STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
RESEARCH AND DEVELOPMENT DIVISION

FINAL REPORT
Project No. 2722

EVALUATION OF COATINGS APPLIED OVER CORRODED STRUCTURAL STEEL SURFACES

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June 1991

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.
FHWA/OK 91(05)

2. GOVERNMENT ACCESSION NO.

3. RECIPIENT'S CATALOG NO.

4. TITLE AND SUBTITLE
Evaluation of Coatings Applied Over Corroded Structural Steel Surfaces

5. REPORT DATE
June 1991

6. PERFORMING ORGANIZATION CODE
Project 157-683

7. AUTHOR(S)
R. D. Daniels
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8. PERFORMING ORGANIZATION REPORT
91-1

9. PERFORMING ORGANIZATION AND ADDRESS
School of Chemical Engineering and Materials Science
University of Oklahoma
Norman, OK 73019

10. WORK UNIT NO.

11. CONTRACT OR GRANT NO.
Project Agreement No. 2722

12. SPONSORING AGENCY NAME AND ADDRESS
State of Oklahoma, Department of Transportation
Research and Development Division
200 N.E. 21st Street
Oklahoma City, OK 73105

13. TYPE OF REPORT AND PERIOD COVERED
Final Report
January 1990 - June 1991

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Conducted in Cooperation with the U.S. Department of Transportation, Federal Highway Administration

16. ABSTRACT
Results are presented for accelerated corrosion tests of five coating systems evaluated for use over corroded structural steel surfaces. This was the second series of such tests in a testing program initiated in 1988. The coatings were applied over both clean (non-corroded) steel panels and pre-corroded panels. The coated panels were then exposed for 1200 hours (50 days) in a salt fog chamber. Visual observations were made on a daily basis to obtain data on blister size, blister frequency, rust rating, and scribe rating.

Using an overall performance index which is a sum of the four individual ratings, the best performing coating in this second series was the Carboline Carbozinc 11, Polyclad 936 system. The remaining four coatings were judged to have poorer overall performance, but they exhibited mixed results that made ranking more difficult.

Comparison of results obtained in the two test series demonstrated that coating thickness was a significant test variable. Hence, changes in performance index with time were given more significance than the absolute values of the index. On this basis, DuPont 25P/Imron, from the first test series, and Carboline PC936/CZ11, from the second test series, were the best performing coatings evaluated.

In reviewing the literature on maintenance painting strategies and cost considerations, it was concluded that surface-tolerant maintenance coatings could be of economic benefit even if their performance is inferior to that of coatings applied over clean grit-blasted surfaces.

17. KEY WORDS
corrosion, rusting, coatings, paints, steel, maintenance painting, abrasive blasting

18. DISTRIBUTION STATEMENT
No restrictions

19. SECURITY CLASSIF. (OF THIS REPORT)	20. SECURITY CLASSIF. (OF THIS PAGE)	21. NO. OF PAGES	22. PRICE
None	None	63	

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NOTICE

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ABSTRACT

Results are presented for accelerated corrosion tests of five coating systems evaluated for use over corroded structural steel surfaces. This was the second series of such tests in a testing program initiated in 1988. The coatings were applied over both clean (non-corroded) steel panels and panels pre-corroded in a salt fog chamber. The coated panels were then exposed for 1200 hours (50 days) in the accelerated laboratory testing conditions of the salt fog chamber. Visual observations were made on a daily basis to obtain data on blister size, blister frequency, rust rating, and scribe rating.

The coatings tested were: (1) Carboline, Carbozinc 11, primer, with Polyclad 936, topcoat; (2) Carboline, Carbomastic 15, Low Odor, a self priming single coat system; (3) State of California, Formula Pb-201, a high solids phenolic type primer; (4) Steel Structures Painting Council, Paint Specification No. 11, a red iron oxide, zinc chromate, raw linseed oil and alkyd primer; and (5) Praxis, Prax-Ten, a penetrant base coat and a concentrate top coat of metal alkyl sulfonate.

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Comparison of results obtained in the two test series demonstrated that coating thickness was a significant test variable. Hence, changes in performance index with time were given more significance than the absolute values of the index. On this basis, DuPont 25P/Imron, from the first test series, and Carboline PC936/CZ11, from the second test series, were the best performing coatings evaluated.

In reviewing the literature on maintenance painting strategies and cost considerations, it was concluded that surface-tolerant maintenance coatings could be of economic benefit even if their performance is inferior to that of coatings applied over clean grit-blasted surfaces.

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EVALUATION OF COATINGS APPLIED OVER CORRODED STRUCTURAL STEEL SURFACES

I. INTRODUCTION

Surface preparation is the single most important factor in coating performance. The preferred method of preparing a structure for repainting has been dry sand blast cleaning. New environmental protection laws dictate containment and recovery of debris generated by sand blasting of surfaces covered with lead-base paint. This requirement may markedly increase the costs of maintenance painting where the steel must be sand blasted down to bare metal to remove rust. As a result, many companies have developed paints that they claim will provide corrosion protection when applied over rusted surfaces. Test and service data to support such claims are limited.

Starting in 1988 with State of Oklahoma, Department of Transportation support, R. D. Daniels and B. R. Rogers of the University of Oklahoma employed an accelerated corrosion test to evaluate five coating systems intended for application on highway bridge steel that is rusty and less than abrasively blast cleaned [1]. The present work is an extension of that initial study. Five more coating systems have been evaluated in a second test series. In this report, results obtained in the second test series are presented, and results obtained in the two test series are compared.

The coating system evaluation procedure employed in both series of tests was as follows: Coatings were applied to both pre-corroded and clean (non-corroded) steel test panels. The accelerated testing procedure consisted of exposing the coated test panels to a salt fog environment for a period of 50 days with daily inspection of the coatings. Coatings were evaluated using four test ranking procedures: blister size, blister frequency, rust rating, and scribe rating.

To facilitate comparisons of overall performance of coatings within the second test series and to make comparisons between test results in the first and second series, a performance index was computed. The index sums the four individual test rankings.

II. ACCELERATED CORROSION TESTS ON SECOND COATING SERIES

A. COATING MATERIALS

Coating materials were provided by the State of Oklahoma, Department of Transportation (ODOT). The materials were supplied to ODOT by vendors who wished to have their product tested or were prepared at ODOT's request.

The five coatings tested in the second series are: (1) Carboline CarboZinc 11, primer, with Polyclad 936, topcoat (PC936/CZ11), (2) Carboline Carbomastic 15, Low Odor, a self priming single coat system (CM15LO), (3) State of California Formula Pb-201, a high solids phenolic type primer (Calif.Pb-201), (4) Steel Structures Painting Council, Specification No. 11, a red oxide, zinc chromate, raw linseed oil and alkyd primer (SSPC No.11), and (5) Praxis, Prax-Ten, a penetrant base coat and a concentrate top coat of metal alkyl sulfonate (Prax-Ten). A description of the coatings and information on coating application provided by suppliers is contained in Appendix A.

The Praxis coating, Prax-Ten, is the only one of the five coating systems tested in this second series that was also included in the first series of tests [1]. It was included in this new series of tests to provide a basis for comparing test results for the two series. The California Formula Pb-201 is a coating used in a similar study by the State of California, Department of Transportation, completed in 1988 [2].

B. TEST PROCEDURES

1. Panel Surface Preparation

The coatings were applied to both pre-corroded and clean steel surfaces. The test panels were Q-panels, 4 in. x 6 in. x 0.032 in. thick with a dull matte finish. Panels were pre-corroded by exposure in a salt fog chamber constructed for this project. The chamber test conditions conformed to ASTM B 117, except that the test temperature was ambient (23°C). Uncoated panels were exposed for 168 hours (7 days). This produced a thick but non uniform rust. These corroded panels were dried for 7 days and then the loose scale was removed in accordance with SSPC procedure SP 2, Hand Tool Cleaning. The condition of the panels as-received (clean), corroded, and hand cleaned are shown in Figure 1.

2. Coating of Panels

The pre-corroded and hand cleaned panels (referred to as pre-corroded panels) and clean (non-corroded) panels were coated in accordance with supplier specifications, Appendix A. Coatings were applied with an air sprayer. The supplier recommendations for mixing and thinning were followed. Cure times between coats for two coat systems followed specifications. All coatings were cured for seven days before beginning the salt fog exposure test, in accord with NACE recommended practice RP 02-81.

Appendix B summarizes the panel treatments and indicates the number of panels prepared with each treatment, i.e., clean or pre-corroded, scribed or non-scribed. Some of the coatings were cut with a scribe before testing. The scribing tool and the procedure are described in ASTM D 1564-84. Reference panels with each coating were saved for comparison with those subjected to the salt fog test.

Coating thicknesses were determined at the time of application using a wet film gage and were judged to be within specifications. A dry film thickness gage was obtained only after the salt fog test was initiated. Except for Prax-Ten, the dry film thickness of all of the coatings was less than that specified by suppliers. The measured values of dry film thickness are given in Appendix C.

3. Coating Exposure Test

The coated panels were placed in test racks within the salt fog chamber. The racks are horizontal and test panels sit in slots in the rack inclined at a 15 degree angle from the vertical. Panel locations in the racks are displayed in Appendix D. There were two racks with two rows of panels on each rack. The coatings were randomly distributed on the racks. All of the scribed panels were on one rack. Panels were coded for purposes of identification with the coding scheme listed in Appendix E. This coding was used in recording data on visual examinations of the panels.

During the period of testing, 50 days, the panels were examined once each day. The examination consisted of removing the panels from the chamber and allowing them to dry for 15 to 20 minutes and then inspecting them visually. The panels were then returned to the chamber for another 24 hours.

Visual examination was used to assign coating ratings for Blister Size, ASTM D 714-87, Blister Frequency, ASTM D 714-87, Rust Rating, ASTM D 610-85, and Scribe Rating, ASTM D 1654-84. These rating scales are summarized in Appendix F.

C. TEST RESULTS

The daily visual observations were recorded for 50 days. There were 2 panels for each of the 4 test conditions, for each of the 5 coatings, for a total of 40 panels. For the unscribed panels the blister size, blister frequency, and rust rating were recorded. For the scribed panels, only the scribe rating was recorded. The visual observations data along with the averaged values of the replicate data are listed in Appendix G.

After the test program was completed, the test panels were allowed to dry for about 30 days. Then the test panels, along with the reference (untested) panels were photographed in color. The photographs are Figures 2-6.

Summary data for all 5 coatings are presented graphically in Figures 7-10. Blister Size is plotted in Figure 7, Blister Frequency in Figure 8, Rust Rating in Figure 9, and Scribe Rating in Figure 10.

D. DISCUSSION OF RESULTS

1. Carboline Carbozinc 11, Polyclad 936

The PC936/CZ11 coating, Figure 2, was a hard, bright but not so smooth coating. The performance of this coating was the best of the five coatings on pre-corroded panels. Small blisters developed after 330 hours on the pre-corroded panels. The blister size rating and the blister frequency rating were 8 after 1200 hours. The rust rating was 4 after 1200 hours, but this was still better performance than the other coatings. Performance of the clean panels was among the best for blister frequency and rust rating, but the panels degraded to a blister size rating of 2 after 1200 hours because of formation of a few large blisters. Bonding of the coating to the steel was poorer on the clean surface than on the pre-corroded surface. The scribe rating remained a 10 throughout the 1200 hour test on both the pre-corroded and clean panels.

2. Carboline Carbomastic 15, Low Odor

The CM15LO coating, Figure 3, was a bright but not so smooth coating. The performance of this coating was inferior to that of the PC936/CZ11 coating. On the pre-corroded panels the blister size, blister frequency, and rust rating all degraded to a 4 in 1200 hours. The blister frequency dropped to 4 in less than 600 hours. On clean panels large and numerous blisters developed early in the test degrading both the blister size and frequency ratings to a 2 in less than 600 hours. The rust rating for the clean panels was better, an 8 at 1200 hours. Scribe rating remained a 10 throughout the test for both the pre-corroded and clean panels.

3. State of California, Formula Pb-201

The Calif. Pb-201, Figure 4, was a soft, rough and dull finish coating. Performance among the clean panels was among the poorest. Blister size and blister frequency ratings degraded to 2 earlier in the test than any of the other coatings. The rust rating after 1200 hours was 5, second worst among the coatings. The coating on the clean panels developed several large blisters 2/3 in. by 4 in. (across the width of the panel) after only 150 hours. These blisters later collapsed back on to the surface producing a rough wrinkled surface texture. On the pre-corroded panels the blister size and blister frequency degraded to 4 and 2, respectively in about 300 hours and remained that way through 1200 hours. The rust rating degraded to 3 at 1200 hours. This coating ranked in third position among the five coatings. Scribe rating after 1200 hours was 9 for both the clean and the pre-corroded panels. This was the only coating to have a scribe rating less than 10 on pre-corroded panels.

4. SSPC Specification No. 11

SSPC No. 11, Figure 5, was a soft, smooth coating. A peculiar property of the coating was that condensation in the salt fog chamber was sticking to the surface of the clean panels. The performance of this coating was generally poor on both the clean and the pre-corroded surfaces. On the clean panels the blister size and blister frequency ratings degraded to 4 after 800 hours. Rust rating degraded to 5. On pre-corroded panels the blister sized degraded to 4 in less than 200 hours and the frequency degraded to 2 in 216 hours. This indicated a high density of blistering and, along with the Calif. Pb-201, exhibited the poorest resistance to blistering. The rust rating performance of this coating on pre-corroded panels was the poorest among the five coatings, degrading to 1 after only 120 hours of test. A rating of 1 means that one-half the panel was rusted. The scribe rating remained 10 on clean panels, but degraded to 8 on the pre-corroded panels after 750 hours.

5. Praxis, Prax-Ten

The Prax-Ten, Figure 6, was a soft, tacky, rough and dull coating. It is a two-coat system. The peculiar behavior of this coating system was that the top coat failed very early in the test, but the penetrant held the surface for a long period. The result was a not very attractive surface starting early in the test which caused some confusion in the observations. Initial observations relate principally to the top coat, while later observations relate to the base coat and the whole surface of the panel. On clean panels large blisters (but only one or two) of size rating 2 were observed after 144 hours. These blisters slowly moved down the panels with time. The blister size and frequency ratings of the clean panels degraded slowly when compared to pre-corroded panels, but they degraded to 2 and 4, respectively, after 1100 hours. On clean panels the rust rating was the worst of the coatings tested. It degraded to 5 after 950 hours. On pre-corroded panels the blister size rating degraded to 2 after 260 hours. The blister frequency only degraded to 6. The rust rating on the pre-corroded panels held up well for about 600 hours (rating of 7) but then degraded to 1 at 900 hours (along with the SSPC No. 11, the poorest performance among the coatings). The scribe rating remained 10 on both scribed panels throughout the 1200 hour test.

E. OVERALL PERFORMANCE INDEX

Following a procedure used by Simpson, Ray, and Skerry [3], an overall "Performance Index" was calculated by summing the individual ratings for blister size, blister frequency, rust rating and scribe rating. With a scale range of 0-10 for the individual ratings, the performance index has a scale range of 0-40. These performance index values were then plotted versus exposure time to generate the graphs in Figures 11 through 17.

In Figures 11 through 15 the performance of each coating on clean panels is compared with the same coating on pre-corroded panels. This comparison facilitates a determination of the overall degradation of coating performance when applied over corroded steel surfaces.

Figures 16 and 17 compare the overall performance of the five coating systems on clean (Figure 16) and pre-corroded (Figure 17) surfaces. This comparison facilitates a relative ranking of coating system performance.

Based on performance index it can be concluded that, while coating performances differ, the Carboline coating systems, Figures 11 and 12, and the California Pb-201 coating, Figure 13, perform as well on a corroded surface as on a clean steel surface. In contrast, performance of the SSPC No. 11, Figure 14, and Prax-Ten, Figure 15, is degraded on a corroded surface.

In overall performance the Carboline PC936/CZ11 ranked best on both the clean, Figure 16, and the corroded, Figure 17, steel surfaces. This conclusion is consistent with observations drawn from the individual rating scales, Figures 7 through 10.

The poorest performing coating on corroded panels was the SSPC No.11, although this coating behaved relatively well on clean surfaces. The California Pb-201 performed poorly on both clean and corroded surfaces. The Prax-Ten performed relatively well on the clean surfaces, but poorly on corroded surfaces. The Carboline CM15LO coating performance was unimpressive, in that it was definitely inferior to Carboline PC936/CZ11 on both clean and corroded panels.

F. CONCLUSIONS - TESTS ON SECOND COATING SERIES

The relative ranking of the coating systems in the second test series, based on their performance index on corroded panels, is as follows: Carboline PC936/CZ11, best, Carboline CM15LO, second, Prax-Ten, third, California Pb-201, fourth, and SSPC No. 11, worst.

III. COMPARISON OF RESULTS FOR TWO SERIES OF SALT FOG TESTS

A. PRAX-TEN

Since the Praxis, Prax-Ten, coating was the only coating system included in both series of salt fog tests, it provides the bridge between results obtained on the two sets of coatings. However, because of the differences in coating thicknesses of the panels, comparisons must be employed with caution. The dry film thickness of coatings employed in both series of tests are listed in Appendix C. In the first series coating thicknesses generally exceeded recommended thicknesses; whereas, in the second series the thicknesses were less than recommended.

What may be the consequence of a difference in coating thickness can be seen in comparative results obtained with Prax-Ten. Data on the performance index for Prax-Ten for both series of tests are plotted in Figure 18. In the first test series (series 1) the coating thickness was 7.2 mil (0.0072 in). In the second series (series 2) the thickness was 2.3 mil (.0023 in).

Schemes using the Prax-Ten data for converting or "normalizing" data obtained for the two series of salt fog tests were considered. However, the nature of the data make this impossible. For example, the only truly mathematical scale is that for rust rating, and that is a logarithmic scale of the form $R = -a \log A + b$, where R is the ASTM rust rating, A is the percentage of area rusted and a and b are coefficients. For $a = 2$ and $b = 6$, the equation is valid over the range $4 < R < 10$. In the range $R < 4$, $a = 4.3$ and $b = 8.3$. The blister size and blister frequency scales are also certainly non-linear and cannot be converted to a mathematical expression.

B. PERFORMANCE INDEX - FIRST TEST SERIES

Graphs of the overall "Performance Index" of the coatings evaluated in the first test series were prepared in a manner similar to the graphs presented in Figures 16 and 17. The graphs are presented as Figures 19 and 20.

Based on the performance index on corroded panels, Figure 20, the coating systems evaluated in the first series of salt fog tests ranked as follows: DuPont, 25P/Imron, best, Prax-Ten, second, Tenemec, third, Corroseal, fourth, and Black Gold, worst. This use the performance index, which gives equal weight to each of the four evaluation criteria, switches the overall rankings of the Prax-Ten and Tenemec coatings as reported earlier [1].

C. DISCUSSION

The difference in performance index from one test series to the other for the one coating system (Prax-Ten) included in both series of salt fog tests raises the question of the reproducibility and reliability of this accelerated corrosion test as a method of assessing the performance of coatings for corrosion control on steel. The deficiencies in the salt fog test and other accelerated corrosion tests in predicting field performance of corrosion control coatings have been documented [3, 4]. However, the tests should provide a measure of internal consistency in ranking coatings against the environmental conditions existing in the test environment. Since coating thickness is a variable, changes in performance index with time may be more significant than the absolute values of the index. Using Prax-ten as a baseline, the performance index data indicate that the DuPont 25P/Imron from the first series of coatings and Carboline PC936/CZ11 from the second series are the best performing coating systems studied.

IV. MAINTENANCE PAINTING STRATEGIES AND COST CONSIDERATIONS

Guidelines for developing cost data for new construction and maintenance painting have evolved over the years so that helpful information on which to base such calculations is now readily available. The cost guide developed by Brevoort and Roebuck is an example [5]. Their guide includes tables of data on estimated service life of coatings in various environments, typical material costs for paints and protective coatings, and shop and field painting costs per square foot, including labor, equipment, and related costs for cleaning and application. These data are used to calculate installed costs and may be used in economic analyses to compare alternative coating system costs over the service life of the project. The guide provides conversion factors for computing maintenance painting costs from total installed system costs. These conversion factors are determined by the condition of the surface to be repainted and can be used to determine the economics of repainting for various degrees of deterioration of the coating system. However, the guide does not treat the incremental costs of blast containment for lead paint removal or disposal costs of recovered wastes.

A bibliography of articles and conference publications on lead-base paint removal and containment is provided in a recent issue of *JPLC* [6]. A recent report by Vavarapis and Laguros [7] on "Maintenance Strategies for Corroded Structural Steel" includes some 1983 data on various paint removal and containment methods including the cost of transportation and disposal of waste materials. However, these data are suspect because cost considerations are changing with technological developments in containment on the one hand and more stringent environmental controls on waste treatment and disposal on the other. Recent efforts to concentrate hazardous wastes and to treat wastes on-site and use of recyclable abrasives are intended to reduce disposal costs. Countering these attempts at cost reduction are the more stringent standards of the TCLP (Toxic Constituent Leaching Procedure) which replaces the EP toxicity test for waste materials [8].

Results from a ten-year field study, which compared environmentally acceptable coating systems for steel with standard U.S. industry and government systems, are contained in a recently published report, "Performance of Alternative Coatings in the Environment (PACE), Volume I" [9]. "Environmentally acceptable" is defined in terms of restrictions on type and level of volatile organic compounds (i.e., solvents) and heavy metal pigments (i.e., lead and chromates) in the coating formulation. The study also evaluated coating performance as a function of alternative surface preparation procedures, including hand and power tool cleaning as well as a variety of abrasive blasting procedures. Performance of coating systems over hand tool cleaned surfaces was substantially inferior to that for other cleaning methods. Only one power tool method was employed, rotary peening. This method provided substantial improvement over hand tool cleaning and approached in performance some of the blast cleaned systems.

Ellor, Kogler, and Parks [10] evaluated surface-tolerant maintenance coatings over hand and power tool-cleaned surfaces for the Navy. The study involved cleaning of a localized area of corrosion on a partially coated panel and then painting the entire panel, i.e., painting over the cleaned area and over the aged original coating. The performance of maintenance-type coatings applied in this manner was monitored over a twenty-month period. Differences in coating performance were observed, but none of the coatings performed as well over hand or power tool cleaned surfaces as over a near white metal blast SSPC-SP 10 surface finish.

In assessing the merits of coatings for use over imperfectly prepared surfaces, consideration must be given to the percentage of the surface that is in need of repainting. Power tool cleaning is slower and more labor intensive than abrasive blasting and it generally leaves more contamination on the surface [11]. However, it may be an economic alternative if the rusted areas in need of repainting are a small fraction of the total area of the structure. If the area to be cleaned is less than 25 percent of the total surface area, then power tool cleaning of affected areas only, followed by repainting of the entire structure, should be considered. Power tool cleaning eliminates the problem and expense of large quantities of blast abrasive residues. Vacuum hoods are available for power tools to catch debris removed from the surface, and the quantity of debris is far less than that generated in blasting processes. If such procedures can buy time, perhaps a 10 to 12 year extension in service life of the system, technology developments by then will, hopefully, provide more long term solutions to the problem [12].

V. CONCLUSIONS AND RECOMMENDATIONS

Coatings that can be applied over corroded structural steel surfaces without removal of the previous coatings and without the generation of potentially hazardous blasting waste materials could be of economic benefit even if their performance is inferior to that of coatings applied over clean grit blasted surfaces.

Two of the coating systems evaluated in this study performed well over a corroded steel surface in a salt fog corrosion test. However, a single accelerated corrosion test is not adequate to qualify a coating system for such service. Long term field exposure tests are needed to evaluate the performance of surface-tolerant coating systems.

Studies should be continued to evaluate coating systems applied over corroded steel surfaces, but parallel studies should be undertaken to evaluate these same coating systems applied over aged original coatings. These systems are likely to be applied over the entire structure after hand or power tool cleaning of coating damaged and corroded areas.

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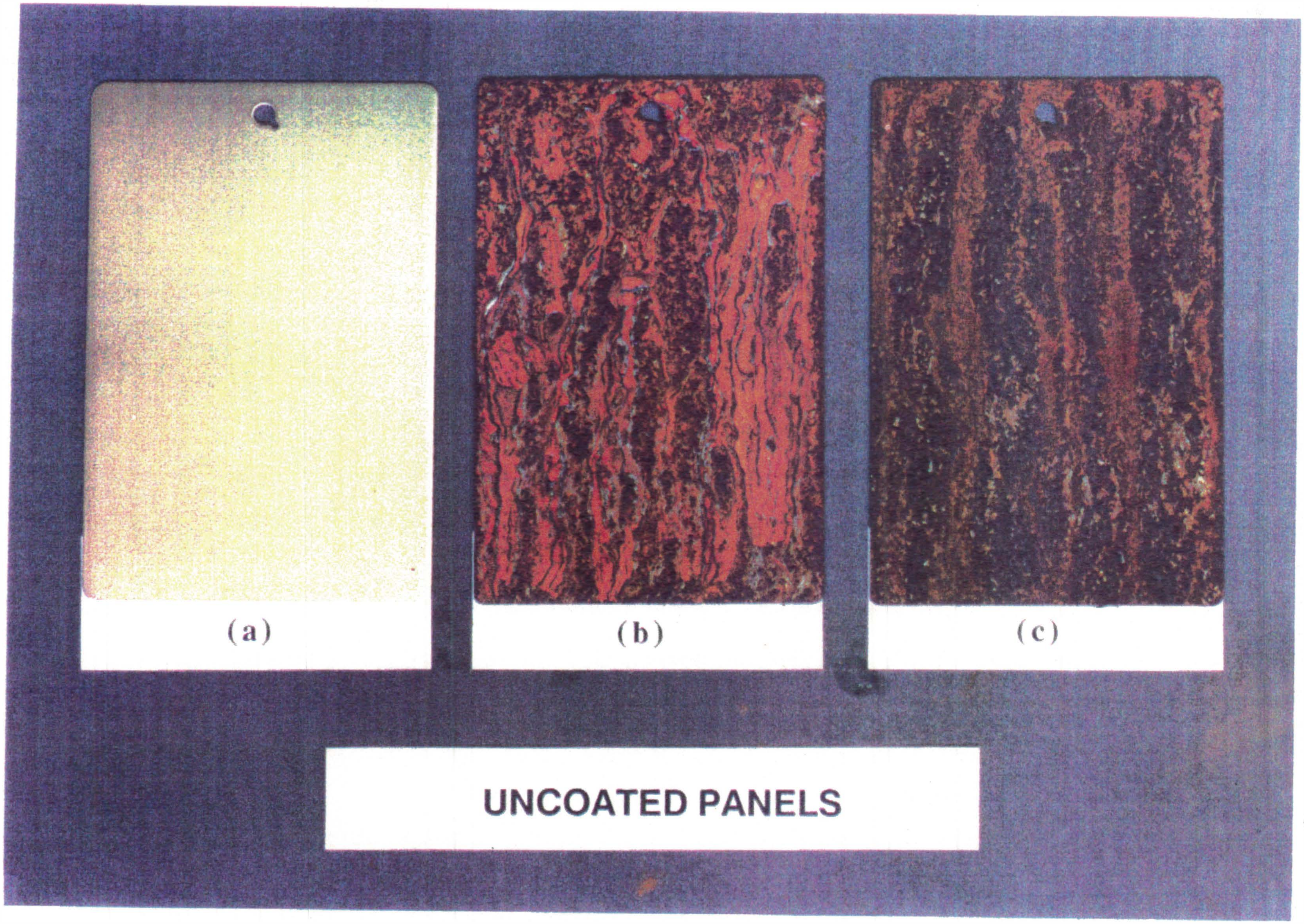


Figure 1 Test panel surface appearance before application of coatings: **(a)** clean panel without any treatment, **(b)** pre-corroded panel, and **(c)** pre-corroded panel after hand tool cleaning

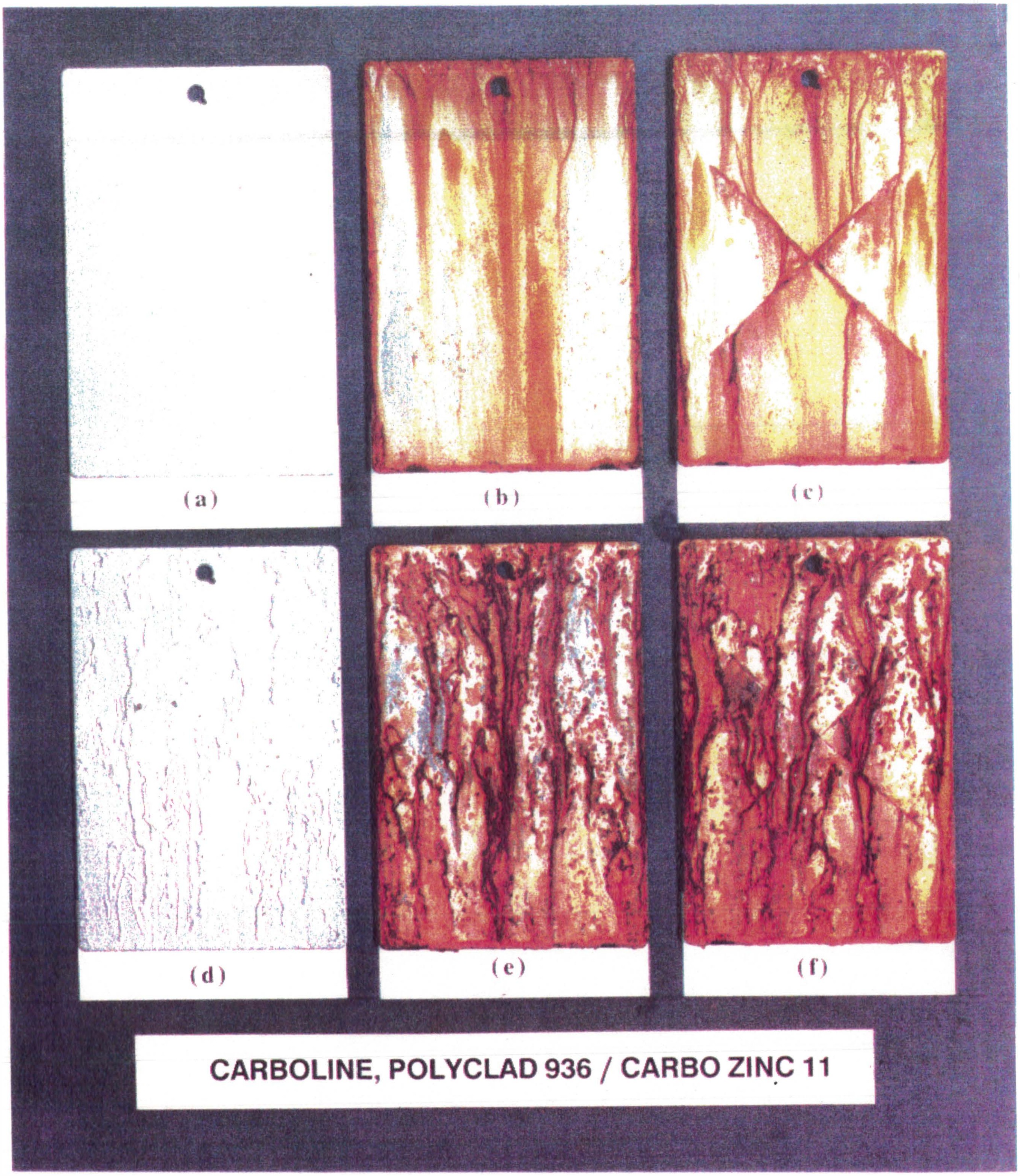


Figure 2 Carboline CarboZinc 11, Polyclad 936 coating exposed to salt fog environment applied on surfaces of **(a,b,c)** clean panels and **(d,e,f)** pre-corroded and hand tool cleaned panels. **(b)** and **(e)** are non-scribed panels. **(c)** and **(f)** are scribed panels. Reference panels **(a)** and **(d)** illustrate the condition of the coating before exposure.

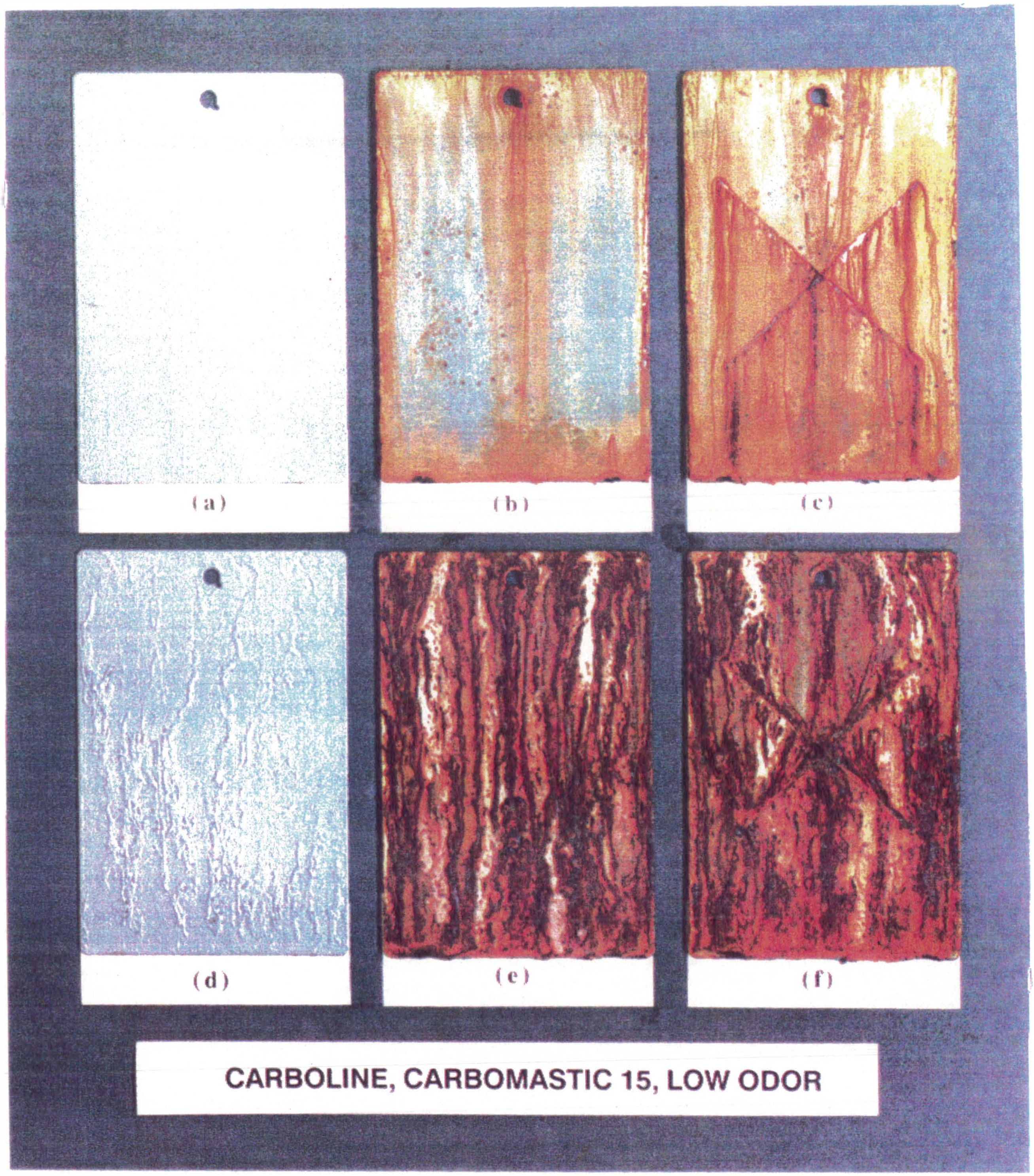


Figure 3 Carboline Carbomastic 15, Low Odor coating exposed to salt fog environment applied on surfaces of **(a,b,c)** clean panels and **(d,e,f)** pre-corroded and hand tool cleaned panels. **(b)** and **(e)** are non-scribed panels. **(c)** and **(f)** are scribed panels. Reference panels **(a)** and **(d)** illustrate the condition of the coating before exposure.

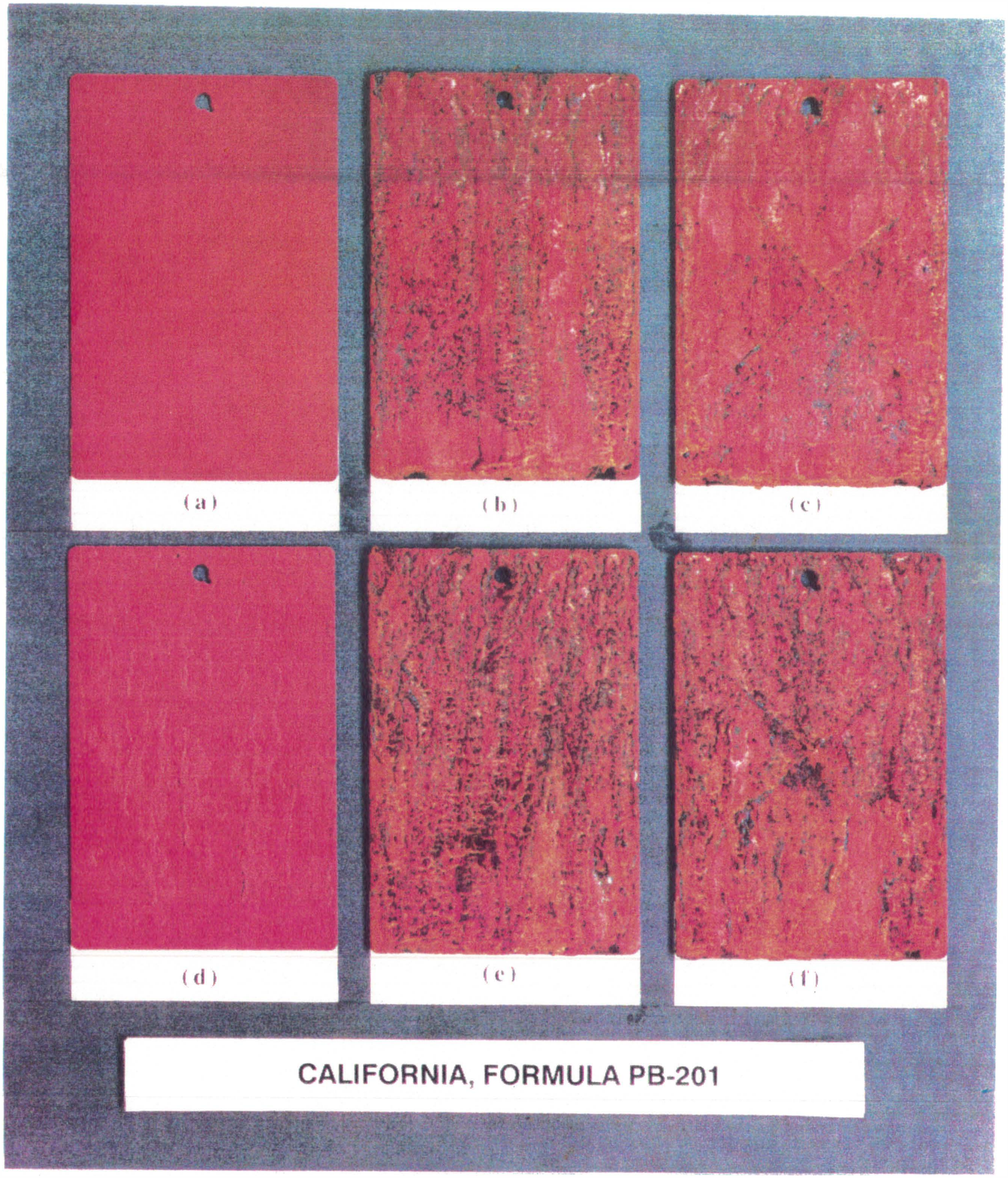


Figure 4 California, Formula Pb-201 coating exposed to salt fog environment applied on surfaces of **(a,b,c)** clean panels and **(d,e,f)** pre-corroded and hand tool cleaned panels. **(b)** and **(e)** are non-scribed panels. **(c)** and **(f)** are scribed panels. Reference panels **(a)** and **(d)** illustrate the condition of the coating before exposure.

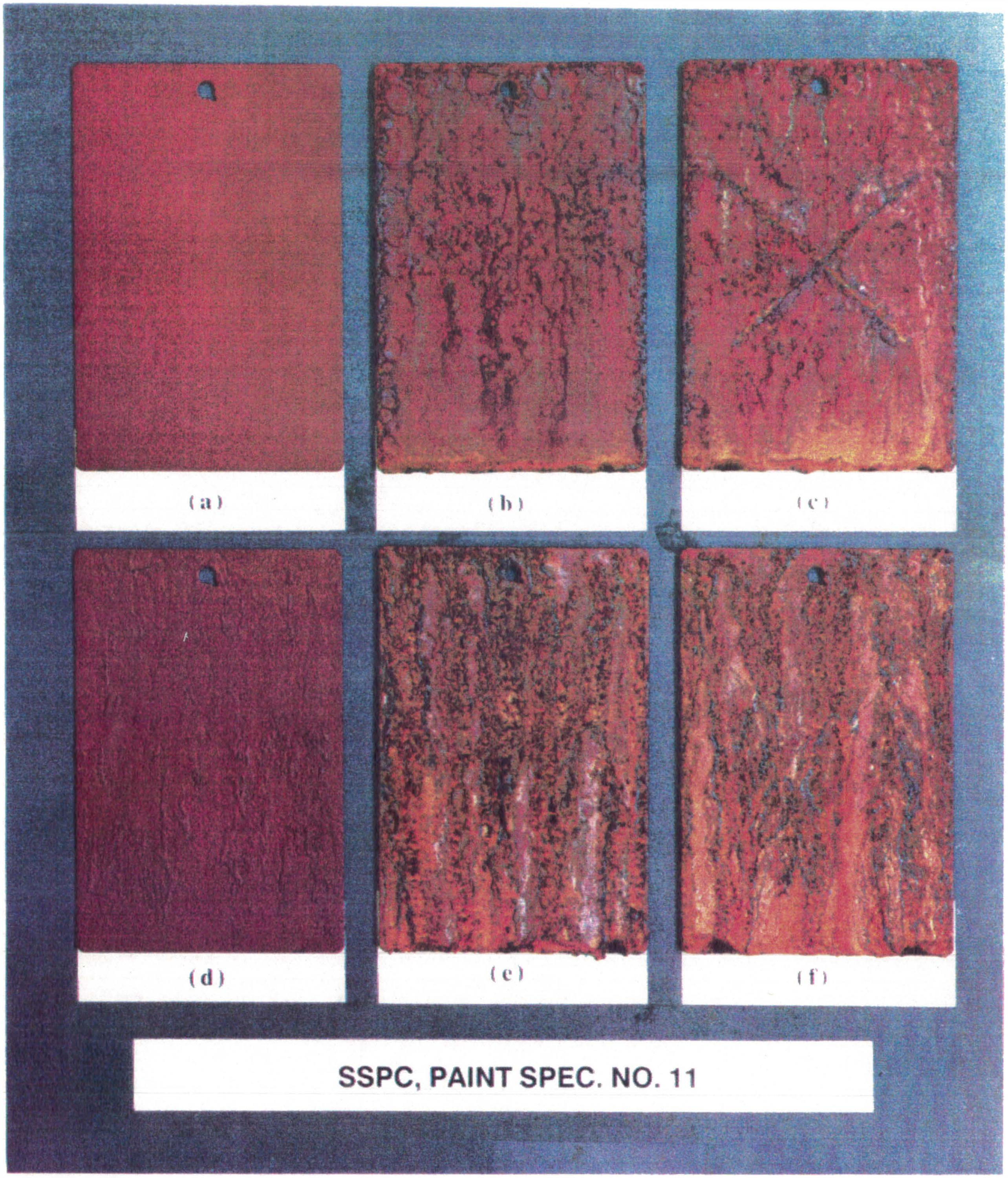


Figure 5 SSPC, Specification No. 11 coating exposed to salt fog environment applied on surfaces of **(a,b,c)** clean panels and **(d,e,f)** pre-corroded and hand tool cleaned panels. **(b)** and **(e)** are non-scribed panels. **(c)** and **(f)** are scribed panels. Reference panels **(a)** and **(d)** illustrate the condition of the coating before exposure.

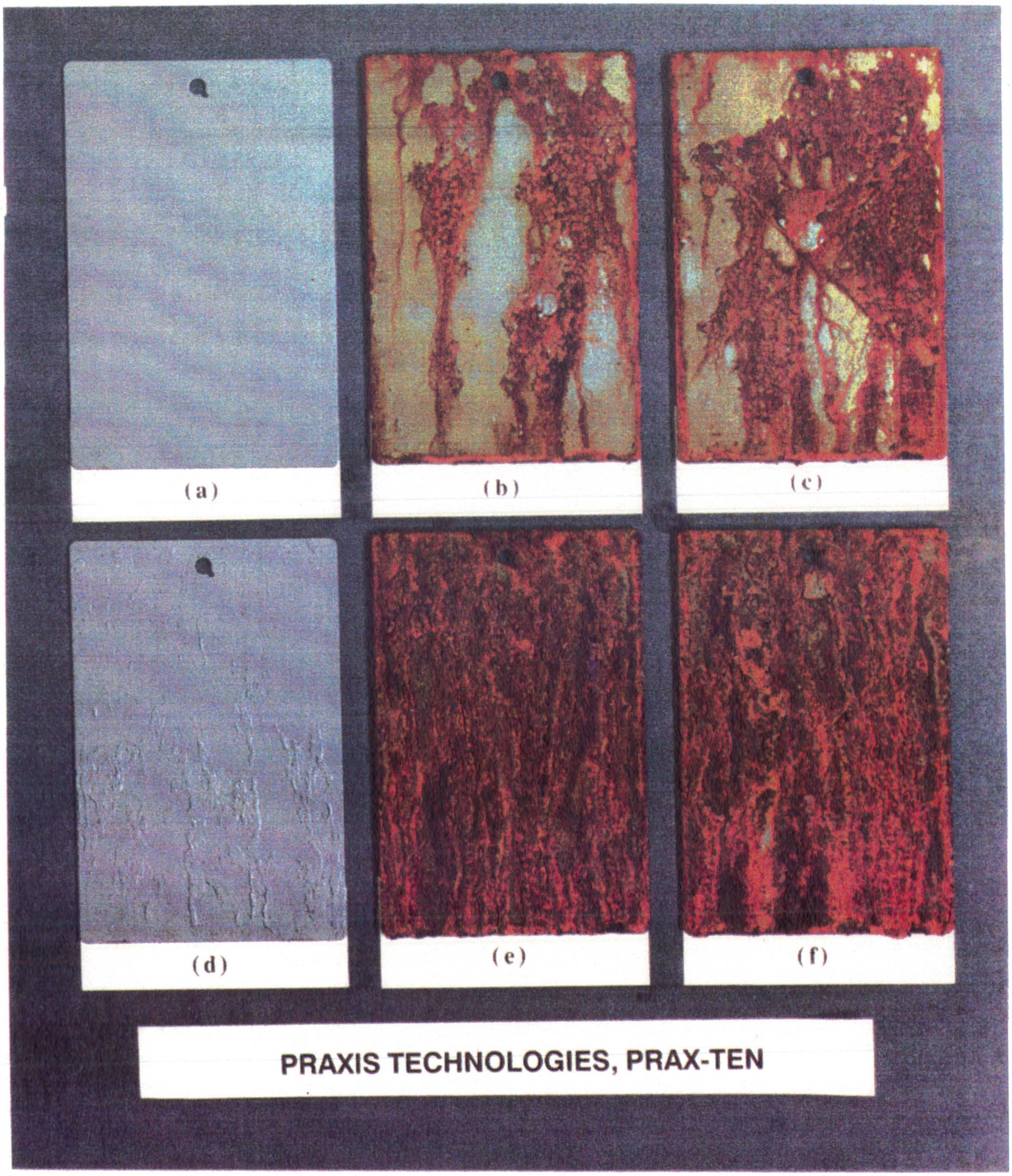
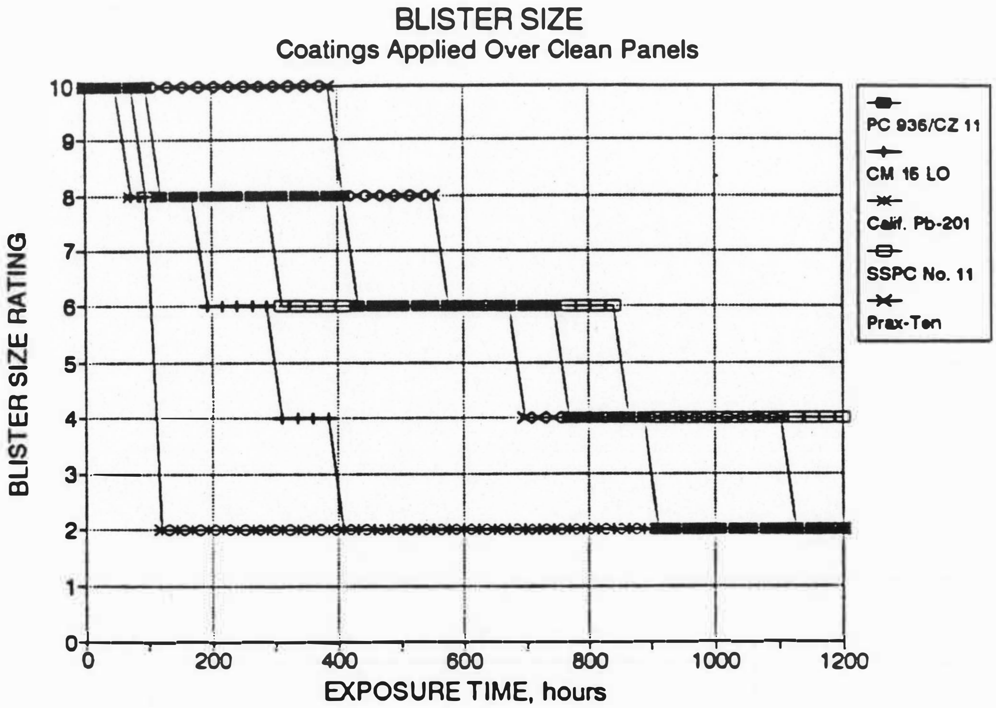


Figure 6 Praxis, Prax-Ten coating exposed to salt fog environment applied on surfaces of **(a,b,c)** clean panels and **(d,e,f)** pre-corroded and hand tool cleaned panels. **(b)** and **(e)** are non-scribed panels. **(c)** and **(f)** are scribed panels. Reference panels **(a)** and **(d)** illustrate the condition of the coating before exposure.



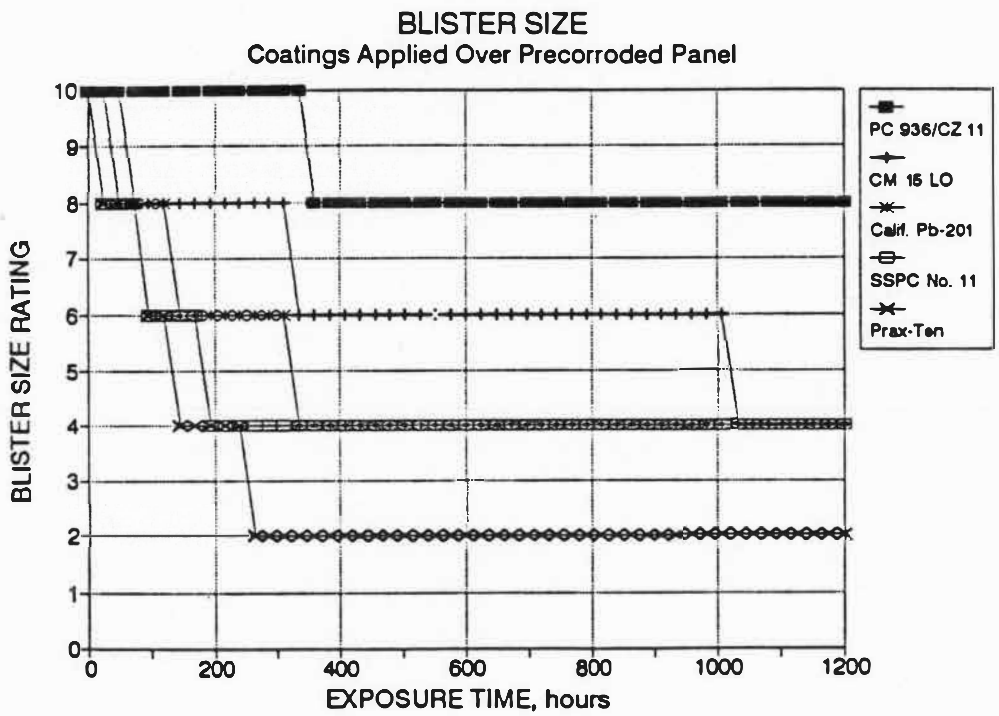
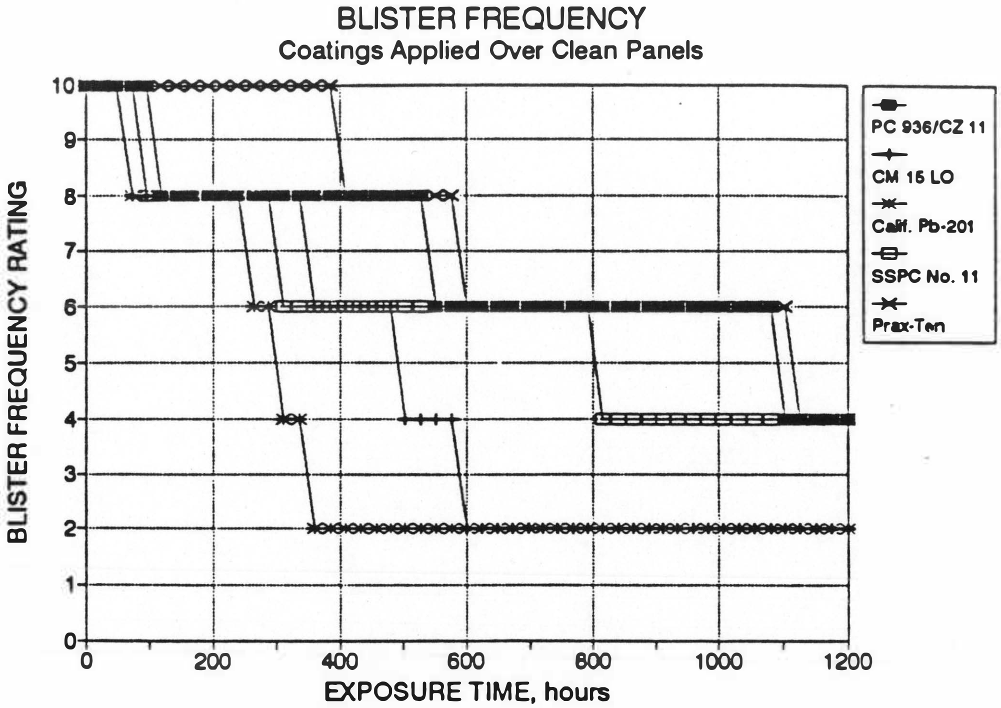


Figure 7 Blister size vs. exposure time in salt fog chamber for the five test coatings on **(a)** clean and **(b)** pre-corroded panel surfaces.



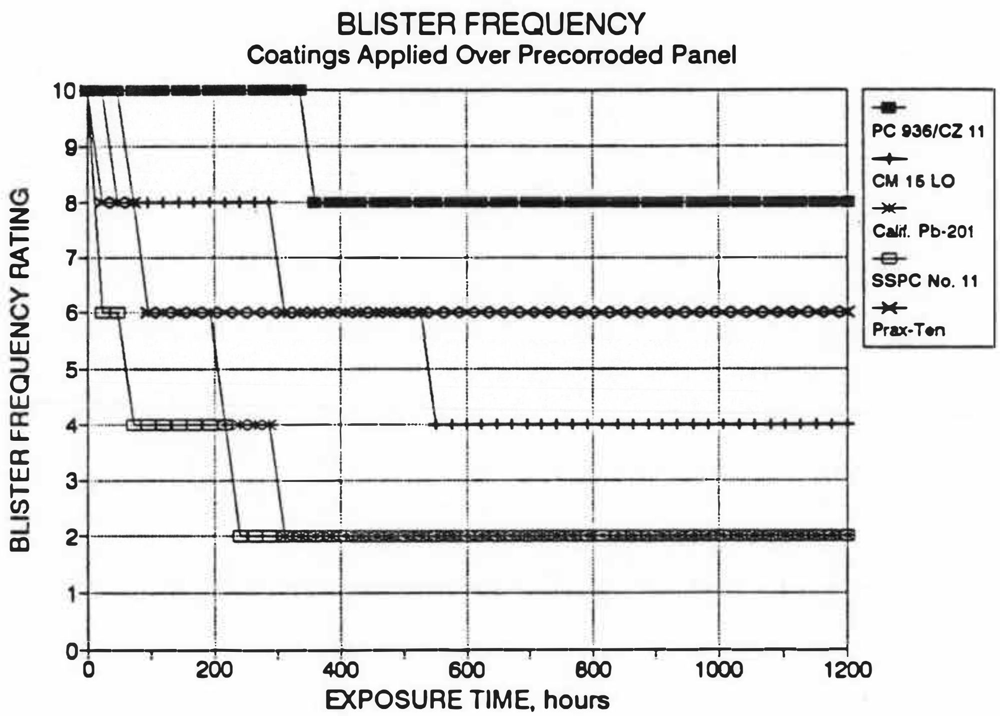


Figure 8 Blister frequency vs. exposure time in salt fog chamber for the five test coatings on **(a)** clean and **(b)** pre-corroded panel surfaces.

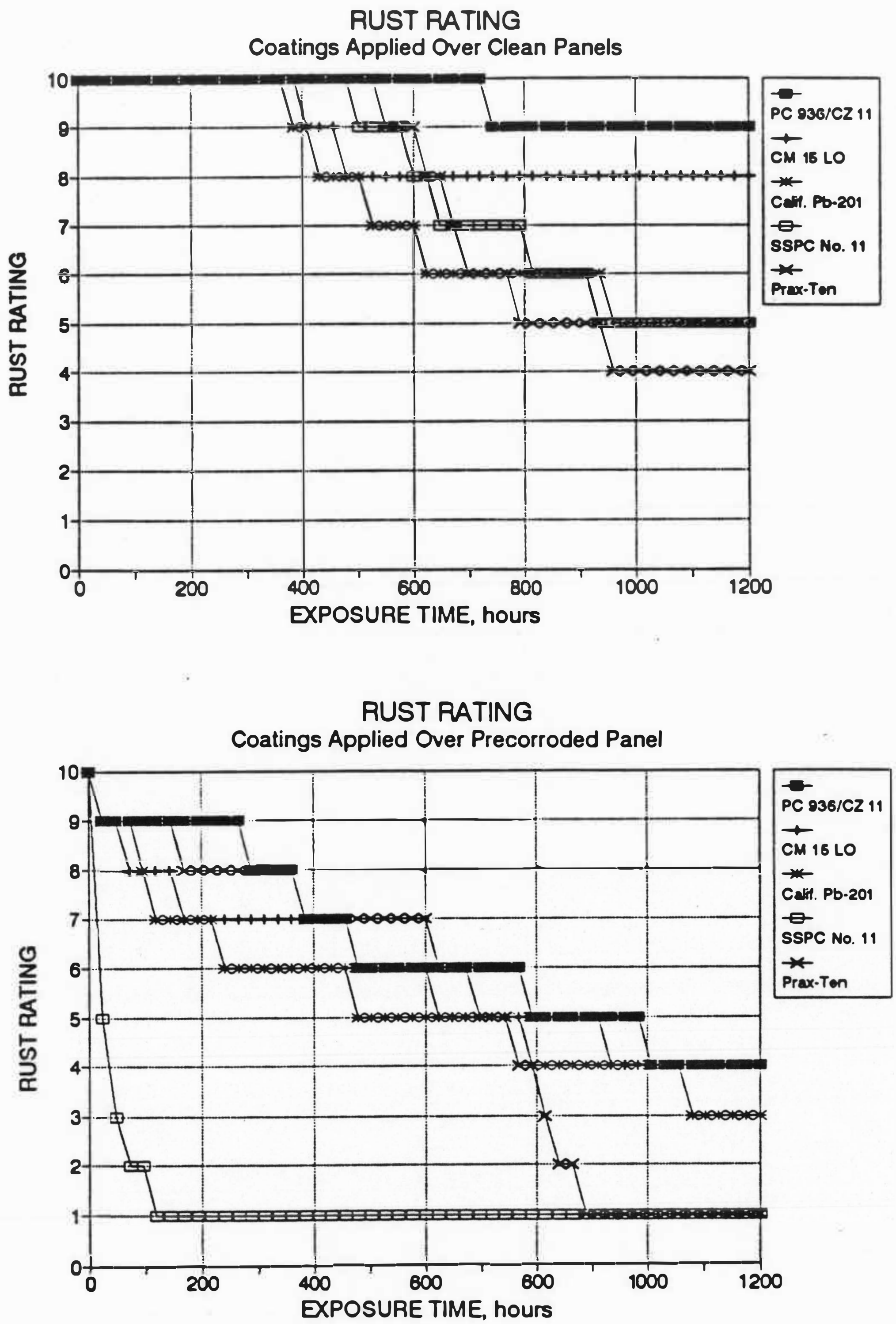
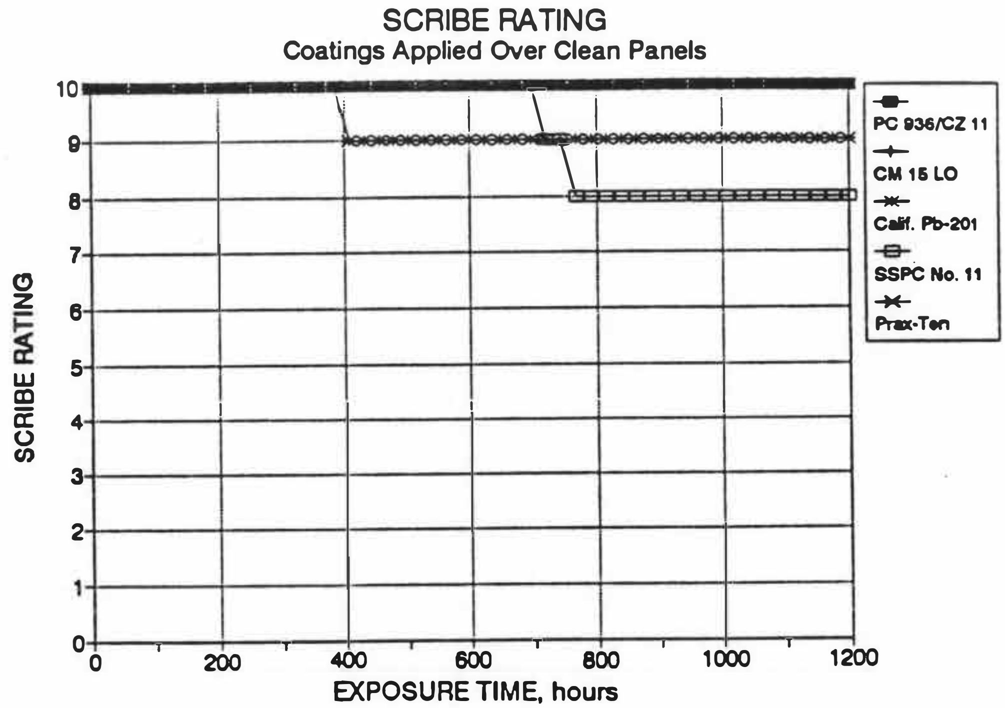


Figure 9 Rust rating vs. exposure time in salt fog chamber for the five test coatings on **(a)** clean and **(b)** pre-corroded panel surfaces.



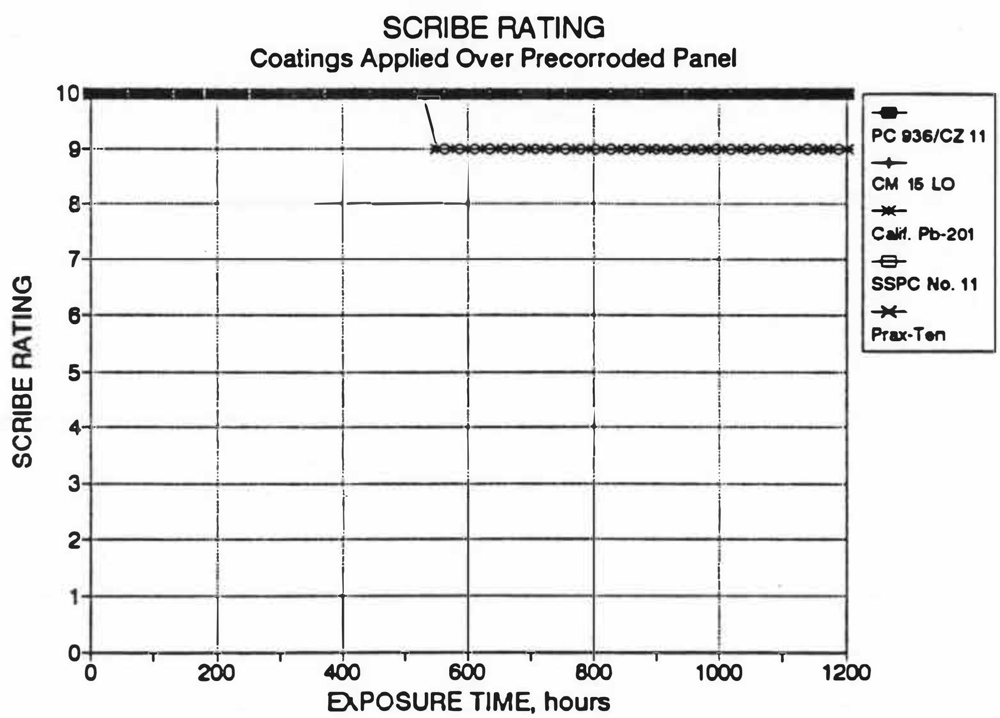


Figure 10 Scribe rating vs. exposure time in salt fog chamber for the five test coatings on **(a)** clean and **(b)** pre-corroded panel surfaces.

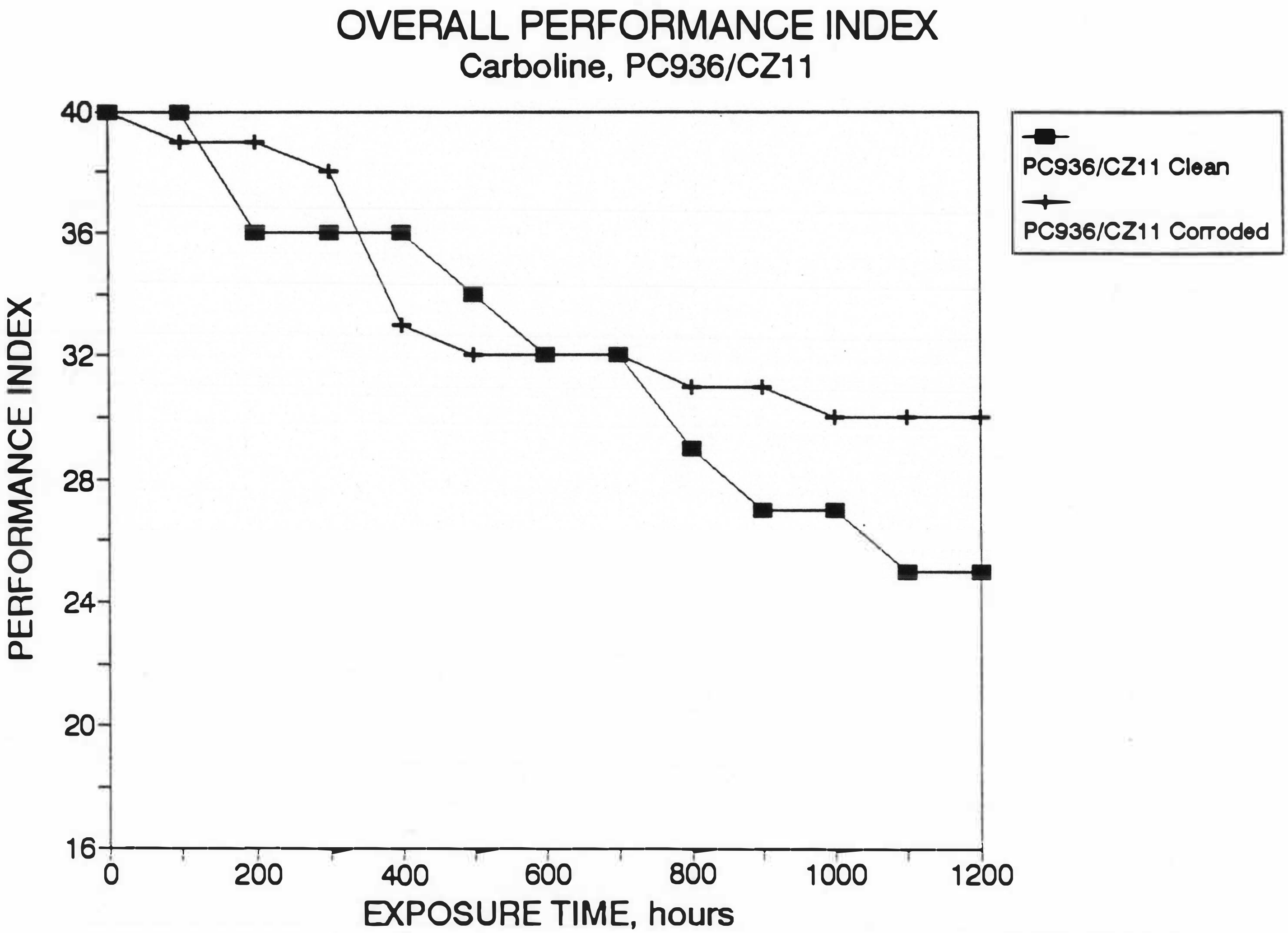


Figure 11 Performance Index vs. exposure time in salt fog chamber determined at 100 hour intervals for the Carboline PC936/CZ11 coating system. Comparison of performance on both clean and pre-corroded panel surfaces.

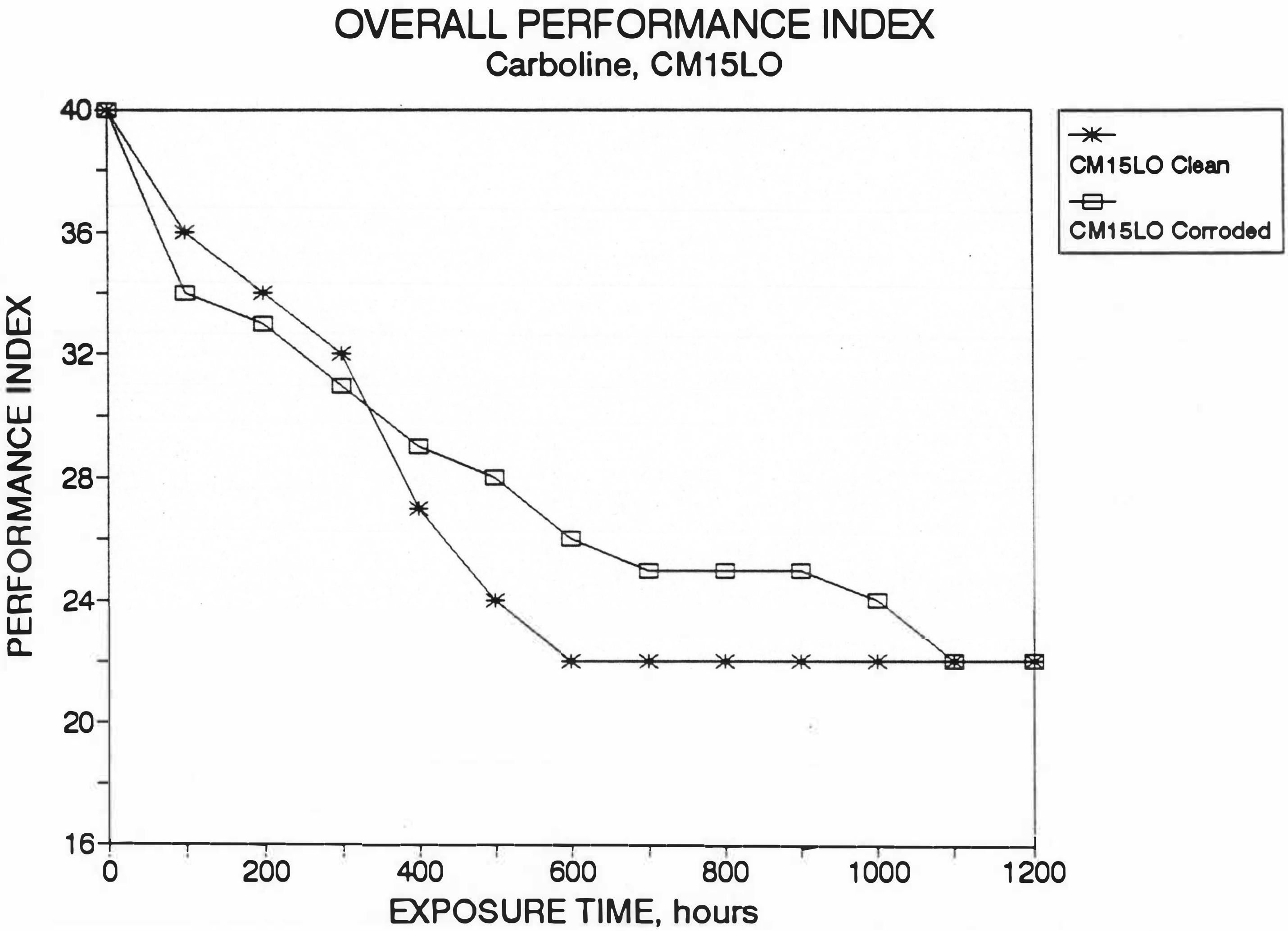


Figure 12 Performance Index vs. exposure time in salt fog chamber determined at 100 hour intervals for the Carboline CM15LO coating system. Comparison of performance on both clean and pre-corroded panel surfaces.

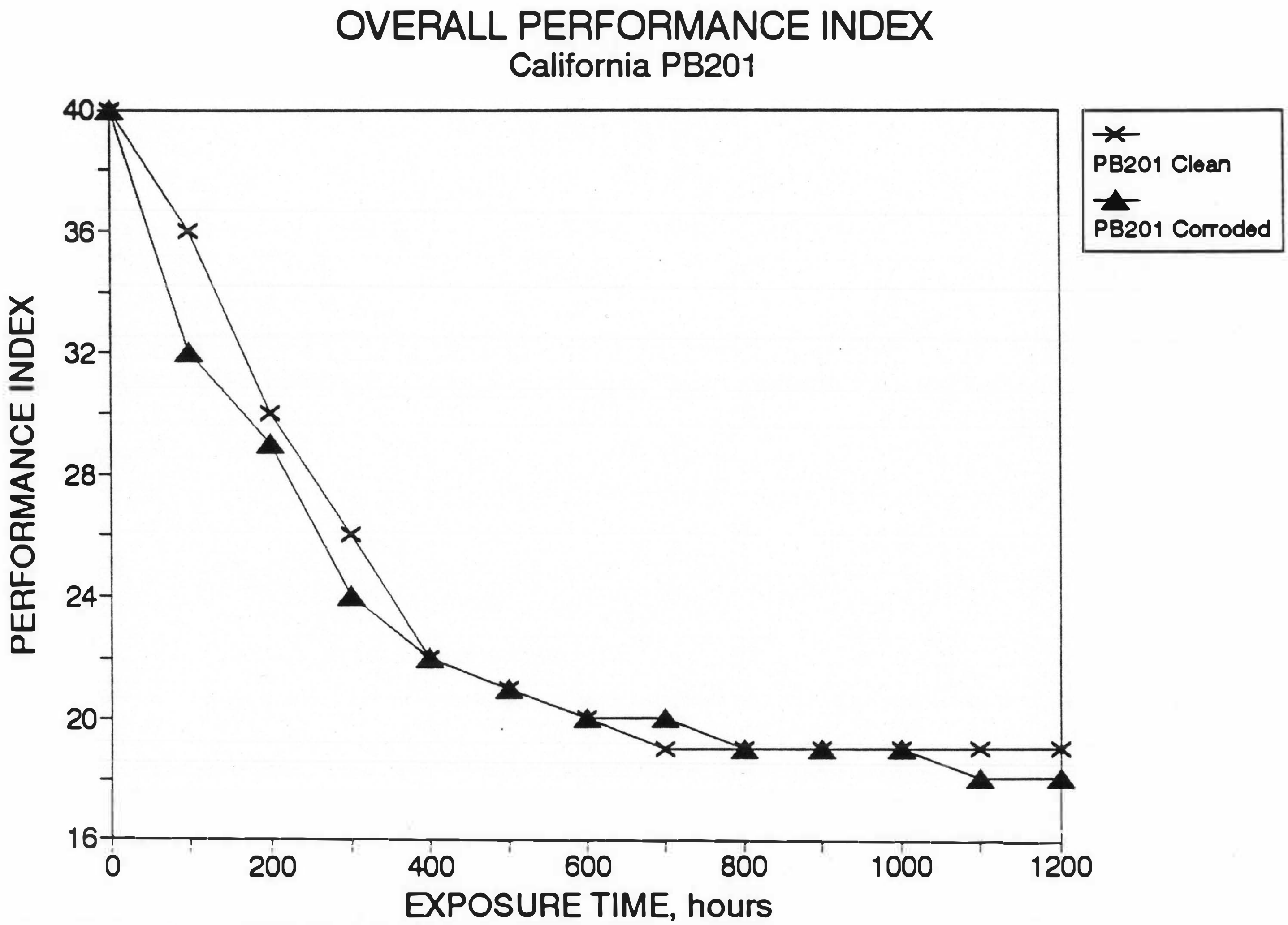


Figure 13 Performance Index vs. exposure time in salt fog chamber determined at 100 hour intervals for the California Pb-201 coating system. Comparison of performance on both clean and pre-corroded panel surfaces.

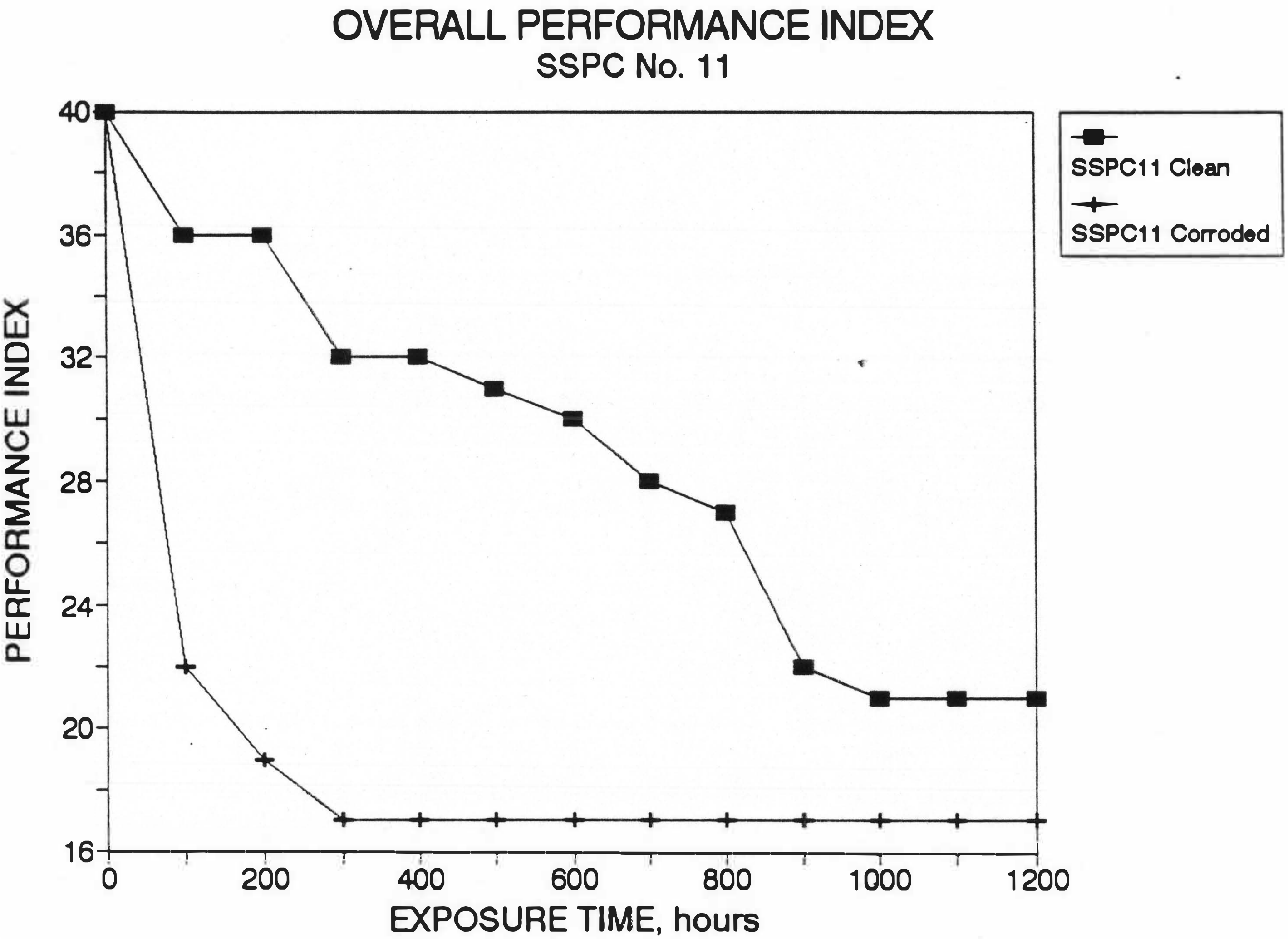


Figure 14 Performance Index vs. exposure time in salt fog chamber determined at 100 hour intervals for the SSPC No. 11 coating system. Comparison of performance on both clean and pre-corroded panel surfaces.

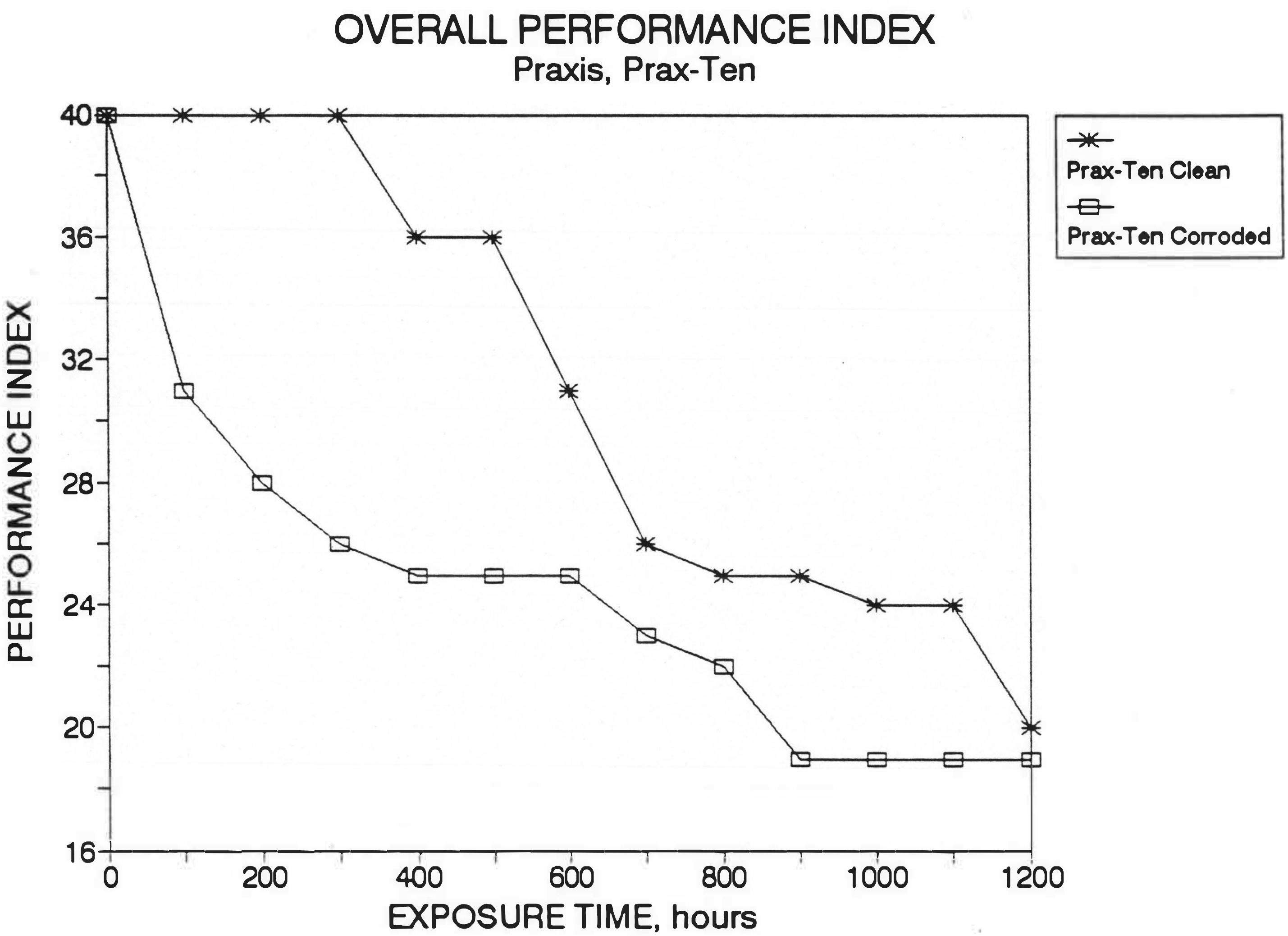


Figure 15 Performance Index vs. exposure time in salt fog chamber determined at 100 hour intervals for the Praxis, Prax-Ten coating system. Comparison of performance on both clean and pre-corroded panel surfaces.

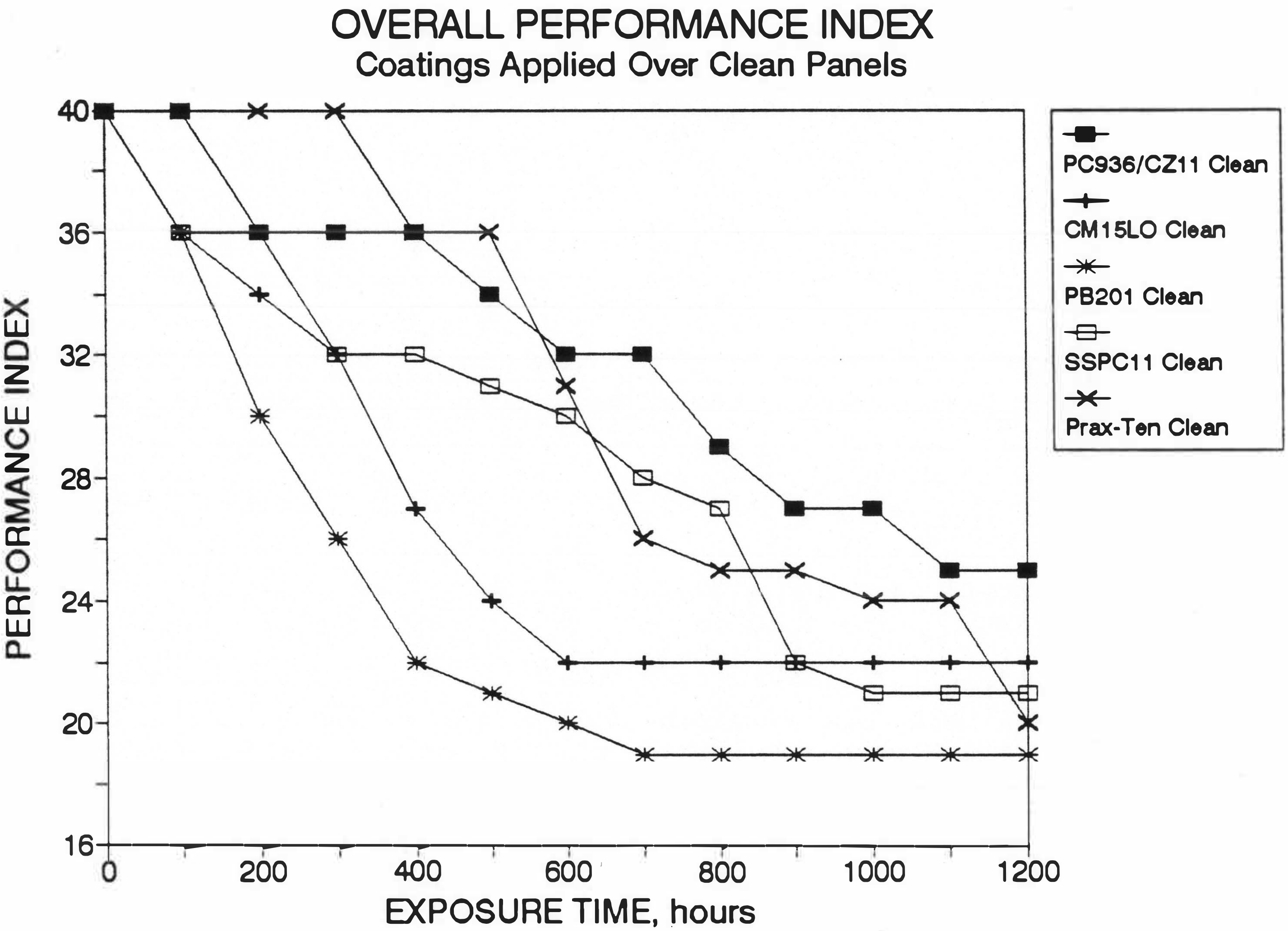


Figure 16 Performance Index vs. exposure time for the five coating systems in the second test series applied over clean panels.

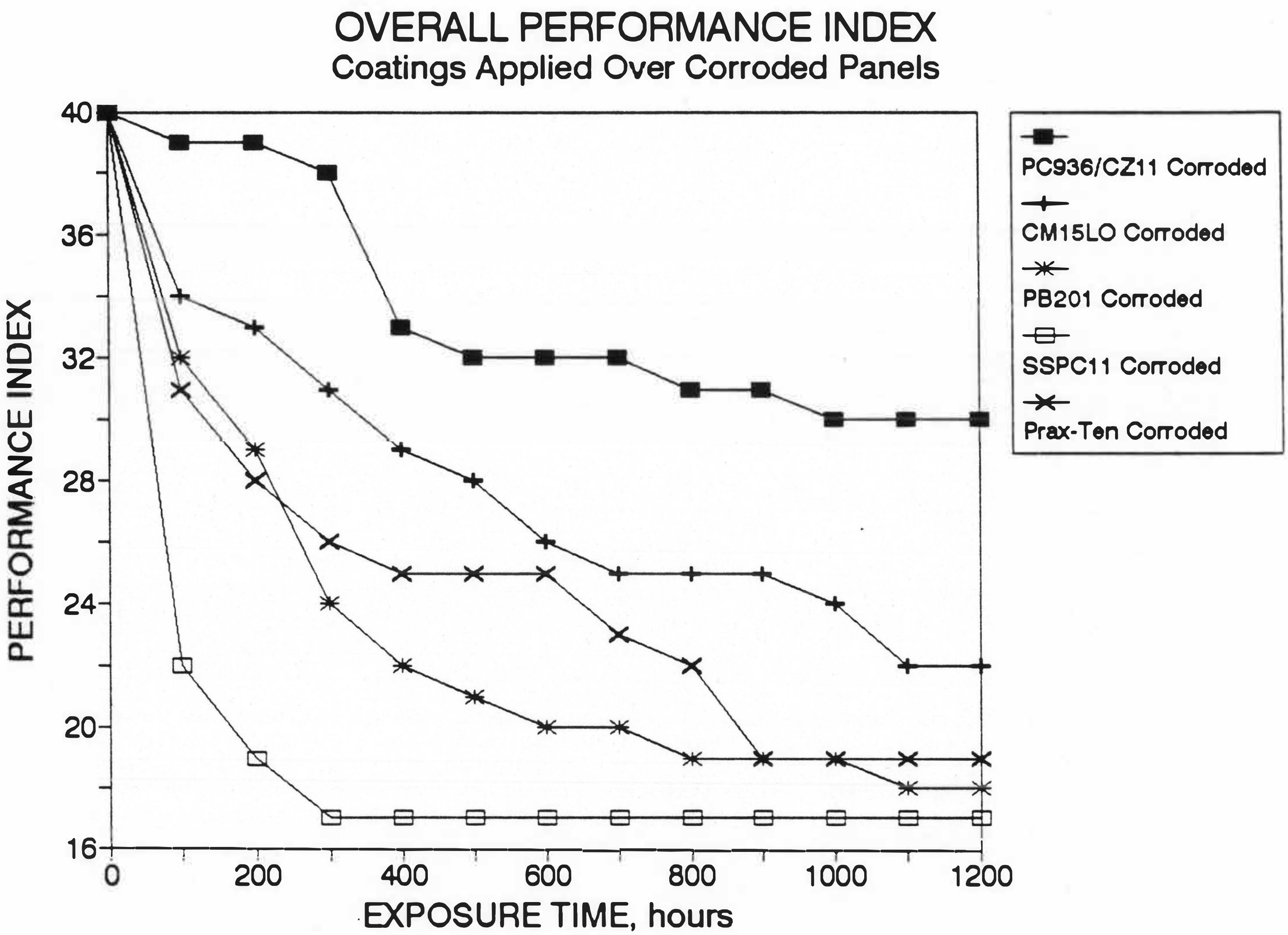


Figure 17 Performance Index vs. exposure time for the five coating systems in the second test series applied over pre-corroded panels.

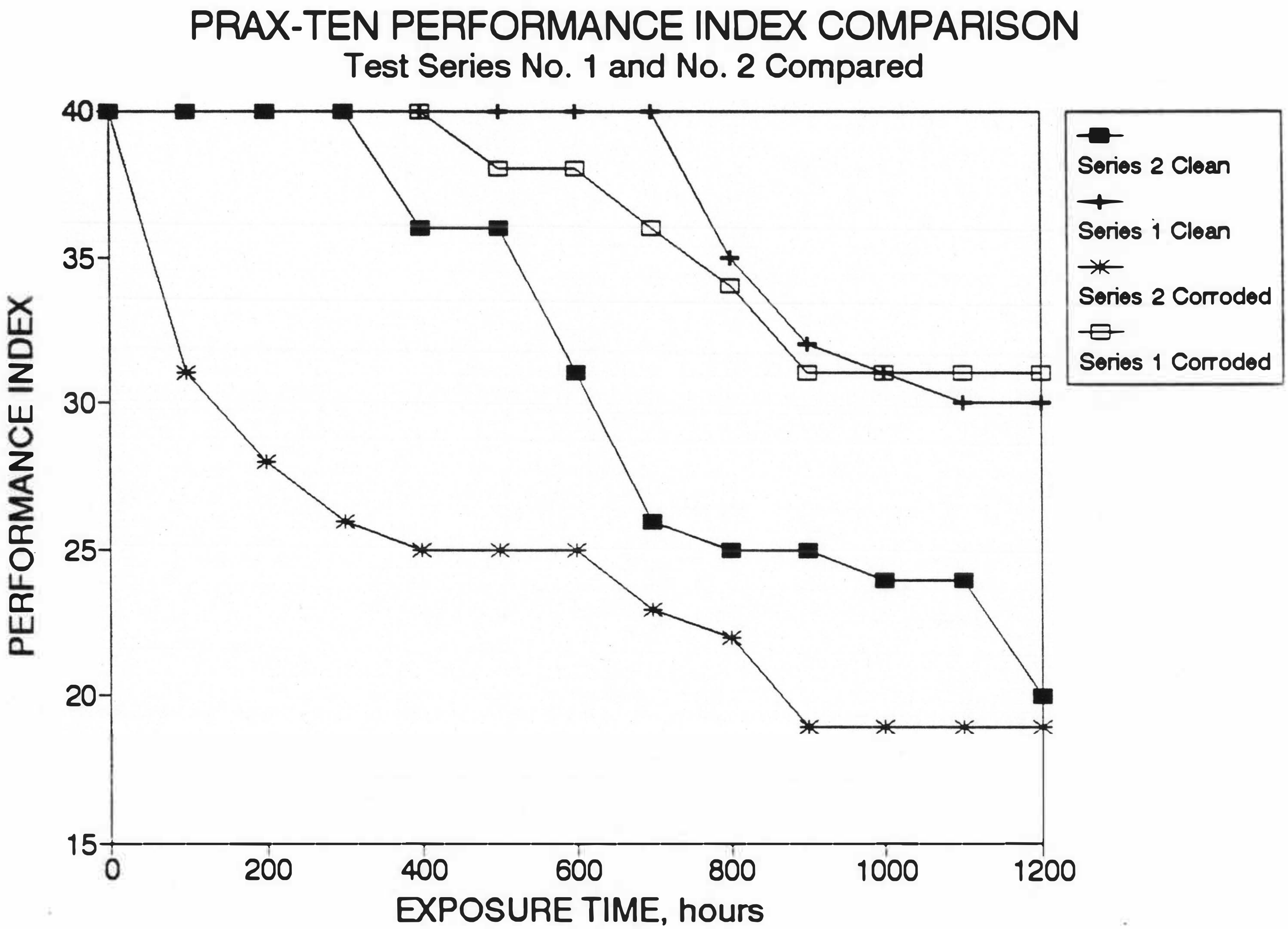


Figure 18 Comparison of series 1 and series 2 performance data for Prax-Ten coating system. Performance Index vs. exposure time for Prax-Ten coating system on both clean and pre-corroded test panels.

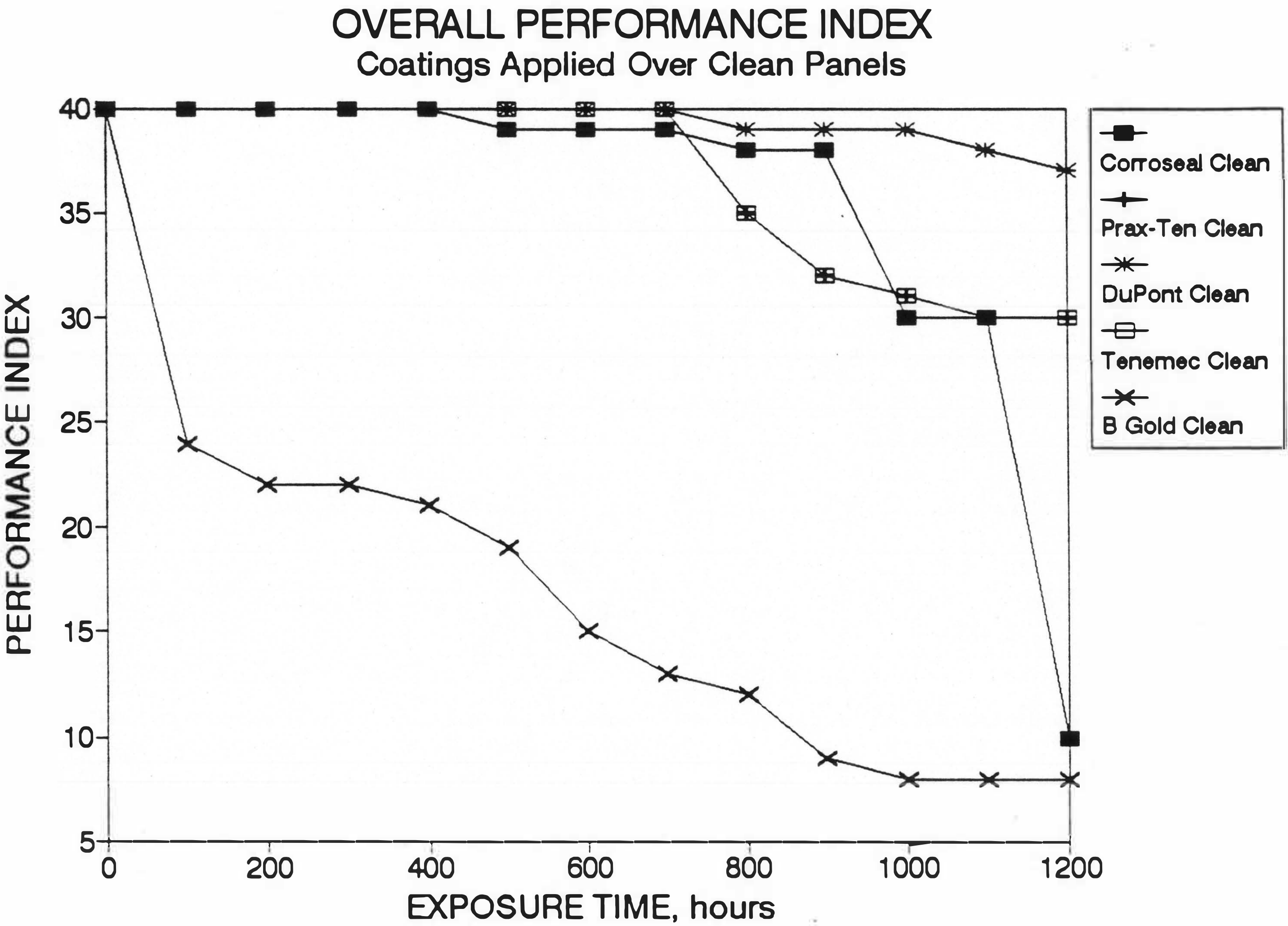


Figure 19 Performance Index vs. exposure time for the five coating systems in the first test series applied over clean panels.

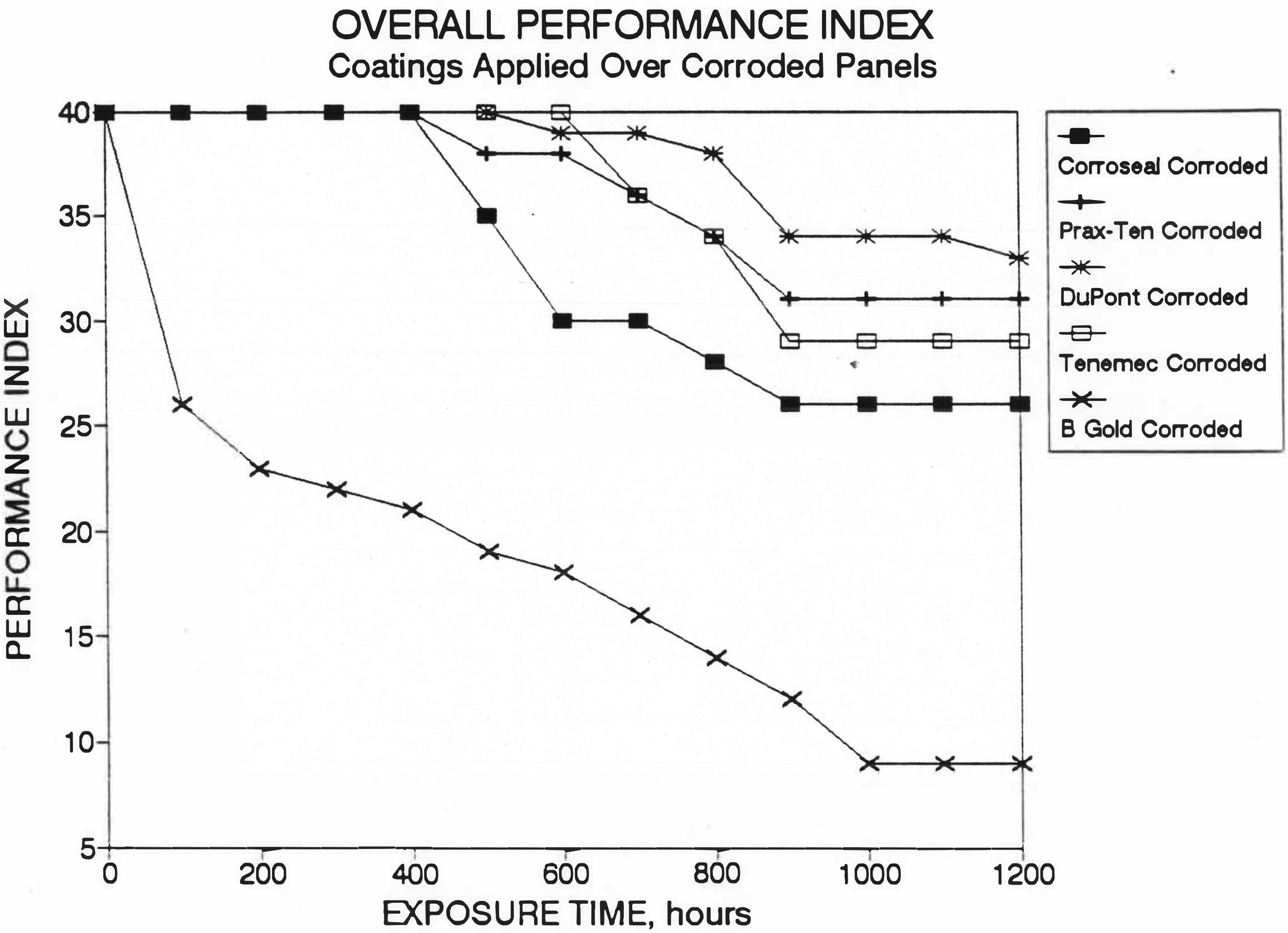


Figure 20 Performance Index vs. exposure time for the five coating systems in the first test series applied over clean panels.

APPENDIX A

COATING APPLICATION PROCEDURES

Coating System No. 1

Carboline CarboZinc 11, primer, with Polyclad 936, top coat

Primer requires: CarboZinc 11 Base
Zinc Filler
Thinner #26

Topcoat requires: Polyclad 936
Thinner #25

For mixing and thinning requirements, see specification sheets supplied with product.

Use one coat of primer, 2.0-3.0 mils dry film thickness. Allow a minimum of 24 hours at 60 ^{o}F before topcoating. Apply one coat of topcoat, 4.0 mils dry film thickness.

Coating System No. 2

Carboline Carbomastic 15, Low Odor

This is a self-priming, single coat system

Requirements: Carbomastic 15, Low Odor, Part A
Carbomastic 15, Low Odor, Part B
Thinner #10

For mixing and thinning requirements see specification sheet supplied with product.

Coating thickness 5 mils minimum, dry film thickness. Apply in one coat.

Coating System No. 3

State of California, Formula Pb-201

This is a Red, high solids phenolic type primer

Requirements: Primer appears to be ready mixed in one gallon can.

No mixing or thinning specifications provided.

Coating thickness 3 mils wet film thickness per coat.

Apply 2 coats. Drying time between coats 8 hours.

Coating System No. 4

Steel Structures Painting Council, Paint Specification No. 11

This is a red iron oxide, zinc chromate, raw linseed oil, and alkyd primer.

Requirements: Primer appears to be ready mixed in one gallon can.

No thinning should be required, but mineral spirits may be used if necessary, up to one pint of thinner per gallon of primer. See specification sheets.

Coating thickness not specified, so use minimum of 2 mils dry film thickness (3 mils wet film thickness).

Apply two coats. Drying time 24 hours.

Coating System No. 5

Praxis Technologies, Inc., Prax-Ten, Sulfonate Barrier Coating

This is one of the coatings used in the last set of tests.

Requirements: Penetrant
Concentrate

In previous tests penetrant was applied to 1 mil dry film thickness and concentrate was added as topcoat to 1 mil dry film thickness. We should try for 2 mil DFT per coat, if possible.

Drying times not indicated. Use 8 to 24 hours.

APPENDIX B

COATINGS APPLICATION SCHEDULE AND PANEL TREATMENTS

<u>Test Panel Requirements</u>

Forty test panels will be run in salt fog test:
- 20 pre-corroded panels
- 20 clean panels

Five coating systems will be evaluated:
- 4 pre-corroded panels per coating,
  - 2 scribed and 2 unscribed
- 4 clean panels per coating,
  - 2 scribed and 2 unscribed

<u>Reference Panels (coated but not tested)</u>

- 5 pre-corroded panels, 1 with each coating
- 10 clean panels, 2 with each coating,
  - 1 scribed and 1 unscribed

<u>Painting requirements (minimum number of panels needed)</u>

- 5 pre-corroded panels with each coating
  - 5 x 5 = 25 panels
- 6 clean panels with each coating
  - 6 x 5 = 30 panels

To allow for possible painting rejects, use:
- 35 pre-corroded panels
- 35 clean panels

APPENDIX C

COATING THICKNESSES

Dry film thicknesses of coatings used in this study.

Coating	Recommended Thickness (mils)	Applied Thickness (mils)
PC936/CZ11	6 - 7	2.4
CM15LO	5	2.1
Cal.Pb-201	6 (wet film)	1.5
SSPC No.11	4	1.0
Prax-Ten	2	2.3

Dry film thicknesses of coatings used in earlier study.

Coating	Recommended Thickness (mils)	Applied Thickness (mils)
Tenemec	9	16
Prax-Ten	2	7.2
Dupont 25P/Imron	8	28
Corroseal	2	14
Black Gold	<2	4.0

APPENDIX D

COATINGS IDENTIFIED BY TRAY POSITION IN SALT FOG CHAMBER

ROW	NON-SCRIBED		SCRIBED	
	A	B	C	D
1	PC936/CZ11 (P)		PC936/Cz11 (P)	
2		CM15LO		CM15LO
3	SSPC11 (P)		SSPC11 (P)	
4		Cal.Pb-201		Cal.Pb-201
5	CM15LO (P)		CM15LO (P)	
6		Prax-Ten (P)		Prax-Ten (P)
7	Cal.PB-201 (P)		Cal.Pb-201 (P)	
8		SSPC11 (P)		SSPC11 (P)
9	Prac-Ten		Prax-Ten	
10		PC936/CZ11 (P)		PC936/CZ11 (P)
11	SSPC11		SSPC11	
12		CM15LO (P)		CM15LO (P)
13	PC936/CZ11		PC936/CZ11	
14		Cal.Pb-201 (P)		Cal.Pb-201 (P)
15	Cal.Pb-201		Cal.Pb-201	
16		Prax-Ten		Prax-Ten
17	CM15LO		CM15LO	
18		SSPC11		SSPC11
19	Prax-Ten (P)		Prax-Ten (P)	
20		PC936/CZ11		PC936/CZ11

(P) Coating on pre-corroded panel.

APPENDIX E

EXPLANATION OF PANEL IDENTIFICATION NUMBERS

Panel ID Number	Tray Location Column	Tray Location Row	Pretreatment Panel	Pretreatment Coating
A1-CN	A	1	Clean	Non-scribed
B2-PN	B	2	Pre-corroded & hand tool cleaned	Non-scribed
C3-CS	C	3	Clean	Scribed
D4-PS	D	4	Pre-corroded & hand tool cleaned	Scribed

APPENDIX F

STANDARD COATING RATING SCALES

Standard	Scale	Description
ASTM D714-56	Size of Blister	
	10	No blister
	8	Pinpoint
	6	Pinpoint to 1/16 inch
	4	1/6 inch
	2	3/8 or larger
	Frequency of Blister	
	10	None
	8	Few
	6	Medium
	4	Medium-Dense
	2	Dense
ASTM D610-68	Rust Rating	
	10	No rusting or less than 0.01% of surface rusted
	9	Minute rusting, less than 0.03% of surface rusted
	8	Few isolated rust spots, less than 0.1% of surface rusted
	7	Less than 0.3% of surface rusted
	6	Extensive rust spots, bu less than 1% of surface rusted
	5	Rusting of the extent of 3% of surface rusted
	4	Rusting to the extent of 10% of surface rusted
	3	Approximately 1/6 of surface rusted
	2	Approximately 1/3 of surface rusted
	1	Approximately 1/2 of surface rusted
	0	Approximately 100% of surface rusted
ASTM D1654	Scribe Rating	Failure at Scribe, inch
	10	0
	9	0 - 1/64
	8	1/64 - 1/32
	7	1/32 - 1/16
	6	1/16 - 1/8
	5	1/8 - 3/16
	4	3/16 - 1/4
	3	1/4 - 3/8
	2	3/8 - 1/2
	1	1/2 - 5/8
	0	5/8 +

APPENDIX G

DAILY VISUAL OBSERVATIONS ON PANELS EXPOSED IN SALT FOG CHAMBER

DAILY VISUAL OBSERVATIONS OF PC 936/CZ11
CLEAN NON-SCRIBED PANELS

	CCZ 11 A13 CN			CCZ 11 B20 CN			AVERAGE CCZ11 CN		
TIME (HRS)	BL. SIZE	BL. FREQ	BL. RATE	BL. SIZE	BL. FREQ	BL. RATE	BL. SIZE	BL. FREQ	BL. RATE
0	10	10	10	10	10	10	10	10	10
24	10	10	10	10	10	10	10	10	10
48	10	10	10	10	10	10	10	10	10
72	10	10	10	10	10	10	10	10	10
96	10	10	10	10	10	10	10	10	10
120	8	8	10	10	10	10	8	8	10
144	8	8	10	8	8	10	8	8	10
168	8	8	10	8	8	10	8	8	10
192	8	8	10	8	8	10	8	8	10
216	8	8	10	8	8	10	8	8	10
240	8	8	10	8	8	10	8	8	10
264	8	8	10	8	8	10	8	8	10
288	8	8	10	8	8	10	8	8	10
312	8	8	10	8	6	10	8	8	10
336	8	8	10	8	6	10	8	8	10
360	8	8	10	8	6	10	8	8	10
384	6	8	9	8	6	10	8	8	10
408	6	8	9	8	6	10	8	8	10
432	6	8	9	8	6	10	6	8	10
456	6	8	9	8	6	10	6	8	10
480	6	8	9	8	6	10	6	8	10
504	6	8	9	6	6	10	6	8	10
528	6	8	9	6	6	10	6	8	10
552	6	8	9	6	6	10	6	6	10
576	6	8	9	6	6	10	6	6	10
600	6	8	9	6	6	10	6	6	10
624	6	8	9	6	6	10	6	6	10
648	6	8	9	6	6	10	6	6	10
672	6	8	9	6	6	10	6	6	10
696	4	8	9	6	6	10	6	6	10
720	4	8	9	6	6	10	6	6	10
744	4	8	9	6	6	10	6	6	9
768	4	6	9	6	6	10	4	6	9
792	4	6	9	6	6	10	4	6	9
816	4	6	9	4	6	10	4	6	9
840	2	6	9	4	6	10	4	6	9
864	2	6	9	4	6	10	4	6	9
888	2	6	9	4	6	10	4	6	9
912	2	6	9	4	6	10	2	6	9
936	2	6	9	4	6	10	2	6	9
960	2	6	9	2	6	10	2	6	9
984	2	6	9	2	6	10	2	6	9
1008	2	6	9	2	6	10	2	6	9
1032	2	6	9	2	6	10	2	6	9
1056	2	6	9	2	6	10	2	6	9
1080	2	6	9	2	6	10	2	6	9
1104	2	4	9	2	6	10	2	4	9
1128	2	4	9	2	6	10	2	4	9
1152	2	4	9	2	6	10	2	4	9
1176	2	4	9	2	6	10	2	4	9
1200	2	4	9	2	6	10	2	4	9

DAILY VISUAL OBSERVATIONS OF PC 936/CZ11
PRE-CORRODED NON-SCRIBED PANELS

	CCZ 11 A1 PN			CCZ 11 B10 PN			AVERAGE CCZ11 PN		
TIME (HRS)	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE
0	10	10	10	10	10	10	10	10	10
24	10	10	9	10	10	9	10	10	9
48	10	10	9	10	10	9	10	10	9
72	10	10	9	10	10	9	10	10	9
96	10	10	9	10	10	9	10	10	9
120	10	10	9	10	10	9	10	10	9
144	10	10	9	10	10	9	10	10	9
168	10	10	9	10	10	9	10	10	9
192	10	10	9	8	8	9	10	10	9
216	10	10	9	8	8	9	10	10	9
240	10	10	9	8	8	9	10	10	9
264	10	10	8	8	8	9	10	10	9
288	10	10	8	8	8	9	10	10	8
312	10	10	8	8	8	9	10	10	8
336	10	10	8	8	8	8	10	10	8
360	10	10	7	8	8	8	8	8	8
384	10	10	7	8	8	8	8	8	7
408	10	10	6	8	8	7	8	8	7
432	10	10	6	8	8	7	8	8	7
456	10	10	6	8	8	7	8	8	7
480	10	10	6	8	8	7	8	8	6
504	10	10	6	8	8	7	8	8	6
528	10	10	6	8	8	6	8	8	6
552	8	8	6	8	8	6	8	8	6
576	8	8	6	8	8	6	8	8	6
600	8	8	6	8	8	6	8	8	6
624	8	8	6	8	8	6	8	8	6
648	8	8	6	8	8	6	8	8	6
672	8	8	6	8	8	6	8	8	6
696	8	8	6	8	8	6	8	8	6
720	8	8	6	8	8	6	8	8	6
744	8	8	5	8	8	6	8	8	6
768	8	8	5	8	8	6	8	8	6
792	8	8	5	8	8	6	8	8	5
816	8	8	5	8	8	6	8	8	5
840	8	8	5	8	8	5	8	8	5
864	8	8	5	8	8	5	8	8	5
888	8	8	5	8	8	5	8	8	5
912	8	8	5	8	8	5	8	8	5
936	8	8	5	8	8	5	8	8	5
960	8	8	4	8	8	5	8	8	5
984	8	8	4	8	8	5	8	8	5
1008	8	8	4	8	8	5	8	8	4
1032	8	8	4	8	8	4	8	8	4
1056	8	8	4	8	8	4	8	8	4
1080	8	8	4	8	8	4	8	8	4
1104	8	8	4	8	8	4	8	8	4
1128	8	8	4	8	8	4	8	8	4
1152	8	8	4	8	8	4	8	8	4
1176	8	8	4	8	8	4	8	8	4
1200	8	8	4	8	8	4	8	8	4

DAILY VISUAL OBSERVATIONS OF PC 936/CZ11
CLEAN AND PRE-CORR. SCRIBED PANELS

	CCZ 11 C13 CS	CCZ 11 D20 CS	AVE. CCZ CS	CCZ 11 C1 PS	CCZ 11 D10 PS	AVE. CCZ PS
TIME (HRS)	SC. RATE	SC. RATE	SC. RATE	SC. RATE	SC. RATE	SC. RATE
0	10	10	10	10	10	10
24	10	10	10	10	10	10
48	10	10	10	10	10	10
72	10	10	10	10	10	10
96	10	10	10	10	10	10
120	10	10	10	10	10	10
144	10	10	10	10	10	10
168	10	10	10	10	10	10
192	10	10	10	10	10	10
216	10	10	10	10	10	10
240	10	10	10	10	10	10
264	10	10	10	10	10	10
288	10	10	10	10	10	10
312	10	10	10	10	10	10
336	10	10	10	10	10	10
360	10	10	10	10	10	10
384	10	10	10	10	10	10
408	10	10	10	10	10	10
432	10	10	10	10	10	10
456	10	10	10	10	10	10
480	10	10	10	10	10	10
504	10	10	10	10	10	10
528	10	10	10	10	10	10
552	10	10	10	10	10	10
576	10	10	10	10	10	10
600	10	10	10	10	10	10
624	10	10	10	10	10	10
648	10	10	10	10	10	10
672	10	10	10	10	10	10
696	10	10	10	10	10	10
720	10	10	10	10	10	10
744	10	10	10	10	10	10
768	10	10	10	10	10	10
792	10	10	10	10	10	10
816	10	10	10	10	10	10
840	10	10	10	10	10	10
864	10	10	10	10	10	10
888	10	10	10	10	10	10
912	10	10	10	10	10	10
936	10	10	10	10	10	10
960	10	10	10	10	10	10
984	10	10	10	10	10	10
1008	10	10	10	10	10	10
1032	10	10	10	10	10	10
1056	10	10	10	10	10	10
1080	10	10	10	10	10	10
1104	10	10	10	10	10	10
1128	10	10	10	10	10	10
1152	10	10	10	10	10	10
1176	10	10	10	10	10	10
1200	10	10	10	10	10	10

DAILY VISUAL OBSERVATIONS OF CM 15LO
CLEAN AND NON-SCRIBED PANELS

	CC 15 A17 CN			CC15 B2 CN			AVERAGE CC15 CN		
TIME (HRS)	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE
0	10	10	10	10	10	10	10	10	10
24	10	10	10	10	10	10	10	10	10
48	10	10	10	10	10	10	10	10	10
72	8	8	10	8	8	10	8	8	10
96	8	8	10	8	8	10	8	8	10
120	8	8	10	8	8	10	8	8	10
144	8	8	10	8	8	10	8	8	10
168	8	8	10	8	8	10	8	8	10
192	6	8	10	6	8	10	6	8	10
216	6	8	10	6	8	10	6	8	10
240	6	8	10	6	8	10	6	8	10
264	6	8	10	6	8	10	6	8	10
288	6	8	10	6	8	10	6	8	10
312	6	8	10	4	8	10	4	8	10
336	4	8	10	4	8	10	4	8	10
360	4	6	10	4	8	10	4	6	10
384	4	6	10	2	6	10	4	6	10
408	2	6	9	2	6	10	2	6	9
432	2	6	9	2	6	9	2	6	9
456	2	6	9	2	6	9	2	6	9
480	2	4	8	2	6	9	2	6	8
504	2	4	8	2	6	8	2	4	8
528	2	4	8	2	4	8	2	4	8
552	2	4	8	2	4	8	2	4	8
576	2	2	8	2	4	8	2	4	8
600	2	2	8	2	2	8	2	2	8
624	2	2	8	2	2	8	2	2	8
648	2	2	8	2	2	8	2	2	8
672	2	2	8	2	2	8	2	2	8
696	2	2	8	2	2	8	2	2	8
720	2	2	8	2	2	8	2	2	8
744	2	2	8	2	2	8	2	2	8
768	2	2	8	2	2	8	2	2	8
792	2	2	8	2	2	8	2	2	8
816	2	2	8	2	2	8	2	2	8
840	2	2	8	2	2	8	2	2	8
864	2	2	8	2	2	8	2	2	8
888	2	2	8	2	2	8	2	2	8
912	2	2	8	2	2	8	2	2	8
936	2	2	8	2	2	8	2	2	8
960	2	2	8	2	2	8	2	2	8
984	2	2	8	2	2	8	2	2	8
1008	2	2	8	2	2	8	2	2	8
1032	2	2	8	2	2	8	2	2	8
1056	2	2	8	2	2	8	2	2	8
1080	2	2	8	2	2	8	2	2	8
1104	2	2	8	2	2	8	2	2	8
1128	2	2	8	2	2	8	2	2	8
1152	2	2	8	2	2	8	2	2	8
1176	2	2	8	2	2	8	2	2	8
1200	2	2	8	2	2	8	2	2	8

DAILY VISUAL OBSERVATIONS OF CM 15LO
PRE-CORR. NON-SCRIBED PANELS

	CC15 A5 PN			CC15 B12 PN			AVERAGE CC15 PN		
TIME (HRS)	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE
0	10	10	10	10	10	10	10	10	10
24	10	10	9	10	10	9	10	10	9
48	10	10	9	10	10	9	10	10	9
72	8	8	9	8	8	8	8	8	8
96	8	8	8	8	8	8	8	8	8
120	8	8	8	8	8	8	8	8	8
144	8	8	8	8	8	8	8	8	8
168	8	8	7	8	8	7	8	8	7
192	8	8	7	8	8	7	8	8	7
216	8	8	7	8	8	7	8	8	7
240	8	8	7	8	8	7	8	8	7
264	8	6	7	8	8	7	8	8	7
288	8	6	7	8	8	7	8	8	7
312	8	6	7	6	8	7	8	6	7
336	8	6	7	6	8	7	6	6	7
360	8	6	7	6	6	7	6	6	7
384	6	6	7	6	6	7	6	6	7
408	6	6	7	6	6	7	6	6	7
432	6	6	7	6	6	7	6	6	7
456	6	6	7	6	6	6	6	6	7
480	6	6	6	6	6	6	6	6	6
504	6	4	6	6	6	6	6	6	6
528	6	4	6	6	6	6	6	6	6
552	6	4	6	6	6	6	6	4	6
576	6	4	6	6	6	6	6	4	6
600	6	4	6	6	4	5	6	4	6
624	6	4	6	6	4	5	6	4	5
648	6	4	5	6	4	5	6	4	5
672	6	4	5	6	4	5	6	4	5
696	6	4	5	6	4	5	6	4	5
720	6	4	5	6	4	5	6	4	5
744	6	4	5	6	4	5	6	4	5
768	6	4	5	6	4	5	6	4	5
792	6	4	5	6	4	5	6	4	5
816	6	4	5	6	4	5	6	4	5
840	6	4	5	6	4	5	6	4	5
864	6	4	5	6	4	5	6	4	5
888	6	4	4	6	4	5	6	4	5
912	6	4	4	6	4	5	6	4	5
936	6	4	4	6	4	5	6	4	4
960	6	4	4	6	4	4	6	4	4
984	6	4	4	6	4	4	6	4	4
1008	6	4	4	6	4	4	6	4	4
1032	4	4	4	4	4	4	4	4	4
1056	4	4	4	4	4	4	4	4	4
1080	4	4	4	4	4	4	4	4	4
1104	4	4	4	4	4	4	4	4	4
1128	4	4	4	4	4	4	4	4	4
1152	4	4	4	4	4	4	4	4	4
1176	4	4	4	4	4	4	4	4	4
1200	4	4	4	4	4	4	4	4	4

DAILY VISUAL OBSERVATIONS OF CM 15LO
CLEAN AND PRE-CORRODED SCRIBED PANELS

	CC15 C17 CS	CC 15 D2 CS	AVE. CC CS	CC 15 C5 PS	CC 15 D12 PS	AVERAG CC15 P
TIME (HRS)	SC. RATE	SC. RATE	SC. RATE	SC. RATE	SC. RATE	SC. RATE
0	10	10	10	10	10	10
24	10	10	10	10	10	10
48	10	10	10	10	10	10
72	10	10	10	10	10	10
96	10	10	10	10	10	10
120	10	10	10	10	10	10
144	10	10	10	10	10	10
168	10	10	10	10	10	10
192	10	10	10	10	10	10
216	10	10	10	10	10	10
240	10	10	10	10	10	10
264	10	10	10	10	10	10
288	10	10	10	10	10	10
312	10	10	10	10	10	10
336	10	10	10	10	10	10
360	10	10	10	10	10	10
384	10	10	10	10	10	10
408	10	10	10	10	10	10
432	10	10	10	10	10	10
456	10	10	10	10	10	10
480	10	10	10	10	10	10
504	10	10	10	10	10	10
528	10	10	10	10	10	10
552	10	10	10	10	10	10
576	10	10	10	10	10	10
600	10	10	10	10	10	10
624	10	10	10	10	10	10
648	10	10	10	10	10	10
672	10	10	10	10	10	10
696	10	10	10	10	10	10
720	10	10	10	10	10	10
744	10	10	10	10	10	10
768	10	10	10	10	10	10
792	10	10	10	10	10	10
816	10	10	10	10	10	10
840	10	10	10	10	10	10
864	10	10	10	10	10	10
888	10	10	10	10	10	10
912	10	10	10	10	10	10
936	10	10	10	10	10	10
960	10	10	10	10	10	10
984	10	10	10	10	10	10
1008	10	10	10	10	10	10
1032	10	10	10	10	10	10
1056	10	10	10	10	10	10
1080	10	10	10	10	10	10
1104	10	10	10	10	10	10
1128	10	10	10	10	10	10
1152	10	10	10	10	10	10
1176	10	10	10	10	10	10
1200	10	10	10	10	10	10

DAILY VISUAL OBSERVATIONS OF CALIF. PB-201
CLEAN AND NON-SCRIBED PANELS

	S. CAL A15 CN			S. CAL B4 CN			AVERAGE S.CAL CN		
TIME (HRS)	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE
0	10	10	10	10	10	10	10	10	10
24	10	10	10	10	10	10	10	10	10
48	10	10	10	10	10	10	10	10	10
72	8	8	10	8	8	10	8	8	10
96	8	8	10	2	8	10	8	8	10
120	8	8	10	2	8	10	2	8	10
144	2	8	10	2	8	10	2	8	10
168	2	8	10	2	8	10	2	8	10
192	2	8	10	2	8	10	2	8	10
216	2	8	10	2	8	10	2	8	10
240	2	8	10	2	8	10	2	8	10
264	2	6	10	2	6	10	2	6	10
288	2	6	10	2	6	10	2	6	10
312	2	4	10	2	4	10	2	4	10
336	2	4	10	2	4	10	2	4	10
360	2	2	10	2	4	10	2	2	10
384	2	2	9	2	2	9	2	2	9
408	2	2	9	2	2	8	2	2	9
432	2	2	8	2	2	8	2	2	8
456	2	2	8	2	2	8	2	2	8
480	2	2	8	2	2	8	2	2	8
504	2	2	8	2	2	7	2	2	8
528	2	2	8	2	2	7	2	2	7
552	2	2	7	2	2	7	2	2	7
576	2	2	7	2	2	7	2	2	7
600	2	2	7	2	2	6	2	2	7
624	2	2	7	2	2	6	2	2	6
648	2	2	6	2	2	6	2	2	6
672	2	2	6	2	2	6	2	2	6
696	2	2	6	2	2	6	2	2	6
720	2	2	6	2	2	6	2	2	6
744	2	2	6	2	2	6	2	2	6
768	2	2	6	2	2	6	2	2	6
792	2	2	6	2	2	6	2	2	6
816	2	2	6	2	2	6	2	2	6
840	2	2	6	2	2	6	2	2	6
864	2	2	6	2	2	6	2	2	6
888	2	2	6	2	2	6	2	2	6
912	2	2	6	2	2	6	2	2	6
936	2	2	6	2	2	6	2	2	6
960	2	2	5	2	2	5	2	2	5
984	2	2	5	2	2	5	2	2	5
1008	2	2	5	2	2	5	2	2	5
1032	2	2	5	2	2	5	2	2	5
1056	2	2	5	2	2	5	2	2	5
1080	2	2	5	2	2	5	2	2	5
1104	2	2	5	2	2	5	2	2	5
1128	2	2	5	2	2	5	2	2	5
1152	2	2	5	2	2	5	2	2	5
1176	2	2	5	2	2	5	2	2	5
1200	2	2	5	2	2	5	2	2	5

DAILY VISUAL OBSERVATIONS OF CALIF. PB-201
PRE-CORRODED AND NON-SCRIBED PANELS

	S. CAL A7 PN			S. CAL B14 PN			AVERAGE S.CAL PN		
TIME (HRS)	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE
0	10	10	10	10	10	10	10	10	10
24	10	10	9	10	10	9	10	10	9
48	8	8	9	8	8	9	8	8	9
72	8	8	9	8	8	9	8	8	9
96	8	6	8	6	6	9	8	6	8
120	8	6	7	6	6	8	8	6	7
144	8	6	7	6	6	7	6	6	7
168	6	6	7	6	6	7	6	6	7
192	6	4	7	6	6	7	6	6	7
216	6	2	7	6	6	7	6	4	7
240	6	2	6	6	4	7	6	4	6
264	6	2	6	4	4	6	6	4	6
288	6	2	6	4	4	6	6	4	6
312	6	2	6	4	4	6	6	2	6
336	6	2	6	4	4	6	4	2	6
360	6	2	6	4	4	6	4	2	6
384	6	2	6	4	4	6	4	2	6
408	4	2	6	4	2	6	4	2	6
432	4	2	6	4	2	6	4	2	6
456	4	2	5	4	2	6	4	2	6
480	4	2	5	4	2	6	4	2	5
504	4	2	5	4	2	5	4	2	5
528	4	2	5	4	2	5	4	2	5
552	4	2	5	4	2	5	4	2	5
576	4	2	5	4	2	5	4	2	5
600	4	2	5	4	2	5	4	2	5
624	4	2	5	4	2	5	4	2	5
648	4	2	5	4	2	5	4	2	5
672	4	2	5	4	2	5	4	2	5
696	4	2	5	4	2	5	4	2	5
720	4	2	5	4	2	5	4	2	5
744	4	2	5	4	2	5	4	2	5
768	4	2	4	4	2	5	4	2	5
792	4	2	4	4	2	5	4	2	4
816	4	2	4	4	2	5	4	2	4
840	4	2	4	4	2	4	4	2	4
864	4	2	4	4	2	4	4	2	4
888	4	2	4	4	2	4	4	2	4
912	4	2	4	4	2	4	4	2	4
936	4	2	4	4	2	4	4	2	4
960	4	2	4	4	2	4	4	2	4
984	4	2	4	4	2	4	4	2	4
1008	4	2	4	4	2	4	4	2	4
1032	4	2	4	4	2	4	4	2	4
1056	4	2	4	4	2	4	4	2	4
1080	4	2	3	4	2	4	4	2	3
1104	4	2	3	4	2	3	4	2	3
1128	4	2	3	4	2	3	4	2	3
1152	4	2	3	4	2	3	4	2	3
1176	4	2	3	4	2	3	4	2	3
1200	4	2	3	4	2	3	4	2	3

DAILY VISUAL OBSERVATIONS OF CALIF.PB-201
CLEAN AND PRE-CORRODED SCRIBED PANELS

	S. CAL C15 CS	S. CAL D4 CS	AVE. S.CAL	S. CAL C7 PS	S. CAL D14 PS	AVE. S.CAL
TIME (HRS)	SC. RATE	SC. RATE	SC. RATE	SC. RATE	SC. RATE	SC. RATE
0	10	10	10	10	10	10
24	10	10	10	10	10	10
48	10	10	10	10	10	10
72	10	10	10	10	10	10
96	10	10	10	10	10	10
120	10	10	10	10	10	10
144	10	10	10	10	10	10
168	10	10	10	10	10	10
192	10	10	10	10	10	10
216	10	10	10	10	10	10
240	10	10	10	10	10	10
264	10	10	10	10	10	10
288	10	10	10	10	10	10
312	10	10	10	10	10	10
336	10	10	10	10	10	10
360	10	10	10	10	10	10
384	9	10	10	10	10	10
408	9	10	9	10	10	10
432	9	9	9	10	10	10
456	9	9	9	10	10	10
480	9	9	9	10	10	10
504	9	9	9	10	10	10
528	9	9	9	10	10	10
552	9	9	9	9	10	9
576	9	9	9	9	9	9
600	9	9	9	9	9	9
624	9	9	9	9	9	9
648	9	9	9	9	9	9
672	9	9	9	9	9	9
696	9	9	9	9	9	9
720	9	9	9	9	9	9
744	9	9	9	9	9	9
768	9	9	9	9	9	9
792	9	9	9	9	9	9
816	9	9	9	9	9	9
840	9	9	9	9	9	9
864	9	9	9	9	9	9
888	9	9	9	9	9	9
912	9	9	9	9	9	9
936	9	9	9	9	9	9
960	9	9	9	9	9	9
984	9	9	9	9	9	9
1008	9	9	9	9	9	9
1032	9	9	9	9	9	9
1056	9	9	9	9	9	9
1080	9	9	9	9	9	9
1104	9	9	9	9	9	9
1128	9	9	9	9	9	9
1152	9	9	9	9	9	9
1176	9	9	9	9	9	9
1200	9	9	9	9	9	9

DAILY VISUAL OBSERVATIONS OF SSPC NO. 11
CLEAN AND NON-SCRIBED PANELS

	S. OKL A11 CN			S.OKL B18 CN			AVERAGE S.OKL CN		
TIME (HRS)	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE
0	10	10	10	10	10	10	10	10	10
24	10	10	10	10	10	10	10	10	10
48	10	10	10	10	10	10	10	10	10
72	10	10	10	10	10	10	10	10	10
96	8	8	10	8	8	10	8	8	10
120	8	8	10	8	6	10	8	8	10
144	8	8	10	8	6	10	8	8	10
168	8	8	10	8	6	10	8	8	10
192	8	8	10	8	6	10	8	8	10
216	8	8	10	8	6	10	8	8	10
240	8	8	10	8	6	10	8	8	10
264	6	8	10	8	6	10	8	8	10
288	6	8	10	8	6	10	8	8	10
312	6	8	10	8	6	10	6	6	10
336	6	8	10	8	6	10	6	6	10
360	6	8	10	8	6	10	6	6	10
384	6	8	10	6	6	10	6	6	10
408	6	8	10	6	6	10	6	6	10
432	6	8	10	6	6	10	6	6	10
456	6	8	10	6	6	10	6	6	10
480	6	8	10	6	6	10	6	6	10
504	6	6	9	6	6	9	6	6	9
528	6	6	9	6	6	9	6	6	9
552	6	6	9	6	4	8	6	6	9
576	6	6	9	6	4	8	6	6	9
600	6	6	9	6	4	7	6	6	8
624	6	6	9	6	4	7	6	6	8
648	6	6	8	6	4	6	6	6	7
672	6	6	8	6	4	6	6	6	7
696	6	6	7	6	4	6	6	6	7
720	6	6	7	6	4	6	6	6	7
744	6	6	7	6	4	6	6	6	7
768	4	6	7	6	4	5	6	6	7
792	4	6	7	6	4	5	6	6	7
816	4	6	7	6	4	5	6	4	6
840	4	6	7	6	4	5	6	4	6
864	4	6	7	6	4	5	4	4	6
888	4	6	7	6	4	5	4	4	6
912	4	6	7	6	4	5	4	4	6
936	4	6	7	6	4	5	4	4	5
960	4	6	6	4	4	5	4	4	5
984	4	6	6	4	4	5	4	4	5
1008	4	6	6	4	4	5	4	4	5
1032	4	6	6	4	4	5	4	4	5
1056	4	6	6	4	4	5	4	4	5
1080	4	6	6	4	4	5	4	4	5
1104	4	4	5	4	4	5	4	4	5
1128	4	4	5	4	4	5	4	4	5
1152	4	4	5	4	4	5	4	4	5
1176	4	4	5	4	4	5	4	4	5
1200	4	4	5	4	4	5	4	4	5

DAILY VISUAL OBSERVATIONS OF SSPC NO. 11
PRE-CORR. NON-SCRIBED PANELS

	S.OKL A3 PN			S.OKL B8 PN			AVERAGE S.OKL PN		
TIME (HRS)	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE
0	10	10	10	10	10	10	10	10	10
24	8	4	6	8	6	5	8	6	5
48	8	4	3	8	6	3	8	6	3
72	8	4	2	6	6	2	8	4	2
96	8	4	2	6	4	2	6	4	2
120	6	4	1	6	4	1	6	4	1
144	6	4	1	4	4	1	6	4	1
168	6	4	1	4	4	1	6	4	1
192	6	4	1	4	4	1	4	4	1
216	4	2	1	4	4	1	4	4	1
240	4	2	1	4	2	1	4	2	1
264	4	2	1	4	2	1	4	2	1
288	4	2	1	4	2	1	4	2	1
312	4	2	1	4	2	1	4	2	1
336	4	2	1	4	2	1	4	2	1
360	4	2	1	4	2	1	4	2	1
384	4	2	1	4	2	1	4	2	1
408	4	2	1	4	2	1	4	2	1
432	4	2	1	4	2	1	4	2	1
456	4	2	1	4	2	1	4	2	1
480	4	2	1	4	2	1	4	2	1
504	4	2	1	4	2	1	4	2	1
528	4	2	1	4	2	1	4	2	1
552	4	2	1	4	2	1	4	2	1
576	4	2	1	4	2	1	4	2	1
600	4	2	1	4	2	1	4	2	1
624	4	2	1	4	2	1	4	2	1
648	4	2	1	4	2	1	4	2	1
672	4	2	1	4	2	1	4	2	1
696	4	2	1	4	2	1	4	2	1
720	4	2	1	4	2	1	4	2	1
744	4	2	1	4	2	1	4	2	1
768	4	2	1	4	2	1	4	2	1
792	4	2	1	4	2	1	4	2	1
816	4	2	1	4	2	1	4	2	1
840	4	2	1	4	2	1	4	2	1
864	4	2	1	4	2	1	4	2	1
888	4	2	1	4	2	1	4	2	1
912	4	2	1	4	2	1	4	2	1
936	4	2	1	4	2	1	4	2	1
960	4	2	1	4	2	1	4	2	1
984	4	2	1	4	2	1	4	2	1
1008	4	2	1	4	2	1	4	2	1
1032	4	2	1	4	2	1	4	2	1
1056	4	2	1	4	2	1	4	2	1
1080	4	2	1	4	2	1	4	2	1
1104	4	2	1	4	2	1	4	2	1
1128	4	2	1	4	2	1	4	2	1
1152	4	2	1	4	2	1	4	2	1
1176	4	2	1	4	2	1	4	2	1
1200	4	2	1	4	2	1	4	2	1

DAILY VISUAL OBSERVATIONS OF SSPC NO. 11
CLEAN AND PRE-CORRODED SCRIBED PANELS

	S. OKL C11 CS	S. OKL D18 CS	AVE. S.OKL	S. OKL C3 PS	S. OKL D8 PS	AVE. S.OKL
TIME (HRS)	SC. RATE	SC. RATE	SC. RATE	SC. RATE	SC. RATE	SC. RATE
0	10	10	10	10	10	10
24	10	10	10	10	10	10
48	10	10	10	10	10	10
72	10	10	10	10	10	10
96	10	10	10	10	10	10
120	10	10	10	10	10	10
144	10	10	10	10	10	10
168	10	10	10	10	10	10
192	10	10	10	10	10	10
216	10	10	10	10	10	10
240	10	10	10	10	10	10
264	10	10	10	10	10	10
288	10	10	10	10	10	10
312	10	10	10	10	10	10
336	10	10	10	10	10	10
360	10	10	10	10	10	10
384	10	10	10	10	10	10
408	10	10	10	10	10	10
432	10	10	10	10	10	10
456	10	10	10	10	10	10
480	10	10	10	10	10	10
504	10	10	10	10	10	10
528	10	10	10	10	10	10
552	10	10	10	10	10	10
576	10	10	10	10	10	10
600	10	10	10	10	10	10
624	10	10	10	10	10	10
648	10	10	10	10	10	10
672	10	10	10	10	10	10
696	9	10	10	10	10	10
720	9	10	9	10	10	10
744	8	9	9	10	10	10
768	8	9	8	10	10	10
792	8	8	8	10	10	10
816	8	8	8	10	10	10
840	8	8	8	10	10	10
864	8	8	8	10	10	10
888	8	8	8	10	10	10
912	8	8	8	10	10	10
936	8	8	8	10	10	10
960	8	8	8	10	10	10
984	8	8	8	10	10	10
1008	8	8	8	10	10	10
1032	8	8	8	10	10	10
1056	8	8	8	10	10	10
1080	8	8	8	10	10	10
1104	8	8	8	10	10	10
1128	8	8	8	10	10	10
1152	8	8	8	10	10	10
1176	8	8	8	10	10	10
1200	8	8	8	10	10	10

DAILY VISUAL OBSERVATIONS OF PRAX-TEN
CLEAN NON-SCRIBED PANELS

	PRAXIS A9 CN			PRAXIS B16 CN			AVERAGE PRAX CN		
TIME (HRS)	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE	BL. SIZE	BL. FREQ	RU. RATE
0	10	10	10	10	10	10	10	10	10
24	10	10	10	10	10	10	10	10	10
48	10	10	10	10	10	10	10	10	10
72	10	10	10	10	10	10	10	10	10
96	10	10	10	10	10	10	10	10	10
120	10	10	10	10	10	10	10	10	10
144	10	10	10	10	10	10	10	10	10
168	10	10	10	10	10	10	10	10	10
192	10	10	10	10	10	10	10	10	10
216	10	10	10	10	10	10	10	10	10
240	10	10	10	10	10	10	10	10	10
264	10	10	10	10	10	10	10	10	10
288	10	10	10	10	10	10	10	10	10
312	10	10	10	10	10	10	10	10	10
336	10	10	10	10	10	10	10	10	10
360	10	10	10	10	10	10	10	10	10
384	10	10	10	10	10	10	10	10	10
408	8	8	10	10	10	10	8	8	10
432	8	8	10	8	8	10	8	8	10
456	8	8	10	8	8	10	8	8	10
480	8	8	10	8	8	10	8	8	10
504	8	8	10	8	8	10	8	8	10
528	8	8	10	8	8	10	8	8	10
552	8	8	10	8	8	9	8	8	9
576	6	8	9	6	8	9	6	8	9
600	6	6	9	6	6	9	6	6	9
624	6	6	8	6	6	8	6	6	8
648	6	6	8	6	6	8	6	6	8
672	6	6	7	6	6	7	6	6	7
696	4	6	6	6	6	7	4	6	6
720	4	6	6	4	6	6	4	6	6
744	4	6	6	4	6	6	4	6	6
768	4	6	5	4	6	6	4	6	6
792	4	6	5	4	6	6	4	6	5
816	4	6	5	4	6	5	4	6	5
840	4	6	5	4	6	5	4	6	5
864	4	6	5	4	6	5	4	6	5
888	4	6	5	4	6	5	4	6	5
912	4	6	5	4	6	5	4	6	5
936	4	6	5	4	6	5	4	6	5
960	4	6	4	4	6	5	4	6	4
984	4	6	4	4	6	4	4	6	4
1008	4	6	4	4	6	4	4	6	4
1032	4	6	4	4	6	4	4	6	4
1056	4	6	4	4	6	4	4	6	4
1080	4	6	4	4	6	4	4	6	4
1104	4	6	4	4	6	4	4	6	4
1128	2	4	4	2	6	4	2	4	4
1152	2	4	4	2	4	4	2	4	4
1176	2	4	4	2	4	4	2	4	4
1200	2	4	4	2	4	4	2	4	4

DAILY VISUAL OBSERVATIONS OF PRAX-TEN
PRE-CORR. NON SCRIBED PANELS

TIME (HRS)	PRAXIS A19 PN BL. SIZE	PRAXIS A19 PN BL. FREQ	PRAXIS A19 PN RU. RATE	PRAXIS B6 PN BL. SIZE	PRAXIS B6 PN BL. FREQ	PRAXIS B6 PN RU. RATE	AVERAGE PRAX PN BL. SIZE	AVERAGE PRAX PN BL. FREQ	AVERAGE PRAX PN RU. RATE
0	10	10	10	10	10	10	10	10	10
24	8	8	9	8	8	9	8	8	9
48	8	8	9	8	8	9	8	8	9
72	8	8	9	8	8	9	8	8	9
96	6	6	9	8	8	9	6	6	9
120	6	6	9	6	6	9	6	6	9
144	4	6	9	6	6	9	4	6	9
168	4	6	9	4	6	8	4	6	8
192	4	6	8	4	6	8	4	6	8
216	4	6	8	4	6	8	4	6	8
240	4	6	8	4	6	8	4	6	8
264	2	6	8	2	6	8	2	6	8
288	2	6	8	2	6	8	2	6	8
312	2	6	8	2	6	8	2	6	8
336	2	6	8	2	6	8	2	6	8
360	2	6	8	2	6	7	2	6	8
384	2	6	8	2	6	7	2	6	7
408	2	6	7	2	6	7	2	6	7
432	2	6	7	2	6	7	2	6	7
456	2	6	7	2	6	7	2	6	7
480	2	6	7	2	6	7	2	6	7
504	2	6	7	2	6	7	2	6	7
528	2	6	7	2	6	7	2	6	7
552	2	6	7	2	6	7	2	6	7
576	2	6	7	2	6	7	2	6	7
600	2	6	7	2	6	7	2	6	7
624	2	6	7	2	6	6	2	6	6
648	2	6	6	2	6	6	2	6	6
672	2	6	6	2	6	5	2	6	6
696	2	6	6	2	6	5	2	6	5
720	2	6	5	2	6	5	2	6	5
744	2	6	5	2	6	5	2	6	5
768	2	6	5	2	6	4	2	6	4
792	2	6	4	2	6	4	2	6	4
816	2	6	3	2	6	3	2	6	3
840	2	6	2	2	6	3	2	6	2
864	2	6	2	2	6	2	2	6	2
888	2	6	1	2	6	2	2	6	1
912	2	6	1	2	6	1	2	6	1
936	2	6	1	2	6	1	2	6	1
960	2	6	1	2	6	1	2	6	1
984	2	6	1	2	6	1	2	6	1
1008	2	6	1	2	6	1	2	6	1
1032	2	6	1	2	6	1	2	6	1
1056	2	6	1	2	6	1	2	6	1
1080	2	6	1	2	6	1	2	6	1
1104	2	6	1	2	6	1	2	6	1
1128	2	6	1	2	6	1	2	6	1
1152	2	6	1	2	6	1	2	6	1
1176	2	6	1	2	6	1	2	6	1
1200	2	6	1	2	6	1	2	6	1

DAILY VISUAL OBSERVATIONS OF PRAX-TEN
CLEAN AND PRE-CORR. SCRIBED PANELS

	PRAXIS C9 CS	PRAXIS D16 CS	AVE. PRX CS	PRAXIS C19 PS	PRAXIS D6 PS	AVE. PRX PS
TIME (HRS)	SC. RATE	SC. RATE	SC. RATE	SC. RATE	SC. RATE	SC. RATE
0	10	10	10	10	10	10
24	10	10	10	10	10	10
48	10	10	10	10	10	10
72	10	10	10	10	10	10
96	10	10	10	10	10	10
120	10	10	10	10	10	10
144	10	10	10	10	10	10
168	10	10	10	10	10	10
192	10	10	10	10	10	10
216	10	10	10	10	10	10
240	10	10	10	10	10	10
264	10	10	10	10	10	10
288	10	10	10	10	10	10
312	10	10	10	10	10	10
336	10	10	10	10	10	10
360	10	10	10	10	10	10
384	10	10	10	10	10	10
408	10	10	10	10	10	10
432	10	10	10	10	10	10
456	10	10	10	10	10	10
480	10	10	10	10	10	10
504	10	10	10	10	10	10
528	10	10	10	10	10	10
552	10	10	10	10	10	10
576	10	10	10	10	10	10
600	10	10	10	10	10	10
624	10	10	10	10	10	10
648	10	10	10	10	10	10
672	10	10	10	10	10	10
696	10	10	10	10	10	10
720	10	10	10	10	10	10
744	10	10	10	10	10	10
768	10	10	10	10	10	10
792	10	10	10	10	10	10
816	10	10	10	10	10	10
840	10	10	10	10	10	10
864	10	10	10	10	10	10
888	10	10	10	10	10	10
912	10	10	10	10	10	10
936	10	10	10	10	10	10
960	10	10	10	10	10	10
984	10	10	10	10	10	10
1008	10	10	10	10	10	10
1032	10	10	10	10	10	10
1056	10	10	10	10	10	10
1080	10	10	10	10	10	10
1104	10	10	10	10	10	10
1128	10	10	10	10	10	10
1152	10	10	10	10	10	10
1176	10	10	10	10	10	10
1200	10	10	10	10	10	10