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

A. J. Permoda
A. R. Gabel

Progress Report on a Highway Planning and Research Investigation
Conducted in Cooperation with
The U. S. Department of Transportation—Bureau of Public Roads

Research Laboratory Section
Testing and Research Division
Research Project 49 G-50(5)
Research Report No. R-696

State of Michigan
Department of State Highways
Lansing, April 1969
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 95°F 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. Cabel, 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

<table>
<thead>
<tr>
<th>Test System</th>
<th>Identification</th>
<th>Composition</th>
<th>Drying Time, hr</th>
<th>System Thickness, mils</th>
<th>Ratings*</th>
<th>Total**</th>
<th>Test</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (a)</td>
<td>Primer: 47 PR-160</td>
<td>No. 1A (1) red lead</td>
<td>48(a) 1.0</td>
<td>7.0 10.0 6.0</td>
<td>25.0 5</td>
<td>Standard Mil-Sil system</td>
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<tr>
<td>Topcoat: 60 PR-112</td>
<td>No. 5B alloyed aluminum</td>
<td>18(b) 3.0</td>
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<tr>
<td>2</td>
<td>Primer: 47 PR-160</td>
<td>No. 1A (1) red lead</td>
<td>48 2.0</td>
<td>4.7 8.0 6.6</td>
<td>19.3 10</td>
<td>Alternate Mil-Sil system, Topcoat from Hammond Lead</td>
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<td>Topcoat: 66 PR-54a</td>
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<td>3</td>
<td>Primer: 47 PR-163</td>
<td>No. 1A (1) red lead</td>
<td>48 2.0</td>
<td>7.0 10.0 6.6</td>
<td>23.7 11</td>
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<td>Topcoat: 60 PR-112</td>
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<td>48 2.0</td>
<td>6.0 9.7 6.6</td>
<td>23.3 12</td>
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<td>9 2.5</td>
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<td>6</td>
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<td>48 2.0</td>
<td>5.0 9.3 6.6</td>
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<td>Topcoat: 67 PR-150</td>
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<td>Green aluminum Mil-Silx</td>
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<td>6.7 10.0 5.5</td>
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<td>3.3 5.3 6.4</td>
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<td>10</td>
<td>Primer: 48 PR-6</td>
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<td>24 1.7</td>
<td>6.7 8.7 5.3</td>
<td>20.7 16</td>
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<td>Topcoat: 60 PR-112</td>
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<td>18 2.7</td>
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<td>24 1.7</td>
<td>7.3 8.7 7.3</td>
<td>24.3 6</td>
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<td>Topcoat: 67 PR-148</td>
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<td>24 1.7</td>
<td>5.7 8.3 5.7</td>
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<td>Topcoat: 67 PR-118</td>
<td>No. 5A (2) gray-green Hi-Build</td>
<td>24 4.2</td>
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<td>13</td>
<td>Primer: 66 PR-55a</td>
<td>No. 2MP (1) brown</td>
<td>17 1.2</td>
<td>3.7 8.7 4.3</td>
<td>15.7 21</td>
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<td>14</td>
<td>Primer: 66 PR-55b</td>
<td>No. 2MP brown with P1</td>
<td>17 1.2</td>
<td>6.0 8.7 6.0</td>
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<td>Primer: 66 PR-63</td>
<td>White primer with P1</td>
<td>17 2.7</td>
<td>7.2 8.7 6.0</td>
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<td>16 (b)</td>
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<td>5.7 8.3 6.7</td>
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<td>5.7 8.7 5.3</td>
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<td>19</td>
<td>Primer: 66 PR-123</td>
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<td>7 1.0</td>
<td>6.7 10.0 7.0</td>
<td>23.7 5</td>
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<td>TT-P-61Id type 3 brown electro.</td>
<td>6(c) 1.2</td>
<td>5.7 10.0 5.0</td>
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<td>Primer: 72 PR-145</td>
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<td>6(c) 1.2</td>
<td>7.0 8.3 5.7</td>
<td>22.0 14</td>
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<td>Primer: 66 PR-120</td>
<td>M-50 brown Mil-Silx</td>
<td>4 3.2</td>
<td>6.7 10.0 6.0</td>
<td>22.3 13</td>
<td>Both from Washburn</td>
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<td>Topcoat: 67 PR-120</td>
<td>Green aluminum Mil-Silx</td>
<td>7 3.2</td>
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<td>23</td>
<td>Primer: 66 PR-121</td>
<td>M-50 brown Mil-Silx</td>
<td>4 3.2</td>
<td>6.7 8.0 5.0</td>
<td>20.3 17</td>
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<td>Gray Mil-Silx</td>
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<td>24</td>
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<td>No. 5A (1) gray-green</td>
<td>4 3.2</td>
<td>4.6 8.7 6.0</td>
<td>18.7 11</td>
<td>Primer from Washburn</td>
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<td>Topcoat: 66 PR-121</td>
<td>Org. Mounzil: ZnCoCr</td>
<td>2 3.3</td>
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<td>No. 5B alloyed aluminum</td>
<td>18 3.2</td>
<td>6.3 14.0 4.4</td>
<td>29.7 16</td>
<td>Primer from fabrication</td>
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</table>

Notes:
* Based on scale from 1 to 10; with 10 = no deterioration and 0 = complete failure.
** Parenthesized ratings in this column indicate early removal from test due to failure.

Systems 38 and 39 after 100 hours, 625, 38, 30A after 100 hours, 950 & 36 after 600 hours.
(a) Felt company identification.
(b) Roof exposure; gable vertical, facing East.
(c) Under field test on bridge structures.
### TABLE 1 (Cont.)

**IDENTIFICATION AND PERFORMANCE OF TEST COATING SYSTEMS**

**SERIES 6 COATINGS**

<table>
<thead>
<tr>
<th>Test System</th>
<th>Identification</th>
<th>Composition</th>
<th>Drying Time, hr.</th>
<th>System Thickness, mils</th>
<th>Ratings*</th>
<th>Remarks</th>
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<td>25</td>
<td>Primer: 65 PB-151</td>
<td>Org. Phosphates &amp; Zn(IV)C4</td>
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<td>Topcoat: #62</td>
<td>Nc, 2A (1) gray-green</td>
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<td>26</td>
<td>Primer: 60 R-34</td>
<td>Cal-V-Tal 2-601 (Zinc Rich)</td>
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<td>ZINC (Zinc Rich)</td>
<td>10(c)</td>
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<td>3.0</td>
<td>7.2</td>
<td>9.4</td>
</tr>
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<td>MIL-E-16501A vinyl aliph gray</td>
<td>4(c)</td>
<td>5.0</td>
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<tr>
<td>29 (o)</td>
<td>Primer: 66 PR-119</td>
<td>Chem-Zinc (Zinc Rich)</td>
<td>10(c)</td>
<td>3.2</td>
<td>7.1</td>
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</tr>
<tr>
<td>Topcoat: 68 R-59</td>
<td>Chlor-Rubber, gray Hi-Build</td>
<td>4</td>
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<td>29</td>
<td>Primer: 67 PB-105</td>
<td>Calvins (Zinc Rich)</td>
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<td>3.0</td>
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<td>Topcoat: 67 CH-127</td>
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<td>4.2</td>
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<td>30</td>
<td>Primer: 65 PR-194</td>
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<td>Chlor-Rubber, gray Hi-Build</td>
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<td>Primer: 65 PR-150</td>
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<td>4(c)</td>
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<td>33</td>
<td>Primer: 65 PR-139</td>
<td>Leadez gray Hi-Build</td>
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<td>7.3</td>
<td>4.4</td>
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<td>Chlor-Rubber, gray Hi-Build</td>
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<td>34</td>
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<td>Chlor-Rubber, gray Hi-Build</td>
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<td>36</td>
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<tr>
<td>Topcoat: 66 RR-60</td>
<td>No-2c Si 400 Hi-Build black</td>
<td>36</td>
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<tr>
<td>36 (o)</td>
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<td>Tecl T-174 Al black</td>
<td>36</td>
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<tr>
<td>37 (o)</td>
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<td>Quaker-Black</td>
<td>36</td>
<td>—</td>
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<td>Quaker-Coat black</td>
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<td>38 (o)</td>
<td>Primer: 67 PB-141</td>
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<td>39 (o)</td>
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<td>Tecl T-174 Al aluminum</td>
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<td>Topcoat: 60 PB-112</td>
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<td>Primer: 69 B-6</td>
<td>No. 1A (2) red lead &amp; additive</td>
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<td>Topcoat: 69 PB-112</td>
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<td>Primer: 68 R-4</td>
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<td>Epoxy aluminum (5 comp.)</td>
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<td>Primer: 68 P-72</td>
<td>DMC Zinc Rich (1 lb.)</td>
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<td>Topcoat: 66 PR-132</td>
<td>Epoxy aluminum (5 comp.)</td>
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<td>8.7</td>
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<td>45</td>
<td>Primer: 68 P-44</td>
<td>Mo-Te-C 106 (3 comp.)</td>
<td>12</td>
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<td>46</td>
<td>Primer: 68 P-82</td>
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<td>MIL-E-16501A vinyl gray</td>
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<td>31A</td>
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<td>36</td>
<td>—</td>
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<tr>
<td>Topcoat: 66 RB-60</td>
<td>No-2c Si 400 Hi-Build black</td>
<td>36</td>
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<tr>
<td>33A</td>
<td>Primer: 67 RB-142</td>
<td>Tecl T-174 brown</td>
<td>36</td>
<td>—</td>
<td>2.3</td>
<td>4.3</td>
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<tr>
<td>Topcoat: 68 P-113</td>
<td>Tecl T-174 Al aluminum</td>
<td>36</td>
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<td>Primer: 67 PB-341</td>
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<td>Topcoat: 68 P-113</td>
<td>Tecl T-174 Al aluminum</td>
<td>36</td>
<td>—</td>
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**Notes:**
- * Rated on scale from 10 to 0; with 10 = no deterioration and 0 = complete failure.
- ** Permeability ratings in this column indicate early removal from test due to failure.
- Systems 30 & 30 after 100 hrs., #31, #36 after 200 hrs., #35 & #38 after 500 hrs.
- (a) Faulty company identification.
- (b) Roof exposure; pansal 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

<table>
<thead>
<tr>
<th>Test System</th>
<th>Identification</th>
<th>Composition</th>
<th>Notes</th>
<th>System Thickness, mils</th>
<th>Performance Comments (as of 2-12-69)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Primer: 67 PR-153</td>
<td>No. 1A (1) red lead</td>
<td>b</td>
<td>²/₃ 3</td>
<td>very slight dulling</td>
</tr>
<tr>
<td></td>
<td>Topcoat: 60 PR-112</td>
<td>No. 5B aluminum</td>
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<tr>
<td>4</td>
<td>Primer: 67 PR-153</td>
<td>No. 1A (1) red lead</td>
<td>b</td>
<td>²/₃ 3</td>
<td>very slight dulling</td>
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<tr>
<td></td>
<td>Topcoat: 67 PR-148</td>
<td>No. 4A (1) green</td>
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<tr>
<td>8</td>
<td>Primer: 67 PR-153</td>
<td>No. 1A (1) red lead</td>
<td>b</td>
<td>²/₃ 2-1/2</td>
<td>slight dulling</td>
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<td>Topcoat: 65 PR-106</td>
<td>Silicone alkyd aluminum</td>
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<td>11</td>
<td>Primer: 68 P-6</td>
<td>No. 1A (2) red lead</td>
<td>b</td>
<td>²/₃ 3-1/2</td>
<td>very slight dulling</td>
</tr>
<tr>
<td></td>
<td>Topcoat: 67 PR-148</td>
<td>No. 4A (1) green</td>
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<td>16</td>
<td>Primer: 66 PR-53</td>
<td>White primer with P7</td>
<td>b</td>
<td>²/₃ 5-1/2</td>
<td>slight dulling</td>
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<tr>
<td></td>
<td>Topcoat: 68 P-67</td>
<td>hi-build green</td>
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<td>28</td>
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<td>Chem-Zinc (zinc rich)</td>
<td>b</td>
<td>²/₃ 5</td>
<td>very slight dulling</td>
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<td>Topcoat: 67 CH-127</td>
<td>MIL-E-Vinyl alkyd gray</td>
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<tr>
<td>29</td>
<td>Primer: 66 PR-116</td>
<td>Chem-Zinc (zinc rich)</td>
<td>b</td>
<td>²/₃ 5</td>
<td>no dulling</td>
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<tr>
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<td>Topcoat: 68 P-59</td>
<td>Parlon hi-build gray</td>
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GREASE-TYPE COATINGS

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<th>Test System</th>
<th>Identification</th>
<th>Composition</th>
<th>Notes</th>
<th>System Thickness, mils</th>
<th>Performance Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>Primer: 66 PR-60</td>
<td>No-Ox-ld 400 black</td>
<td>b</td>
<td>²/₃ 5</td>
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<td>No-Ox-ld 400 black</td>
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<td>36</td>
<td>Primer: 66 PR-60</td>
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<td>a, b</td>
<td>²/₃ 5</td>
<td>fine grain alligating</td>
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<td>Tectyl Al-black</td>
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<td>37</td>
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<td>Quaker coat black</td>
<td>a, b</td>
<td>²/₃ 5</td>
<td>slight chalking</td>
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<td>Quaker coat black</td>
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<td>38</td>
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<td>Tectyl 506 brown</td>
<td>a, b</td>
<td>²/₃ 4</td>
<td>checking and cracking</td>
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<td>Tectyl Al-black</td>
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<td>Tectyl 127B aluminum</td>
<td>a, b</td>
<td>²/₃ 3</td>
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<td>Tectyl Al-black</td>
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<td>Kencote 60 brown</td>
<td>b</td>
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<td>c</td>
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<td>No-Ox-ld 400 black</td>
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<td>²/₃ 2-1/2</td>
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<td>Tectyl 127C aluminum</td>
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<td>c</td>
<td>²/₃ 2</td>
<td>good, no dulling</td>
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<td>Tectyl 127C aluminum</td>
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Notes: a) Faulty company identification
       b) Exposed June 12, 1968
       c) Exposed September 25, 1968.