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MICHIGAN
STATE HIGHWAY DEPARTMENT
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METCOSEAL

A PROTECTIVE COATING FOR STRUCTURAL STEEL

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A Cooperative Project with the Bridge Division

Research Project 49 G-50 (1)

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SYNOPSIS

This report covers a study made to evaluate the merits of a specific metallizing process, Metcoseal, as a protective coating on steel bridge railings. This metallizing process utilizes a spray technique to deposit a fused metal onto a more corrodible base metal. The process can be applied in the shop or in the field.

The tested Metcoseal process uses aluminum metal, sprayed on steel at an average thickness of six mils, plus subsequent sealing of the deposit with an organic type (silicone) finish.

Flat Metcoseal-treated panels were laboratory tested in comparison with two other aluminum alloys, both of which were recommended for fabrication into aluminum bridge railings. In addition a fourth test system was used, consisting of one of these alloys coated with an aluminum-pigmented silicone finish in the laboratory, in order to note the contribution of a sealer toward corrosion resistance on a Metcoseal surface.

Laboratory conducted salt spray and accelerated weathering tests on the test specimens show that:

1. Exposure of the tested aluminum to sodium chloride fog, either as an alloy or Metcoseal coating, causes corrosion and produces white, unsightly surface deposits.

2. Exposure of a Metcoseal panel to 400 hours of accelerated weathering (Weather-Ometer) did not show metallic corrosion. System No. 2, an alloy containing 98 percent of aluminum, showed a slight amount of corrosion or surface dulling in the same test.

3. An organic coating, whether applied as a sealer in the Metcoseal system or a finish on aluminum alloys, inhibits the corrosion process. This inhibitive period is expected to be temporary and depend upon the effective life of the organic top-coat.

4. An anodizing surface treatment on a 99 percent aluminum alloy, Test System No. 4, did retard the corrosion rate when that specimen was exposed to alternating salt spray and accelerated weathering for 700 hours.

Exposure of a Metcoseal panel and the 98 percent aluminum alloy in a fender-well of a car in winter showed that abrasive action and de-icing salts also corrode aluminum, but that the sealer on the Metcoseal panel inhibits the corrosion rate, at least temporarily.

The Bridge Division has had a Metcoseal-treated bridge railing section under field exposure since October, 1955. Continued examinations of this railing show that the rough finish of this system induces dirt retention, while the sealer is subject to a spotty type of yellowing, which was also evident in the laboratory conducted tests. Incipient corrosion at junctures of the top rail sub-members of the railing was also evident, and was progressing slowly with time of exposure. If the Metcoseal treatment is unable to prevent such early localized corrosion, then this is a serious disadvantage for a coating system known to be more expensive than a paint system.

Both the Metcoseal treatment on bridge railings and aluminum bridge railings are scheduled for in-service exposures in separate bridge projects. Examinations of these railings will yield more extensive performance data on the weatherability and service life of those materials.

METCOSEAL
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Metcoseal is a proprietary name given by the Dix Engineering Company of Lincoln Park, Michigan, to its process of metallizing aluminum onto a steel base, including subsequent sealing of the aluminum coating with an organic-type (silicone) finish. A letter from W. W. McLaughlin dated September 29, 1955, initiated laboratory and field evaluation of aluminum metal deposited onto steel by the Metcoseal process as a possible replacement for paint-type coatings on steel bridge railings.

The Metcoseal metallizing process is to be field evaluated on 415.8 feet of steel bridge railing on a grade separation structure to be completed in 1956, carrying Ten Mile Road over relocated US-16, two miles west of Farmington (Bridge Project No. IN B1 of 63-6-4, C1-RO).

Laboratory Evaluation

Two Metcoseal-treated 3- by 6-inch panels were originally supplied to the Research Laboratory, but subsequently four additional panels were obtained from the producer. The Metcoseal panels were put through a variety of laboratory tests together with the following comparison aluminum materials:

TABLE 1

Test Materials

Test System	Material	Supplier
1	Metcoseal	Dix Engineering Co.
2	Aluminum Alloy No. 6061-T6	Reynolds Metals Co.
3	Aluminum Alloy No. 6061-T6 Laboratory coated with one spray-coat of a Silicone Aluminum Pigmented finish	Reynolds Metals Co. Sherwood Products Co.
4	Aluminum Alloy No. 2S with an anodized surface treatment	Reynolds Metals Co.

The aluminum alloys used for comparative purposes in these laboratory tests, have been recommended by the supplier for fabrication into aluminum bridge-railing components. Some similar type of alloy will be used in the aluminum metal bridge railings specified for a new bridge over the Grand River in Kent County, 0.6 mi. east of Ada on M-21 (F B2 of 41-1-4, C2R).

Laboratory Tests

Different panels of each test system were put through the following tests:

1. Salt Spray test run in accordance with ASTM Method B117-49T utilizing a 20 percent salt solution and a chamber temperature of 95 F. The panel surfaces were cross-scratched prior to testing. The test period was 300 hours.

The ratings of the systems in the salt-spray test, together with comments are given in Table 2. Photographs of the tested panels are shown in Figure 1.

2. Accelerated Weathering, Carbon-Arc tests were run in an Atlas Twin-Arc Weather-Ometer in accordance with Method 615.2 of Federal Specifications TT-P-141a. Each machine cycle consisted of 20 minutes exposure to light including one 3-minute period exposure to water wetting. The test period was 400 hours.

The ratings of the test systems in the accelerated weathering tests are also given in Table 2. Photographs of the tested panels are shown in Figure 1.

3. Alternating accelerated weathering and salt spray tests were run on a third set of test panels whose surfaces were cross-scratched prior to testing. The salt spray and accelerated weathering cycles were run as outlined in paragraphs 1 and 2 above, respectively. The cycling of the test panels from one test to another was performed on the following schedule:

a) 100 hours of Weather-Ometer exposure.

b) 25 hours of salt spray exposure.

c) 50 hours of Weather-Ometer exposure.

d to q) Repeat cycles b) and c), respectively.

TABLE 2

TEST RESULTS

Test System No.	Salt Spray 300 - hours		Weather-Ometer 400 - hours		Alternating Salt Spray and Weather-Ometer 700 - hours	
	Rating*	Comments	Rating*	Comments	Rating*	Comments
1**	4	Panel covered with some white corrosion products, plus a little yellow stain.	9	Slight bleaching	6	Yellow staining along cross-scratches due to sealer degradation.
2	3	Panel covered with white corrosion products	7	Slight uneven corrosion and loss of brightness - not unsightly.	5	Panel covered with some white corrosion products and yellow staining.
3	7	Some blistering along cross-scratches.	8	Dulling of applied surface coating.	6	Slight corrosion of metal base where applied finish blistered.
4	-		-		8	Appearance of some small localized points of corrosion.

Test System No.	Automobile Fender-Well Exposure				Field Exposure	
	1.5 months (Feb. 6 - March 20)		5-1/4 months (Feb. 6 - July 12)		9 months (Oct. 1955 - July, 1956)	
	Rating*	Comments	Rating*	Comments	Rating*	Comments
1**	8	Panel shows light brown staining due to sealer degradation.	8	Panel shows light brown staining due to sealer degradation.	7	Railing shows light brown staining due to sealer degradation plus incipient corrosion at junctures of top railing sub-members.
2	7	Panel has light deposit of white corrosion products.	6	Panel has deposit of white corrosion products.	-	

* Rating System: 10 designates no degradation, and 0 designates total surface failure.

** Thickness of metallized coating on test panels varied from 6.5 to 11 mils.

The entire test included a total of 500 hours of Weather-Ometer exposure and 200 hours of salt spray exposure. The ratings of the systems in the alternating accelerated weathering and salt spray tests are also given in Table 2. Photographs of the tested panels are shown in Figure 1.

4. Exposure in a Fender-Well of an Automobile:

It was believed that exposure of the test panels in the fender-well of an automobile at the time of year when salts are used to de-ice roads, would simulate the corrosion and abrasion conditions that are most damaging to surface finishes of emplaced bridge railings. Accordingly, Mr. S. Cardone arranged to have one Metcoseal-treated panel and one Aluminum Alloy No. 6061-T6 Panel (System No. 2) mounted in a fender-well of a State-Owned automobile from February 6 to March 20, 1956.

Examination of the two panels after removal showed that under these conditions, the aluminum alloy System No. 2, exhibited an uneven, light formation of white corrosion products. The Metcoseal-treated panel, although not corroded, exhibited a spotty, light-brown surface deposit which, because it was soluble in and removable with organic solvents, was considered to be a degradation product of the silicone sealer used in the treatment.

After the first examination the two panels were remounted in the fender-well of the State-owned automobile and further exposed until July 12, 1956.

Upon removal, the panels were found to be coated with a heavy layer of wet sand. It is not known whether the adhering sand functioned as a protective layer for the panels, but the Metcoseal panel was essentially unchanged while the aluminum test System No. 2 showed a slight increase of surface corrosion during the additional 3-3/4 months of exposure. Figure 2 shows the condition of these panels.

5. Preliminary Field Exposure:

Mr. S. Cardone arranged to have one section of bridge railing which was Metcoseal-treated installed in October, 1955 on the southwest portion of the grade separation over PMRR on Highway US-16 just west of Lansing. Examinations of this test railing, shown in Figure 3, in the first half of 1956 have revealed the following:

a) The Metcoseal metallizing treatment, because it produces a rough, matte finish, is more dirt retentive than paint-type coatings.

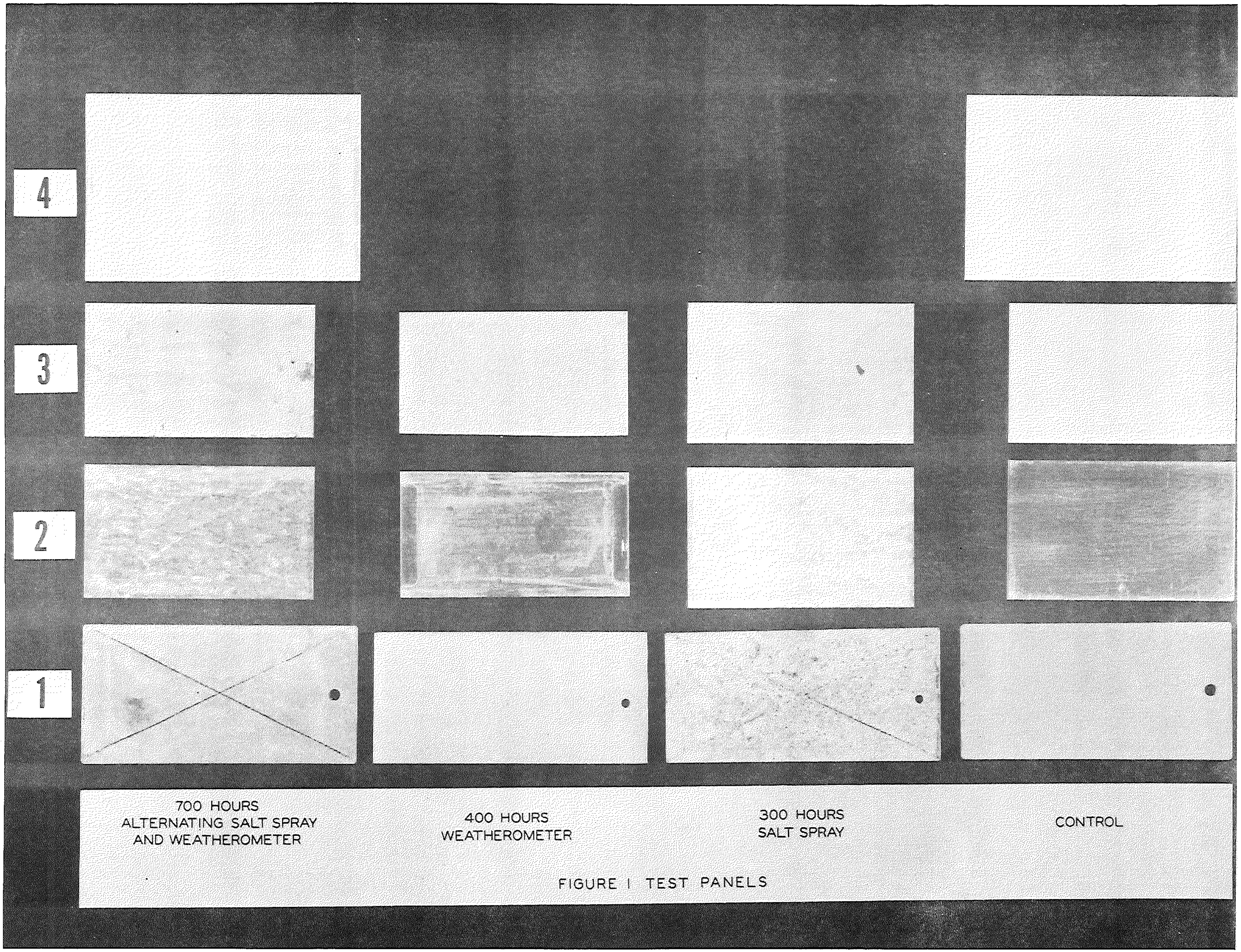

FIGURE I TEST PANELS

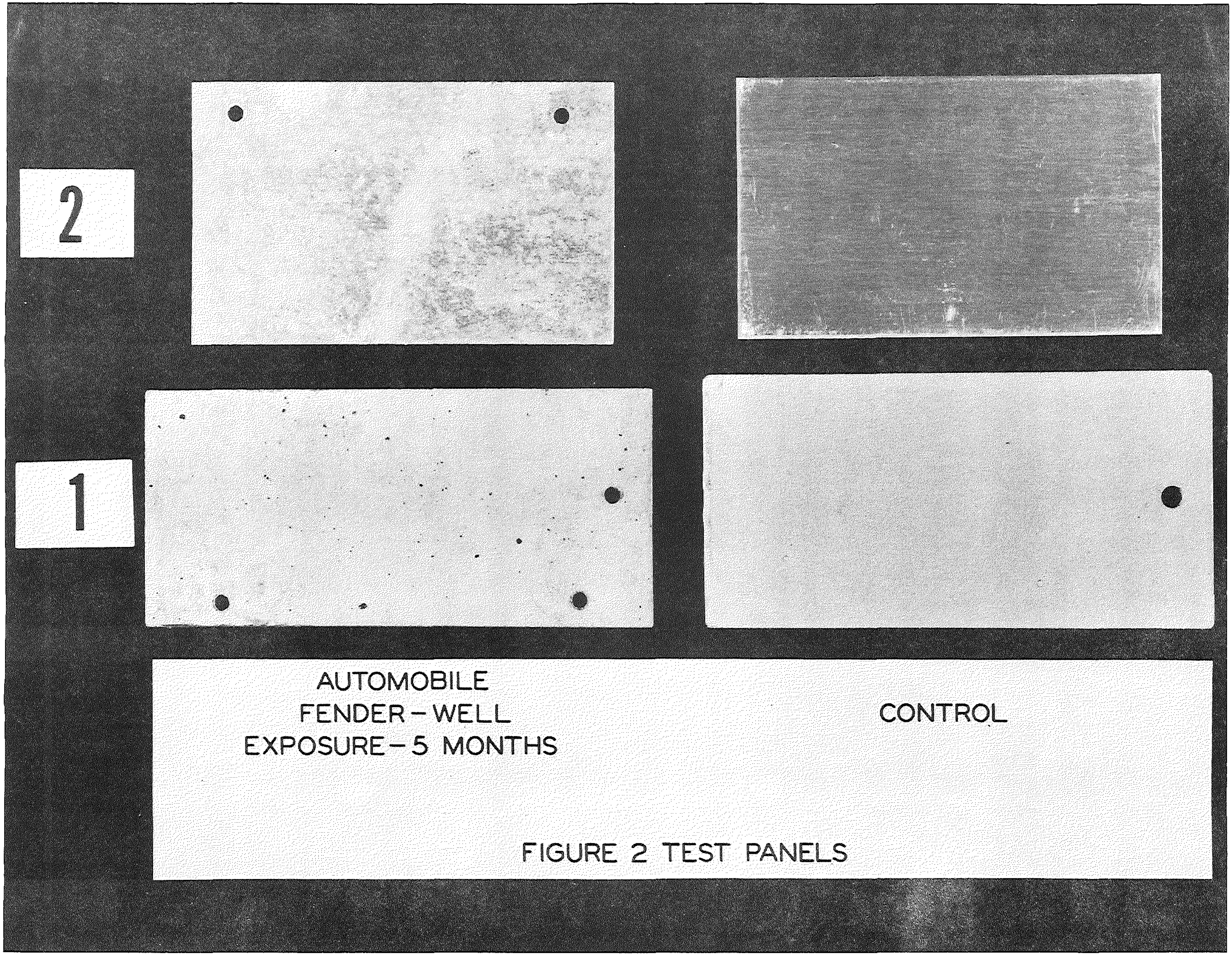

FIGURE 2 TEST PANELS

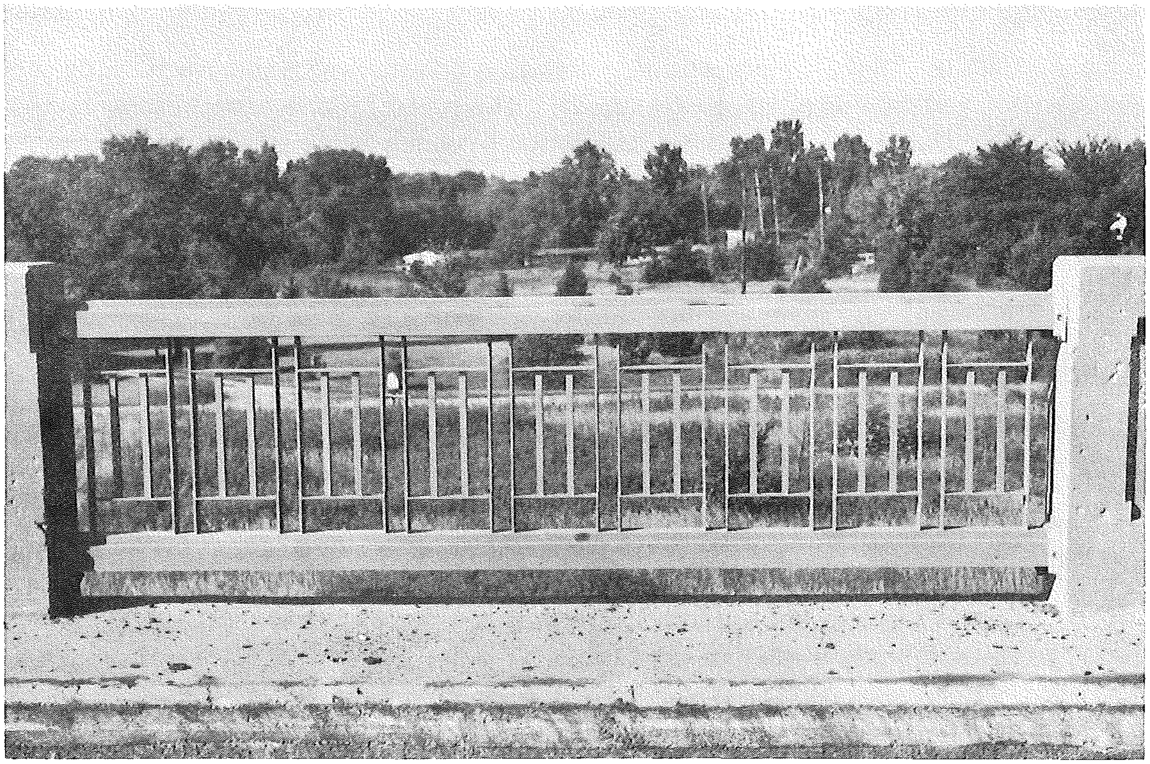

FIGURE 3. PRELIMINARY FIELD EXPOSURE OF METCOSEAL PROCESSED BRIDGE RAILING.

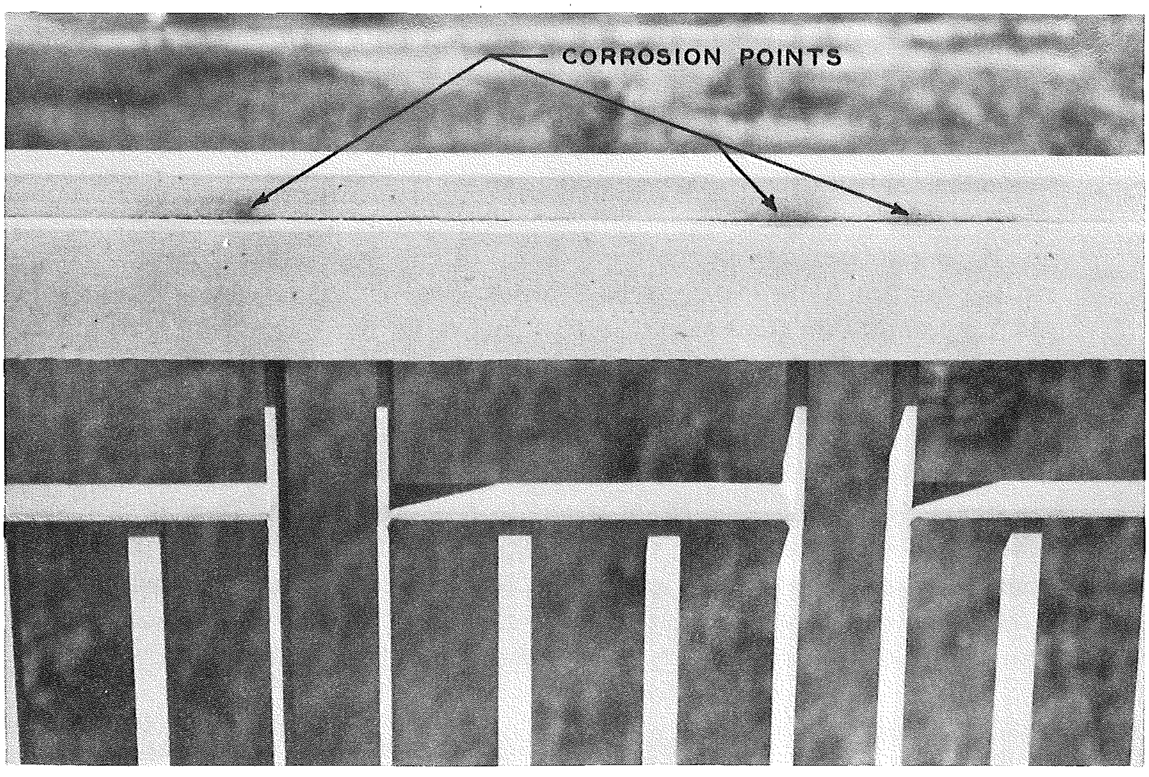

FIGURE 4. INCIPIENT CORROSION AT JUNCTURES OF TOP RAIL SUB-MEMBERS OF METCOSEAL PROCESSED BRIDGE RAILING. EMPLACED OCTOBER, 1955. PHOTOGRAPH TAKEN JULY 6, 1956.

b) Light-brown staining was in evidence and was progressing slowly with time (Figure 4). The staining was analyzed as being due both to a degradation product of the organic sealer used in the treatment and to corrosion of the steel base metal at juncture points on the sub-members of the top rail, which could not be sealed properly by this treatment when applied on assembled railing units.

Specifications describing the metallizing, cleaning, and coating treatment are appended to this report.

6. Weather resistance of the test panels is being determined by Method 616.1 of Federal Specifications TT-P-141b. The exposure-rack containing the test panels is set at an angle of 45 deg. from the vertical, facing south, on the roof of Olds Hall at the Research Laboratory. The test panels were set outdoors on April 13, 1956. These panels will be examined periodically in the future.

Conclusions

Laboratory tests show that aluminum, either as a solid metal or a Metcoseal treatment deposit, under accelerated weathering conditions, oxidizes to form a thin, white, adherent surface deposit. Salt spray tests accelerated the corrosion process on aluminum, either as a solid metal or a Metcoseal treatment overlay, to form spotty white surface deposits. The organic sealer used in the Metcoseal treatment inhibits both the oxidization and corrosion processes, at least temporarily, but degrades to form spotty yellow deposits. The anodizing surface treatment on aluminum also inhibits the oxidation and corrosion of the base metal.

A preliminary surface exposure of one Metcoseal-treated bridge railing section shows early initial breakdown of that coating system only at juncture points on the top rail. The failure as measured by corroded area has increased during the six-to-nine month period of exposure. The relatively short period of the service exposure test for the Metcoseal coating system yields too little information to allow a prediction of the service life for such coatings. Except at the juncture cracks present in the top rail, the service life of a Metcoseal metallic coating (similar in type to a galvanized coating), is expected to be greater than that of the paint-type coatings currently being used on railings; the Metcoseal coating is thicker, more durable, more chip and scratch resistant, and also is capable of protecting small breaks by an anodic type of electrochemical reaction.

A more thorough evaluation and analysis of the merits of the Metcoseal coating on bridge railings and also of aluminum bridge railings will be possible from the in-service exposures which have been scheduled by the Department for these materials on two separate bridge projects.

It should be noted here that the problem of maintaining a coating or a metallic finish on bridge railings would be alleviated, if the present design were altered to eliminate the many sharp edges and 90-deg. angles which in service so often become focal points for corrosion.

APPENDIX

METALLIZING STEEL BRIDGE RAILING

General:

This work shall consist of:

1. Pressure blast cleaning of steel railing.
2. Metallizing blasted surfaces with sprayed metallic aluminum.
3. Seal coating Metallized surfaces with 2 coats of Silicone Aluminum Sealer.

The process shall result in a metallized aluminum coating on all exposed surfaces of the steel railing equivalent to that produced by the Dix Engineering Co., 1415 Dix Road, Lincoln Park, Michigan, using the Metco System #120 or equal.

Blast Specification:

Any of the following materials may be used for force-feed pressure type blast machines.

1. BB-16 to 25 mesh slag abrasive at 50 p.s.i. clean and free of excessive fines.
2. Aluminum oxide abrasive 16 to 25 mesh at 50 p.s.i. clean and free of excessive fines.

Equipment:

This should be of conventional force feed or pressure type. Nozzle size shall be such that a pressure of not less than 50 p.s.i. is maintained at the blast generator.

Blast Operation:

All surfaces to be metal sprayed shall be thoroughly cleaned and roughened by blasting with abrasive as specified herein. If paint, oil, or other contaminating products are present on surface that may be removed by flame cleaning or blast cleaning by fine sand prior to final blast preparation.

The air supply for blasting must be sufficiently free of oil and moisture so that no visible oil or moisture appears on the blasted surface.

Inspection:

Any surface which shows visible moisture, rust, scale, or other contamination shall be re-blasted prior to metallizing.

Metallizing Specifications:

Material:

The metallizing wire shall be either 99.0% aluminum or 95% aluminum plus 5% Silicon.

Metallizing Operation:

Clean, dry air shall be used and supplied at the gun manufacturer's recommended pressure for spraying aluminum.

The metal coating shall be applied to a minimum thickness of .0045". (This minimum thickness is based on a nominal average thickness of approximately .006").

At least one sprayed aluminum coating must be applied within four hours of blasting and the surface must be completely coated to the specified thickness within eight hours of blasting.

The specified thickness of coating shall be applied in multiple layers, and in no case shall be less than two passes of the metal spraying unit over every part of the surface. The sprayed metal shall overlap on each pass of the gun to assure uniform coverage.

The coating shall be firmly adherent and free from uncoated spots. The surface after spraying shall be uniform and free from lumps or loosely adherent, spattered metal.

Protection of Surface:

Special care shall be used in handling the metallized railing to avoid damage during shipment and erection. Any section which shows damage to the extent that the base metal is exposed will be rejected by the Engineer and a re-application of metallized aluminum will be required.

Inspection:

The metal coating shall be inspected with an approved type Magnetic Thickness Gauge. This to follow as closely as possible after completion of spraying.

Finish Coating Specifications:

Material:

The finish coating shall be METCO SEAL SA Silicone Aluminum Sealer, or equal, thinned with one part METCO SEAL ST Thinner (or equal), to 3 parts sealer for spray application.

Application:

Finish coatings must be applied to clean, dry metallized surfaces. Any oil, grease or other contamination should be removed by thorough washing with METCO SEAL ST Thinner until no visible traces exist, and the surfaces should be allowed to dry for 15 minutes minimum before applying the Metco seal. Coatings must be applied heavy enough to produce a thoroughly wet appearance.

The first coat shall be METCO SEAL SA mixed as recommended by the manufacturer. Minimum drying time shall be 30 minutes.

The second coat shall be METCO SEAL SA mixed as recommended by the manufacturer. Minimum drying time shall be at least 2 hours before placing parts in service.

In addition the inside surfaces of the top and bottom rail shall receive two coats of sprayed Silicone Aluminum Sealer.

Method of Measurement and Basis of Payment:

"Metallizing Steel Bridge Railing" will be measured by length in lineal feet of steel railing sections, coated with aluminum. The contract unit price per lineal foot shall be payment in full for furnishing all materials, labor and equipment as herein specified and as called for on the plans to make a complete job. Railing flanges and clips shall be painted as hereinafter specified under "FIELD PAINTING".

FIELD PAINTING

General:

This work shall be in accordance with Article 5.02.-03-g of the Standard Specifications and consists of spot painting with Painting Mixture No. 2A all surfaces where Painting Mixture No. 1A is specified, and, after completion of all concrete work which is supported by steel work, cleaning all exposed surfaces of structural steel, railing flanges and railing clips, and applying thereto one complete coat of Painting Mixture No. 2A.

After the expansion joint assemblies in the bridge floor have been properly filled with filler material the exposed portions of these assemblies shall be thoroughly cleaned of rust, dirt, oil or grease and other substances and shall then be painted with Painting Mixture No. 2A.

The Contractor's attention is called to the requirement of the Standard Specifications for spot painting the structural steel immediately after the erection of the structural steel has been completed and approved by the Engineer.

Material:

All material shall meet specification requirements and shall be furnished by the Contractor. Sufficient paint shall be provided to perform all field painting herein specified.