EVALUATION OF ZINC COATING PROCEDURES

FINAL REPORT

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Research Report No. 116
Research Project No. 72-1CH(B)
Louisiana HPR 0010(001)

Conducted by
LOUISIANA DEPARTMENT OF
TRANSPORTATION AND DEVELOPMENT
Research and Development Section
In Cooperation With
U. S. Department of Transportation
FEDERAL HIGHWAY ADMINISTRATION

January, 1978

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ABSTRACT

This research project was conducted in order to compare the existing procedure of zinc coating by hot-dip galvanizing with the other zinc coating systems of painting and electroplating.

Hardware coated by these processes was exposed to varied laboratory tests. Based upon the results of these tests, the protection afforded by the GS grade of electroplated hardware was determined to be equivalent to that of the hot-dip galvanized hardware having a coating thickness of approximately 2 ounces of zinc per square foot of surface area (0.061 g/cm^2). The LS grade of electroplated hardware was found to be inferior in performance to both the GS grade of electroplated and hot-dip galvanized hardware. The zinc-rich paints used as repair systems gave adequate protection to the hardware after being exposed in a hot and humid environment for 12 months.

Results using the scanning electron microscope showed a distinct difference in the layer of zinc deposited on the steel surface using the electroplating and hot-dip galvanizing procedures. The layer of zinc observed on a hot-dip galvanized washer showed the presence of an alloy layer. However, there was no alloy layer detected in the photomicrograph taken of an electroplated washer.

Four years of field evaluation have been completed. The results showed that generally all the zinc coatings were performing satisfactorily. The only significant amount of corrosion was rusting of the bolt threads which were painted with an organic zinc-rich paint.

EVALUATION OF ZINC COATING PROCEDURES

INTRODUCTION

There has been an increase in the amount of steel being coated with zinc by the electroplating method. Questions have been raised as to the relative protection of this procedure with the old hot-dip galvanizing method.

The purpose of this research project was to make this comparison along with determining the effectiveness of using zinc-rich paints as repair systems. Varied laboratory tests and a field evaluation were used in determining the relative protection afforded by these systems.

SCOPE

An evaluation of several types of procedures for coating metal with zinc was performed using varied laboratory tests including exposure to a hot humid environment and exposure to a hot salt fog environment, both of which were controlled in the laboratory.

In addition to laboratory testing, four years of field exposure, intended as a comparative study, have been completed.

Use of a scanning electron microscope has enabled a detailed comparison to be made between the alloy layers formed when steel is coated by the electroplating and hot-dip galvanizing processes.

Phase I (Laboratory Evaluation)

A. Weathering of Zinc Coating Systems in a Hot Humid Environment

In order to compare hot-dip galvanizing, electroplating and painting as methods of coating steel with zinc, specimens of hardware coated by each process were evaluated. Each set of hardware consisted of a bolt, a washer and two nuts. The bolt had dimensions of 5 x 3/4 inches (13 x 2 cm) and was made of A-325 steel (high tensile strength). The washer and nuts were of standard size to be used with this size bolt.

Two nuts, separated by a washer, were tightened against one another on each bolt to a force of 88 foot-pounds (119 n-m). This was the same amount of force applied when these bolts were used in the field to connect interstate sign posts to the base mounts as part of the field evaluation.

The GS and LS grades of electroplating are specified in ASTM Designation A-164 as having a zinc coating thickness of ≥ 1.0 mils (≥ 0.025 mm) and ≥ 0.5 mils (≥ 0.013 mm), respectively. These grades of electroplated hardware, along with the hot-dip galvanized and painted hardware, were then exposed in an environmental chamber set at a temperature of 150°F (66°C)

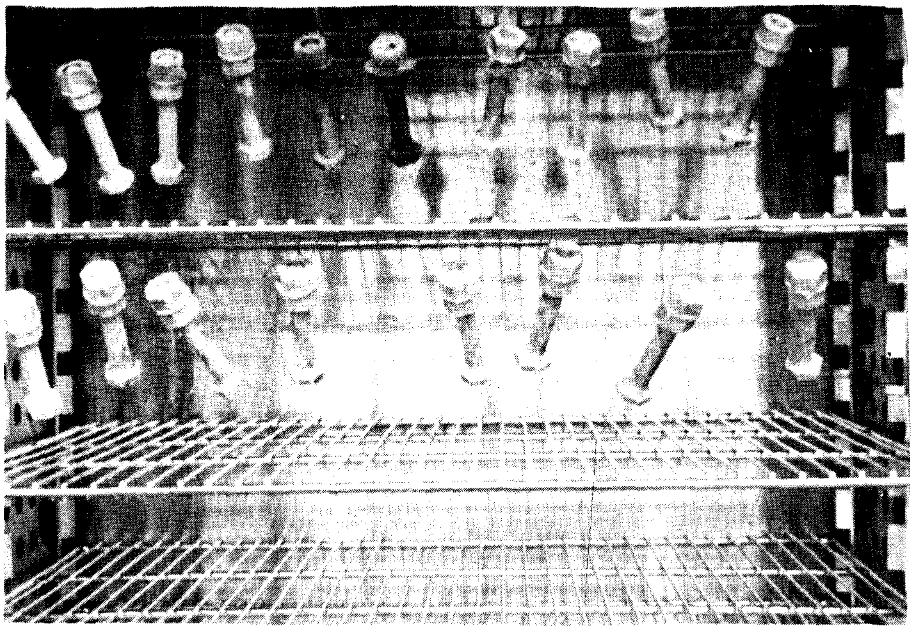

Figure 1. Environmental chamber containing hardware

and a relative humidity in excess of 95% as shown in Figure 1. The exposed hardware was analyzed periodically over a period of 16 months. Pictures were taken during this period in order to document any change in appearance of the specimens.

B. *Weathering of Zinc Repair Systems in a Hot Humid Environment*

Several bolts were partially stripped of the original electroplated and hot-dip galvanized zinc coating and painted with a zinc-rich paint overlapping the original coating by approximately 1 inch. This test was performed in order to examine zinc-rich paint as a repair system.

The zinc-rich paints used in this test were two cold galvanizing compounds and one organic zinc-rich primer. The cold galvanizing compounds were applied, by the use of aerosol cans, at a dry film thickness of 2 to 4 mils (0.05 to 0.10 mm). The organic zinc-rich primer was applied at a dry film thickness of approximately 4 mils by dipping the bolts into the paint.

After preparation of the bolts as described above, they were placed into the environmental chamber having a temperature of 150°F (66°C) and a relative humidity in excess of 95%. The specimens were inspected and photographed after 2, 3 3/4, 5, 8, 12 and 15 months of exposure.

C. *Salt Fog Exposure of Zinc Coating and Repair System*

The electroplated and hot-dip galvanized hardware was exposed to a salt fog atmosphere as described in LDH Designation TR 1011-74 (included in the appendix) for a period of one week. The intent of the salt fog exposure was to develop a test which could be performed in a shorter time than necessary for the exposure in the environmental chamber and which could be correlated to the results obtained in the environmental chamber.

In addition, 6-inch (15 cm) lengths of a 2 1/2-inch (6.4 cm) diameter galvanized pipe were cut in half lengthwise and stripped of the first 2 inches (5 cm) of coating. This bare area, along with 2 inches (5 cm) of the galvanized coating, was coated with a zinc-rich cold galvanizing compound. Six compounds were tested as repair systems by this procedure. Two of the compounds were the same as the two applied to the bolts and tested as repair compounds in the environmental chamber.

After being prepared, these sections of pipe were placed into the salt fog apparatus for two weeks and exposed to the environmental conditions as described in Paragraph 3(a) of LDH Designation TR 1011-74.

D. *Comparison of Hot-Dip Galvanized and Electroplated Zinc Coatings Using Scanning Electron Microscopy*

The cross sections of a hot-dip galvanized washer and an electroplated washer were examined with a scanning electron microscope to compare the alloy layer formed by each method of zinc coating.

The washers were first cut and mounted in cross section. They were ground and polished using standard metallurgical procedures. The washers were then etched with a mixture of chromic acid and sodium sulfate and then etched again with chromic acid. Photomicrographs were then taken of the zinc-steel interface areas.

The hot-dip galvanized washer which was photographed to show the voids present was prepared as described above with the exception of the etching.

Phase II (Field Evaluation)

An installation of 5 x 3/4-inch (13 x 1.9 cm), high-tensile-strength bolts, along with washers 3/4-inch (19 cm) nuts, was made in the base of breakaway interstate sign supports as shown in Figure 2. One of the two locations selected for the test sites was I-10 near the Chloe exit. This location is in the general area of Lake Charles, Louisiana. The second location selected was I-20 near the Garret Road Exit east of Monroe, Louisiana.

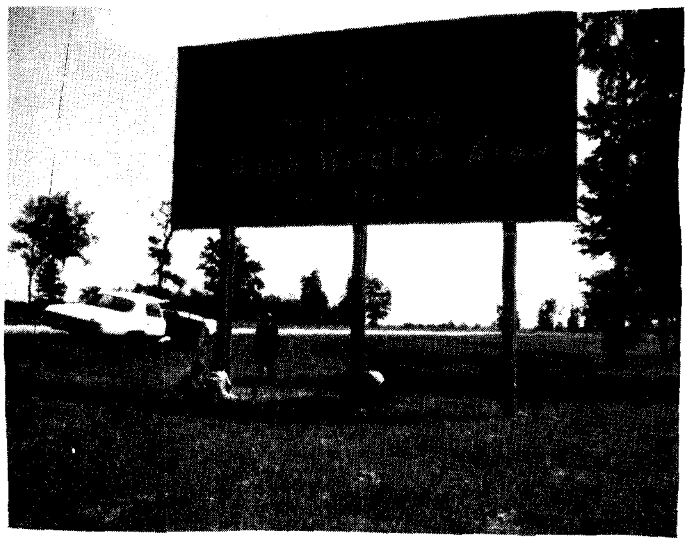

Figure 2. Installation of hardware in the field

The hot-dipped galvanized bolts which were used to originally connect the interstate sign structure to the base were removed and replaced by the experimental hardware. Three washers and one nut were assembled with each bolt as shown in Figure 3. The nuts were tightened to a force of 88 foot-pounds (119 n-m) with a torque wrench as shown in Figure 4.

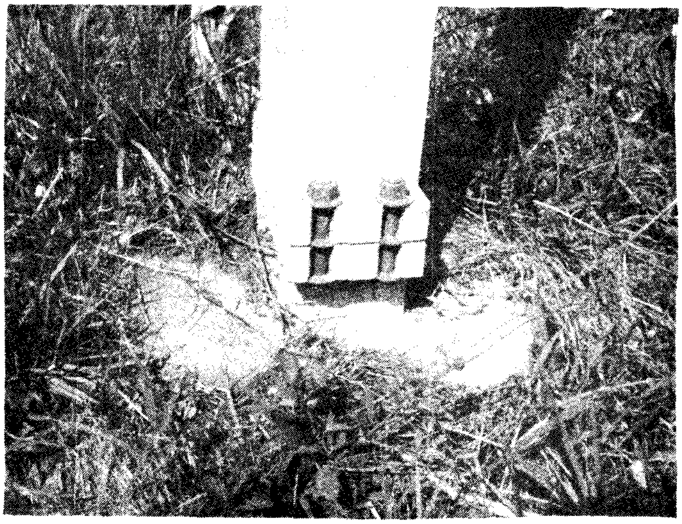

Figure 3. Hardware which has been installed at the base of a sign support

Figure 4. Tightening of hardware to a force of 88 foot-pounds 119 n-m)

Phase I (Laboratory Results)

A. *Weathering of Zinc Coating Systems in a Hot Humid Environment*

Nuts, bolts and washers which were coated with zinc by hot-dip galvanizing, electroplating and painting were subjected to controlled conditions of 150°F (66°C) and a relative humidity in excess of 95%. Exposure time was 15 months. Each separate piece of hardware was given a rating of 1 to 5 as described below:

Rating	*Surface Area Rusted*
1	negligible
2	25%
3	50%
4	75%
5	100%

These ratings were determined and tabulated in Tables 1, 2 and 3. Duplication of the GS grade of electroplating was discovered when the coating thickness of the three different requested grades of electroplating was determined.

Table 1

Rating of Zinc-Coated Bolts

	Sample Number			
	1	2	3	4
Hot-Dip Galvanized 2.1 oz./sq. ft. (0.064 g/cm2)	1	2	1	1
Electroplated				
GS	1	1	2	1
GS	2	1	1	1
LS	4	3	2	2

Table 2

Rating of Zinc-Coated Nuts

	Sample Number			
	1	2	3	4
Hot-Dip Galvanized 1.2 oz./sq. ft. (0.036 g/cm^2)	1	1	1	1
Electroplated				
GS	1	1	1	1
GS	2	1	1	1
LS	2	2	2	2

Table 3
Rating of Zinc-Coated Washers

	Sample Number			
	1	2	3	4
Hot-Dip Galvanized 6.7 oz./sq. ft. (0.20 g/cm^2)	1	1	1	1
Electroplated				
GS	1	1	1	1
GS	1	1	1	1
GS	1	1	1	1

As depicted in the ratings, the GS grade of electroplated hardware performed equally to the hot-dip galvanized hardware except in the case of the nuts. The hot-dip galvanized nuts were rated slightly better in performance than the electroplated nuts. Equal amounts of slight rusting were first noticed on the hot-dip galvanized and the GS grade electroplated hardware after 12 months of exposure in the environmental chamber.

The performance of bolts and nuts coated with an LS grade of electroplating was inferior to that of the two types of coatings discussed in the preceding paragraph. Rusting of this LS grade was first noticed at the inspection made after 3 3/4 months of exposure in the environmental chamber set 150°F (66°C) and a relative humidity in excess of 95% as can be seen in Figure 5.

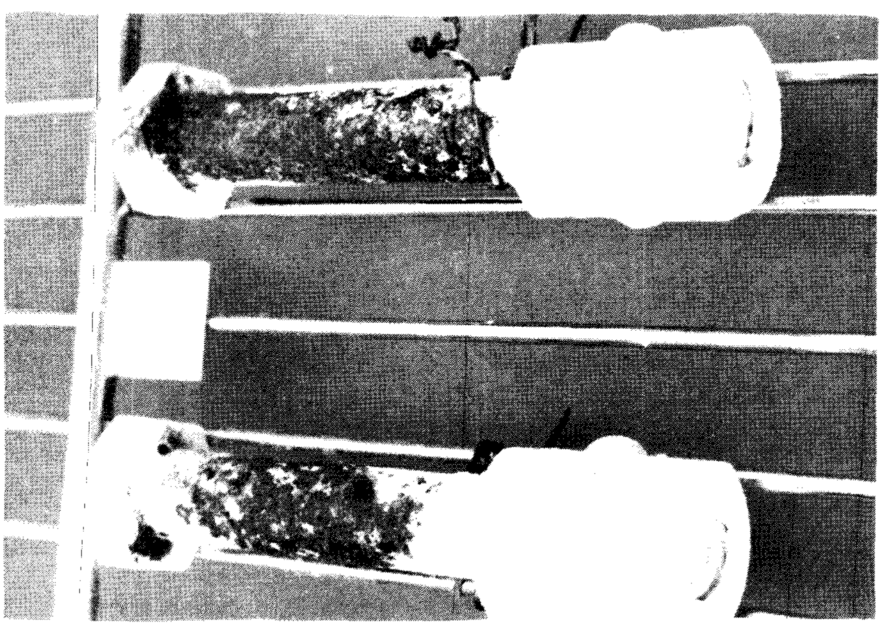

Figure 5. LS grade of electroplating after 3 3/4 months of exposure in the environmental chamber

There was no significant amount of rusting present on any of the electroplated washers after 15 months in the environmental chamber. However, the washers which were coated by hot-dip galvanizing had very slight amounts of pinholes present.

A comparison of the corrosion of the electroplated and the hot-dip galvanized hardware can be seen in Figures 6 through 8.

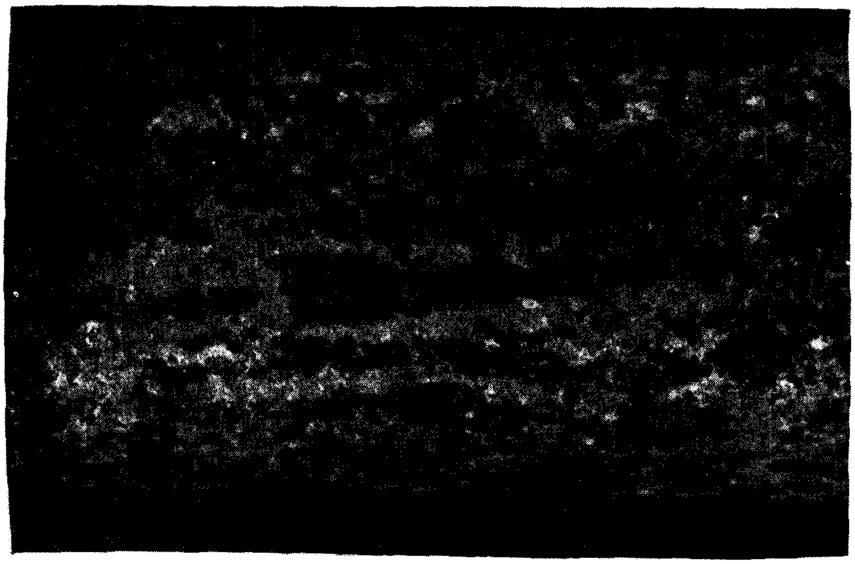

Figure 6. Side view of a hot-dip galvanized bolt after being exposed in the environmental chamber for 15 months

Figure 7. Side view of a GS grade electroplated bolt after being exposed in the environmental chamber for 15 months

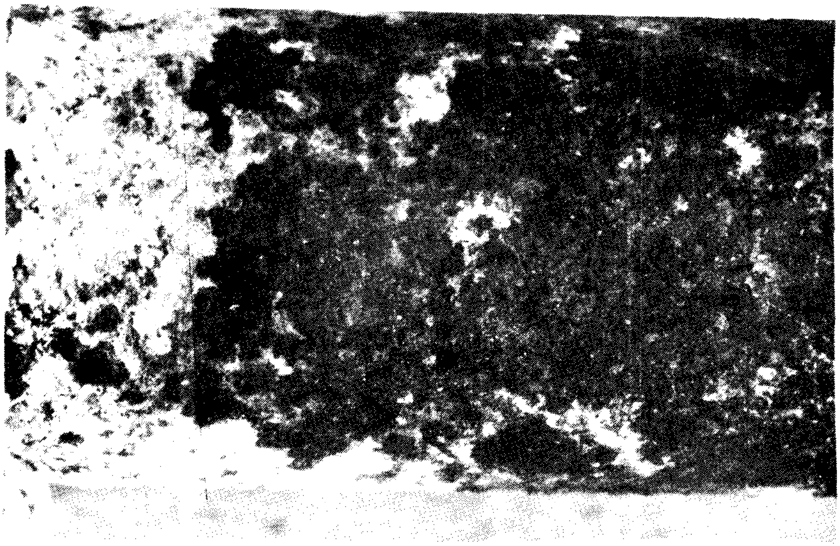

Figure 8. Side view of an LS grade electroplated bolt after being exposed in the environmental chamber for 15 months

The hardware coated with an organic zinc-rich paint showed severe rusting after 3 3/4 months in the environmental chamber, as can be seen in Figure 9. However, these results were not listed in Tables 1, 2 and 3 due to a contradiction with the results obtained in testing the repair systems. After 12 months in the humidifier, set at the same controlled condition, the portion of the bolts coated with the organic zinc-rich paint which was tested as a repair system, were in excellent condition. This apparent contradiction will be discussed later.

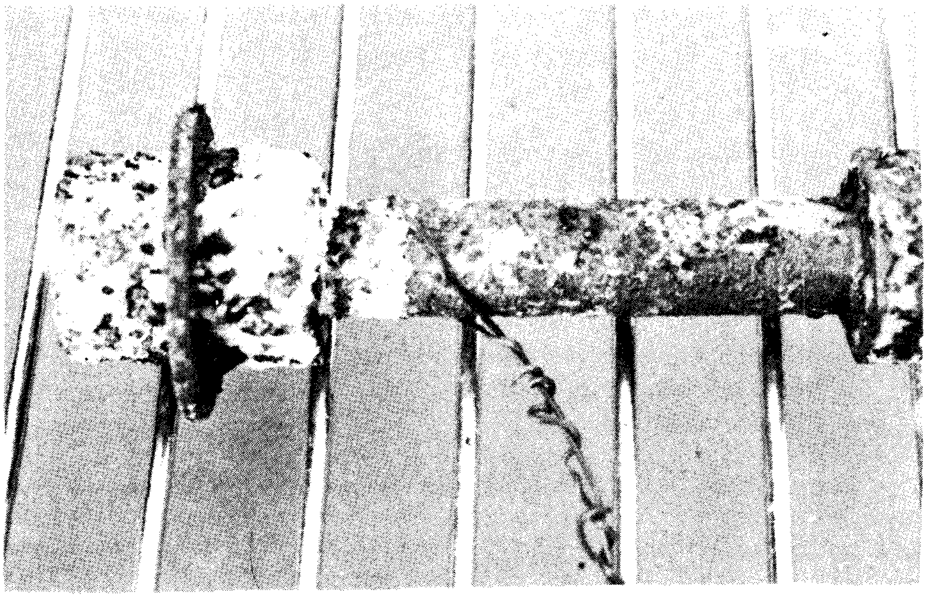

Figure 9. Painted bolt after being exposed in the environmental chamber for 3 3/4 months

B. *Weathering of Zinc Repair Systems in a Hot Humid Environment*

After 12 months of exposure in an environmental chamber set at a temperature of 150°F (66°C) and a relative humidity in excess of 95%, all three paints used as repair systems blistered to some degree where they overlapped the original hot-dip galvanized or electroplated zinc coating. In some cases, it was noticed that the blisters promoted further corrosion due possibly to entrapment of moisture beneath the painted coating.

As can be seen in Figure 10, an area near the blister is observed to be in excellent condition upon scraping the painted coating.

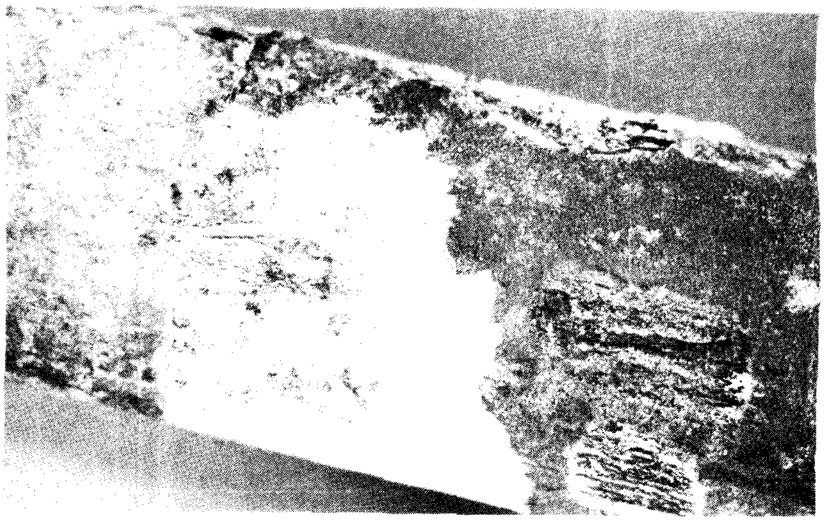

Figure 10. Scratched area of painted coating yields original uncorroded zinc coating (Notice area in lower right corner)

An extremely slight amount of pinholing was noticed on the portions of the bolt which were protected only by the applied repair systems. This observance was only present in the case of the two zinc-rich cold galvanizing repair compounds which were applied from aerosol cans.

C. *Salt Fog Exposure of Zinc Coating and Repair Systems*

Electroplated bolts of type GS and LS were exposed to accelerated weathering in the salt fog apparatus, set at the conditions specified in section 3(a) of the LDH Designation: TR 1011-74, along with hot-dip galvanized and painted bolts. After an exposure time of 46 hours, all the bolts showed some signs of corrosion. However, of the bolts which were included in this test, only the painted and the LS grade electroplated bolts had any signs of noticeable rusting. Spots of rust stains were present on the hot-dip galvanized bolts which seemed to be caused by small pinhole rusting.

Another laboratory test consisted of exposing six zinc-rich cold galvanizing paints in the salt fog apparatus for a period of two weeks. Six sections 6-inch (15 cm) hot-dip galvanized pipe were stripped of 2 inches (5 cm) of coating which was then painted along with 2 inches (5 cm) of the galvanized surface prior to the salt fog exposure.

After the two weeks of exposure, blistering occurred in all areas of the samples where the cold galvanizing paint overlapped the original hot-dip galvanized surface. The area of bare steel coated by these six paints performed as well or better than the area protected by the hot-dip galvanizing.

D. Comparison of Hot-Dip Galvanized and Electroplated Zinc Coatings Using Scanning Electron Microscopy

Analysis of the zinc-steel interface, using a scanning electron microscope, showed that the alloy layer of the hot-dip galvanized washer was much larger than that of the electroplated washer. In fact, as can be seen in Figure 11, no detectable alloy layer was present in the photomicrograph taken at a magnification of X 1680 of the interface of the electroplated washer.

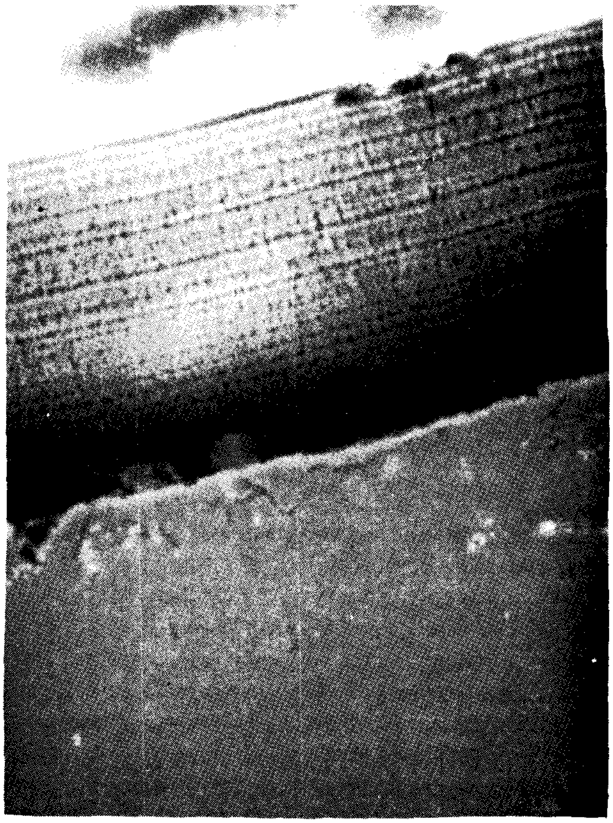

Figure 11. Cross section of electroplated washer showing the zinc-steel interface (X 1680)

However, Figure 12, taken of the hot-dip galvanized washer, shows that the outer zinc layer, known as the eta layer in the literature, contains a small amount of steel.

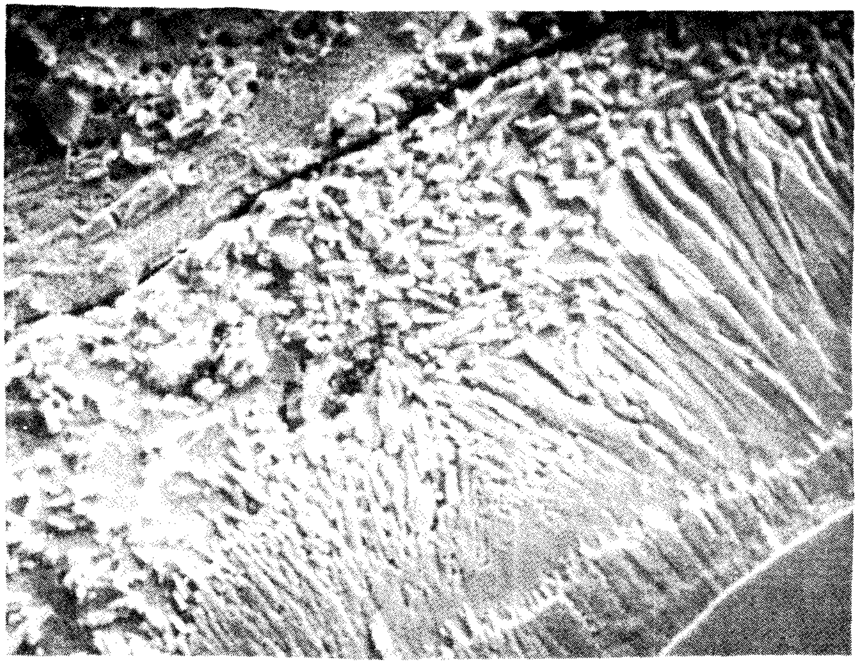

Figure 12. Cross section of hot-dip galvanized washer showing the zinc-steel interface (X 750)

The cross section of an electroplated washer observed in Figure 11 showed no steel present in the zinc layer. The surface of the zinc layer also appeared much smoother than that of the hot-dip galvanized washer.

As can be seen in Figure 13, small voids were detected in the coating of the hot-dip galvanized washer. Voids, such as these, were not found in the zinc layer of the electroplated washer which was analyzed.

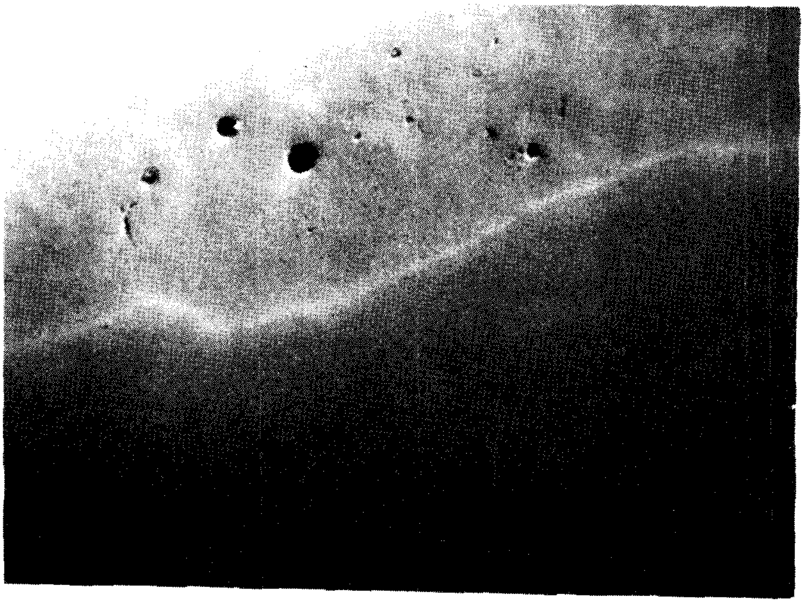

Figure 13. Cross section of hot-dip galvanized washer showing voids present in the zinc coating (X 400)

Phase II (Field Results)

After four years of field exposure in areas of north and south Louisiana, the GS and LS grade of electroplated hardware and the hot-dip galvanized hardware were in excellent condition. However, in both geographic locations, a small amount of rust was present on the threads of the bolts painted with the organic zinc-rich paint. The washers of this set of hardware also had a few small specks of rust present. The rest of the painted hardware had good performance after four years of field exposure.

DISCUSSION OF RESULTS

Phase 1 (Laboratory Results)

A. *Weathering of Zinc Coating Systems in a Hot Humid Environment*

The ratings given to the different types of zinc-coated hardware exposed in the environmental chamber for 15 months showed that the protection offered by the GS grade of electroplating was equivalent to that offered by the hot-dip galvanizing. The performance of the LS grade of electroplating was inferior to that of the previously mentioned coatings.

The corrosion of the GS grade electroplated nuts was slightly more excessive than that of the hot-dip galvanized nuts. One possible explanation for this difference was that the coating may have been damaged upon tightening one nut against the other at a torque of 88 foot-pounds (119 n-m). Since the coating of the electroplated nut is thinner than that of the hot-dip galvanized nut, it would be expected that the former is more susceptible to abrasion resulting from the use of a torque wrench.

After 3 3/4 months of exposure in the environmental chamber, the painted hardware showed severe signs of rusting. However, exposure of the painted bolts included in the test of repair systems showed superior performance even though the paint used was the same organic zinc-rich primer. The superior performance may have been due to either a thicker coating of material or a more uniform mixture of the paint. A difference in color suggests that the zinc powder was not well mixed with the base portion of the paint when it was used to coat the first set of hardware. However, the results of the first set of bolts, which quickly rusted, could be used as a control to monitor the rate of corrosion in the field. The set of the painted hardware should have been the first to rust in the field. However, after four years of field exposure only the threads of the painted bolts were showing signs of significant rusting along with a few specks of rust on the washers. Due to this slight amount of corrosion, the only correlation that could be made was that two months exposure in an environmental chamber at 150°F (66°C) and a relative humidity in excess of 95% was much more severe than four years of field exposure in either north or south Louisiana.

Another discovery made was that the area where the zinc-rich paint was applied over the bare metal of the test specimen had been equally protected from corrosion compared to that area protected by the electroplated and hot-dip galvanized zinc coating. As indicated by these results, a zinc-rich paint of good quality was found to be a suitable material to be used for repairing damaged surfaces of zinc coating.

B. *Weathering of Zinc Repair Systems in a Hot Humid Environment*

As a result of comparing the protection afforded by paint systems to be used as a means of repair, it was discovered that, even though the partially stripped test specimens were thoroughly cleaned, poor adhesion resulting in *blisters ocurred where the paint was overlapped onto the hot-dip galvanized and electroplated zinc coating. In some cases the blistering promoted further corrosion due possibly to entrapment of moisture beneath the painted coating.*

This characteristic of poor adhesion of paint over a zinc-coated surface has been a problem for some time. The present solution is to treat the zinc coating with a wash primer prior to painting. This procedure should aid in the prevention of premature failure.

C. Salt Fog Exposure of Zinc Coating and Repair Systems

All the zinc-coated bolts showed signs of corrosion after being exposed in the salt fog apparatus for a period of 46 hours. The results of this test did indicate the superiority of the hot-dip galvanized and GS grade electroplated zinc coating over the LS grade electroplated and painted coating.

Although an advantage considered of this test was the relatively short period of time in which the results were obtained, it should be noted that the differences of corrosion obtained were not as discrete as those obtained in the environmental chamber because corrosion in the salt fog apparatus occurred much more rapidly. It should also be noted that the conditions of high humidity and high temperature may be better related to field conditions with the exception of close contact with a coastal environment.

The pipe specimens coated with the zinc-rich paints also corroded very rapidly. However, the data obtained supported the results of the repair systems applied to the bolts which were tested in the environmental chamber.

D. Comparison of Hot-Dip Galvanized and Electroplated Zinc Coatings Using Scanning Electron Microscopy

In comparing the zinc-steel interface using scanning electron microscopy it was found that the hot-dip galvanized washer had a measurable alloy layer. However, the electroplated washer had no detectable alloy layer when examined at a magnification of X 1680.

This difference in alloy layers was present due to the high temperature to which the surface of the base metal was heated upon contact with the molten zinc in the hot-dip galvanizing process. The increase of surface temperature allows for the base metal to amalgamate with the zinc and form an alloy layer.

In the literature, it is noted that the zinc coating of a specimen which has been hot-dip galvanized has three layers as can be seen in Figure 14. The delta layer consists of 6 to 11% iron. The zeta layer consists of approxi mately 6% iron. The eta layer consists of relatively pure zinc.

The thickness of the alloy layer, shown in Figure 14 as the delta and zeta layers, of hot-dip galvanized products is primarily dependent upon the following factors: (1) surface roughness of the steel, (2) temperature of the galvanizing bath, (3) time of immersion and (4) rate of cooling.

In this discussion of alloy thickness, it should be pointed out that, according to ASTM, the ductility of the coating decreases as the thickness of the zinc-steel alloy layer increases.

As seen in Figure 13, voids were present in the hot-dip galvanized coating of the washer examined. Although these voids did not appear to be significantly detrimental to corrosion protection, they may have been the initial cause of pinhole formation.

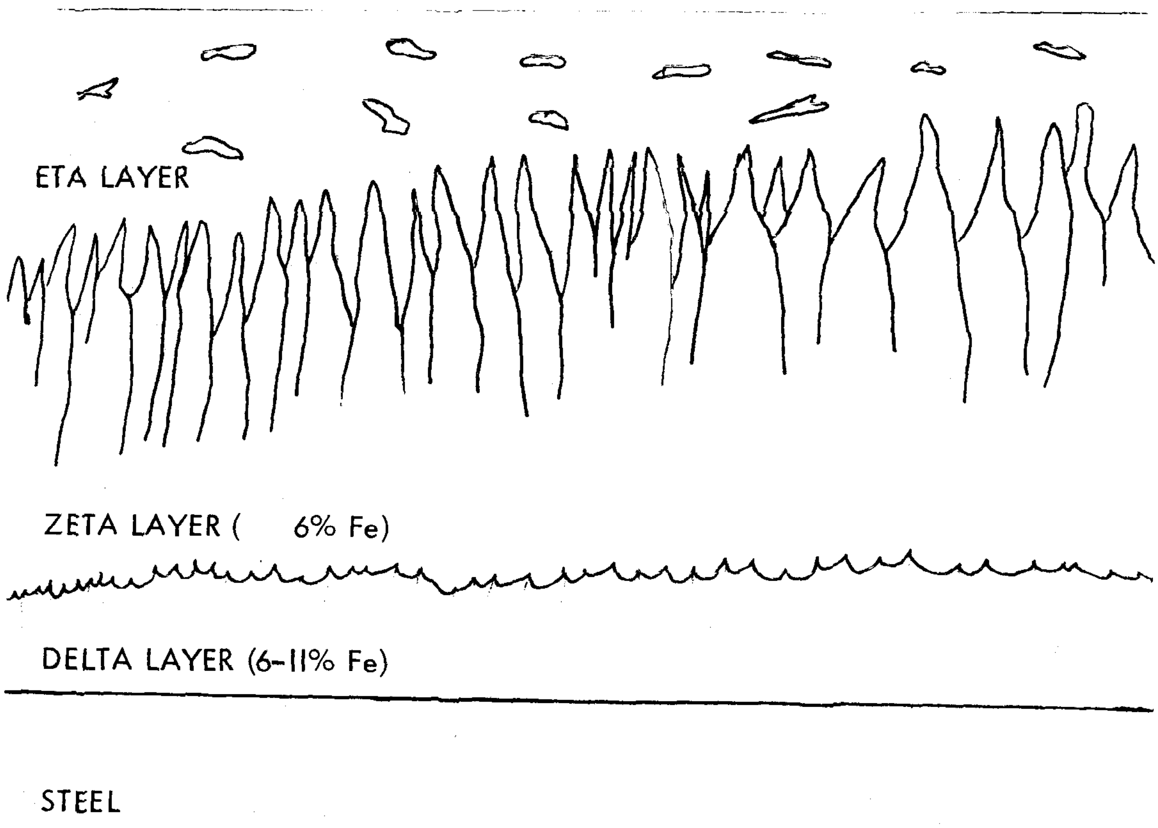

Figure 14. Cross sectional layers of a zinc coating applied by the process of hot-dip galvanizing

Phase II (Field Evaluation)

The hardware installed at the base of the interstate signs in north and south Louisiana was last inspected after four years of exposure. At that time all the hardware was in good condition. Only the threads of the bolts painted with the organic zinc-rich paint had slight rusting present along with a few smaller specks of rust on the washers. These painted bolts were of the same batch (painted at the same time) as those which failed considerably after 3 3/4 months in the environmental chamber.

CONCLUSIONS

1. The protection offered by the GS grade of electroplating appears to be equal to that offered by hot-dip galvanizing having a coating thickness of approximately 2 ounces of zinc per square foot of surface area (0.061 g/cm^2). However, laboratory results indicate that the protection offered by the LS grade of electroplating is inferior to that of the GS grade and the hot-dip galvanizing.

2. The zinc-rich paints included as repair systems afford adequate protection to the bare steel. However, in order to increase the adhesion to electroplated and hot-dip galvanized surfaces, it is suggested that a suitable wash solution be applied prior to painting.

3. Salt fog exposure of zinc-coated hardware can be used to determine relative protection of various zinc coatings. However, due to the rapid rate of corrosion, the results may not be as accurate as those obtained through exposure in the environmental chamber.

4. The distinct difference of the alloy layers observed by using scanning electron microscopy enables one to use this method to distinguish between an electroplated and hot-dip galvanized coating.

5. After four years of field exposure, no significant amount of corrosion has been recorded for the hardware installed at the base of the interstate sign supports. The resulting field corrosion was not nearly as severe as that of the two months exposure in the environmental chamber set at 150°F (66°C) and a relative humidity in excess of 95%. It can therefore be concluded that laboratory exposure at the above conditions for two months was much more severe than four years of field exposure in either north and south Louisiana.

RECOMMENDATIONS

1. The GS grade of electroplated hardware should be specified as an equivalent to that of 2.0 oz./sq.ft. (0.061 g/cm) of hot-dip galvanized hardware for use in either north or south Louisiana as long as abrasion of the nuts during installation does not present a problem.

2. The LS grade of electroplated hardware should not be used as an alternate for 2.0 oz./sq.ft. of hot-dip galvanized.

3. Zinc-rich paints should be allowed as repair systems of zinc coated hardware. However, a suitable wash primer should be used to increase adhesion.

4. If one is unable to determine by observation whether zinc coating has been applied by hot-dip galvanizing or electroplating, scanning electron microscopy should be used if the cost is justifiable.

REFERENCES

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Tomashov, N. D., *Theory of Corrosion and Protection of Metals:* Edited and translated by B. H. Tytell. New York: The McMillian Company, 1966.

APPENDIX

Method of Test for

ACCELERATED EXPOSURE FOR ZINC PRIMERS AND RESPECTIVE TOPCOATS

LDH Designation: TR 1011 - 74

Scope

1. The objective of this method of test is to subject zinc primers and the appropriate topcoats to accelerated exposure for the purpose of qualifying the complete system for the Qualified Products List. Each manufacturer that submits a zinc paint for approval must submit a complete system -- primer and topcoat -- to be tested and approved because there shall be no intermixing of primer and topcoat from various manufacturers.

Apparatus

2. The apparatus shall consist of the following:

(a) Salt Spray Cabinet capable of maintaining 135 ± 8 F (57 ± 4 C) inside temperature, 15 ± 3 psi (103 ± 20 kN/m^2) atomization pressure, and a cam that gives 8 hours heating and 16 hours non-heating.

(b) Sunshine Carbon Arc Atlas Weatherometer (triple arc continuous) capable of maintaining 145 ± 9 F (63 ± 5 C) black panel temperature, 18 minutes of 20 ± 3 psi (138 ± 20 kN/m^2) water spray, for each 102 minutes of ultraviolet light.

Procedure

3. (a) Salt Fog Exposure

Reference ASTM B 117. Three steel panels, A-36, approx 4 by 8 by 0.13 in.(102 by 203 by 3.3 mm) shall be sandblasted to a SSPC - 10 or SSPC - 5 near white or white blast. The coating will be applied at a dry film thickness of 0.003 in. (0.08 mm) minimum for organic zinc primer and 0.003 in. to 0.005 in. (0.08 mm - 0.13 mm) minimum dry film thickness for inorganic zinc primer. The topcoats will be applied at 0.003 in. (0.08 mm) minimum dry film thickness over organic zinc and 0.005 in. (0.13 mm) minimum dry film thickness over inorganic zinc. The panels will have a diagonal scribe 1/8 in. ± 1/16 in. (3.2 ± 1.6 mm) wide. The coated panels will be placed in the salt fog cabinet for a period of four weeks for organic zinc coating and four weeks for inorganic coating, at a salt concentration of 18% salt by weight and a temperature of 135 ± 8 F (57 ±4 C).

(b) Weatherometer Exposure

Reference ASTM D 609. Two steel panels approx 3 by 9 by 0.03 in. (76 by 229 by 0.8 mm) will be coated as prescribed below and shall remain in the weatherometer for a period of 1500 ± 48 hours. The weatherometer will be operated at a black panel temperature of 145 ± 9 F (63 ± 5 C) with an intermittent water spray lasting 18 minutes at 20 ± 3 psi (138 ± 20 kN/m^2) for each 102 minutes of continuous ultraviolet light. The relative humidity shall be maintained at 85 ± 5%.

The coating thickness applied to weatherometer panels shall be the same as those specified for preparing panels for (a) Salt Fog Exposure above. Only the topcoat (no primer) shall be applied when preparing panels for weatherometer exposure.

Report

4. The report of the salt fog exposure and weatherometer exposure is subjective and is reported as satisfactory or unsatisfactory for the specified number of hours exposure. When evaluating the test results, the following properties shall be observed and the applicable ASTM designations used as guidelines in determining whether or not the tested system is satisfactory or unsatisfactory:

PROPERTY	AMOUNT ALLOWED	ASTM REFERENCES
BLISTERING	NONE	D 714
CHALKING	SLIGHT	D 659
CHECKING	NONE	D 660
CRACKING	NONE	D 661
DELAMINATION	NONE	
DISCOLORATION	SLIGHT	
RUSTING	NONE	D 610
UNDERCUTTING	NONE	

Normal testing time is approx 18 weeks.