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Predicting Exterior Marine Performance of Coatings from Salt Fog: Two Types of Errors

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This article presents a brief description of the various approaches to determine long-term durability of coatings. Following the introduction, some data from SSPC's Performance of Alternate Coatings in the Environment (PACE) program are presented, comparing salt fog testing and exterior marine performance for several industrial maintenance coating systems. The analysis focuses on 2 types of errors that can occur when relying on salt fog: accepting poor coatings and rejecting good coatings. An alternate scheme for early prediction of performance is presented.

Determining Long-Term Coating Performance

There are several approaches for determining long-term durability, i.e., how well a coating performs in a long-term atmospheric exterior test.

Exterior Exposures

First, one can actually perform long-term testing by placing test panels on exposure in aggressive areas or by applying coatings to chemical storage tanks, bridges, or other facilities. Exterior testing is considered the most reliable means of determining long-term performance, although there are obvious disadvantages to the method, especially the time required to make the appropriate judgments.

Accelerated Approach

The second approach is to accelerate the degradation, commonly done with salt fog cabinets, humidity chambers, and ultraviolet light-condensation cabinets. Here, degradation (e.g., rusting, scribe undercutting, or blistering) will occur in a shorter time period, so in a matter of approximately 1,000 hours instead of 5 years, one can observe degradation. An important concern is whether or not that degradation reflects the degradation produced in an exterior environment.

Early Detection of Degradation

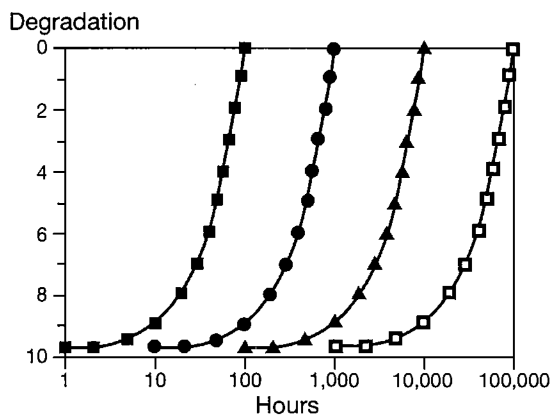
Another approach is to detect the degradation early, rather than waiting for conventional means of degradation such as rusting and blistering. A prime example is using electrochemical means for early detection of degradation. There are other types of tests including water permeability or other characteristics for detecting early degradation.

Early detection of degradation can also be achieved with quantitative visual evaluation of rusting or blistering. This technique examines the surface in detail rather than comparing the surface to an ASTM standard.

In addition, these 3 basic approaches, exterior exposures, accelerated degradation, and early detection of degradation, can also be combined.

Time Frames

What is the time frame for obtaining this information? The main reason long-term degradation is not always used is the length of time required for results. In exterior exposure, the time frame for degradation is in the tens of thousands of hours (Fig. 1). (Ten thousand



■ Fig. 1
Typical time frames for degradation

□ *Typical degradation rate based on rusting and undercutting in exterior*

▲ *Typical degradation rate based on rusting and undercutting in accelerated testing (e.g., salt fog) or early indicator (e.g., electrochemical response) in exterior*

● *Typical degradation rate based on early indicator in accelerated test*

■ *Degradation rate for new experimental test procedure (sought in future)*

Note:
1 month = 30 days = 720 hours
1 year = 8,760 hours

hours is a little over 1 year.) Degradation typically begins to occur between 30,000 and 50,000 hours (3 to 5 years). One order of magnitude less time (on the order of 1,000-2,000 hours) is what typically occurs when using an accelerated test, e.g., humidity testing, salt fog testing.

By using accelerated testing, one is able to reduce the time frame by about 1 order of magnitude. Of course, the question of the validity of the evaluation must still be addressed. Another way to reduce the magnitude is by using early degradation of the exterior exposures. Rather than looking at parameters like rust rating and blistering, which may not be evident for 3 to 5 years, there are perhaps some parameters (such as electrochemical response) that will be manifest in 1,000 to 3,000 hours of exterior exposure (a matter of months rather than years).

These are 2 ways to shorten the time frame. It may be possible to combine these 2 approaches, selecting an accelerated test that reduces the time by 1 order of magnitude and selecting a means of evaluating degradation that reduces this time by a second order of magnitude. That would result in a range of hundreds of hours. This would be a major advance if one could get valid information about coating performance in that time frame. Going even further, to the range of 10-50 hours, would be a very desirable goal, but currently there are few prospects for achieving that in a practical test.

The coatings industry is still struggling with the first order of magnitude, to get valid data within 1,000-2,000 hours. Perhaps as a long-term goal, we can aspire to obtain valid performance data in the 10- to 50-hour range.

Time to Failure versus Average Rating

The performance of coatings can be assessed and compared in several ways. Suppose one has a number of coating systems and wants to know how coating A compares to coating B.

■ Fig. 3
Five replicates showing variable undercutting (three-coat polyamide at approximately 4 years)

■ Fig. 2
Alkyd in marine, 5 replicates; average of 5 panels

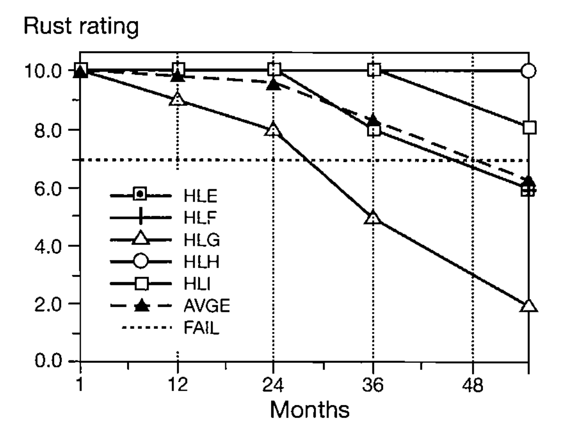


Table 1 Ratings and Rankings of Acrylic Coatings over SSPC-SP 2

Coating	Time to Failure[a] Salt Fog Hours	Time to Failure[a] Kure Months	Ranking[b,c] Salt Fog	Ranking[b,c] Kure
C-4	400	54	6	8
C-8	400	2	5	11
C-10	900	92	4	5
C-11	1,070	130+	2	3
C-12	1,070	130+	3	4
C-19	310	130+	8	2
C-20	50	130	11	1
C-23	350	92	7	6
C-24	1,070	92	1	7
C-27	200	2	9	10
C-35	70	4	10	9

[a] *Time for panels to reach a rust rating of 7 (SSPC-VIS 2/ASTM D 610)*

[b] *1 is best, 11 is worst*

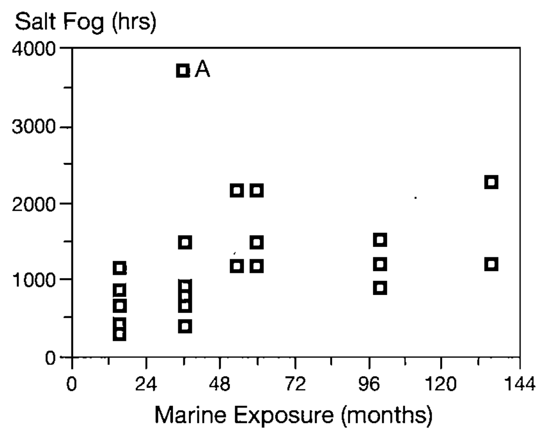
[c] *Where times to failure were equivalent, other factors were used, including time to reach 8 and 9 rust ratings and time to failure by scribe undercutting*

Two common approaches are the time to failure and the rating after a given time, for example, 36 months.[1]

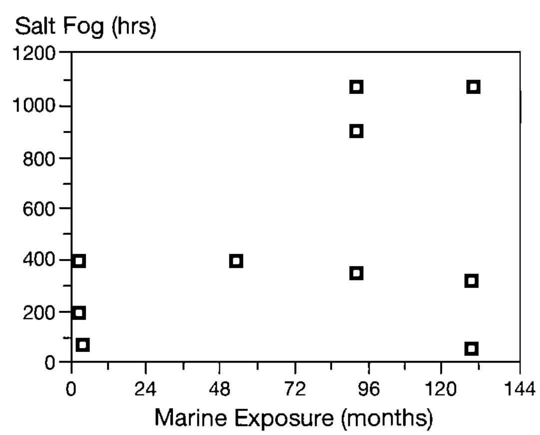
Time to failure is considered the superior method. Figure 2 shows rust ratings of an alkyd coating exposed in a marine environment. Five replicates were used. The data show quite a spread in performance among the replicates, which is typical. (See Fig. 3 of scribe undercutting of 5 replicate epoxy coating system.) The worst is the one with the triangle; the best one was perfect (10 rust rating) for the entire 54 months of the experiment, with the others ranging in between. The dashed line with the triangle is the average (the mean) of the five replicates.

These data help illustrate the difference between the average rating and the time to failure. As illustrated by the dotted horizontal line, when a failure is defined as 7 rust rating, which is very typical, the average time to failure is shown to be about 48 months. It is seen that the worst of the individual panels failed at about 28 months. This panel represented 1 out of 5 specimens, or 20 percent of the samples. If 20 percent of the surface fails within 28 months, that would be more significant than knowing that the average rating after 36 months was 8, or the average rating after 48 months was 6.

Information is needed on when to repaint the structure, not the "average" condition. This illustrates why SSPC typically uses time to failure as a measure of performance and why we think it is a more valuable parameter than the average rating after a given time period.



■ Fig. 4
PACE, Branch A, lead- and chromate-free oil/alkyd. Each point corresponds to a specific coating system. (E.g., for coating A, rust failure in salt fog occurred after 3,700 hours, and rust failure at marine exposure occurred after 36 months.)



■ Fig. 5
PACE, Branch C, acrylic over SSPC-SP 2. Each point corresponds to a specific coating system.

Comparing Salt Fog and Exterior Performance

The PACE program was completed in 1989, having started in 1976.[2] SSPC has produced a series of reports; the present data are derived from SSPC Reports 79-01 and 89-03.[2,3] The study included 8 branches, with each branch a complete experiment in itself.[3,4,5]

Linear Correlation of Alkyd Coatings over Blast-Cleaned Steel
It is of interest to examine correlations between the salt fog testing and the exterior exposure for selected groups of coatings.

The first group is a series of 20 lead- and chromate-free oil and alkyd coating systems applied over SSPC-SP 10. Coated panels were exposed in salt fog (ASTM B 117) for 8,000 hours and at the LaQue Center marine site at Kure Beach, NC (250-meter lot) for up to 12 years.

The coatings were evaluated for rusting and blistering in the salt spray and for rusting and scribe undercutting at the marine site. The parameter of interest here is the time for coatings failure by rusting (i.e., the time until the coating system deteriorates to a rust rating of 7 per SSPC-VIS 2 or ASTM D 610).

Figure 4 is a scattergram (i.e., a corre-

Table 2 Rejecting Good Coatings
Water-Borne Coatings Over SSPC-SP 2

Salt Fog Reject (<500 hours)	Kure Lifetime (Months)
C-4	54
C-89	2
C-19	>130
C-20	>130
C-23	92
C-25	41
C-27	2
C-33	8
C-35	4
Total 9	3 excellent 2 fair 4 poor

Table 3 Accepting Poor Coatings
Water-Borne Coatings Over SSPC-SP 2

Kure Reject (<36 Months)	Salt Fog Lifetime (hours)
C-2	1,070
C-5	1,840
C-7	1,840
C-8	400
C-13	1,840
C-14	1,070
C-22	2,400
C-27	200
C-31	2,400
C-33	720
C-35	4
Total 11	5 Excellent 2 Good 1 Fair 3 Poor

spondence diagram showing how data are scattered) of the time to failure in salt spray vs. the time to failure at Kure Beach for the group of alkyd coatings. The X axis is the number of months the panels were exposed at Kure Beach, running from 0 to 140. The Y axis is the number of hours the panels spent in the salt fog cabinet running from 0 to 8,000. The circles represent times to failure based on a rust rating of 7. There is a tremendous amount of scatter, which indicates that this is *not* a good correlation. Good correlation would be represented by a straight line.

The measure of correlation, known as R, is 0.32. R^2 is 0.10, which indicates the correlation is only accounting for about 10 percent of the variation. In other words, overall for the 20 lead- and chromate-free alkyd coatings, there is a very weak correlation between time to failure in salt spray and time to failure at Kure Beach.

Linear Correlation of Acrylic Coatings over Hand-Cleaned Steel

The next section describes some data derived from coatings applied over hand-cleaned steel in another study (Branch C) of the PACE program. In this branch, a variety of water-borne coatings was evaluated, including acrylics, styrene acrylics, and water-soluble alkyds. In addition, a number of oil-alkyd coating systems were used as controls. These were water-bornes available in 1976. The intent is not to show how the water-borne coatings performed compared to other coatings, but rather to show how the salt fog performance of water-bornes correlated with their exterior exposure.

An important point concerns the type of degradation observed and recorded. In the exterior exposure, rust and undercutting were recorded, but not blistering, because none was observed. In the salt fog, rusting and blistering were recorded, because both

Table 4 Rejecting Good Coatings *Water-Borne Coatings Over SSPC-SP 10*

Salt Fog Reject (<500 hours)	Kure Lifetime (Months)
C-8	>130
C-24	>130
C-25	>130
C-28	>130
C-33	15
C-35	111
Total 6	5 Excellent 1 Poor

Table 5 Accepting Poor Coatings *Water-Borne Coatings Over SSPC-SP 10*

Kure Reject (<36 Months)	Salt Fog Lifetime (hours)
C-5	>2,380
C-8	44, 0
C-22	>2,380
C-31	>2,380
C-33	24
Total 5	3 Excellent 1 Fair 1 Poor

modes of failure were observed. Therefore, there was an additional mode of failure in salt fog that did not occur in exterior exposures. In this set of correlations, only rust ratings were analyzed, so that the comparison would be "apples and apples."

Figure 5 plots the time to failure in salt fog vs. time to failure at Kure Beach for the series of acrylic water-bornes applied over hand-cleaned steel. The R^2 is 0.21, and the R about 0.46, indicating again a very poor correlation. These data and others illustrate the difficulty of assigning an acceleration factor (represented by the slope) to these 2 types of exposures.

Rank Correlation

An alternative approach to the linear regression model is to compare these 2 exposures in their ability to rank the coatings from best to worst. The most common type of rank correlation is Spearman Rank. Using a simple formula, one can compute a Spearman correlation coefficient, R_s. R_s ranges from -1 to +1, with +1 indicating perfect correlation, 0 indicating complete absence of correlation, and -1 indicating perfect negative correlation.

The ratings and ranking of the 11 acrylic coatings for salt fog and exterior exposure applied over SSPC-SP 2-prepared panels are shown in Table 1. It is seen that the rankings are quite different. The difference is reflected in the extremely low correlation coefficient of 0.016.

Types of Errors in Predicting Performance

What does this mean in terms of selecting coatings? Two types of errors can occur when performing accelerated testing:

- rejecting good coatings and
- accepting poor coatings.

It is obviously desirable to avoid either of these errors. Let's examine the data to see how successful salt fog testing is in avoiding these errors.

Table 2 analyzes data for the series of water-borne coatings over hand-cleaned steel. The first column lists coatings rejected by the salt fog test. It was decided arbitrarily that if a coating failed in less than 500 hours in the salt fog, the coating would be rejected. Nine of the 35 coatings in Branch C failed in less than 500 hours.

The second column indicates the lifetimes of these same coatings at the marine exposure site. Coating C-4 lasted 54 months and was considered "fair." Coating C-8 lasted only 2 months and is a failure. Two coatings, C-19 and C-20, lasted more than 130 months in the marine exposure, yet they failed the

Table 6 Comparison of Kure Rankings for Full and Reduced Exposure Time

Full Exposure Time (Months)	Reduced Exposure Time (Months)	Rust Failure Criterion[a]	Correlation Coefficient (Rs)
130	60	7	0.98[b]
130	48	7	0.89
130	36	7	0.85
130	24	7	0.73
130	60	8	0.98
130	48	8	0.95
130	36	8	0.91
130	24	8	0.80
130	1,200 hrs[c]	7	0.02

[a]*Coatings rated and ranked based on number of months until rust rating of 7(8) or less (SSPC-VIS 2/ASTM D 610) was reached. All coatings that remained at 7(8) or greater for the specified exposure time were ranked based on final rust ratings.*

[b]*This represents the Spearman rank correlation between Set A (35 water-borne coatings ranked at 130 months at marine site) vs. Set B (same 35 water-borne coatings ranked at 60 months at same marine site).*

[c]*Salt fog test*

salt fog cabinet test. Another (C-23) lasted 92 months (almost 8 years) in exterior exposure yet would have been rejected based on the salt fog test.

In summary, of the 9 coatings rejected in salt fog, 3 were excellent, 2 fair, and 4 poor. So the salt fog resulted in substantial error of the first type, rejecting good coatings, as 3 excellent coatings would have been rejected if salt fog had been used as a screening test and the exterior exposures had not been run. (Note: Of the 16 coatings rated excellent in salt fog (greater than 1,800 hours), the qualitative ratings at Kure Beach were 4 excellent, 4 good, 3 fair, and 5 poor.)

How about accepting poor coatings? The left side of Table 3 lists coatings that would have been rejected based on the Kure Beach long-term exposures using a criterion of rust rating of 7 within 36 months. In other words, if these coatings failed in less than 36 months at Kure, we would reject them as not being suitable exterior coatings. The second column shows the salt fog lifetimes of those 11 coatings. The first was 1,070 hours, 2 were at 1,840, and 3 were at 2,400 hours. For application over hand-cleaned steel, any coating lasting more than about 1,500 hours is considered excellent in salt fog. Five of these 11 coatings would have been rejected based on long-term exterior exposure.

Thus, 5 of these coatings, though considered excellent in salt fog (lifetime of more than 1,800 hours), failed at Kure Beach. Of the other 6 coatings that failed at Kure Beach, 2 were good in salt fog (more than 1,000 hours), 1 fair (more than 500 hours), and 3 poor (less than or equal to 500 hours). Looking at it the other way, salt fog testing would have accepted at least 5, possibly 7 coatings that were ultimately rejected based on their Kure Beach exposure.

Therefore, the salt fog test accepted a large number of poor coatings *and* rejected a large number of good coatings. So even though some correlation was observed, the salt fog was found not to be a suitable screening test for exterior exposure at Kure Beach. Kure Beach was chosen in this analysis rather than an industrial environment because one would think that if there were 1 exposure site that salt fog would be able to reproduce, it would be the marine exposure. Yet we see that this is not the case with the vast majority of the data.

The next example is of water-borne coatings over blast-cleaned steel. Table 4 shows the extent of rejection of good coatings. Six coatings were rejected based on salt fog data. Of these 6 coatings, 5 did extremely well at Kure Beach, 4 of them lasting beyond the duration of the 130-month experiment.

Table 5 shows that of the 5 coatings rejected based on exterior exposure results, salt fog testing would have accepted 3. The validity of results of salt fog over blast-cleaned steel (Tables 4 and 5) is even poorer than over hand-cleaned steel (Tables 2 and 3). Thus, once again, the salt fog is shown to be very unsuitable for predicting the performance of these coatings in an exterior marine environment.

Predicting from Data Based on Exterior Exposures

General Approaches

Because of poor correlation and the likelihood of major errors with salt fog and other accelerated tests, it is often preferable to evaluate coatings based on exterior testing. There are several means by which short-term answers can be derived from exterior exposures. These include the following.

- Prediction from early data (Rather than running data out for 5 to 10 years, we can look at that data at 1, 2, or 3 years and make some prediction.)
- Alternate failure criteria (For example, utilize a rust rating of 8 rather than 7 as a failure criterion.)
- Enhanced evaluation procedures (Obtain a better, clearer, or more detailed picture of what the panel looks like through visual, mechanical, physical, or electrochemical approaches.)
- Increased sample size (replicates) (SSPC has recently issued a report on a study using sample sizes of 20 and 30, showing how the size of samples helps provide earlier information on failures.)[6]
- Accelerate exterior environment (For example, spray with acid or salt water, use reflective mirrors to enhance the amount of sunlight, or place samples in a black box that heats up the panels.)

Two of these approaches will be illustrated below.

Predictions from Early Field Data

Suppose instead of running the experiment for 130 months at Kure Beach, we terminate it at 60 months (5 years) and try to make predictions. How closely would the predictions at 60 months match the results at 130 months? Table 6 shows that the Spearman correlation (R_s) between these 2 rankings is 0.93, which is quite good. After 48 months, the rank correlation dropped to 0.89, at 36 months to 0.85, and at 24 months to 0.73. So the shorter the time period, the poorer the ability to predict the ranking of the coatings at 130 months. Yet this is still quite a bit better than the salt fog. Even at 2 years' exterior exposure, we could make a better prediction of long-term exposure than if we had 1,000 or 2,000 hours in salt fog.

It is important to determine the validity of this approach in distinguishing poor from good coatings. Table 7 presents data on how reducing the exposure time affects the ability to distinguish among different levels of coating performance. Based on 130 months' data, 11 coatings were found to be poor performers;

Table 7 Distinguishing Poor vs. Good, Rust Failure Criterion of 7
PACE C—Water-Borne Over SSPC-SP 2, Exterior Marine

Time (Months)	Failure Criterion	Nos. of Coatings in Category			
		P*	F	G	E
130	7	11	5	4	15
60	7	11	5	19	—
48	7	11	2	22	—
36	7	11	—	24	—
24	7	6	—	29	—

** P = Poor, F = Fair, G = Good, E = Excellent*

Table 8 Distinguishing Poor vs. Good, Rust Failure Criterion of 8
PACE C—Water-Borne Over SSPC-SP 2, Exterior Marine

Time (Months)	Failure Criterion	Nos. of Coatings in Category			
		P*	F	G	E
130	8	9	9	7	10
48	8	9	9	17	—
36	8	9	6	30	—
24	8	9	—	26	—

** P = Poor, F = Fair, G = Good, E = Excellent*

New Developments in Cyclic Accelerated Testing

by Bernard R. Appleman, SSPC

Since the *JPCL* article of November 1989, "Cyclic Accelerated Testing: The Prospects for Improved Coating Performance Evaluation," there has been increased interest in using cyclic tests for accelerated degradation of corrosion protective coatings. Recent activities focusing on cyclic testing are described below.

In May 1991, SSPC, in conjunction with the Naval Civil Engineering Laboratory (NCEL), organized a workshop on accelerated testing of coatings. Work groups were established to address 3 critical areas: accelerated testing, statistical analysis and evaluation, and electrochemical testing. The work group on accelerated testing focused on the value and validity of cyclic testing versus conventional testing such as salt fog.

The workshop recommended, as an urgent industry need, systematic programs to evaluate cyclic methods against conventional accelerated test methods and exterior exposure tests. Specific objectives are

- to determine if cyclic tests provide a reasonable simulation of exterior exposures,
- to identify the principal variations and parameters of cyclic testing,
- to identify the appropriate tests to corroborate preliminary conclusions of the merits of cyclic testing, and
- to determine the overall value of cyclic accelerated testing compared to conventional testing and the needs of the protective coatings industry.

Among the parameters recommended for study are the following.

- Cycle time
- Sequence of stresses
- Temperature of cabinet solution panel and control
- Source of ultraviolet light
- Relative humidity
- Repeatability within a cabinet
- Reproducibility among cabinets
- Electrolyte concentration
- Effect of different cycles on different coatings

SSPC and ASTM have taken steps to carry out some of the recommendations. SSPC has developed a multi-client test program to compare various cyclic tests to conventional accelerated tests as well as to exterior and enhanced exterior exposure testing. This program is also being supported by SSPC membership through general research funding allocations. The program is designated as APEC (Advances in Performance Evaluation of Coatings). It includes the following tests.

- Cycle 1: 2 hours' spray at 30 C (86 F) with Timmins solution 3.5 percent $(NH_4)_2SO_4$ and 0.25 percent NaCl/2 hours' forced dry air at 40 C (104 F)
- Cycle 2: 1 week of Cycle 1 followed by 1 week of another cycle consisting of 4 hours of UV radiation (using UV-A bulbs) at 60 C (140 F) and 4 hours of condensation at 40 C (104 F)
- Cycle 3: 6 hours' immersion in 5 percent NaCl/6 hours' ambient dry (panels placed on rack that rotates 60 degrees every 2 hours, for a total cycle time of 12 hours)
- Cycle 4: 6 hours' immersion in 5 percent NaCl/6 hours' exposure to UV-A lamps
- Standard Accelerated Test: Salt fog in accordance with ASTM B 117
- Standard Marine: 250-meter (800-foot) lot at La Que Corrosion Center, Kure Beach, North Carolina
- Standard Industrial: Pittsburgh, PA
- Accelerated Exterior Marine: Exterior marine panels sprayed twice a week with 5 percent NaCl
- Accelerated Exterior Industrial: Exterior industrial panels sprayed twice a day with 3.5 percent $(NH_4)_2SO_4$ and 0.25 percent NaCl solution

To date, approximately 20 coatings have been accepted into the testing program, with testing initiated in late 1990. Preliminary analysis has been made of data using Cycle 1 and 40 months' exterior marine. (Forty-month data are derived from the predecessor program, Advances in Coatings Technology for Steel [ACTS], which utilized the same control panels as APEC.) On the basis of scribe undercutting data, Cycle 1 shows considerably higher correlation with exterior than does salt spray. These results are still preliminary. They are based on a limited number of

5 were fair; 4 were good; and 15 were excellent. After 60 months, the poor and fair coatings could still be distinguished, but insufficient time had elapsed to distinguish the excellent from the good coatings. Even down to 36 months, it was still possible to distinguish the 11 poor coatings. However, 24 months was apparently too short a time period to distinguish poor from good coatings based on a failure criterion of 7.

Alternate Failure Criterion

Now let's examine the effect of an alternate failure criterion, that is, from a rust rating of 8 rather than 7. The rust scale in ASTM D 610 is logarithmic, so a rust rating of 8 (0.01 percent of area rusted) is much more stringent that a rust rating of 7 (0.3 percent of the area rusted). Therefore, a coating will reach an 8 rating before it reaches a 7 rating. So, if we can use the 8 rating as our failure criterion, we will observe "failure" in a shorter time period.

Table 6 shows rank correlation for evaluations at various time intervals using an 8 failure criterion. The Kure ratings after 60 months vs. those at 130 months result in a rank correlation of 0.98, almost a perfect 1:1 correspondence. Again, the shorter the rating period, the poorer the correlation, but even at 24 months, one still gets a reasonably good rank correlation of 0.8. Salt fog at 1,200 hours resulted in a rank correlation of 0.2. Thus, 1,200 or 2,400 hours' salt fog data give considerably poorer prediction than 24 months at Kure Beach.

Table 8 shows how the ability to differentiate among poor, fair, good, and excellent coatings is influenced by the number of months of exposure.

If one reduces the exposure time to 18 months (not shown here), major deviations in rank are observed. 24 months in this particular approach is the shortest exposure time required to eliminate the poor coatings.

Comparing Tables 7 and 8 shows that with a failure criterion of 8, one can reduce the time for screening poor coatings from 36 to 24 months. This reduced time frame is the advantage of using a more stringent failure criterion. This approach is markedly superior to salt fog in predicting long-term field performance.

Conclusions

The statistical techniques of regression correlation and rank correlation both demonstrated lack of correspondence between salt fog and marine exterior exposure. Further, data were presented demonstrating that salt fog results in quite a large number of 2 types of samples (10 paint systems) and have not been subjected to a rigorous statistical analysis for significance.

A task group under ASTM Subcommittee D1.27 on Accelerated Tests for Paints is drafting 2 new standards for consensus review. The first is on cyclic salt fog, dry-off, and UV/condensation, consistent with Cycle 2 above. The second covers cycling between salt and UV, and is consistent with Cycle 4 above. It is anticipated that both of these will initially be issued as Standard Practices. They would describe how to conduct the tests and identify available equipment, but they are not expected to establish definitive test procedures, cycle times, or parameters. Standard methods would be developed at a later date, based on results from user data on the methods and apparatus. ASTM D1.27 is also planning to administer an interlaboratory test to evaluate industrial maintenance coatings and pre-finished metal coatings in 4 to 5 test cycles and several outdoor test sites. This work would be coordinated with the SSPC test program to provide the maximum amount of data for the development of standards. Organizations that use accelerated testing will be asked to participate in the SSPC and ASTM programs by furnishing laboratory test facilities, test specimens, coatings, and funding.

Another ASTM Committee, G.1, on Corrosion of Metals, is preparing to revise the current salt spray test, ASTM B 117, to incorporate cycling. An important question that must be addressed is the difference between cabinets designed to produce a cycle internally, and those in which panels must be physically removed from an existing cabinet and placed in another chamber or location.

The critical need for improved accelerated testing is confirmed by the number of organizations that have had or are planning technical sessions on this subject. The National Association of Corrosion Engineers (NACE) has sponsored a symposium on Accelerated Testing at its annual conference in Nashville in April 1992. ASTM Committee G-3 on Durability of Non-Metallic Materials and Subcommittee D1.27 on Accelerated Testing of coatings are co-sponsoring a symposium on Accelerated and Outdoor Durability Testing, January 19-20, 1993 in Fort Lauderdale. In November 1993, ASTM Committee G-1 is likewise sponsoring a special symposium on Cyclic Corrosion Testing. The American Chemical Society is responding with a symposium on "Durability of Coatings," to be held April 18-23, 1993, in Denver. The Federation of Societies for Coatings Technology (FSCT) has included sessions on accelerated testing at several recent conferences, and, earlier, it sponsored a survey on the various accelerated testing techniques. SSPC is tentatively planning to hold its Second Conference on Accelerated Testing and Durability in Spring of 1994.

Finally, at the SSPC National Conference in Kansas City, the Accelerated Testing Committee will meet on November 19, to review new sources of data and programs to evaluate and standardize test procedures.

Although there is a substantial amount of new development and activity under way, an accepted industry test for cyclic testing remains elusive. One important goal of SSPC and *JPCL* is to track and coordinate these various activities, and periodically assess their progress. ■

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errors. This "screening" test accepted poor coatings (i.e., coatings that ultimately failed in atmospheric exposure) and rejected good coatings (i.e., those that weathered atmospheric exposure very well).

It was shown that early data from exterior exposures can be used for prediction of long-term field performance. A more stringent alternative failure criterion (i.e., an 8 rather than a 7 rating per ASTM D 610/SSPC-VIS 2) can also allow earlier prediction in shorter time periods. This approach is much superior to using accelerated testing because actual exterior data are being utilized.

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