PROTECTIVE COATINGS FOR HIGHWAY METALS
Fourth Progress Report: Protective Coatings for Structural Steel

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

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Fourth Progress Report: Protective Coatings for Structural Steel

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PROTECTIVE COATINGS FOR HIGHWAY METALS
Fourth Progress Report

This progress report continues the presentation of data on performance of specification and proprietary structural steel primers and coatings as determined in accelerated laboratory tests. These tests have been adopted by the coatings industry because they permit easy and rapid screening of coatings' quality, even though the results admittedly may not exactly duplicate service performance. This is the sixth series to be tested using coatings of interest to the Department; series one through five having been reported in Research Report Nos. R-260 (July 1956), R-361 (Aug. 1961) and R-508 (July 1965). The last and subject reports have been prepared under an HPR study.

The primers and topcoats under test were accumulated over the period from early 1965 through mid-1968. Forty-six systems, plus three additional replacements, were covered in the series. The laboratory phase of subject evaluations covering panel preparation, equipment exposures, and rating of test systems were conducted from May to December 1968.

Laboratory Test Procedure

The test paint systems were applied on steel panels in two coats, consisting generally of a primer and a topcoat, prior to exposure in laboratory equipment. The panels were flat, 16-gage, hot-rolled steel. They were cleaned by sandblasting prior to coating.

Duplicate panels were made of all systems although some, including all of the "grease type" coatings, were applied on triplicate panels to allow roof exposure of one panel. All panels were edge-sealed with a fast-drying zinc chromate primer. A three week drying period was allowed on all panels except the replacement grease type paints which were put into test exposure after one week's drying time.

The panel, one of each set, selected for test exposure was given a vertical scratch through the coating to the metal while the other panel was used for comparison purposes during the rating of performance. A single test cycle consisted of 200 hours exposure in the Weatherometer (continuous artificial sunlight with a 9 minute water spray interval per hour) followed

by 50 hours at 95F in a combination salt spray-humidity cabinet. The coated panels were exposed to seven such cycles for a total exposure of 1400 hours in the Weatherometer and 350 hours in the cabinet. At the conclusion of the laboratory testing, the exposed test panels were photographed with their respective control panels to show the amounts of degradation (Fig. 1) and were also rated visually.

Performance Ratings

As in the previous reports, in order to assign numerical values to the performance of the coating systems in the tests, observers (F. J. Bashore, A. R. Gabel, and A. J. Permoda) rated the panels on the following three quality factors:

1. Topcoat appearance; taking into consideration fading, chalking, and gloss change.

2. Amount of coating breakdown on the panel face.

3. Extent of rusting and rust creepage at the vertical scratch.

Each factor was rated numerically on a 10 to 0 scale, with 10 denoting perfect condition and 0 complete failure. For convenience, these three ratings were added into a single total indicating the overall merit of the coating system, with the highest total representing the best performing system. These totals are presented in Table 1 as averages for the three observers. Individual averaged factor ratings are also given in the table, as is the relative rank of the test systems, and sources of the coatings.

Test Results

Of the 46 test systems (listed in Table 1 and shown in Figure 1) 14 were classified as "very good" (defined as having received 24 or more points of a possible 30-point maximum performance rating) and carry the highest potential for possible Department use. They are listed in descending order of rating merit:

Rank 1 - 27 Points

System 29: Proprietary, one-package, zinc-rich primer and proprietary gray hi-build topcoat. Primer is on field test on Snow Bowl and Military Road structures over I 75 near Houghton Lake.

System 34: Proprietary, three-package, zinc-rich primer and proprietary gray hi-build topcoat.

Rank 2 - 26.3 Points

System 45: Proprietary, two-package, inorganic zinc-rich primer and vinyl-alkyd gray topcoat. Topcoat is on field test on Snow Bowl Road structure over I 75 near Houghton Lake.

Rank 3 - 25.7 Points

System 28: Proprietary, one-package, zinc-rich primer and vinyl-alkyd gray topcoat. (Primer same as System 29, and topcoat same as System 45, above).

System 31: Proprietary, one-package zinc-rich primer and proprietary gray hi-build topcoat. (Topcoat as on Systems 29 and 34, above).

Rank 4 - 25.3 Points

System 30: Proprietary, one-package zinc-rich primer and vinyl-alkyd gray topcoat. (Primer is on field test on M 71 structure over M 78 near Durand).

Rank 5 - 25 Points

System 1: MDSH Nos. 1A (1) red lead primer and No. 5B aluminum-alkyd topcoat (Department and test standard).

System 15: Proprietary lead pigmented white primer and No. 5B aluminum-alkyd topcoat.

System 32: Proprietary lead sub-oxide pigmented gray hi-build primer and vinyl-alkyd gray topcoat.

Rank 6 - 24.3 Points

System 11: MDSH Nos. 1A (2) red lead primer and No. 4A (1) green topcoat.

System 26: Proprietary, one-package, zinc-rich primer and proprietary aluminum topcoat from same source.

System 44: Proprietary, one-package, zinc-rich primer and proprietary, two-package aluminum-epoxy topcoat.

System 46: Proprietary, fast-dry zinc chromate primer and vinyl-alkyd gray topcoat.

Rank 7 - 24 Points

System 4: MDSH Nos. 1A (1) red lead primer and No. 4A (1) green topcoat.

The remaining systems earned poorer ratings and thereby are of less interest to the Department. However, there is one exception--a group of treated hydrocarbon coatings, sometimes called "grease type," which earned poor ratings in much abbreviated exposures and were withdrawn from the accelerated tests (Fig. 2). This behavior was expected since grease coatings, by experience, do not perform well in the Weatherometer. Consequently, these coatings are being evaluated in a much slower way by outdoor exposure on the roof of the Laboratory (Fig. 3). Remarks on their current performance are given in Table 2, which also describes other systems, so exposed. Future inspections will be made and recorded, covering these exposures.

Discussion of Results

A review of the above listing shows that:

1. Eight of the 14 best performing systems were based on zinc-rich primers, five on lead pigmented primers, and one on a zinc chromate primer. All inhibit corrosion by any of various mechanisms.

2. The top six rating test systems were based on zinc-rich primers, of the 14 mentioned above. Partial reasons for the high ratings are, (a) these primers are high-build coatings yielding greater thickness than standard, (b) they perform well in laboratory tests, i.e. perhaps better than in field tests, and (c) we've learned to marginally improve their performance by proper topcoating.

3. The Department's current paint system of 1A (1) red lead primer and 5B aluminum alkyd topcoat was surpassed in performance by only the zinc-rich primed systems, mentioned above.

4. As pointed out, several other rust inhibiting primed systems performed well in the tests. Three were based on lead pigments or zinc chromate pigments.

5. Regarding topcoats, the Department's Nos. 5A aluminum and 4A (1) green performed well as did a vinyl-alkyd gray (currently under field test because of previous good test performance) and a high-build chlorinated rubber gray. Several other high-build topcoats did not rate up to expectations.

6. The grease-type coatings are being evaluated since they are high-build coatings having potential of being applied in one or two coats to yield a standard 5-mil thickness. They have found some use in the trade, while the new types are being used extensively as autobody undercoaters. They can migrate to seal minor damage breaks. Unfortunately, some do not take direct exposure to sunlight.

Recommendations

As in previous reports in this series, we recommend that evaluations be continued--via field tests on structural steel--on at least some of the best performing systems in these tests. The selection could by-pass systems already under field test, and could be made on either construction or maintenance-repainting projects.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

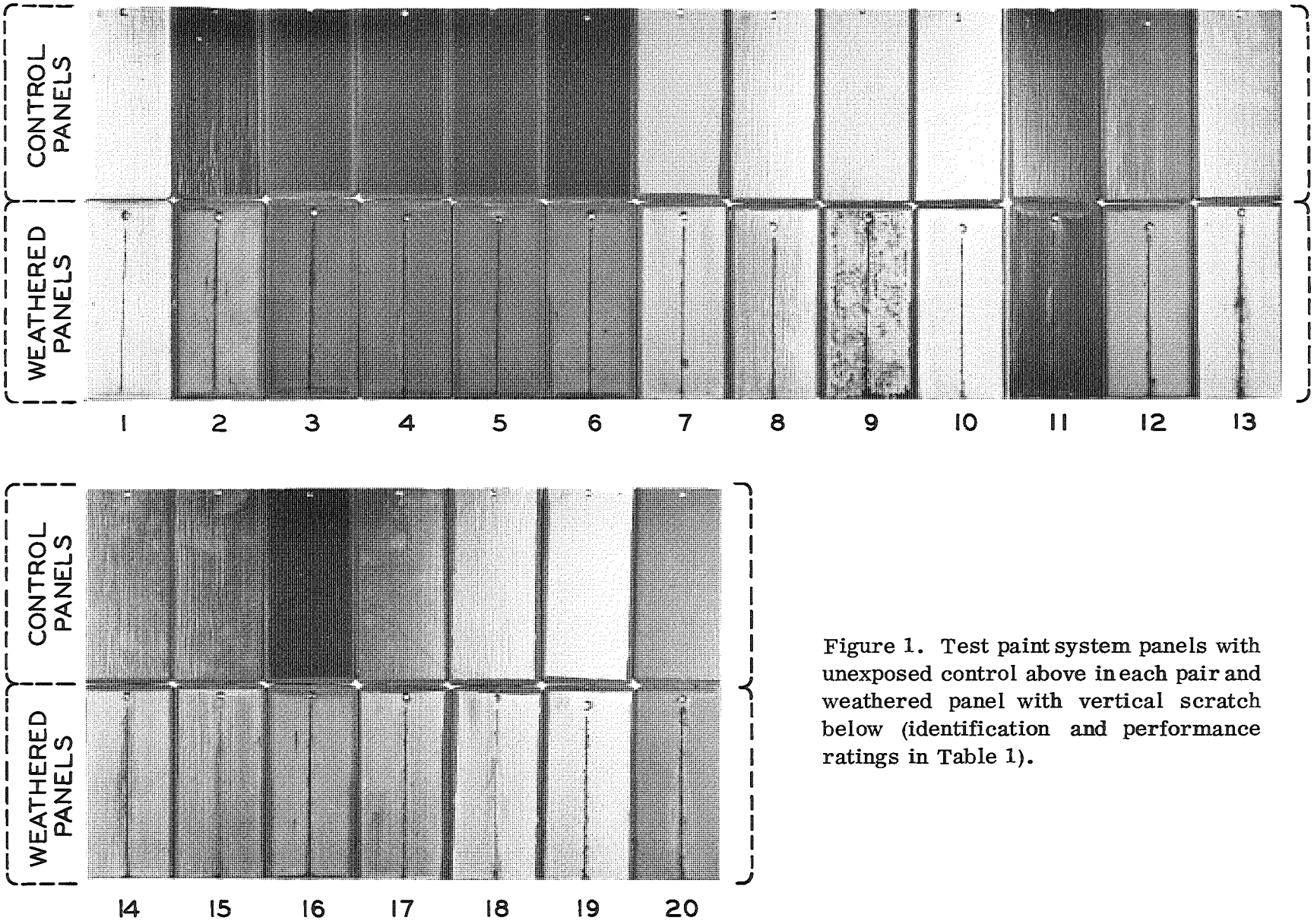
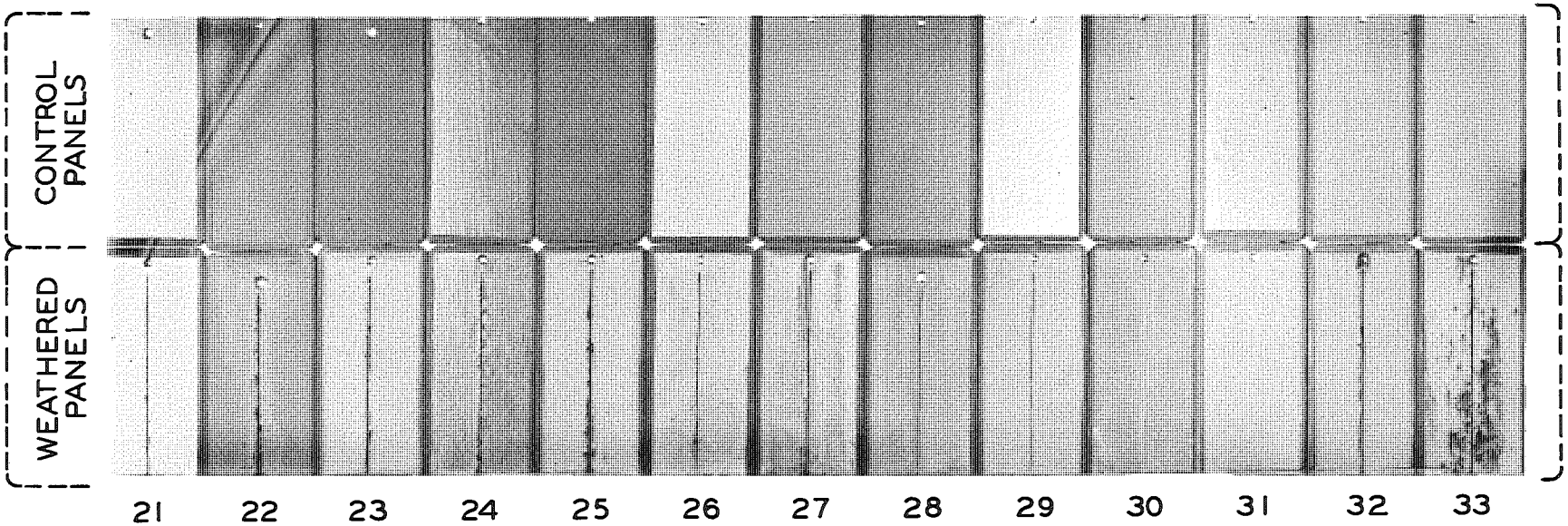


Figure 1. Test paint system panels with unexposed control above in each pair and weathered panel with vertical scratch below (identification and performance ratings in Table 1).



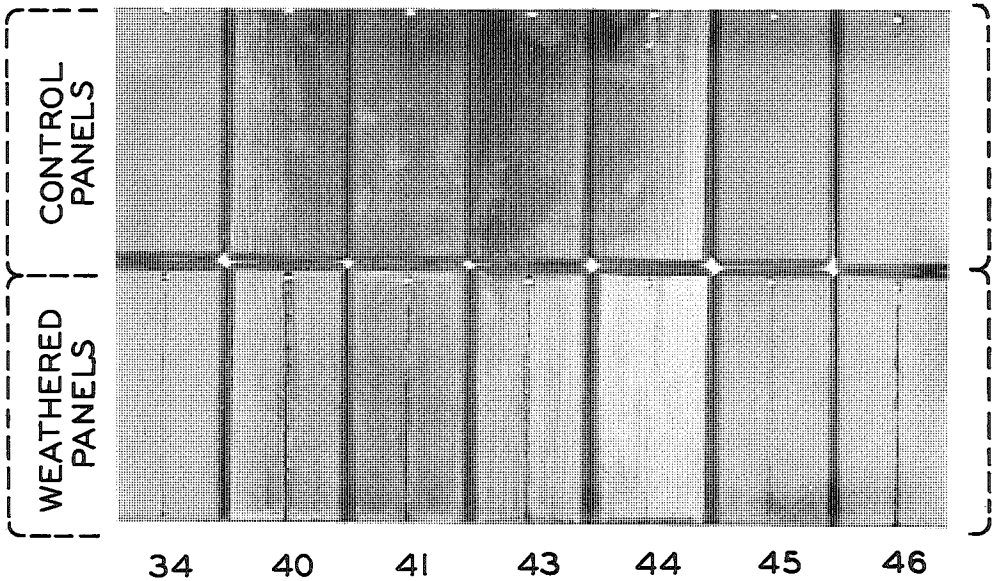


Figure 1 (Cont.). Test paint system panels with unexposed control above in each pair and weathered panel with vertical scratch below (identification and performance ratings in Table 1).

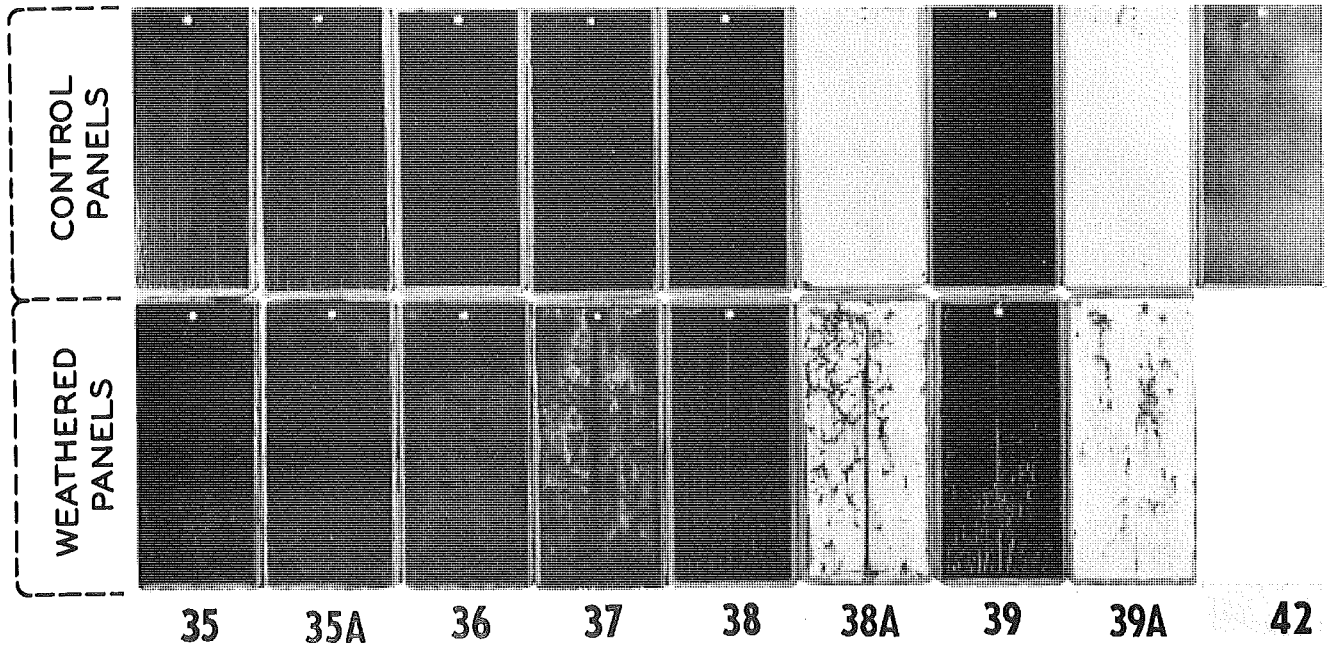


Figure 2. Test "grease type" coated panels with unexposed control, above, and laboratory weathered panel with vertical scratch, below (identification and performance ratings in Table 1).

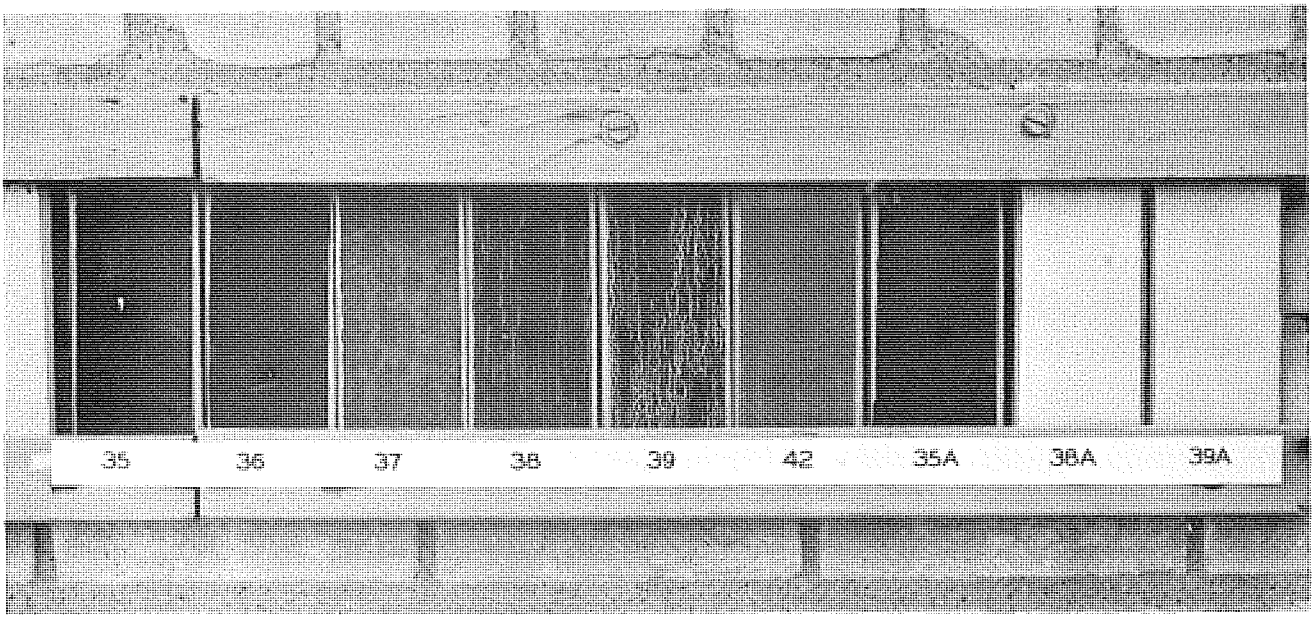


Figure 3. Appearance of test "grease type" coatings on roof exposure, as of February 12, 1969 (identification and performance comments in Table 2).

TABLE 1
IDENTIFICATION AND PERFORMANCE OF TEST COATING SYSTEMS
SERIES 6 COATINGS

Test System	Identification	Composition	Drying Time, hr	System Thickness, mils	Ratings*				Rank	Remarks
					Appearance	Face Rusting	Scratch Rusting	Total**		
1 (b)	Primer: 67 PR-153 Topcoat: 60 PR-112	No. 1A (1) red lead No. 5B alkyd aluminum	48(c) 18(c)	2.0 3.0	7.0	10.0	8.0	25.0	5	Standard MDSH system
2	Primer: 67 PR-153 Topcoat: 66 PR-54a	No. 1A (1) red lead No. 4A green	48 9	2.0 4.5	4.7	8.0	6.6	19.3	20	Alternate MDSH system, Topcoat from Hammond Lead
3	Primer: 67 PR-153 Topcoat: 66 PR-54b	No. 1A (1) red lead No. 4A green with P7	48 7	2.0 3.0	6.7	10.0	6.0	22.7	11	Topcoat from Hammond Lead
4 (b)	Primer: 67 PR-153 Topcoat: 67 PR-148	No. 1A (1) red lead No. 4A (1) green	48 9	2.0 3.0	7.0	9.0	8.0	24.0	7	Topcoat from Nat'l Lead
5	Primer: 67 PR-153 Topcoat: 67 PR-149	No. 1A (1) red lead No. 4A (1) green	48 9	2.0 3.5	6.0	9.7	6.6	22.3	13	Topcoat from Nat'l Lead
6	Primer: 67 PR-153 Topcoat: 67 PR-150	No. 1A (1) red lead No. 4A (1) green	48 8	2.0 3.5	5.0	9.0	6.0	20.0	18	Topcoat from Nat'l Lead
7	Primer: 67 PR-153 Topcoat: 67 PR-120	No. 1A (1) red lead Green aluminum Milthix	48 8	2.0 3.0	7.3	9.3	6.7	23.3	9	Topcoat from Washburn
8 (b)	Primer: 67 PR-153 Topcoat: 65 PR-106	No. 1A (1) red lead Silicone alkyd aluminum	48 1	2.0 2.5	6.7	10.0	5.3	22.0	14	Topcoat from Dow Corning
9	Primer: 67 PR-153 Topcoat: 66 PR-56	No. 1A (1) red lead Alumanation No. 301	48 1	2.0 3.0	3.3	5.3	6.4	15.0	23	Topcoat from Republic Metals
10	Primer: 68 P-6 Topcoat: 60 PR-112	No. 1A (2) red lead No. 5B alkyd aluminum	24 18	1.7 2.7	6.7	8.7	5.3	20.7	16	Primer from Nat'l Lead
11 (b)	Primer: 68 P-6 Topcoat: 67 PR-148	No. 1A (2) red lead No. 4A (1) green	24 9	1.7 3.5	7.3	9.7	7.3	24.3	6	Both from Nat'l Lead
12	Primer: 68 P-6 Topcoat: 67 PR-118	No. 1A (2) red lead No. 3A (2) gray-green Hi-Build	24 24	1.7 4.2	5.7	9.3	5.7	20.7	16	Both from Nat'l Lead
13	Primer: 66 PR-52a Topcoat: 60 PR-112	No. 2MP (1) brown No. 5B alkyd aluminum	17 18	1.2 2.2	5.7	8.7	4.3	18.7	21	Primer from Hammond Lead
14	Primer: 66 PR-52b Topcoat: 60 PR-112	No. 2MP brown with P7 No. 5B alkyd aluminum	17 18	1.2 2.0	6.0	9.7	6.0	21.7	15	Primer from Hammond Lead
15	Primer: 66 PR-53 Topcoat: 60 PR-112	White primer with P7 No. 5B alkyd aluminum	17 18	2.7 3.5	7.3	9.7	8.0	25.0	5	Primer from Hammond Lead
16 (b)	Primer: 66 PR-53 Topcoat: 68 P-67	White primer with P 7 Hi-Build green	17 6	2.7 3.7	5.7	8.3	6.7	20.7	16	Both from Hammond Lead
17	Primer: 65 PR-133 Topcoat: 60 PR-112	White primer No. 5B alkyd aluminum	17 18	1.7 2.5	5.7	8.7	5.3	19.7	19	Primer from Eagle-Picher
18	Primer: 67 PR-117 Topcoat: 66 PR-123	No. 2MP (2) brown Aluminum Milthix	7 6	3.0 3.9	6.7	10.0	7.0	23.7	8	Primer from Nat'l Lead; Topcoat from Washburn
19	Primer: 67 PR-146 Topcoat: 60 PR-112	TT-P-615d type 3 brown electro. No. 5B alkyd aluminum	6(c) 18	1.2 2.0	5.7	10.0	5.0	20.7	16	Primer from Std., Detroit
20	Primer: 67 PR-146 Topcoat: 67 PR-119	TT-P-615d type 3 brown electro. Gray Milthix	6(c) 6	1.2 2.7	7.0	9.3	5.7	22.0	14	Primer from Std., Detroit; Topcoat from Washburn
21	Primer: 66 PR-121 Topcoat: 67 PR-120	M-50 brown Milthix Green aluminum Milthix	4 7	2.2 3.2	6.3	10.0	6.0	22.3	13	Both from Washburn
22	Primer: 66 PR-121 Topcoat: 67 PR-119	M-50 brown Milthix Gray Milthix	4 6	2.2 4.5	6.3	9.0	5.0	20.3	17	Both from Washburn
23	Primer: 66 PR-121 Topcoat: Whse Stk	M-50 brown Milthix No. 3A (1) gray-green	4 24	2.2 3.9	4.0	8.7	6.0	18.7	21	Primer from Washburn
24	Primer: 65 PR-151 Topcoat: 60 PR-112	Org. Phosphate & $ZnCrO_4$ No. 5B alkyd aluminum	2 18	2.5 3.2	6.3	10.0	4.4	20.7	16	Primer from Lubrizol

Notes: * Rated on scale from 10 to 0; with 10 = no deterioration and 0 = complete failure.

** Parenthesized ratings in this column indicate early removal from test due to failures. Systems 38 and 39 after 100 hrs., #(35, 38, 39)A after 200 hrs., #35 & 36 after 600 hrs.

(a) Faulty company identification.

(b) Roof exposure; panels vertical, facing East.

(c) Under field test on bridge structures.

TABLE 1 (Cont.)
IDENTIFICATION AND PERFORMANCE OF TEST COATING SYSTEMS
SERIES 6 COATINGS

Test System	Identification	Composition	Drying Time, hr	System Thickness, mils	Ratings*				Rank	Remarks
					Appearance	Face Rusting	Scratch Rusting	Total**		
25	Primer: 65 PR-151 Topcoat: Whse Stk	Org. Phosphate & $ZnCrO_4$ No. 3A (1) gray-green	2 24	2.5 4.0	4.0	8.7	5.0	17.7	22	Primer from Lubrizol
26	Primer: 68 P-34 Topcoat: 68 P-35	Gal-V-Tal Z-99H (Zinc Rich) Gal-V-Tal I-90 aluminum	10 10	1.6 2.2	6.0	10.0	8.3	24.3	6	Both from United Paint
27	Primer: 65 PR-124 Topcoat: 65 PR-125b	ZRC (Zinc Rich) ZRC Metaz aluminum	10(c) 10	2.1 2.7	5.7	7.7	7.3	20.7	16	Both from Sealube
28 (b)	Primer: 66 PR-116 Topcoat: 67 CH-127	Chem-Zinc (Zinc Rich) MIL-E-16501 vinyl alkyd gray	10(c) 4(c)	3.0 5.0	7.3	9.0	9.4	25.7	3	Primer from Truscon; Topcoat from Std., Detroit
29 (b)	Primer: 66 PR-116 Topcoat: 68 P-59	Chem-Zinc (Zinc Rich) Chlor-Rubber, gray Hi-Build	10(c) 4	3.2 5.0	7.7	10.0	9.3	27.0	1	Primer from Truscon; Topcoat from Pittsburg Plate
30	Primer: 67 PR-155 Topcoat: 67 CH-127	Galvanox (Zinc Rich) MIL-E-16501 vinyl alkyd gray	10(c) 4(c)	3.5 4.2	6.7	9.0	9.6	25.3	4	Primer from Wyandotte; Topcoat from Std., Detroit
31	Primer: 65 PR-134 Topcoat: 68 P-59	Galvicon (Zinc Rich) Chlor-Rubber, gray Hi-Build	10 4	3.5 4.5	7.3	8.4	10.0	25.7	3	Primer from Galvicon; Topcoat from Pittsburg Plate
32	Primer: 65 PR-130 Topcoat: 67 CH-127	Leadox gray Hi-Build MIL-E-16501 vinyl alkyd gray	7 4(c)	3.5 5.0	8.0	10.0	7.0	25.0	5	Primer from Tropical; Topcoat from Std., Detroit
33	Primer: 65 PR-130 Topcoat: 68 P-59	Leadox gray Hi-Build Chlor-Rubber, gray Hi-Build	7 4	3.2 4.7	3.3	4.4	7.0	14.7	24	Primer from Tropical; Topcoat from Pittsburg Plate
34	Primer: 68 P-58 Topcoat: 68 P-59	Aquapon 9685 (Zn Rich - 3 comp) Chlor-Rubber, gray Hi-Build	10 4	3.0 4.0	7.7	10.0	9.3	27.0	1	Both from Pittsburg Plate
35 (b)	Primer: 66 PR-60 Topcoat: 66 PR-60	No-Ox-Id 400 Hi-Build black No-Ox-Id 400 Hi-Build black	36 36	$\cong$ 5	1.7	2.7	6.3	(10.7)	---	Coating from Dearborn Chem.
36 (b)	Primer: 66 PR-60 Topcoat: 68 P-7	No-Ox-Id 400 Hi-Build black Tectyl TL-174 Al black	36 36(a)	$\cong$ 5	1.3	0.7	2.0	(4)	---	Primer from Dearborn Chem; Topcoat from Valvoline
37 (b)	Primer: 65 PR-131 Topcoat: 65 PR-131	Quaker-Coat black Quaker-Coat black	36 36	$\cong$ 5	0.3	1.7	4.7	6.7	25	Both from Quaker Co.
38 (b)	Primer: 67 PR-142 Topcoat: 68 P-7	Tectyl 506, brown Tectyl TL-174 Al black	36 36(a)	$\cong$ 4	2.3	7.0	8.7	(18)	---	Primer and Topcoat from Valvoline Co.
39 (b)	Primer: 67 PR-141 Topcoat: 68 P-7	Tectyl 127B aluminum Tectyl TL-174 Al black	36 36(a)	$\cong$ 3	3.3	7.3	8.7	(19.3)	---	Primer and topcoat from Valvoline Co.
40	Primer: 67 PR-117 Topcoat: 60 PR-112	No. 2MP (2) brown No. 5B alkyd aluminum	7 18	2.2 3.0	6.0	10.0	5.7	21.7	15	Primer from Nat'l Lead
41	Primer: 68 P-6 68 P-18 Topcoat: 60 PR-112	No. 1A (2) red lead & additive No. 5B alkyd aluminum	3 18	1.5 2.3	6.3	10.0	6.7	23.0	10	Primer from Nat'l Lead; Additive from Humko
42 (b)	Primer: 67 PR-156	Kencote 60 brown Hy.Carbon	36	.75	---	---	---	---	---	Coating from Kendall Refining Co.
43	Primer: 68 P-6 Topcoat: 66 PR-12	No. 1A (2) red lead Epoxy aluminum (2 comp)	3 3	1.7 4.5	6.7	10.0	5.7	22.4	12	Primer from Nat'l Lead; Topcoat from Truscon
44	Primer: 68 P-72 Topcoat: 66 PR-12	DMC Zinc Rich (1 pkg) Epoxy aluminum (2 comp)	1 3	3.0 4.0	5.3	9.3	9.7	24.3	6	Primer from DuBois; Topcoat from Truscon
45	Primer: 68 P-74 Topcoat: 67 CH-127	Av-Tec G-100 (2 comp) MIL-E-16501 vinyl alkyd gray	12 1	3.0 (d) 3.5	7.0	10.0	9.3	26.3	2	Primer from Davtec Co.
46	Primer: 68 P-82 Topcoat: 67 CH-127	X-200 Chromate primer MIL-E vinyl alkyd gray	1 1	2.7 4.2	8.0	10.0	6.3	24.3	6	Primer from United Paint
35A(b)	Primer: 66 PR-60 Topcoat: 66 PR-60	No-Ox-Id 400 Hi-Build black No-Ox-Id 400 Hi-Build black	36 36	$\cong$ 2	0.3	3.3	6.7	(10.3)	---	Primer and topcoat from Dearborn Chemical
38A(b)	Primer: 67 PR-142 Topcoat: 68 P-113	Tectyl 506, brown Tectyl TL-127C aluminum	36 36	$\cong$ 2-1/2	2.3	4.3	5.4	(12)	---	Both from Valvoline Co.
39A(b)	Primer: 67 PR-141 Topcoat: 68 P-113	Tectyl 127B aluminum Tectyl TL-127C aluminum	36 36	$\cong$ 2	3.0	5.3	9.0	(17.3)	---	Both from Valvoline Co.

Notes:
* Rated on scale from 10 to 0; with 10 = no deterioration and 0 = complete failure.

** Parenthesized ratings in this column indicate early removal from test due to failures. Systems 38 & 39 after 100 hrs., #(35, 38, 39)A after 200 hrs., #35 & 36 after 600 hrs.

(a) Faulty company identification.

(b) Roof exposure; panels vertical, facing East.

(c) Under field test on bridge structures.

(d) Applied in two coats.

TABLE 2
ROOF PERFORMANCE OF TEST COATING SYSTEMS
SERIES 6 COATINGS

Test System	Identification	Composition	Notes	System Thickness, mils	Performance Comments (as of 2-12-69)
1	Primer: 67 PR-153 Topcoat: 60 PR-112	No. 1A (1) red lead No. 5B aluminum	b	≅ 3	very slight dulling
4	Primer: 67 PR-153 Topcoat: 67 PR-148	No. 1A (1) red lead No. 4A (1) green	b	≅ 3	very slight dulling
8	Primer: 67 PR-153 Topcoat: 65 PR-106	No. 1A (1) red lead Silicone alkyd aluminum	b	≅ 2-1/2	slight dulling
11	Primer: 68 P-6 Topcoat: 67 PR-148	No. 1A (2) red lead No. 4A (1) green	b	≅ 3-1/2	very slight dulling
16	Primer: 66 PR-53 Topcoat: 68 P-67	White primer with P7 Hi-build green	b	≅ 3-1/2	slight dulling
28	Primer: 66 PR-116 Topcoat: 67 CH-127	Chem-Zinc (zinc rich) MIL-E-Vinyl alkyd gray	b	≅ 5	very slight dulling
29	Primer: 66 PR-116 Topcoat: 68 P-59	Chem-Zinc (zinc rich) Parlon Hi-build gray	b	≅ 5	no dulling
GREASE-TYPE COATINGS					
35	Primer: 66 PR-60 Topcoat: 66 PR-60	No-Ox-Id 400 black No-Ox-Id 400 black	b	≅ 5	medium grain alligatoring
36	Primer: 66 PR-60 Topcoat: 68 P-7	No-Ox-Id 400 black Tectyl Al-black	a, b	≅ 5	fine grain alligatoring
37	Primer: 65 PR-131 Topcoat: 65 PR-131	Quaker coat black Quaker coat black		≅ 5	slight chalking
38	Primer: 67 PR-142 Topcoat: 68 P-7	Tectyl 506 brown Tectyl Al-black	a, b	≅ 4	checking and cracking
39	Primer: 67 PR-141 Topcoat: 68 P-7	Tectyl 127B aluminum Tectyl Al-black	a, b	≅ 3	checking and cracking
42	Primer: 67 PR-156	Kencote 60 brown	b	≅ 1	slight bleaching
35A	Primer: 66 PR-60 Topcoat: 66 PR-60	No-Ox-Id 400 black No-Ox-Id 400 black	c	≅ 2	medium grain alligatoring
38A	Primer: 67 PR-142 Topcoat: 68 P-113	Tectyl 506 brown Tectyl 127C aluminum	c	≅ 2-1/2	good, no dulling
39A	Primer: 67 PR-141 Topcoat: 68 P-113	Tectyl 127B aluminum Tectyl 127C aluminum	c	≅ 2	good, no dulling

Notes: a) Faulty company identification
b) Exposed June 12, 1968
c) Exposed September 25, 1968.