168	3	336	6	672	13	1344	20	2016	2688	38
NO.	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Эizө	Frequency	Size
5-1	0	0	0	0	0	0	0	0	0	0	0	0
5-2	0	0	0	0	0	0	0	0	0	0	0	0
5-3	0	0	0	0	0	0	0	0	0	0	0	0
5-4	0	0	0.	0	0	0	0	0	0	0	0	0
5-5	0	0	0	0	0	0	0	0	0	0	0	0
5-6	0	0	0	0	0	0	0	0	0	0	0	0
ASTM D610 C	ASTM D610 DEGREE OF RUSTING	USTING										
						EXPOSURE TIME (HOURS)	VIE (HOURS)					
SAMPLE		168	3	336	.9	672	13	1344	20	2016	2688	88
Ö.	% Rusted	Rust Grade		% Rusted Rust Grade	% Rusted	Rust Grade		% Rusted Rust Grade		% Rusted Rust Grade	% Rusted	Rust Grade
5-1	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	01	<0.01%	10
5-2	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	01	<0.01%	10
5-3	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
5-4	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
5-5	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
5-6	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
ASTM D1654	ASTM D1654 - EVALUATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	N OF COAT	ED SPECIME	NS SUBJECTE	D TO CORRC	SIVE ENVIRC	NMENTS					
		,			UNSCRIBE	UNSCRIBED AREA - EXPOSURE TIME (HOURS)	OSURE TIME	(HOURS)				
SAMPLE		168	3	336	.9	672	13	1344	20	2016	2688	88
Ö.	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Falled	Rating
5-1	0	10	0	10	0	10	0	10	0-1	6	0-1	6
5-2	0	10	0	0.	0	10	0	0	٦-	6	٥-	٥
5-3	0	0	.0	읻	0	2	0	10	1-0	٥	٦	6
5-4	0	01	0	10	0	10	0	ᄋ	0-1	6	<u>P</u>	6
5-5	0	10	0	10	0	0	0	9	٦-1	6	٦	6
5-6	0	10	0	10	0	10	0	10	0-1	٥	0-1	٥
	ME	MEAN CREEPAGE FROM SCRIBE	SE FROM SC	RIBE	COMMENTS:	ö						
SAMPLE	Ð	EXPOSURE TIME - 2688 HOURS	E - 2688 HOU	JRS								
Ö	u u	mm	Rc	Rating								
5-1	_	1-2		7								
5-2		1-2		7								
5-3	-	1-2		7								
5-4	.,,	3-5		5								
5-5		1-2		7								
9-9		1-2		7								

Table B4. Continued.

ASIM D/14 DEGREE OF BLISIERING	Towns or amount					
			EXPOSURE	EXPOSURE TIME (DAYS)		
SAMPLE		_	9	09		120
NO.	Frequency	Size	Frequency	Size	Frequency	Size
5-1	0	0	0	0	0	0
5-2	0	0	0	0	0	0
5-3	0	0	0	0	0	0
5-4	0	0	0	0	0	0
5-5	0	0	0	0	0	0
5-6	0	0	0	0	0	0
STM D610 D	ASTM D610 DEGREE OF RUSTING					
			EXPOSURE .	EXPOSURE TIME (DAYS)		
SAMPLE		4	9	99	-	120
Š	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
5-1	<0.01%	01	<0.01%	01	<0.01%	01
5-2	<0.01%	01	<0.01%	10	<0.01%	10
5-3	<0.01%	01	<0.01%	10	<0.01%	10
5-4	<0.01%	01	<0.01%	10	<0.01%	10
5-5	<0.01%	01	<0.01%	10	<0.01%	10
5-6	<0.01%	01	<0.01%	10	<0.01%	10
STM D1654	- EVALUATION OF CO	<b>NATED SPECIMENS S</b>	ASTM D1654 - EVALUATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	SIVE ENVIRONMENTS		
			UNSCRIBED AREAS - E	UNSCRIBED AREAS - EXPOSURE TIME (DAYS)		
SAMPLE	, ,	7	6	80		120
Ö	% Failed	Rafing	% Failed	Rating	% Failed	Rating
5-1	0	10	0	10	0	10
5-2	0	10	0	10	0	10
5-3	0	10	0	10	0	10
5-4	0	10	0	10	0	01
5-5	0	10	0	10	0	2
2-6	0	10	0	10	0	10
	MEAN CREEPAC	MEAN CREEPAGE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIN	EXPOSURE TIME - 120 DAYS				
Ö.	mm	Rating				
5-1	7	4				
5-2	7	4				
5-3	4	5				
5-4	7	7				
5-5	7	4				

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- 14 UZ	ASIM D714 DEGREE OF BLISTERING					
1			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE	7		09	0	120	ļ
ġ.	Frequency	Size	Frequency	Size	Frequency	Size
1-3	0	0	0	0	0	0
5-2	0	0	1	2	Σ	2
5-3	0	0	0	0	0	0
5-4	0	0	F	2	u.	2
5-5	0	0	0	0	0	0
95	0	0	0	0	0	0
TM D610 DE	ASTM DATO DEGREE OF RUSTING					
			EXPOSURE 1	EXPOSURE TIME (DAYS)		
SAMPLE	7		9	99	12	120
Ö	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
5-1	<0.01%	01	<0.01%	10	<0.01%	10
5-2	<0.01%	01	<0.01%	10	<0.01%	10
5.3	<0.01%	01	<0.01%	10	<0.01%	10
5.4	<0.01%	10	<0.01%	10	<0.01%	10
5-5	%IO'0>	10	%10:0>	10	<0.01%	10
5.6	<0.01%	10	<0.01%	10	<0.01%	10
STM D1654	- EVALUATION OF CO	DATED SPECIMENS	ASTM D1654 - EVALUATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	<b>POSIVE ENVIRONMEN</b>	NTS	
		_	UNSCRIBED AREAS - EXPOSURE TIME (DAYS)	XPOSURE TIME (DAY	(2)	
SAMPLE	7		Ÿ	09		120
Ö.	% Failed	Rating	% Failed	Rafing	% Failed	Rating
5-1	0	10	0	10	0	10
5-2	0	10	0	10	0	10
5-3	0	10	0	10	0	01
5-4	0	01	0	10	0	10
5-5	0	10	0	10	0	10
5-6	0	01	0	10	0	10
	MEAN CREEPAC	MEAN CREEPAGE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIN	EXPOSURE TIME - 120 DAYS	Viewed on 9/22/9£	5. Few #2 blisters in U	Viewed on 9/22/95. Few #2 blisters in unscribed areas on panels 2 & 4.	anels 2 & 4.
Ö.	mm	Rating				
5-1	12	2				
5-2	14	-				
5-3	14	1				
5-4	6	3				
5-5	11	2				
			-			

Table B5. Test data for Kolor-Poxy system.

TEST COATING SPECS (KEELER & LONG							
COATING EVETEM DATA	51	STCOAT	2	2ND COAT		3RD COAT	SOAT
	Kolor-Poxy 1-1		Kolor-Poxy 3500	/ 3500			
	Solid Zinc Rich	Solid Zinc Rich Primer No. 7600	S/P Surfac	S/P Surfacing Enamel	<u>0</u>		
MANUFACTURER	Keeler & Long	6	Keeler & Long	ong.			
VOLUME % SOLIDS	72% +/- 3%		65%				
VOC (unthinned)	2.17 lbs/gal		0.6 lbs/gal				
POT LIFE (unaccelerated)	8 hours @ 72°F		8 hours @ 72°F	72°F			
INDUCTION TIME	None stated		None				
DRYING TIME MINIMUM TO RECOAT	24 hours @ 72°F	Ьo	24-48 hours @	rs @ 72°F			
	2-4 mils		8-55 mils				
MIXING RATIOS	5:1		Kit 4:1				
THINNING, Maximum	No 3700		20%				
APPLICATION							
DATE	26/9/9		5/10/95				
RH	26%		26%				
TEMPERATURE	70° F		70°F				
SUBSTRATE CONDITION	White blast		Clean				
COATING BATCH NUMBERS	Base: 12/Cure:12		Base: 723	Base: 723/Cure: 723	3		
THINNING	None		20%	ŀ			
EQUIPMENT	Devilbiss MBC		Devilpiss MBC	MBC			
	ŀ	1	CALT	LDECU		CAIT FP	EDECH II V
DRY FILM THICKNESS, MILS	1		JAIL!	rkE3n		╫	╬
SAMPLE NO. 8-1	_		14.2		10.1		
SAMPLE NO. 8-2	-		11.3	6.6	0.6		
SAMPLE NO. 8-3	$\frac{1}{1}$	2.4 2.8	97.0	8,0	0.0		
SAMPLE NO. 8-4	+	1	12.2	0.0	0.0		
SAMPLE NO. 8-5	2.0	2.3 2.7	5.1.	8.9	8.8		
SAMPLE NO. 8-6	-	_	12.4	/:/	10.3		
SAMPLE TOTALS			SALT	FRESH	N.		
SAMPLE 8-1 TOTAL (COATS 1 & 2)			17.2	13.5	12.3		
SAMPLE 8-2 TOTAL (COATS 1 & 2)			14.5	12.5	12.0		
SAMPLE 8-3 TOTAL (COATS 1 & 2)			14.5	0.[	12.8		
SAMPLE 8-4 TOTAL (COATS 1 & 2)			14.9	10.8	12.0		
SAMPLE 8-5 TOTAL (COATS 1 & 2)			13.9	11.2	13.0		
SAMPLE 8-6 TOTAL (COATS 1 & 2)			0.61	12.0	0.50		

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PANEL EVALUATION - U.V./PROHESION (KEE	JATION - U.V	V./PROHESIK		LER & LONG)								
ASTM D714 DEGREE OF BLISTERING	EGREE OF B	LISTERING										
						EXPOSURE TIME (HOURS)	ME (HOURS)					
SAMPLE		168	3.	336	9	72	2	1344	20	2016	2688	88
Ö.	Freduency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size
8-1	0		0	0	Ц	4	Ш	4	ш	4	Μ	4
8-2	0	0	0	0	0	0	0	0	0	0	F	9
8-3	0	0	0	0	0	0	Ъ	9	Ŧ	4	M	2
8-4	0	0	0	0	0	0	Ŧ	8	F	8	M	4
8-5	0	0	0	0	F	4	F	4	Ŧ	4	MD	2
8-6	0	0	0	0	<u>Н</u>	4	Н.	4	ц	4	D	2
ASTM D610 DEGREE OF RUSTING	DEGREE OF R	PUSTING										
		1				EXPOSURE TIME (HOURS)	ME (HOURS)					
SAMPLE		168	က် 	336	9	672	1	1344	20	2016	26	2688
Ö.	% Rusted	% Rusted Rust Grade	e % Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
8-1	<0.01%	01	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
8-2	<0.01%	01	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
8-3	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
8-4	<0.01%	10	<0.01%	01	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
8-5	<0.01%	01	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
8-6	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	인	<0.01%	10
ASTM D1654 - EVALUATION OF COATED SPE	- EVALUATI	ON OF CO	<b>NTED SPECIMI</b>	<b>ENS SUBJECT</b>	CIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	<b>OSIVE ENVIR</b>	<b>RONMENTS</b>					
					UNSCRIBE	UNSCRIBED AREA - EXPOSURE TIME (HOURS)	POSURE TIMI	E (HOURS)				
SAMPLE		168	8	336	9	672	1.	1344	20	2016		2688
NO.	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating
8-1	0	10	0	10	0	10	0	10	0	10	0	10
8-2	0	10	0	10	0	10	0	01	0	10	0	10
8-3	0	10	0	10	0	10	0	인	0	10	0	10
8-4	0	10	0	10	0	10	0	10	0	10	0	10
8-5	0	10	0	10	0	2	0	10	0	10	0	10
9-8		10	0	10	0	10	0	10	0	10	0	10
	W	-AN CREEP	MEAN CREEPAGE FROM SCRIBE	SRIBE	COMMENTS	S:						
SAMPLE	<u>ш</u>	EXPOSURE TIME - 268	ME - 2688 HOURS	URS	Blistering or	panels 8UV	11, 8UV5 and	Blistering on panels 8UV1, 8UV5 and 8UV6 at 672 hours is along the scribe edges	2 hours is ak	ong the scril	sedpe ec	
O	<u></u>	mm	Ra	Rating	There are n	to blisters for	and in the ur	There are no blisters found in the unscribed areas.	as.	•		
8-1		2-2		4	Blisters at 1.	344 hours ar	e confined 1	Blisters at 1344 hours are confined to scribe edges.	*	ng is confine	Blistering is confined to scribe edges.	edges.
8-2		2-2		4	Coating al	Coating along scribe is beginning to lift	peginning	to liff.				
8-3	1	13-16		1	At 672 hou	rs, there is co	onsiderable	At 672 hours, there is considerable yellowing of all panels in this set	all panels ir	this set.		
8-4	1	13-16		2								
8-5	^	>16		0								
8-6		13-16										

Table B5. Continued.

ASTM D714 DEGREE OF	EGREE OF BLISTERING					
			EXPOSURE TIME (DAYS)	IIME (DAYS)		
SAMPLE			9	90		120
ON	Frequency	Size	Frequency	Size	Frequency	Size
8-1	0	0	Q	9	D	2
8-2	0	0	MD	9	D	2
8-3	0	0	Σ	7	D	2
8-4	0	0	Ω	9	О	2
8-5	0	0	MD	9	D	2
8-6	0	0	D	9	٥	2
ASTM D610 DEGREE OF	EGREE OF RUSTING					
			EXPOSURE	EXPOSURE TIME (DAYS)		
SAMPLE			9	09		120
ÖZ	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
8-1	0>	10	<0.01%	10	<0.01%	10
8-2	<0.01%	10	<0.01%	10	<0.01%	10
8-3		10	<0.01%	01	<0.01%	10
8-4		01	<0.01%	01	<0.01%	10
8-5		01	<0.01%	10	<0.01%	10
8-6	Ö	01	<0.01%	01	<0.01%	10
ASTM D1654 -	EVALUAT	ATED SPECIMENS S	ON OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	SIVE ENVIRONMENTS		
			UNSCRIBED AREAS - E	<ul> <li>EXPOSURE TIME (DAYS)</li> </ul>		
SAMPLE			9	09		120
Ö	% Failed	Rating	% Falled	Rating	% Failed	Rating
8-1	0	10	0	10	>75 (B)	0
8-2	0	10	0	10	>75	0
8-3	0	10	0	01	>75	0
8-4	0	01	0	10.	>75	0
8-5	0	10	0	01	>75	0
8-6	0	10	0	10	>75	0
	MEAN CREEPAGE FROM SCRIBE	SE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIME	//E - 120 DAYS	(B) Blisters on unscri	(B) Blisters on unscribed areas, but not broken (rusted) through; active carrosion	roken (rusted) throug	gh; active carrosior
Ö.	mm	Rating				
8-1	>16	0				
8-2	>16	0				
8-3	>16	0				
8-4	>16	0				
8-5	>16	0				
7 0		•				

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ASTM D714 DEGREE O	EGREE OF BLISTERING	<b>(</b> )				
			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE	7		09	0		120
Š	Frequency	Size	Frequency	Size	Frequency	Size
8-1	0	0	Σ	8	Q	4
8-2	0	0	MD	8	Ω	4
8-3	0	0	Σ	8	Q	4
8-4	0	0	MD	8	Q	4
8-5	0	0	Σ	9	Q	4
8-6	0	0	D	8	Ω	4
ASTM D610 DEGREE O	EGREE OF RUSTING					
			EXPOSURE 1	EXPOSURE TIME (DAYS)		
SAMPLE	7		9	09		120
NO.	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
8-1	<0.01%	10	<0.01%	01	<0.01%	01
8-2	<0.01%	10	<0.01%	01	<0.01%	10
8-3	<0.01%	10	<0.01%	10	<0.01%	10
8-4	<0.01%	10	<0.01%	10	<0.01%	10
8-5	<0.01%	10	<0.01%	01	<0.01%	01
8-6	<0.01%	10	<0.01%	10	<0.01%	10
ASTM D1654 - EVALU	- EVALUATION OF C	<b>OATED SPECIMENS</b>	ATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	OSIVE ENVIRONMEN	VTS	
			Unscribed areas - exposure time (days)	XPOSURE TIME (DAY		
SAMPLE			9	09		120
ON	% Failed	Rating	% Failed	Rating	% Failed	Rating
8-1	0	10	0	10	>75 (B)	10
8-2	0	01	0	10	>75	01
8-3	0	01	0	10	>75	00
8-4	0	01	0	10	>75	10
8-5	0	01	0	10	>75	10
9-8	0	10	0	10	>75	10
	MEAN CREEPAG	AN CREEPAGE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIN	EXPOSURE TIME - 120 DAYS	At 120 days, there	At 120 days, there are blisters over 100% of coating surface #4 dense;	% of coating surfac	e #4 dense;
Ö.	mm	Rating	active black corrosion under blisters.	sion under blisters.		
8-1	<16	0	(B) Blisters on unscri	(B) Blisters on unscribed areas, but not broken through; active corrosion	broken through; ac	ctive corrosion
8-2	91>	0				
8-3	<16	0				
8-4	<16	0				
8-5	<16	0				
8-6	<16	0				

Table B6. Test data for Poly-Carb epoxy system.

TEST COATING SPECS (POLY-CARB)				ļ. 					
	-								
COATING SYSTEM DATA		1ST COAT		2	2ND COAT			3RD COAT	
COATING I.D.	Zinc rich coating	coating		Polyamide Epoxy	le Epoxy		Polyamic	Polyamide Epoxy	
	Mark 59.3	3		Mark 83.3	3		Mark 83.3	3	
MANUFACTURER	Poly-Carb	0		Poly-Carb	٥		Poly-Carb	ام	
VOLUME % SOLIDS	55% +/- 2%	%		68-72%			68-72%	į	
VOC (unthinned)	Not Given	_		Not Given	_		Not Given	<u>ر</u>	
POT LIFE (unaccelerated)	6 hours @ 75° F	3 75° F		6 hours @ 70° F	§ 70° F		6 hours @ 70° F	Ø 70° F	
INDUCTION TIME	15-30 mir	5-30 minutes @75° F	ட	30 minut	30 minutes @ 75° F		30 minut	30 minutes @ 75° F	
DRYING TIME MINIMUM TO RECOAT	12-18 hou	2-18 hours @ 75° F		12-18 ho	12-18 hours @ 75°	ш	12-18 ho	12-18 hours @ 75 ° F	ш
RECOMMENDED FILM THICKNESS, DRY	5-6 mils			3-5 mils			3-5 mils		
MIXING RATIOS	₹			ΚïŦ			₹		
THINING. Maximum	None			None			None		
APPLICATION				70, 51, 5			7/10/05		
DATE	7/14/95			26//1//			06/01//		
RH	47%			21%			20%		
TEMPERATURE	72° F			73° F			73° F		
SUBSTRATE CONDITION	SSPC SP10	0		Primer		į	Epoxy		
COATING BATCH NUMBERS	Not Legible			Not Legible	ele		Not Legible	ple	
THINNING	None			None		į	None		
EQUIPMENT	<b>Devilbiss MBC</b>	MBC		Devilbiss MBC	MBC		Devilpiss MBC	MBC	
DDV FILM THICKNESS MILS	SALT	FRESH	U.V.	SALT	FRESH	U.V.	SALT	FRESH	U.V.
SAMPLE NO 13-1	6.5	6.5	5.6	1.9	2.4	4.0	3.6	3.6	4.2
SAMPLE NO. 13-2	5.6	9.0	5.0	3.0	3.6	4.4	3.6	3.5	4.1
SAMPLE NO. 13-3	6.7	5.1	5.7	1.6	5.7	3.9	3.5	3.7	0.9
SAMPLE NO. 13-4	6.8	5.5	2'9	1.4	4.1	4.4	3.5	4.2	5.0
SAMPLE NO. 13-5	6.5	2.8	5.0	2.4	4.0	3.2	3.2	4.2	4.0
SAMPLE NO. 13-6	9'9	5.4	4.2	2.1	4.4	3.3	3.5	4.3	6.5
10 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1									
SAMPLE TOTALS				SALT	FRESH	U.V.		las Pas Van Carl	
SAMPLE 13-1 TOTAL (COATS 1, 2 & 3)				12.0	12.5	13.8			
SAMPLE 13-2 TOTAL (COATS 1, 2 & 3)				12.2	13.1	13.5			
SAMPLE 13-3 TOTAL (COATS 1, 2 & 3)				11.8	14.5	10.5			
SAMPLE 13-4 TOTAL (COATS 1, 2 & 3)				12.7	2 2	19.0			
SAMPLE 13-5 IOIAL (COAIS 1, 2 & 3)				12.2	141	14.0	· ·		
SAIVIPLE 13-0 10 AL (COA13 1, 2 & c)									

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		The state of the s	The state of the last of the l									1
ASTM D714 [	ASTM D714 DEGREE OF BLISTERING	ISTERING										
					W	EXPOSURE TIME (HOURS)	<b>AE (HOURS)</b>					
SAMPLE	ľ	168	33	9%	672	5.	13	344	χ X	2016	2688	88
Ö.	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	/ Size	Frequency	Size
13-1	0	0	0	0	0	0	0	0	0		0	0
13-2	0	0	0	0	0	0	0	0	0	0	0	0
13-3	0	0	0	0	0	0	0	0	0	0	0	0
13-4	0	0	0	0	0	0	0	0	0	0	0	0
13-5	0	0	0	0	0	0	0	0	0	0	0	0
13-6	0	0	0	0	0	0	0	0	0	0	0	0
ASTM D610	ASTM D610 DEGREE OF RUSTING	JSTING										
					L L	EXPOSURE TIME (HOURS)	<b>ME (HOURS)</b>					
SAMPLE	ř	168	33	36	672	.2	13	1344	20	2016	2688	88
NO.	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
13-1	<0.01%	01	<0.01%	01	<0.01%	01	%10'0>	01	<0.01%	10	<0.01%	01
13-2	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
13-3	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	10	<0.01%	10	<0.01%	01
13-4	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	01	<0.01%	10	<0.01%	01
13-5	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	10	<0.01%	10
13-6	<0.01%	10	<0.01%		<0.01%	10	<0.01%	9	<0.01%	0	<0.01%	10
ASTM D1654	- EVALUATIC	- EVALUATION OF COATED SPECIMEN		AS SUBJECTED		TO CORROSIVE ENVIRONMENTS	NMENTS					
					UNSCRIBE	UNSCRIBED AREA - EXPOSURE TIME (HOURS)	OSURE IIME	(HOURS)				
SAMPLE	1'	168	35	336	672	72	13	1344		2016	2688	88
NO.	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating
13-1	0	10	0	10	0	10	0	10	0	10	0	욘
13-2	0	10	0	10	0	01	0	인	0	2	0	10
13-3	0	10	0	10	0	10	0	0	0	2	0	10
13-4	0	10	0	10	0	10	0	10	0	01	0	10
13-5	0	10	0	01	. 0	10	0	9	0	9	0	0
13-6	0	01	0	2	0	10	0	10	0	10	0	10
	ME	MEAN CREEPAGE FROM SCI	<b>SE FROM SCI</b>	RIBE	COMMENTS							
SAMPLE	Ä	POSURE TIMI	EXPOSURE TIME - 2688 HOURS	IRS								
Ö Ö	n	mm	Rat	Rating								
13-1		0		0								
13-2		0		0								
13-3	1	1-2	,	7								
13-4		-2		7								
13-5		0		0								
13.6		0		0								ļ

Table B6. Continued.

ASTM D714 DEGREE OF	DEGREE OF BLISTERING	<b>(</b> )				-
			EXPOSURE TIME (DAYS)	IIME (DAYS)		
SAMPLE			9	90		120
Ö.	Frequency	Size	Frequency	Size	Frequency	Size
13-1	0	0	0	0	0	0
13-2	0	0	0	0	0	0
13-3	0	0	0	0	0	0
13-4	0	0	0	0	0	0
13-5	0	0	0	0	0	0
13-6	0	0	0	0	0	0
ASTM D610 DEGREE OF	DEGREE OF RUSTING					
			EXPOSURE 1	EXPOSURE TIME (DAYS)		
SAMPLE			9	09		120
<u>S</u>	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
13-1	<0.01%	10	<0.01%	01	<0.01%	10
13-2	<0.01%	10	<0.01%	01	<0.01%	10
13-3	<0.01%	10	<0.01%	10	<0.01%	0
13-4	<0.01%	10	<0.01%	01	<0.01%	10
13-5	<0.01%	01	<0.01%	01	<0.01%	10
13-6	<0.01%	01	<0.01%	10	<0.01%	10
ASTM D1654	ASTM D1654 - EVALUATION OF CO	DATED SPECIMENS S	OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	<b>DSIVE ENVIRONMENT</b>	Ş	
		n .	UNSCRIBED AREAS - EXPOSURE TIME (DAYS)	XPOSURE TIME (DAY		
SAMPLE				90		120
Ö.	% Failed	Rating	% Failed	Rating	% Failed	Rating
13-1	0	01	0	10	0	10
13-2	0	10	0	10	0	10
13-3	0	10	0	10	0	10
13-4	0	10	0	10	0	10
13-5	0	10	0	10	0	10
13-6	0	10	0	10	0	01
	MEAN CREEPAG	CREEPAGE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIME - 120 DAYS	/E - 120 DAYS				
Ö	mm	Rating				
13-1	0	01				
13-2	0	01				
13-3	0	10				
13-4	0	10				
13-5	0	10				
13-6	0	10				

Table B6. Continued.

PANEL EVALUATION		- SALT WATER IMMERSION (POLY-CARB)	-CARB)			
ASTM D714 DEGREE	EGREE OF BLISTERING	9		British Colored Colore		
			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE	7		09	0	12	120
S S	Frequency	Size	Frequency	Size	Frequency	Size
13-1	0	0	0	0	0	0
13-2	0	0	0	0	0	0
13-3	0	0	0	0	0	0
13-4	0	0	0	0	0	0
13-5	0	0	0	0	0	0
13-6		0	0	0	0	0
ASTM D610 DEGREE	EGREE OF RUSTING					
			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE			09			120
N ON	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
13-1	<0.01%	10	<0.01%	10	<0.01%	10
13-2	<0.01%	10	<0.01%	10	<0.01%	10
13-3	<0.01%	01	<0.01%	10	<0.01%	10
13-4	<0.01%	01	<0.01%	01	<0.01%	10
13-5	<0.01%	10	<0.01%	10	<0.01%	10
13-6	<0.01%	01	<0.01%	10	<0.01%	10
ASTM D1654 -	<b>EVALUATION OF</b>	COATED SPECIMENS	SUBJECTED TO COR	COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	ENTS	
		'n	<b>NSCRIBED AREAS - E</b>	UNSCRIBED AREAS - EXPOSURE TIME (DAYS)		
SAMPLE		7		90		120
Ö.	% Failed	Rating	% Failed	Rating	% Failed	Rating
13-1	0	01	0	10	0	10
13-2	0	10	0	10	0	10
13-3	0	10	0	10	0	10
13-4	0	01	0	10	0	10
13-5	0	10	0	10	0	01
13-6	0	10	0	10	0	01
	MEAN CREEPA		COMMENTS:			
SAMPLE	EXPOSURE TIME -	12				
ON	mm	Rating				
13-1	0	10				
13-2.	0	10				
13-3	0	10				
13-4	0	10				
13-5	0	10				
13-6	0	10				

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epox)
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est data
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Table B7.

TEST COATING SPECS (SHERWIN WILLIAMS	္ထု	٦								
COATING SYSTEM DATA	L		1ST COA	AI		2ND COAT	AI		3RD CC	COAT
COATING I.D.	Ÿ.	Zinc Clad	2		Kem Cure MW	WW e		Kem Cure MW	e MW	
	A 2	packac	ye zinc-rich	A 2 package zinc-rich epoxy primer	High builo	l polyamide	High build polyamide epoxy coating	High build	a polyamide	High build polyamide epoxy coating
MANUFACTURER	똜	Sherwin Williams	illiams		Sherwin Williams	Villiams		Sherwin Williams	Williams	
VOLUME % SOLIDS	2	64.40%			28%			28%		
VOC (unthinned)	2.5	2.57 lbs/gal	_		2.84 lbs/ga	Jal		2.84 lbs/gal	gal	
POT LIFE (unaccelerated)	6 1	6 hours @ 77° F	77° F		10 hours @ 77° F	@ 77° F		10 hours @ 7/° F		
INDUCTION TIME	<u>응</u>	30 minutes @ 77°	3 @ 77° F		30 minute	30 minutes @ 77° F		30 minutes @	es @ 77° F	
DRYING TIME MINIMUM TO RECOAT	4	4 hours @ 77° F	77° F		12 hours @ 77° F	@ 77° F		12 hours @	@ 77° F	
RECOMMENDED FILM THICKNESS, DRY	<u>유</u>	3-5 mils			5-7 mils			5-7 mils		į
MIXING RATIOS	幸	Kit Only			Kit Only			Kit Only		
THINNING, Maximum	<u>8</u>	s than c	or equal to	ess than or equal to 80° F MEK	.255-C-005	35		.255-C-005	189	
						. ·				
APPLICATION										
DATE	2/8	5/8/95			2/6/62			2/10/95		
RH	28%	%			28%			26%		
TEMPERATURE	-89° F	u_ °			68° F			70° F	3	
SUBSTRATE CONDITION	SS	SSPC 10			Primer			Epoxy		
COATING BATCH NUMBERS	8 8	e:B69A8/C	ure:BA661295	Base:869A8/Cure:BA661295/Other:869A8/B69V8	Base: 92(	Base: 920W965/920C965	C965	Base: 20	Base: 20W965/Cure:	9: 920C965
THINNING	<u>®</u>	s than c	or equal to	less than or equal to 80° F MEK	less than	or equal t	less than or equal to 80° F MEK	less thar	or equal t	less than or equal to 80° F MEK
EQUIPMENT	ے	Devilbiss MBC	/BC		Devilbiss MBC	MBC		Devilpiss MBC	MBC	
DDV FILM THICKNESS MILS	Ľ	SALT	FRESH	U.V.	SALT	FRESH	U.V.	SALT	FRESH	U.V.
SAMPLE NO 9-1	<u></u>	5.2	5.1	5.2	5.8	5.4	8'9	5.1	5.8	5.9
SAMPIFNO 9-2	L	4.5	4.5	5.2	5.8	6.4	5.9	3.5	3.9	4.7
SAMPLE NO. 9-3	<u> </u>	4.8	4.8	5.0	6.3	5,4	6.2	3.6	4.3	4.6
SAMPLE NO. 9-4		4.8	5.3	5.4	6.3	9.0	5.8	3.9	5,5	3.7
SAMPLE NO. 9-5		4.8	4.6	5.3	5.5	9'9	8.0	5,3	4.9	3.8
SAMPLE NO. 9-6		5.0	5.2	5.5	5.3	5.6	6.8	4.4	5.0	4.2
	<u> </u>							ſ		
SAMPLE TOTALS					SALT	FRESH	U.V.	. K 1		
SAMPLE 9-1 TOTAL (COATS 1, 2 & 3)	-				16,1	16.3	17.9			
SAMPLE 9-2 TOTAL (COATS 1, 2 & 3)					13.8	14.8	15.8			
SAMPLE 9-3 TOTAL (COATS 1, 2 & 3)					14.7	14.5	15.8			
SAMPLE 9-4 TOTAL (COATS 1, 2 & 3)					15.0	16.8	14.9			
SAMPLE 9-5 TOTAL (COATS 1, 2 & 3)					12.6	15.8	17.1			4 · · · · · · · · · · · · · · · · · · ·
SAMPLE 9-6 TOTAL (COATS 1.2 & 3)					, ;	2.2	25			

Table B7. Continued.

STATE   STAT	ANEL EVAL	PANEL EVALUATION - U.V./PROHES ASTM D714 DEGREE OF BLISTERING	.V./PROHE:	PANEL EVALUATION - U.V./PROHESION (SHERWIN WILLIAMS) ASTM D714 DEGREE OF BLISTERING	IN WILLIA	AS)							
168   336   672   1344   2   2     158   Frequency   Size   Size							EXPOSURE T	TIME (HOURS	6				
Size   Frequency   Size   Size	SAMPLE	1	58	33	l	.9	72	13.	4	20	116	26	2688
0   0   0   0   0   0   0   0   0   0	NO.	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size	Frequency	Size
0   0   0   0   0   0   0   0   0   0	1-6	0	0	0	0	0	0	0	0	0	0	0	0
0   0   0   0   0   0   0   0   0   0	6-5	0	0	0	0	0	0	0	0	0	0	0	0
0   0   0   0   0   0   0   0   0   0	6-3	0	0	0	0	0	0	0	0	0	0	0	0
0   0   0   0   0   0   0   0   0   0	6-4	0	0	0	0	0	0	0	0	0	0	0	0
0   0   0   0   0   0   0   0   0   0	9-5	0	0	0	0	0	0	0	0	0	0	0	0
SECTION   Column	9-6	0	0	0	0	0	0	0	0	0	0	0	0
Sasa	TM D610	DEGREE OF	RUSTING										
168							EXPOSURE T	TIME (HOUR!	(C)				
% Rusted Rust Grade         % Rusted Grade         % Ru	AMPLE	J.	58	38	92	9	72	13	44	20	2016	26	2688
COUING   10   COUING   10   COUING   10   COUING   COUI	NO.	% Rusted	Rust Grade	% Rusted			Rust Grade	ı		% Rusted	Rust Grade	% Rusted Rust	Rust Grade
<0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01% <t< td=""><td>9-1</td><td>&lt;0.01%</td><td>9</td><td>&lt;0.01%</td><td>10</td><td>&lt;0.01%</td><td>01</td><td></td><td>10</td><td>&lt;0.01%</td><td>01</td><td>&lt;0.01%</td><td></td></t<>	9-1	<0.01%	9	<0.01%	10	<0.01%	01		10	<0.01%	01	<0.01%	
COUTING   10   COUTING	9-2	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
Coulty   10	9-3	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	01
COO196   10	6-4	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	01
<0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         10         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%         <0.01%	9-5	<0.01%	10	<0.01%	10	<0.01%	01	<0.01%	10	<0.01%	10	<0.01%	01
- EVALUATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS           LONSCRIBED AREA - EXPOSURE TIME (HOURS)           % Failed         Rating         % Failed         Rating         % Failed         Rating         % Failed           % Failed         Rating         % Failed	9-6		10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10	<0.01%	10
168   336   672   1344	TM D165				MENS SUBJ	ECTED TO C	ORROSIVE	ENVIRONME	ENTS				
% Failled         Rating         % Failled         % Failled <t< td=""><td></td><td></td><td></td><td></td><td></td><td>UNSCRIBE</td><td>D AREA - EX</td><td><b>RESURE TIN</b></td><td>ME (HOURS</td><td></td><td></td><td></td><td></td></t<>						UNSCRIBE	D AREA - EX	<b>RESURE TIN</b>	ME (HOURS				
% Failed         Rating         % Failed	AMPLE	ř	89		92	9	72	13	4		916	24	2688
0 10 0 10 0 10 0 10 0 10 0 10 0 10 0 1	NO.	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating	% Failed	Rating
0 10 0 10 0 10 0 10 0 10 0 10 0 10 0 1	9-1	0	10	0	10	0	10	0	10	0	10	0	01
0 10 0 10 0 10 0 10 0 10 0 10 0 10 0 1	9-2	0	10	0	9	0	10	0	10	0	10	0	01
0 10 0 10 0 10 0 10 0 10 0 10 0 10 0 1	9-3	0	10	0	10	0	10	0	10	0	10	0	10
0         10         0         10         0         10         0         10         0         10	9-4	0	2	0	9	0	9	0	10	0	10	0	10
0   10   0   10   0   10   0   10   0	9-5	0	10	0	10	0	인	0	10	0	10	0	10
MEAN CREEPAGE FROM SCRIBE  EXPOSURE TIME - 2688 HOURS  mm  0 0 10 0 0 10 0 0 10	9-6		10	0	10	0	10	0	10	0	10	0	10
		MEA	IN CREEPA	GE FROM SC	SRIBE	COMMEN	TS;						
0 0 0	AMPLE	EXF	<b>OSURE TIIN</b>	<b>1E - 2688 HO</b>	URS								
00000	Ö.	Ε	E	Rat	ing								
00000	9-1		0		0								
0000	6-2		0	_	0								
000	9-3		0		0								
0	9-4		0	_	0								
C	9-5		0		0								
	9-6		0		0								

Table B7. Continued.

PANEL EVALU	JATION - FRESH WAT	PANEL EVALUATION - FRESH WATER IMMERSION (SHERWIN WILLIAMS)	WIN WILLIAMS)			
ASTM D714 DEGREE OF	EGREE OF BLISTERING	O				
			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE		7	9	09	l	120
NO. Freque	Frequency	Size	Frequency	Size	Frequency	Size
9-1	0	0	0	0	0	0
9-2	0	0	0	0	0	0
9-3	0	0	0	0	0	0
9-4	0	0	0	0	0	0
9-6	0	0	0	0	0	0
9-6	0	0	0	0	0	0
ASTM D610 D	EGREE OF RUSTING					
	m . m		EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE		7	9	09		120
ġ.	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
9-1	<0.01%	10	<0.01%	10	<0.01%	10
9-2	<0.01%	01	<0.01%	10	<0.01%	10
9-3	<0.01%	01	<0.01%	10	<0.01%	10
9-4	<0.01%	01	<0.01%	10	<0.01%	10
9-5	<0.01%	10	<0.01%	10	<0.01%	01
9-6	<0.01%	01	<0.01%	10	<0.01%	10
ASTM D1654 - EVALUAT	NO.	DATED SPECIMENS S	OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	SIVE ENVIRONMENT		
		n	UNSCRIBED AREAS - EXPOSURE TIME (DAYS)	XPOSURE TIME (DAYS		
SAMPLE		7		60.		120
NO.	% Failed	Rating	% Failed	Rating	% Failed	Rating
9-1	0	10	0	10	0	01
9-2	0	01	0	10	0	10
6-3	0	01	0	10	0	10
6-4	0	01	0	10	0	10
9-5	0	10	0	10	0	10
9-6	0	10	0	10	0	10
	MEAN CREEPAG	CREEPAGE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIME - 120 DAYS	/E - 120 DAYS				
ON	mm	Rating				
b-1	0	10				
6-2	0	10				
6-3	0	10				
6-4	0	ᄋ				
9-5	0	0				
9-6	0	10				

TM D714 D	ASTM D714 DEGREE OF BLISTERING	(1)	I LO COXL	NAT (DAVE)		
LIVE	7		EXPOSOIRE LIME (UNIT)	INE (DATS)		120
NO.	Frequency	Size	Frequency	Size	Frequency	Size
0	O	0	0	0	0	0
0-0	C	0	0	0	0	0
0-3	C	0	0	0	0	0
0,0		C	0	0	0	0
0.5		0	0	0	0	0
9-6	0	0	0	0	0	0
TM D610 D	ASTM D610 DEGREE OF RUSTING					
			EXPOSURE TIME (DAYS)	IME (DAYS)		
SAMPLE			09	0		120
9	% Rusted	Rust Grade	% Rusted	Rust Grade	% Rusted	Rust Grade
6	<0.01%	01	<0.01%	10	<0.01%	Ol
9-2	<0.01%	01	<0.01%	10	<0.01%	0
9-3	<0.01%	10	<0.01%	10	<0.01%	10
9-4	<0.01%	10	<0.01%	10.	<0.01%	01
9-5	<0.01%	01	<0.01%	10		10
9-6	<0.01%	10	<0.01%	10		10
TM D1654	ASTM D1654 - EVALUATION OF C	ATION OF COATED SPECIMENS SUBJECTED TO CORROSIVE ENVIRONMENTS	SUBJECTED TO COR	ROSIVE ENVIRONM	ENTS	
		N	JSCRIBED AREAS - E	UNSCRIBED AREAS - EXPOSURE TIME (DAYS)	(S)	
SAMPLE			9	90		120
NO.	% Failed	Rating	% Failed	Rating	% Failed	Rating
9-1	0	10	0	10	0	01
9-2	0	10	0	10	0	0
9-3	0	01	0	10	0	0
9-4	0	10	0	10	0	10
9-5	0	10	0	01	0	01
9-6	0	10	0	10	0	10
	MEAN CREEPAG	MEAN CREEPAGE FROM SCRIBE	COMMENTS:			
SAMPLE	EXPOSURE TIN	AE - 120 DAYS				
Ö	mm	Rating	-			·
9-J	0	01				
9-2	0	01				
9-3	0	01				
9-4	0	01				
9.5	0	01				

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