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ACCELERATED TEST DEVELOPMENT FOR COIL-COATED STEEL BUILDING PANELS

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ABSTRACT

This paper discusses the experimental design and the preliminary findings of an ongoing project designed to establish an accelerated laboratory test that would rank coating system performance the same as their performance in atmospheric exposure. A total of ten materials are included in the program: four substrates each with two coating systems and one substrate with two additional coating systems. Samples were installed at four atmospheric exposure sites: Middletown, OH, Daytona Beach, FL, Monroeville, PA, and Halifax, NS, Canada. Three different orientations were utilized at each of the exposure sites and a variety of building panel features were included on the test panels (roll formed bends, laps, cut drip edges, standing seam closures, and scribes). The work discussed in this paper includes the program design and implementation and preliminary correlation's of the three-year atmospheric exposure results to several standard accelerated test methods including: ASTM B117, ASTM G85, ASTM G87, and GM 9540.

Keywords: coatings, accelerated test, atmospheric corrosion, prepainted, buildings, correlation

INTRODUCTION

In 1989, a Task Group of the American Iron and Steel Institute (AISI) Construction Marketing Committee was established in an effort to identify or develop an accelerated test method that would correlate well with the field performance of specified coil coated steels for building panels. Field performance of the materials would be obtained over a ten-year period at atmospheric corrosion test sites in North America.

The project itself was divided into two main phases: Atmospheric Corrosion Testing, and Accelerated Laboratory Testing.

The Atmospheric Corrosion Testing phase included four main Tasks:

- Test rack design, fabrication, and installation.
- Test panel preparation.
- Test panel exposure.
- Panel evaluation, data analysis and reporting of results after three, six, and ten years of exposure.

The Accelerated Laboratory Testing Phase also consisted of four Tasks:

- Test method selection.
- Test panel preparation.
- Accelerated testing.
- Panel evaluation, data analysis and reporting.

The main objective of the project is to determine laboratory test methods with good correlation to actual exposure environments for assessing the performance of prepainted sheet steels on buildings. The need for the project arose from confusion in the marketplace regarding the durability of various coil-coated steel systems. The confusion arose because paint formulators, paint applicators and steel companies often use different laboratory and atmospheric corrosion tests to determine the performance of a product. Therefore, there appeared to be a need for some method of establishing an accepted test method for performance evaluation.

EXPERIMENTAL

The project Task Group developed and/or specified much of the experimental requirements for the project. This included the location of the atmospheric corrosion test sites, the test materials, the test panel design and orientations, and the accelerated test methods.

Four atmospheric corrosion test sites were identified by the committee for use on the project. These sites are Middletown, Ohio which can be classified as a mild industrial environment, Daytona Beach, Florida which can be classified as subtropical marine, Monroeville, Pennsylvania which can be classified as urban-industrial, and Halifax, Nova Scotia, which can be classified as temperate marine. It was believed that these sites would produce widely different corrosion conditions in which to expose the panels.

A total of ten different materials were selected for evaluation during this project. Four separate substrates are included and were identified simply as substrate 1, 2, 3, and 4. The intention of this project is to correlate the accelerated test methods to field exposures and <u>not</u> to rank the test materials, hence the non-descriptive numerical identification of the substrate materials. To each of these four substrates, two coating systems were applied: silicone modified polyester paint (SMP), and fluorocarbon paint. In addition, two other coating systems (plastisol paint and a polyester paint) were applied to one of the substrate materials.

The substrates with coatings applied were provided by eight individual manufacturers in 5000-pound coils. The individual manufacturers were responsible for the quality and suitability of the materials submitted. The individual coils were then sheeted and rollformed in a sequence that allowed a practical and acceptable randomization during later test panel preparation.

For the atmospheric exposures, two different panel configurations were prepared for three exposure orientations. The two panel configurations include a "double panel" and a "combination panel". The double panel consisted of two 8in by 12in (20.3cm by 30.5cm) rollformed panels joined to form a double panel 15in by 12in (38.1cm by 30.5cm). A typical double panel is shown in Figure 1. The combination panel consists of a small, specialized panel fastened to an 8in by 12in rollformed panel. The small panel was prepared from a 5in by 6in piece of flat sheet and includes a 3T bend, a 90° bend, and a scribe. The special panel and the finished combination panel are shown in Figure 2. A smaller version of the combination panel was utilized in all of the accelerated laboratory tests.

Three different exposure orientations were included in the atmospheric exposures. They included the exposure of double panels at nearly horizontal (5°), the exposure of combination panels in a vertical configuration facing south, and the exposure of combination panels in a vertical configuration facing north but sheltered by a 4ft overhang. These orientations were carried through at each of the exposure sites except for the Daytona Beach site where the vertical panels face east (toward the ocean) and the vertical sheltered panels face west.

Twenty-two samples of each material are exposed in each of the three orientations. This includes three sets of seven sample replicates and one remaining sample. Sets of seven replicates will be removed from the sites following three, six, and ten years' exposure. The remaining sample (number 22) will be removed at each interval, evaluated and returned to the site. The seven replicates were selected to provide statistical significance in the analysis of the data.

The Task Group selected several standardized, accelerated test methods for comparison to the atmospheric exposure results. These methods included the ASTM B117 Salt Fog Test, ASTM G85-Annex A5 (Prohesion), GM9540 (120° F), ASTM G-87 (Kesternich), and SAE-AISI J2334. Samples for the accelerated testing were prepared in a similar manner to the combination panel discussed above; however, due to some size constraints in some of the test methods, slight size variations were required. Five replicates of each material were exposed to these tests (and modified version of these tests).

The ASTM B117 Salt fog testing consists of exposure of the panels to a continuous fog of 5% sodium chloride solution at a neutral pH. Temperature within the cabinet is maintained at 35° C. Panels were exposed in the salt fog environment for a period of 1000 Hours. Two ASTM G85-Annex A5 (Prohesion) tests were performed consisting of cycles of 1-hour dry-off and 1-hour dilute electrolyte fog. The electrolyte is a solution of 0.05% sodium chloride and 0.35% ammonium sulfate by mass at a pH of 5.0 to 5.4. For both the Prohesion-A and the Prohesion-B tests the temperature during the fog cycle in the cabinet was maintained at 24° C. During the drying cycle, the temperature within the cabinet was changed and maintained at 35° C. Prohesion testing was conducted for 1000 Hours (500 cycles).

The GM9540 cyclic corrosion test consisted of the application of a water mist containing 0.9% sodium chloride, 0.1% calcium chloride, and 0.25% sodium bicarbonate at a pH of 6.0 to 8.0. The mist is applied 4 times each cycle, after the panels are visibly dry from the preceding mist. Following the mist application the panels are exposed for 8 hours in a humidity cabinet, followed by an 8 hour dry-off cycle at 120° F, followed by an 8 hour exposure to ambient conditions. This cycle was repeated 40 times for the purposes of this test. The ASTM G-87 (Kesternich) test is a cyclic test consisting of exposure to condensing water and sulfur dioxide at 40° C for eight hours followed by 16 hours of exposure to ambient conditions. For the purposes of this test, the panels were exposed to a total of 20 cycles of this nature.

The SAE-AISI J2334 cyclic test consists of a 6-hour exposure to 100% humidity at 50° C followed by a 15-minute immersion at 25° C in a solution containing 0.5% sodium chloride, 0.1% calcium chloride and 0.25% sodium bicarbonate. The samples are then dried for 17.75 hours at 60° C, 50% relative humidity. This cycle was repeated daily for a total of 41 days/cycles.

Considerable effort was given to the development of the metrics necessary for evaluating the materials performance in both the accelerated tests and the atmospheric exposures. The methods developed were required to evaluate all of the features of the complicated sample geometrics while addressing multiple degradation mechanisms and were in part based on procedures developed by users and suppliers designed to evaluate prepainted buildings. Panels were first evaluated in the as-received condition. Bends were evaluated for red rust, white rust, paint loss, and crazing. Blistering on the bends and surfaces was evaluated according to ASTM D1654. Edges and scribes were also evaluated for red rust and white rust. Following the evaluations in the as received condition, the seven replicates of each material were then soaked in DI water, and scraped with a plastic scraper under running water. After this cleaning, all of the edges and the scribe were evaluated for creep back. To ensure that the data collected on each sample was purely objective, a series of overlays was produced to establish the exact location for the various measurements. All linear measurements were performed utilizing digital calipers that were interfaced through a computer to the sample evaluation form so that the individual data points went directly into the spreadsheet. These precautions were utilized to minimize subjective measurements, to eliminate transcription errors, and to facilitate the collection of a vast quantity of information in a format that easily lent itself to statistical analyses. Figure 3 shows a sample evaluation form.

PRELIMINARY RESULTS

Atmospheric exposures of the panels were begun in 1991. The three-year evaluations of the atmospheric exposure panels were conducted in 1994. The seven-year evaluations of the atmospheric exposure panels are underway now. Accelerated testing commenced in 1994 and is still ongoing. Evaluations of the accelerated test panels have been completed for those panels exposed to the Thermotron, Kesternich, Q-Fog A, Q-Fog B, and Salt Fog tests.

Figures 4, 5, 6, and 7 show a preliminary comparison of the average creep results for each of the four coatings examined on substrate 1, for all of the accelerated tests, and for the south facing vertical (unsheltered), three-year atmospheric exposures. Careful examination of these figures show that several of the accelerated test methods appear to be significantly more severe than the results observed from the atmospheric exposures. This would indicate that these methods do not accurately represent the real life performance of these coatings at the exposure sites and period selected. In some cases, more similar performances are observed for some of the accelerated test methods to the three-year data from the marine site at Daytona Beach.

Figures 4, 8, 9, and 10 represent a series of plots which provide preliminary comparisons of the average creep results for each of the four substrates examined with the SMP coating, for all of the accelerated tests and for the south facing vertical (unsheltered), three-year atmospheric exposures. These plots show widely varying performances of the same coating applied to the different substrates and exposed to different conditions. This preliminary information would indicate that perhaps multiple test methods might be required for different materials with consideration also given to the environment in which they are expected to be exposed.

PRELIMINARY CONCLUSIONS

The preliminary results presented in this report represent only a small portion of the data that will become available as the program continues. However, some preliminary conclusions have been proposed:

- An extensive research program has been undertaken to provide the data necessary to determine laboratory test methods with good correlation to actual exposure environments for assessing the performance of prepainted sheet steels on buildings.

- No single, specific, accelerated test method appears to equally address the infinite combinations of substrates, coatings, and atmospheric exposures.

As more data becomes available, and as additional statistical analyses are completed, a greater understanding of the correlation between accelerated test methods and atmospheric exposures will be established.

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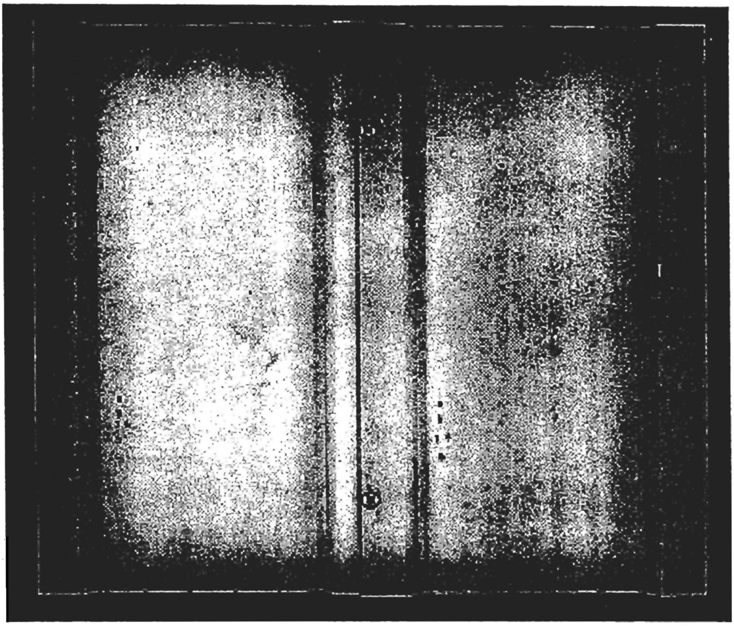

Figure 1. Typical Double Panel Exposed In The Nearly Horizontal (5°) Orientation.

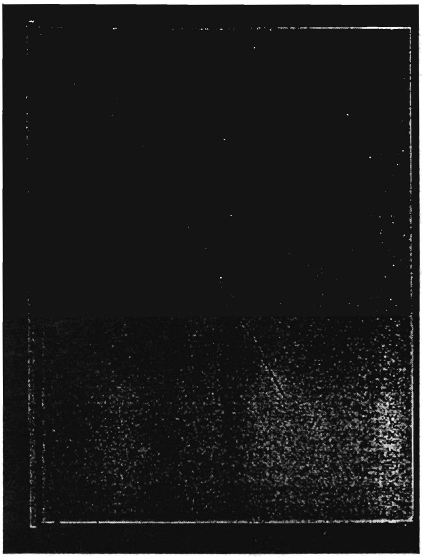

Figure 2a. Detail Of Special Panel Exposed In The Vertical And Sheltered Vertical Orientation.

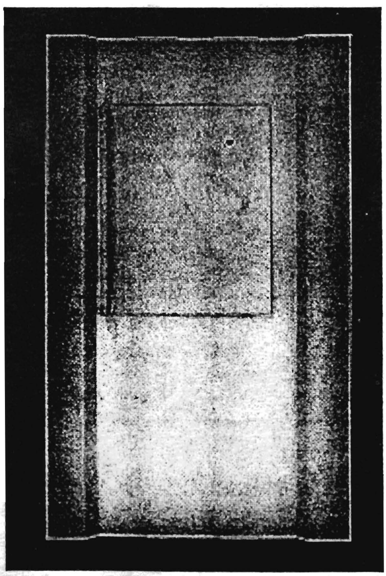

Figure 2b. Typical Combination Panel Exposed In The Vertical And Vertical Sheltered Orientation.

AISI Project CC89 on Accelerated Corrosion Test Development for Coil Coated Steel Building Panels

Evaluation Sheet for Vertical Panels

Sample ID # AD16S

Evaluation Date : Jan-95
Date Installed : Sep-91
Date Removed : Sep-94
Exposure Period : 36 Months

Coating : Silicon Modified Polyester
Material : 1.00

Site : Daytona, Florida
Exposure : Severe Marine

Pre-Clean Visual Inspection

Photograph : N

Edges :

	Left: Red rust	Left: White rust	Right: Red rust	Right: White rust
Average :	0.03	1.35	0.00	1.09
Maximum :	0.19	2.98	0.00	2.16
NAMZAC :	9	8	10	8
CRIL :	L	C	-	C

	Drip: Red rust	Drip: White rust	Lap: Red rust	Lap: White rust
Average :	0.00	1.45	0.00	0.66
Maximum :	0.00	2.61	0.00	0.85
NAMZAC :	10	8	10	9
CRIL :	-	C	-	C

Bends :

	Right Major: Red rust	Paint loss	White rust	Crazing	Right Minor: Red rust	Paint loss	White rust	Crazing
NAMZAC :	2.5	4	3	ND	5	5	4	ND
CRIL :	L	L	C	-	-	-	L	-

3T :

	Red rust	Paint loss	White rust	Crazing
NAMZAC :	1.5	4	2.5	ND
CRIL :	L	L	C	-

Scribe :

	Red rust	White rust
NAMZAC :	5	2.5
CRIL :	-	C

Blistering :

	Surface: D1654	Surface: CRIL		Bends: D1654	Bends: CRIL
Density :	F	C	Density :	M	I
Size :	8		Size :	8	

Comments : ______________________

Post-Clean Visual Inspection

Edges :

Creep-back :

	Left	Right	Drip	Lap	Scribe
1.	0.66 mm	0.77 mm	1.47 mm	0.00 mm	0.00 mm
2.	1.58 mm	2.50 mm	0.00 mm	0.00 mm	0.00 mm
3.	0.64 mm	0.86 mm	2.95 mm	0.00 mm	0.00 mm
4.	0.37 mm	0.75 mm	0.90 mm	0.00 mm	0.00 mm
5.	0.88 mm	1.71 mm	0.71 mm	0.00 mm	0.00 mm
6.	1.41 mm	0.76 mm	0.00 mm	0.71 mm	0.00 mm
7.	0.59 mm	1.63 mm	1.46 mm	0.18 mm	0.00 mm
8.	1.21 mm	1.21 mm		0.62 mm	0.00 mm
9.	0.54 mm	1.02 mm		0.00 mm	0.00 mm
10.	0.77 mm	1.35 mm		0.00 mm	0.00 mm
11.	1.39 mm	1.07 mm		0.00 mm	0.00 mm
Average :	0.91 mm	1.24 mm	1.07 mm	0.14 mm	0.00 mm
Maximum :	1.60 mm	2.64 mm	3.86 mm	1.19 mm	0.00 mm
NAMZAC :	9	8	8	9	10

Figure 3. Example Of Typical Evaluation Form For Atmospheric Exposure Results.

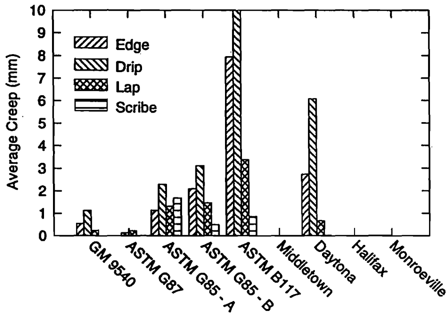

Figure 4. Preliminary Comparison of The Average Creep Results For The Silicone Modified Polyester Coating Applied Over Substrate 1, For All Accelerated Tests, and For The South Facing Vertical (Unsheltered), Three Year Atmospheric Exposures.

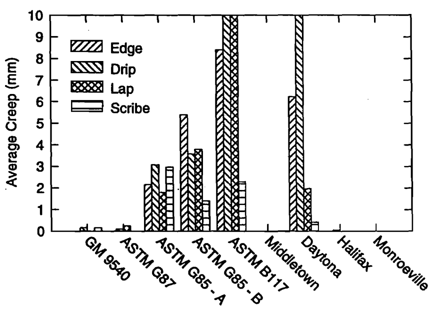

Figure 5. Preliminary Comparison Of The Average Creep Results For The Fluorocarbon Paint Applied Over Substrate 1, For All Accelerated Tests, And For The South Facing Vertical (Unsheltered), Three Year Atmospheric Exposures.

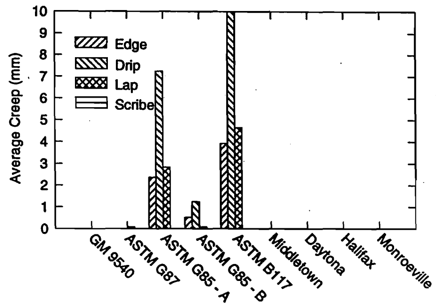

Figure 6. Preliminary Comparison Of The Average Creep Results For The Plastisol Paint Applied Over Substrate 1, For All Accelerated Tests, And For The South Facing Vertical (Unsheltered), Three Year Atmospheric Exposures.

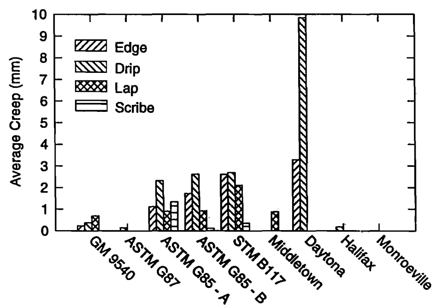

Figure 7. Preliminary Comparison Of The Average Creep Results For The Polyester Paint Applied Over Substrate 1, For All Accelerated Tests, And For The South Facing Vertical (Unsheltered), Three Year Atmospheric Exposures.

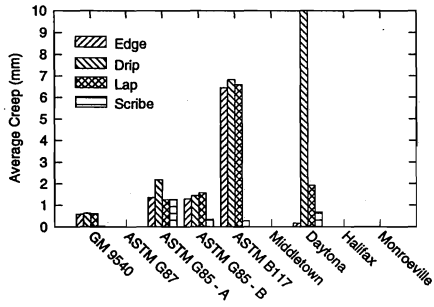

Figure 8. Preliminary Comparison Of The Average Creep Results For The Silicone Modified Polyester Paint Applied Over Substrate 2, For All Accelerated Tests, And For The South Facing Vertical (Unsheltered), Three Year Atmospheric Exposures.

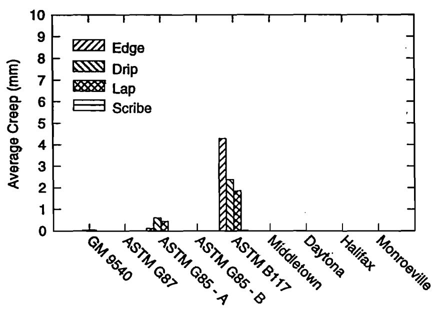

Figure 9. Preliminary Comparison Of The Average Creep Results For The Silicone Modified Polyester Paint Applied Over Substrate 3, For All Accelerated Tests, And For The South Facing Vertical (Unsheltered), Three Year Atmospheric Exposures.

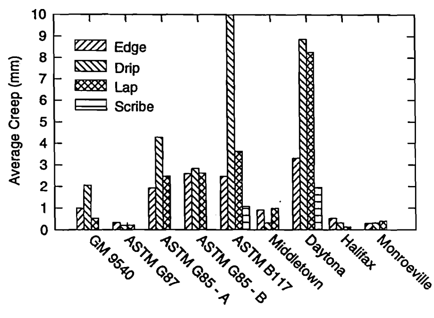

Figure 10. Preliminary Comparison Of The Average Creep Results For The Silicone Modified Polyester Paint Applied Over Substrate 4, For All Accelerated Tests, And For The South Facing Vertical (Unsheltered), Three Year Atmospheric Exposures.