COMPARISON OF METHODS USED TO PRODUCE HOT-DIPPED GALVANIZED W-BEAM GUARDRAIL

CONSTRUCTION AND TECHNOLOGY DIVISION

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Technical Report Documentation Page

1. Report No. Research Report R-1357	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Comparison Of Methods Used to Produce Hot-Dipped Galvanized W-Beam Guardrail		5. Report Date January 1998
7. Author(s) Roger Till, P.E. and Chris Davis		6. Performing Organization Code
9. Performing Organization Name and Address Michigan Department of Transportation Construction and Technology Division P.O. Box 30049 Lansing, MI 48909		8. Performing Org Report No. R-1357
12. Sponsoring Agency Name and Address Michigan Department of Transportation Construction and Technology Division P.O. Box 30049 Lansing, MI 48909		10. Work Unit No. (TRAIS) 11. Contract/Grant No.
15. Supplementary Notes		13. Type of Report & Period Covered Final Report 14. Sponsoring Agency Code 97 TI-1831

16. Abstract

The study compares the corrosion performance of hot-dipped galvanized w-beam guardrail. Guardrail that is galvanized prior to fabrication (pre-galvanized) was compared with guardrail that was galvanized after fabrication (post galvanized) through accelerated corrosion methods. Bolted, lap spliced samples were placed in a salt fog tank to permit comparison of performance. There was no difference in guardrail corrosion performance for the two methods of manufacturing based on visual inspection and nut loosening torque of the bolted, lap spliced samples.

17. Key Words guardrail, galvanized, corrosion, salt fog	18. Distribution Statement No restrictions. This document is available to the public through the Michigan Department of Transportation.		
19. Security Classification (report) Unclassified	20. Security Classification (Page) Unclassified	21. No of Pages	22. Price

Form DOT F 1700.7 (8-72)

MICHIGAN DEPARTMENT OF TRANSPORTATION
MDOT

Comparison of Methods Used to Produce Hot-Dipped Galvanized W-Beam Guardrail

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Research Laboratory Section
Construction and Technology Division
Research Project 97 TI-1831
Research Report No. R-1357

Lansing, January 1998

INTRODUCTION

As of 1989, the State of Michigan had 2,545,705 meters of guardrail on state trunk line routes. The majority of the guardrail is post-galvanized, which is defined for this report as guardrail that is punched, cut, formed into its shape, and then hot-dipped galvanized after fabrication. In the 1970's, the Maintenance Division investigated the use of pre-galvanized guardrail. Pre-galvanized guardrail, as defined for this report, is composed of steel sheets that are hot-dipped galvanized then punched, cut, and formed into a w-shape. The pre-galvanized guardrail installed in the 1970's was coated with a minimum of 764 grams of zinc per square meter (total of both sides). Maintenance was not satisfied with the results of earlier use of this product as evidenced by the guardrail along US-127 between Grand River Avenue and Kalamazoo Street in Lansing. This run of guardrail showed extensive corrosion at a relatively young age. According to the 1996 Standard Specifications for Construction, all steel beam elements, back-up elements, and end sections shall be hot-dip zinc coated after fabrication according to the requirements for Type II zinc coatings of AASHTO M 180, which requires a minimum of 1100 grams of zinc coating per square meter (total on both sides, single spot test). Currently, the pre-galvanized guardrail producers make the w-beam guardrail with 1100 grams of zinc coating per square meter conforming to AASHTO M 180, Type II zinc coating.

The Structural Research Unit was asked to test this heavier zinc coated, pre-galvanized guardrail and compare it with the post-galvanized guardrail currently being used. Maintenance personnel are concerned because the punched bolt holes and the cut edges of the pre-galvanized guardrail are not zinc coated. They foresaw a corrosion problem with the elongated holes becoming rounded and corrosion products contaminating the threads of the splice bolts making it difficult to remove the bolts when replacing a section of the guardrail.

PROCEDURE

Two sections of pre-galvanized w-beam guardrail were obtained from Gregory Highway Products and two sections of post-galvanized w-beam guardrail were obtained from the Michigan Department of Transportation (MDOT) warehouse. The mill certification of the pre-galvanized and post-galvanized guardrail specimens indicated that they met AASHTO M 180, Type II zinc coating. The Structural Research Unit checked the thickness of the galvanizing using a magnetic thickness gauge, Mikrotest Instrument #85366, on all four samples at the locations shown in Figure 1.

The Structural Research Unit used accelerated environmental testing to determine if there were differences in the guardrail manufacturing processes regarding corrosion. A salt fog tank, as shown Figure 2, was used and ASTM B 117, Standard Practice for Operating Salt Spray (Fog) Apparatus, was followed. The w-beam elements were cut down to 750 millimeters from the ends and then bolted together with a 330 millimeter overlap splice connection, which is the same splice connection as used in field installations. The total lengths of the spliced samples were 1170 millimeters long so that they could be placed into the salt fog tank. When assembling the guardrail samples for placement in the salt fog tank, the pre-galvanized elements were bolted to pre-galvanized elements

and the same was done for the post-galvanized guardrail elements to keep the manufacturing methods spliced together. Edges that were cut for making the splices were coated with zinc rich paint to prevent streaming rust contamination of the samples. The hardware that was used to lap splice the specimens came from the MDOT warehouse. The mill certification for the hardware indicated they met ASTM A 307 and were hot-dipped galvanized according to ASTM A 153. An adjustable torque wrench was used to initially tighten the nine splice bolts and nuts to 67.8 newton-meters of torque. The samples were placed into the salt fog tank as shown in Figure 3, in a manner to eliminate as much bias as possible.

The samples were removed from the salt fog tank every 1000 hours and checked for appearance, nut loosening torque, and corrosion. Four samples were exposed a total of 5000 hours in the salt fog tank. Before the nut loosening torque was checked on the samples at the 1000, 2000 and 3000 hour intervals, the threads of the bolts were cleaned using water and a stiff brush. At the 4000 and 5000 hour intervals, the bolt threads were not cleaned before checking the torque values. A deflecting beam torque wrench was used when checking the torque to loosen the nuts. The bolts were retightened to 67.8 newton-meters using the adjustable torque wrench before being placed in the salt fog tank for the next 1000 hour increment.

RESULTS

All specimens satisfied AASHTO M 180, Type II zinc coating requirement of 1100 grams per square meter, equivalent to an average thickness of 155.1 microns (total on both sides) and there were no major differences in coating thickness. The coating thickness data are shown in Table 1.

The samples after 1000 hours are shown in Figure 4. Figure 5 shows the samples at 2000 hours, and Figure 6 shows the samples after 3000 hours. The 4000 hour specimen results are shown in Figure 7 and the 5000 hours results are shown in Figure 8. Figure 9 shows a closeup view of the splice nuts of all four samples after 5000 hours in the salt fog tank. There were no visual differences between the manufacturing methods of the guardrail as shown in Figures 4-9.

Nut loosening torque values are shown in Table 2. There did not appear to be any significant difference in the torque values whether the threads were cleaned or uncleaned before checking the nut loosening torque. A two sided t-test on the difference between the mean torque values for pre and post galvanized methods of manufacturing at each 1000 hour increment was performed at the 95 percent confidence level. Both the individual sample and the pooled sample torque values were used in the statistical analysis. Results of this statistical analysis indicated that there were no significant differences in the nut loosening torque values at any 1000 hour increments.

After the test was complete, the samples were cleaned with a steam pressure washer. This did not remove any of the zinc salt deposits from the samples. A bead blaster was then used to remove the salt deposits from the samples with good results. For both types of guardrail manufacturing methods, the exposed galvanized coating was sacrificed during the testing procedure in the salt fog tank. Both the pre-galvanized and the post-galvanized guardrail materials performed the same with

no appreciable difference in corrosion levels as shown in Figure 10. There was no pitting in the lapped spliced area or anywhere else on the specimens.

As mentioned previously, one of the Maintenance Division's concerns was the possible rounding of the slotted bolt holes preventing the removal of the nuts and bolts on the pre-galvanized guardrail product. During the salt fog test, the samples did not experience any problems with rounding of the bolt holes.

CONCLUSION

There was no difference in guardrail corrosion performance in the salt fog test for the two methods of manufacturing (pre and post galvanized) based on visual inspection and the nut loosening torque values.

FIGURES

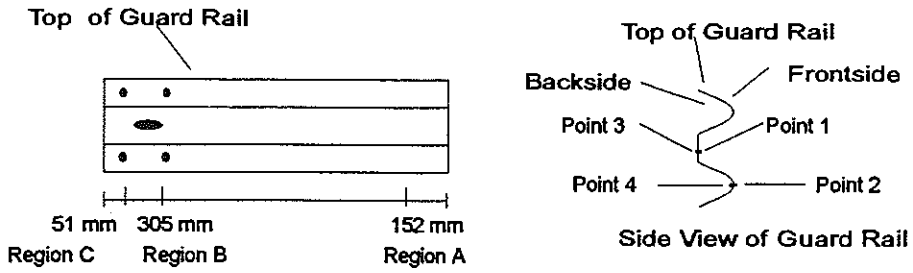


Figure 1 Zinc thickness measurement location

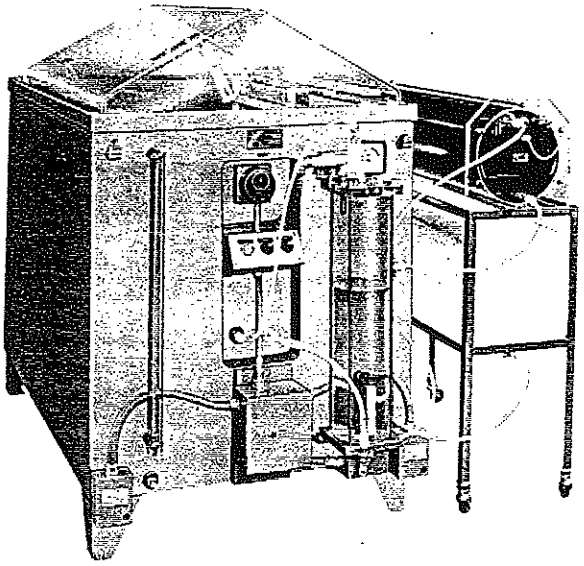


Figure 2 Salt fog tank

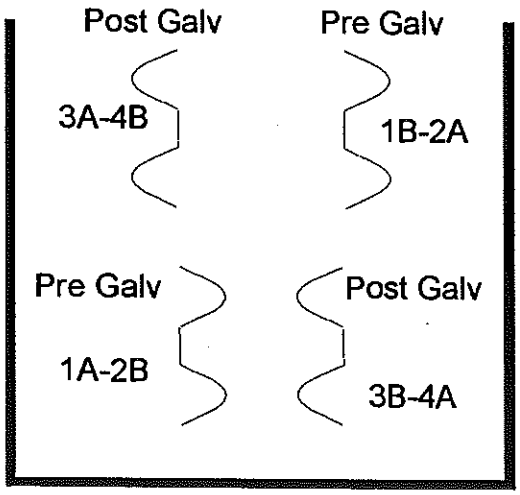
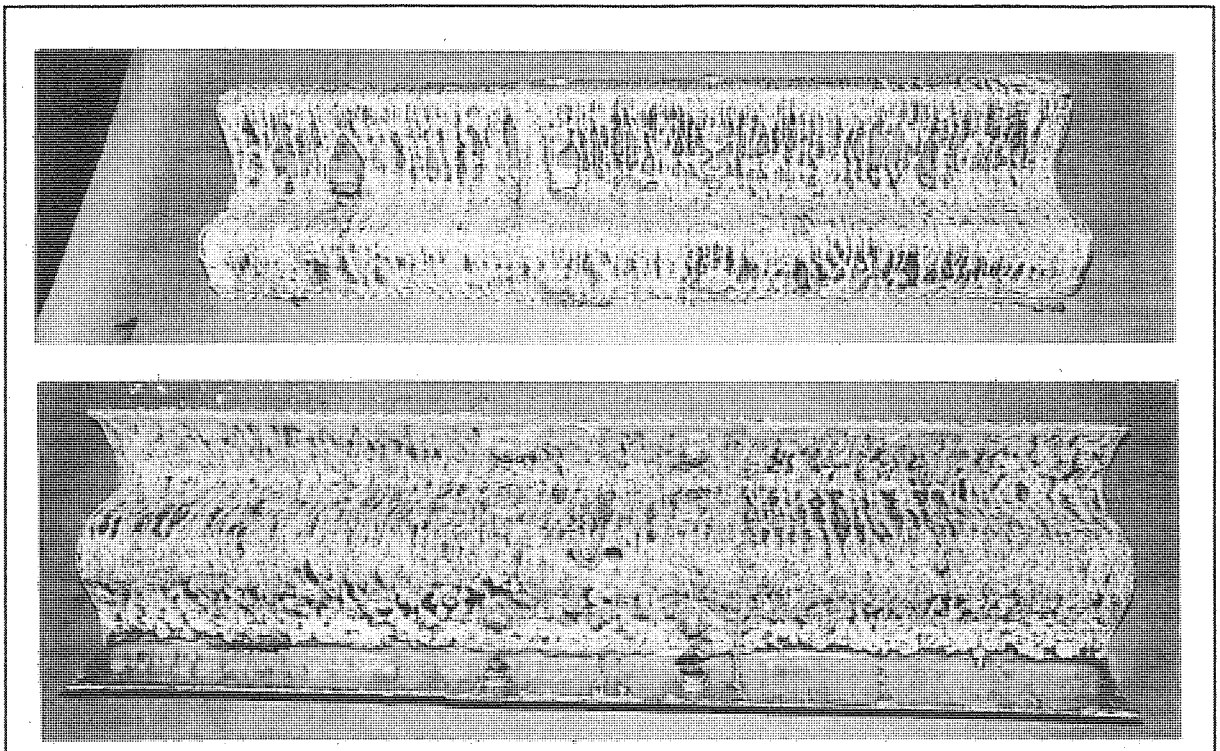
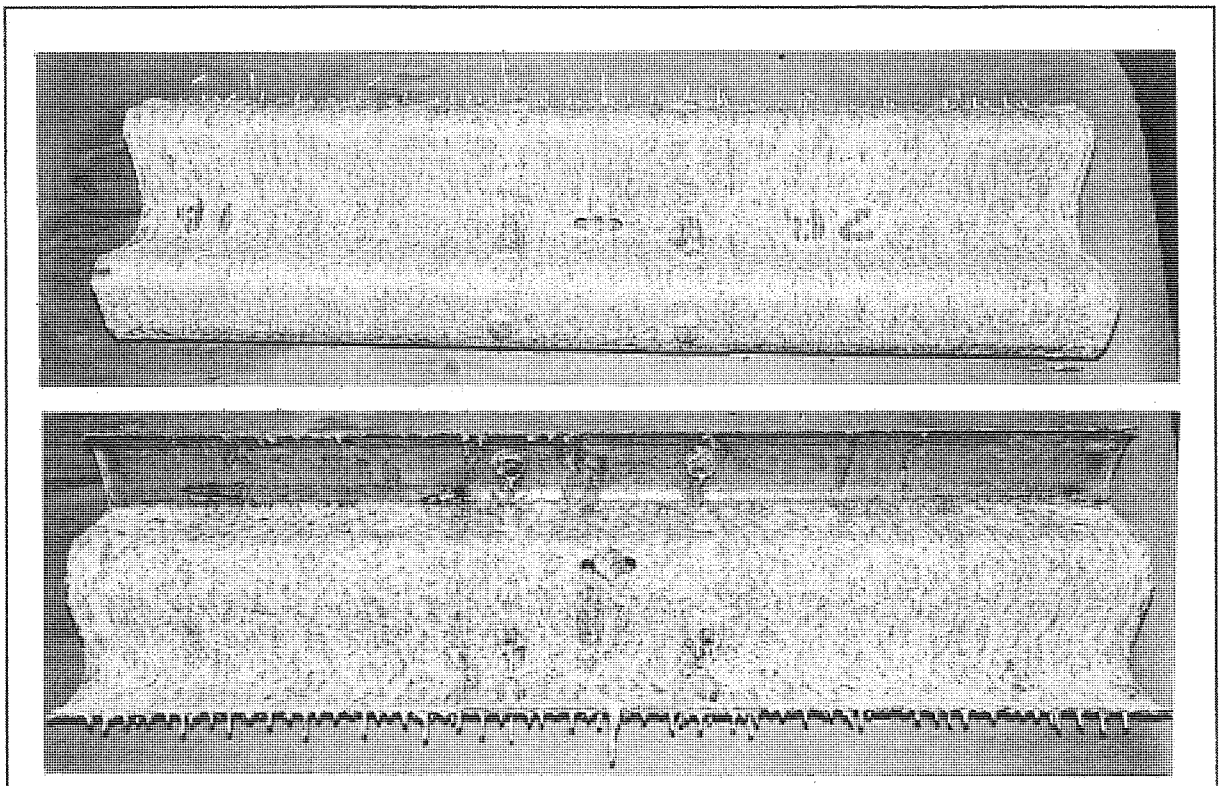


Figure 3 Sample placement in the salt fog tank

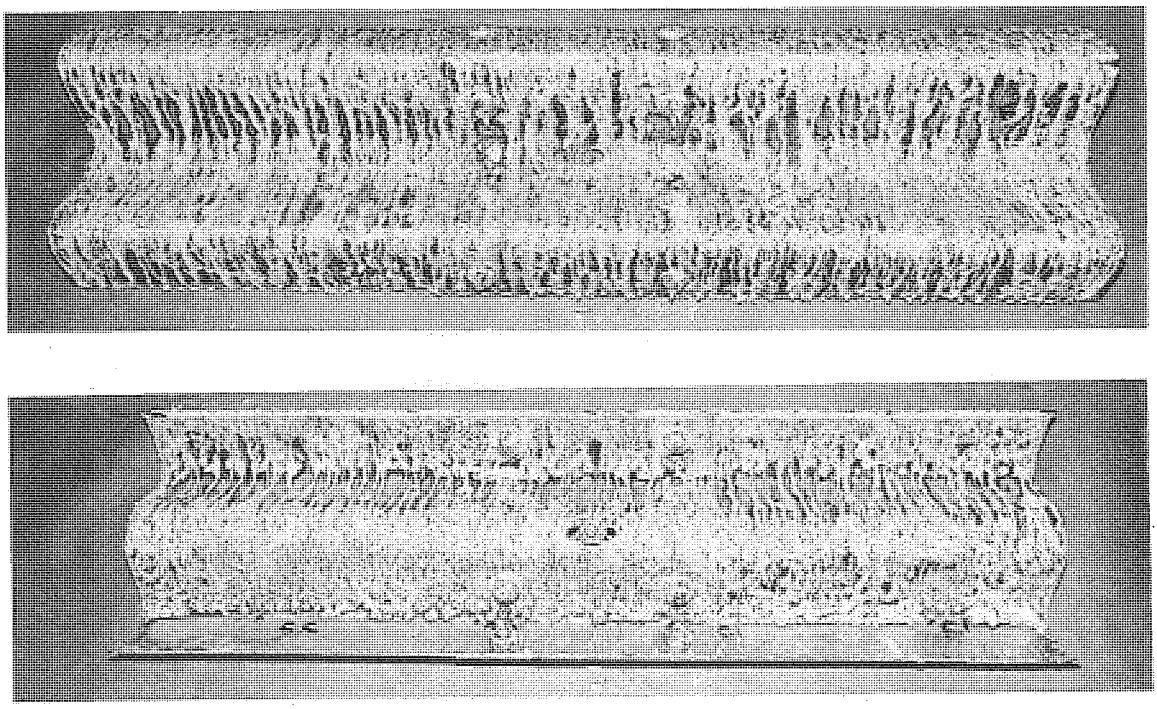


A)Sample 3B-4A post-galvanized

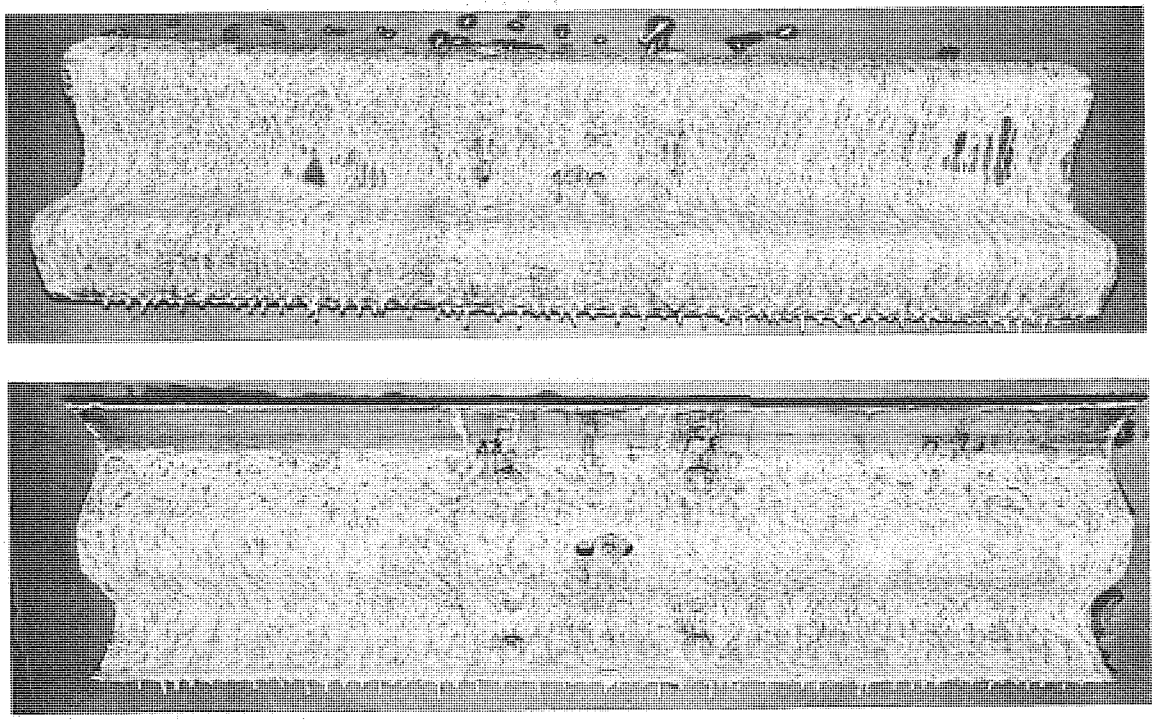


B)Sample 1A-2B pre-galvanized

Figure 4 Samples after 1000 hours

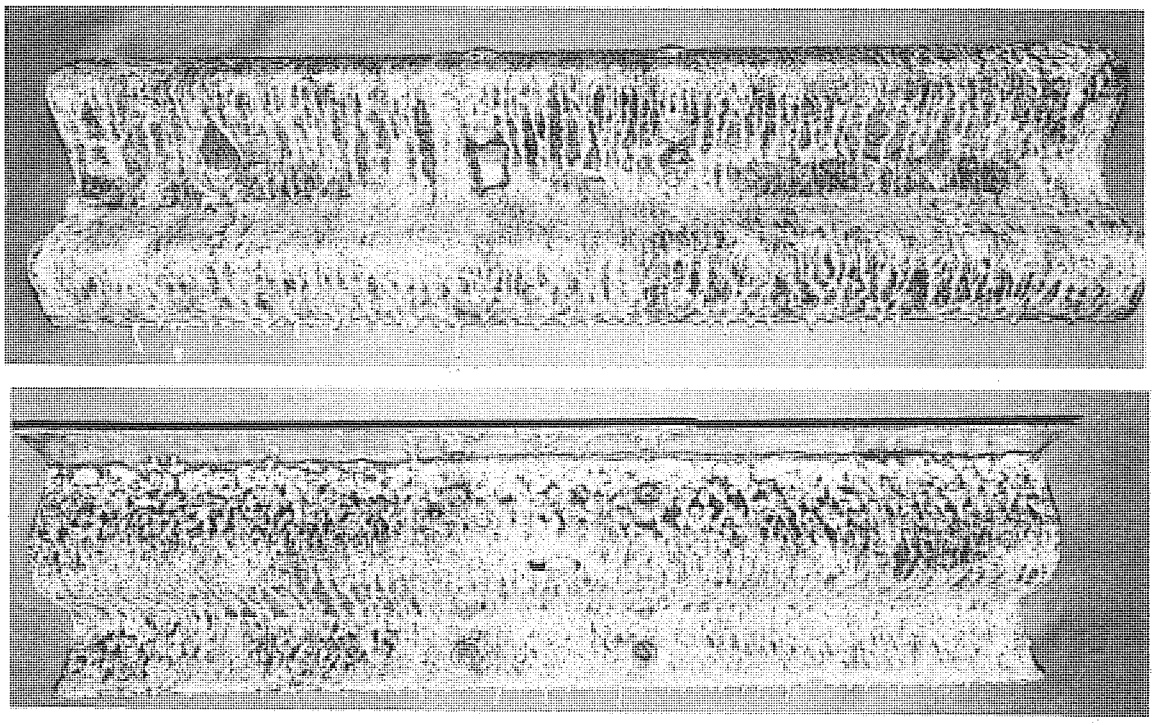


C)Sample 3A-4B post-galvanized

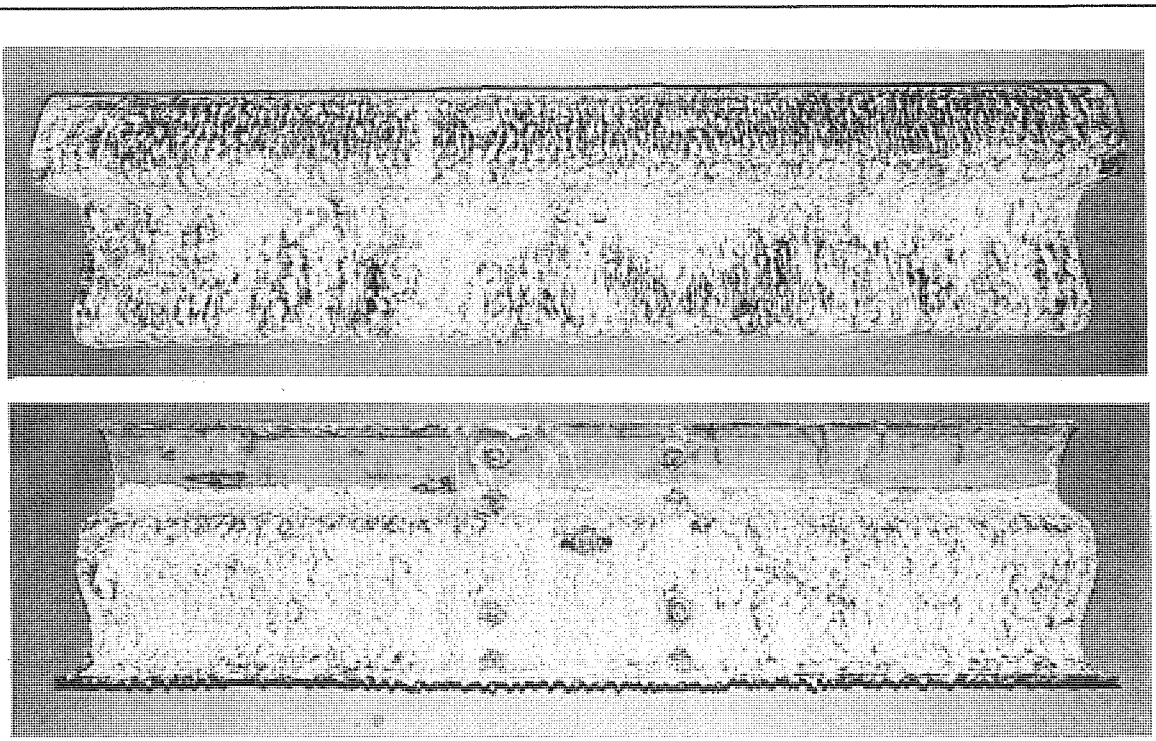


D)Sample 1B-2A pre-galvanized

Figure 4 Samples after 1000 hours

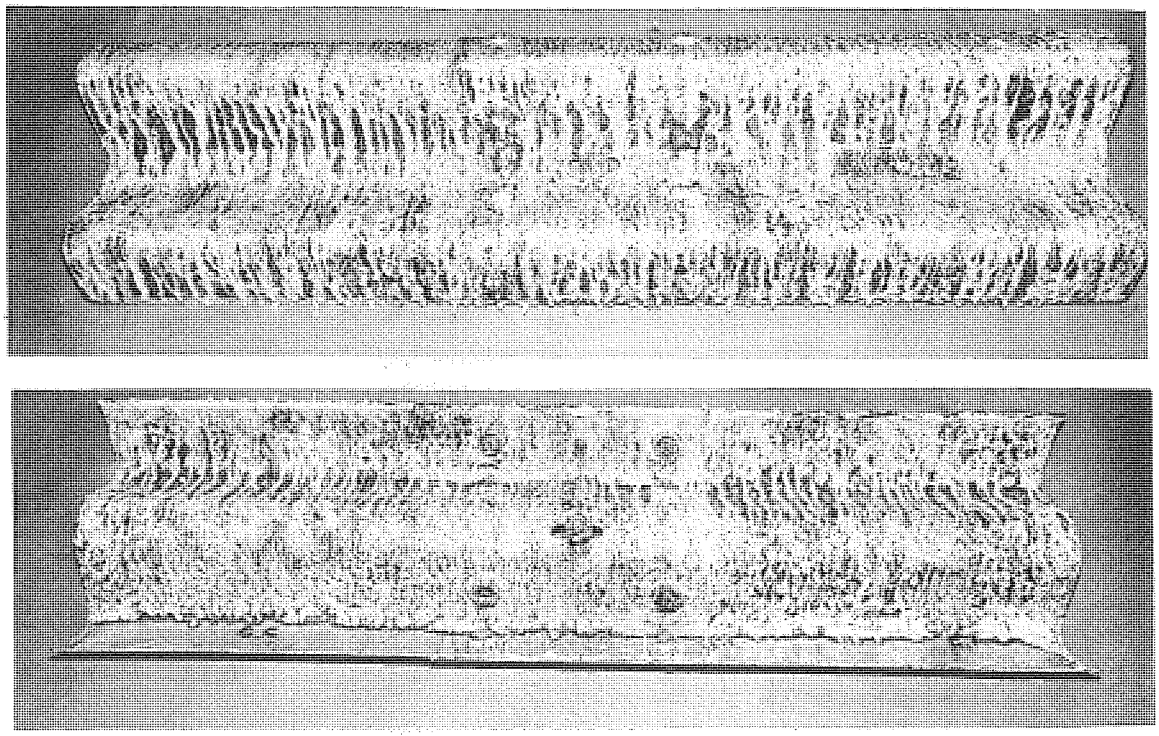


A)Sample 3B-4A post-galvanized

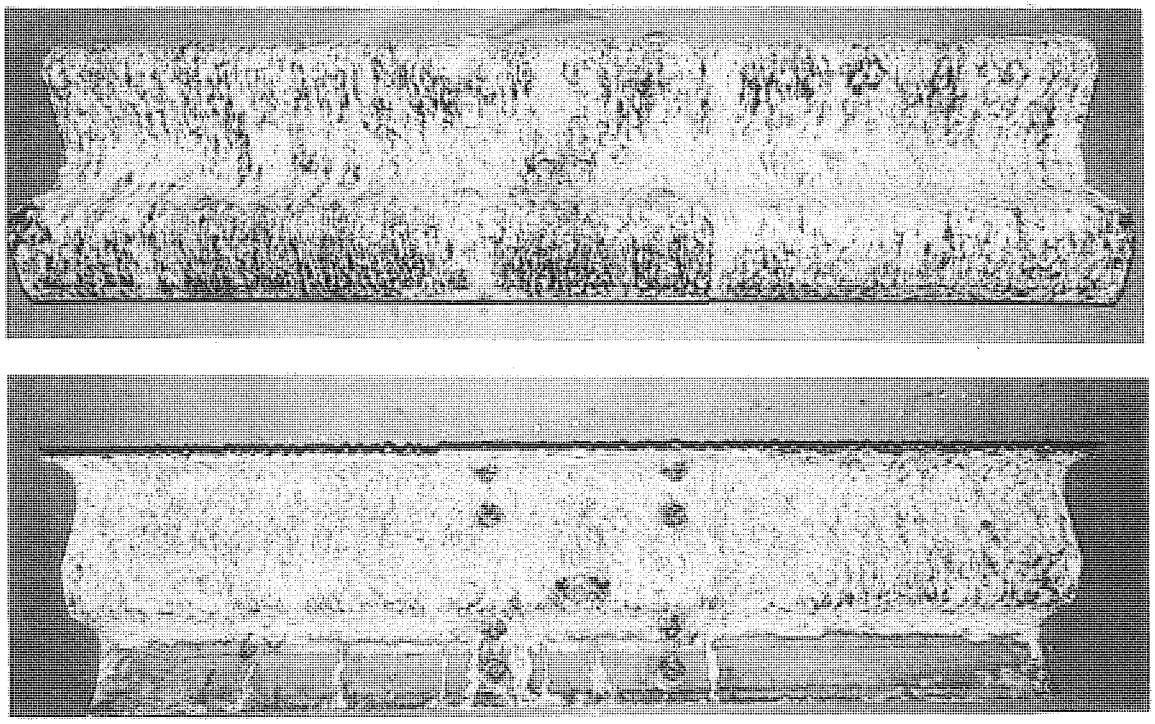


B)Sample 1A-2B pre-galvanized

Figure 5 Samples after 2000 hours

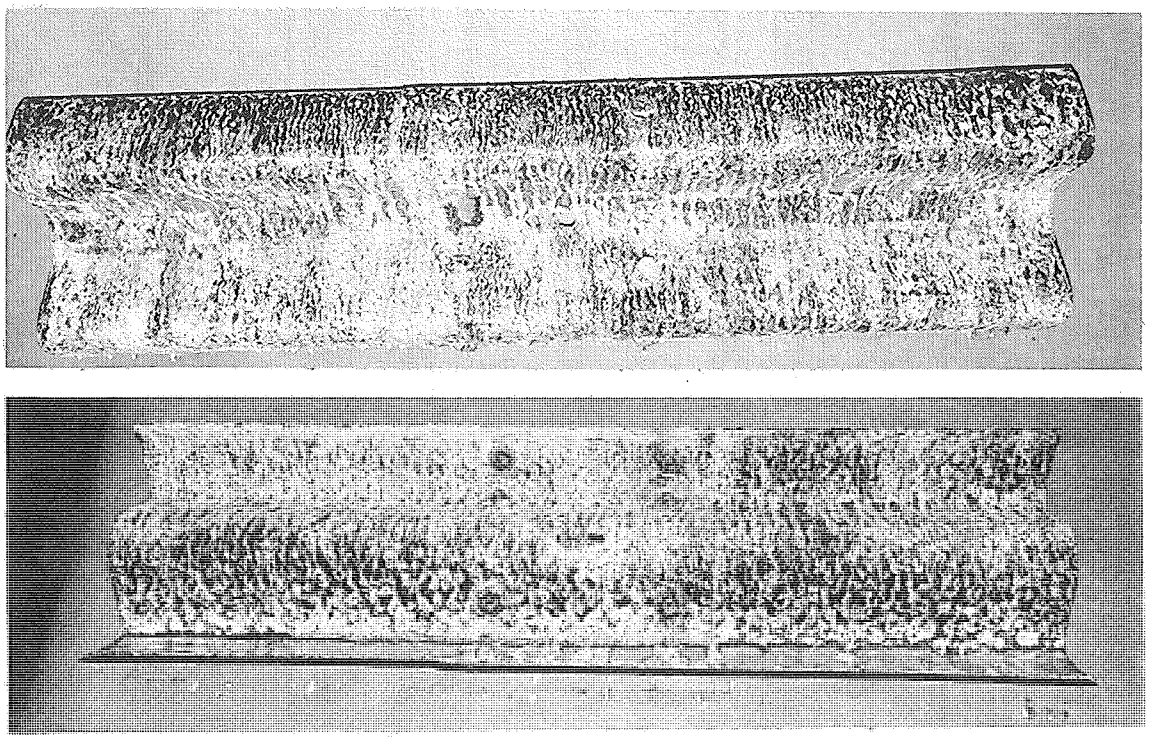


C)Sample 3A-4B post-galvanized

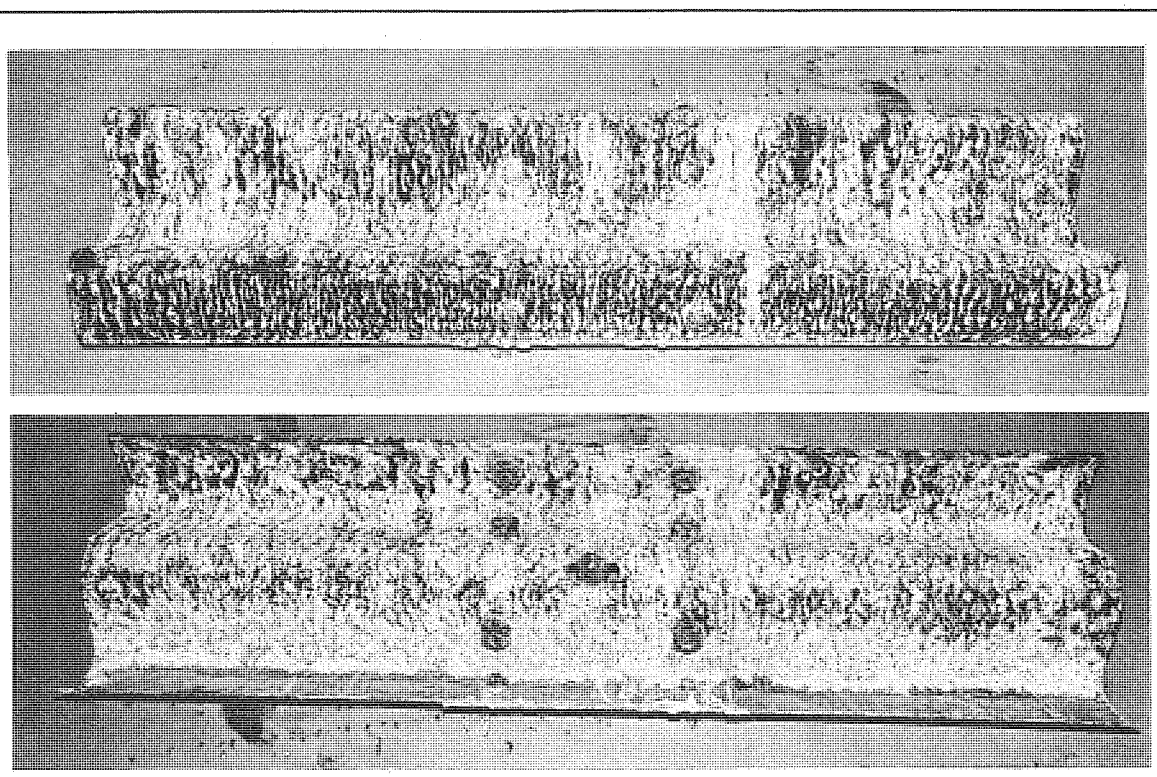


D)Sample 1B-2A pre-galvanized

Figure 5 Samples after 2000 hours

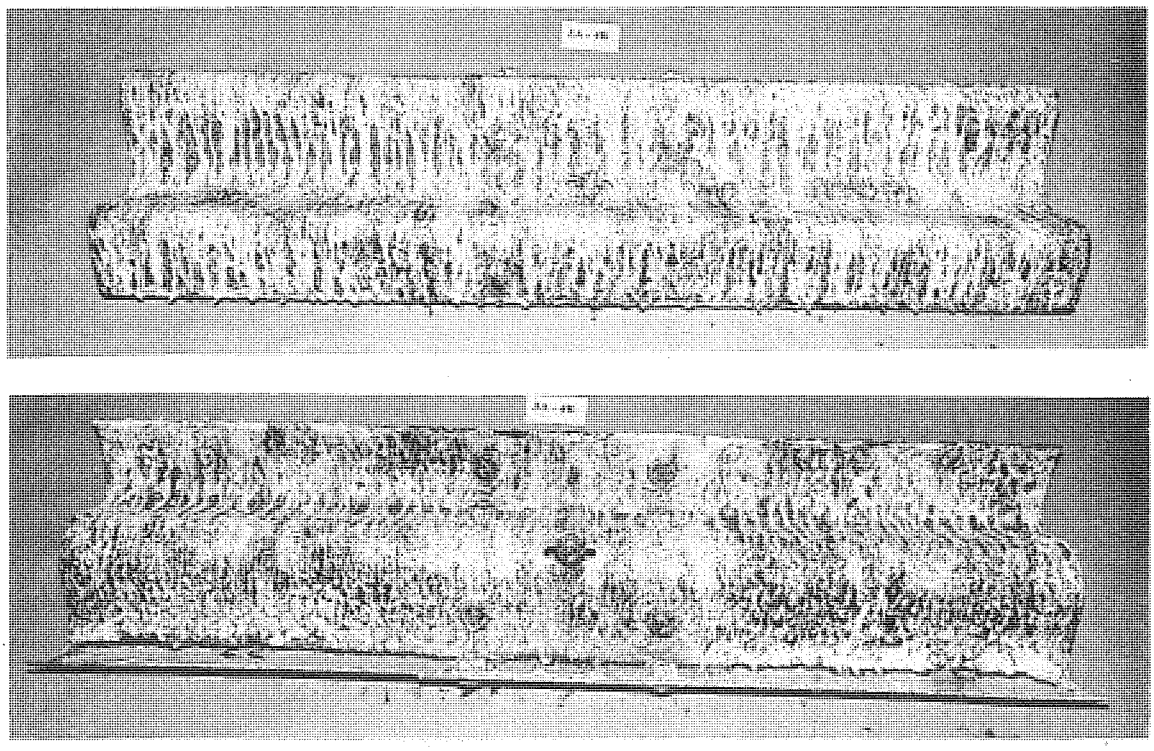


A)Sample 3B-4A post-galvanized



B)Sample 1A-2B pre-galvanized

Figure 6 Samples after 3000 hours



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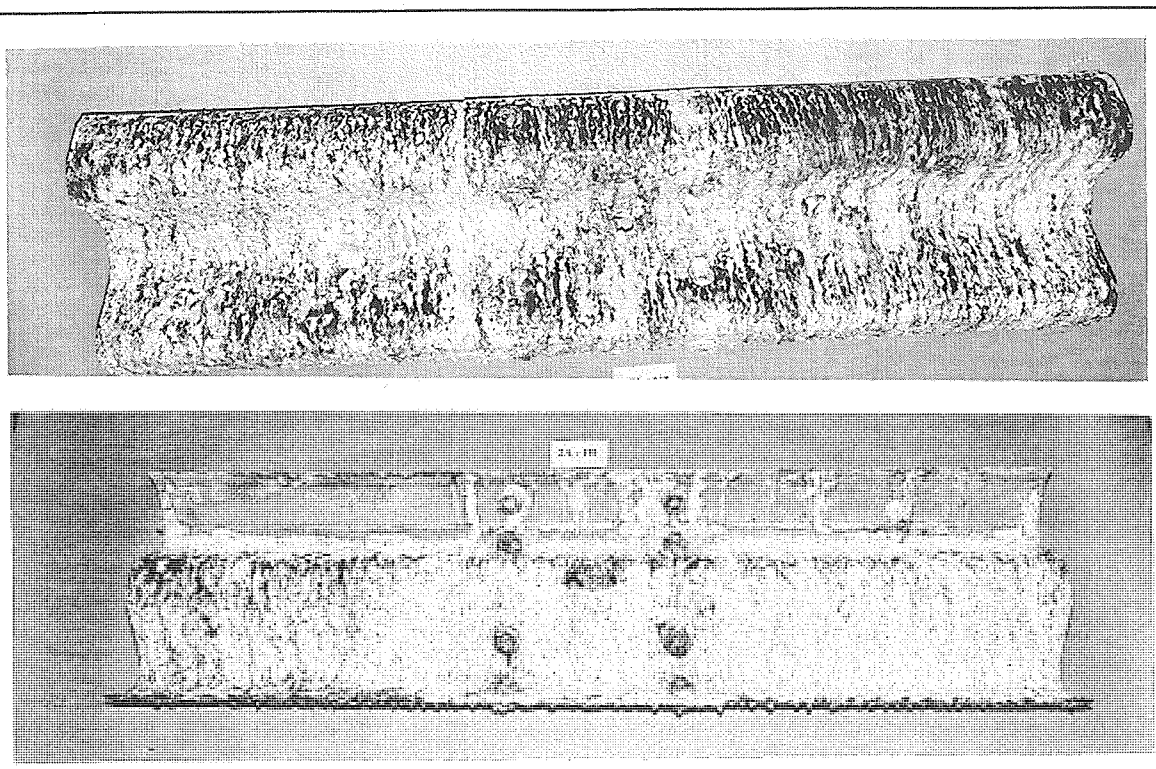
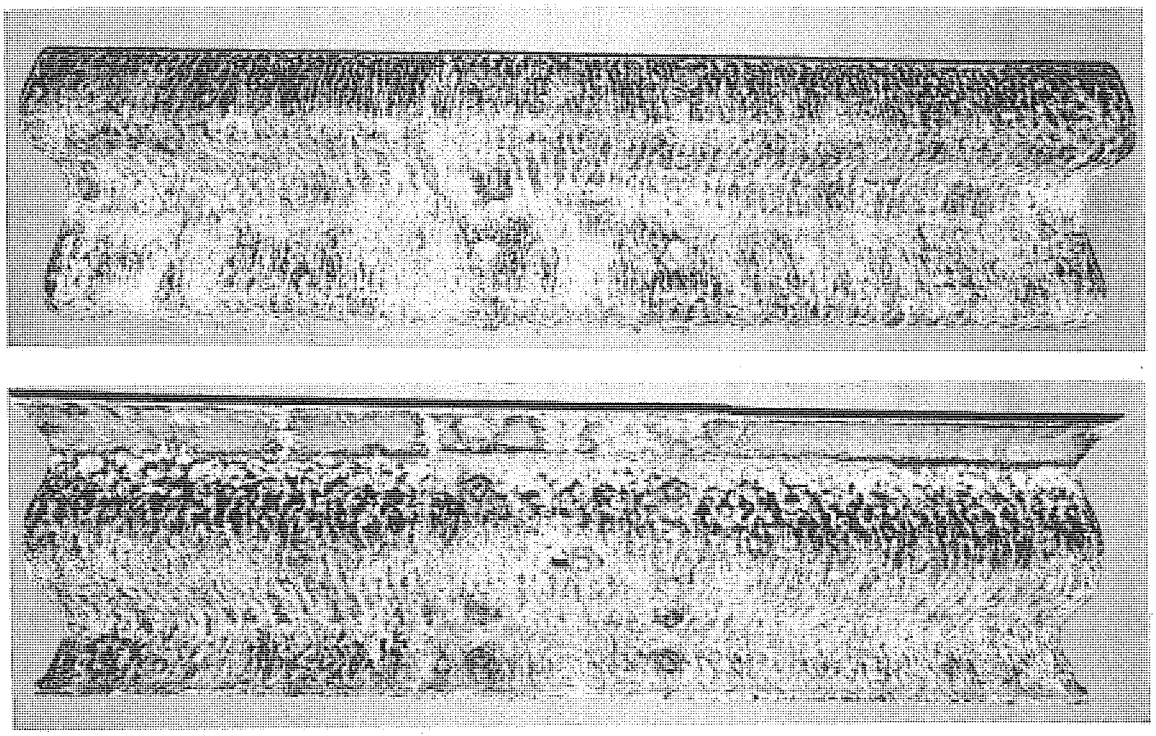
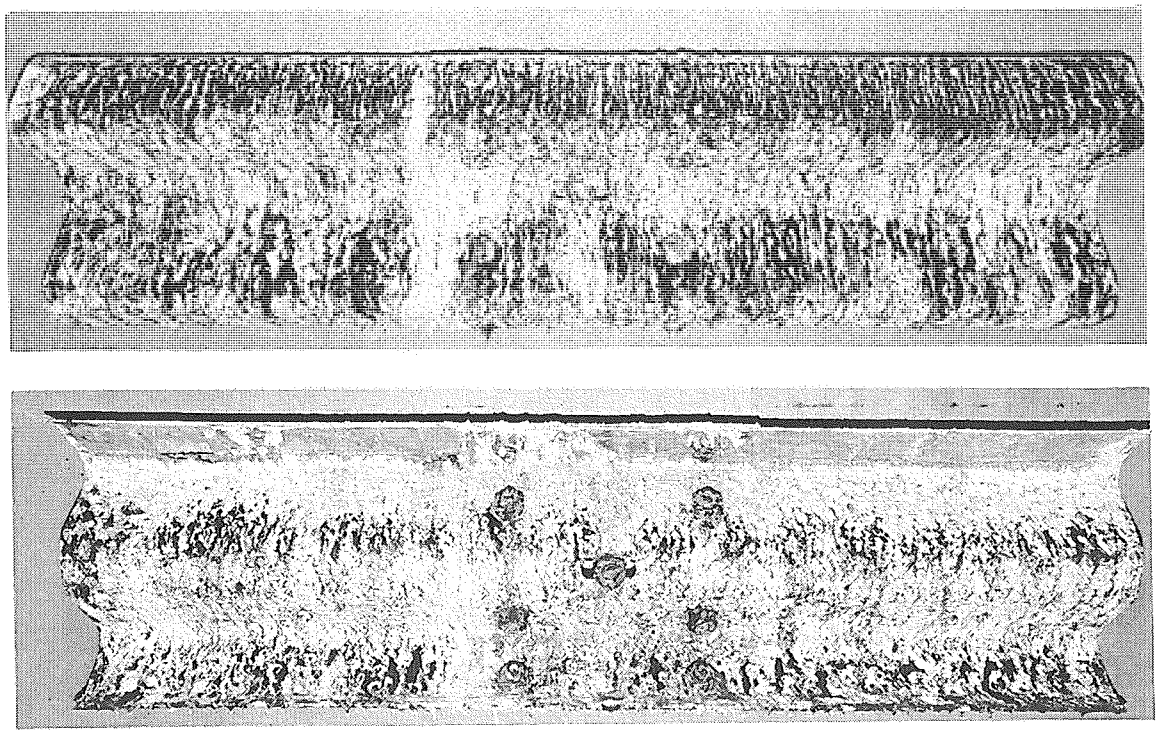


D)Sample 1B-2A pre-galvanized

Figure 6 Samples after 3000 hours

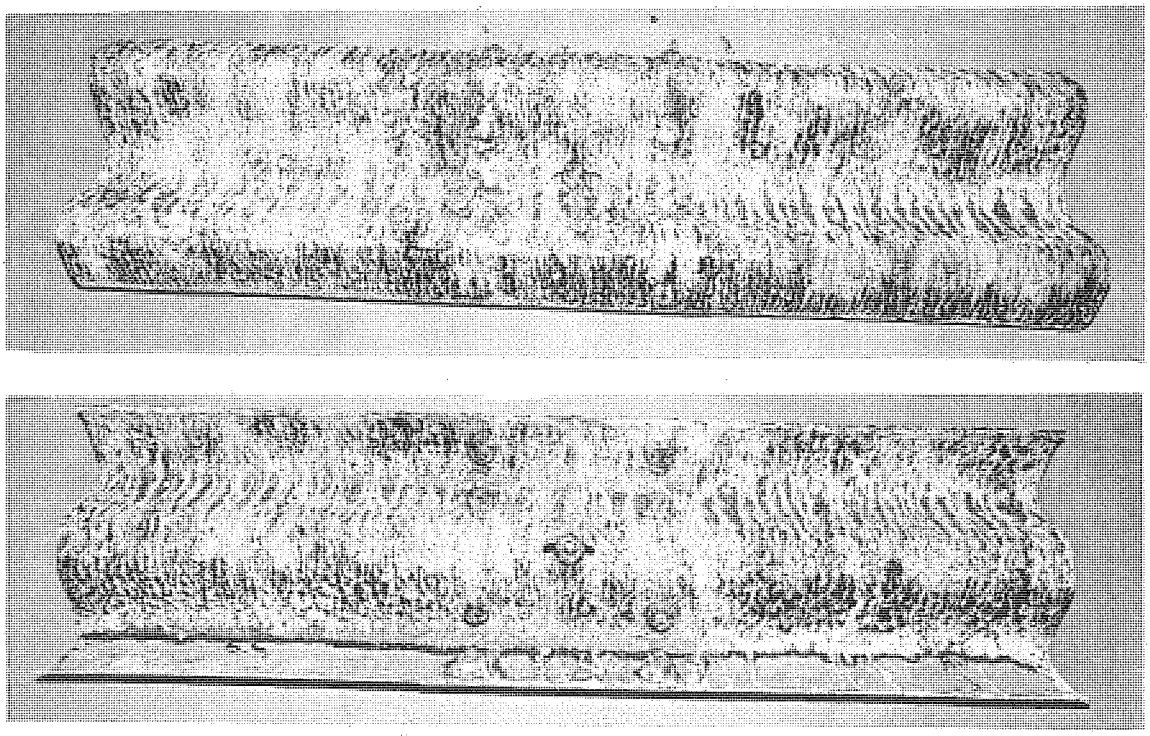


A)Sample 3B-4A post-galvanized

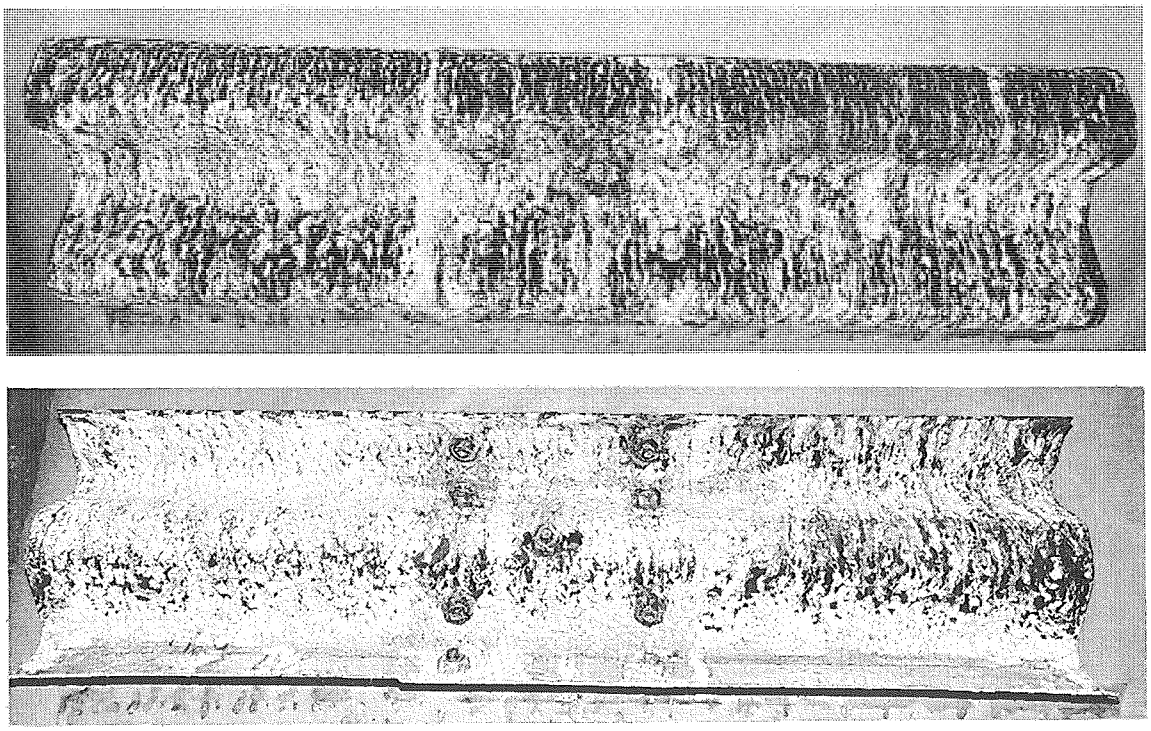


B)Sample 1A-2B pre-galvanized

Figure 7 Samples after 4000 hours

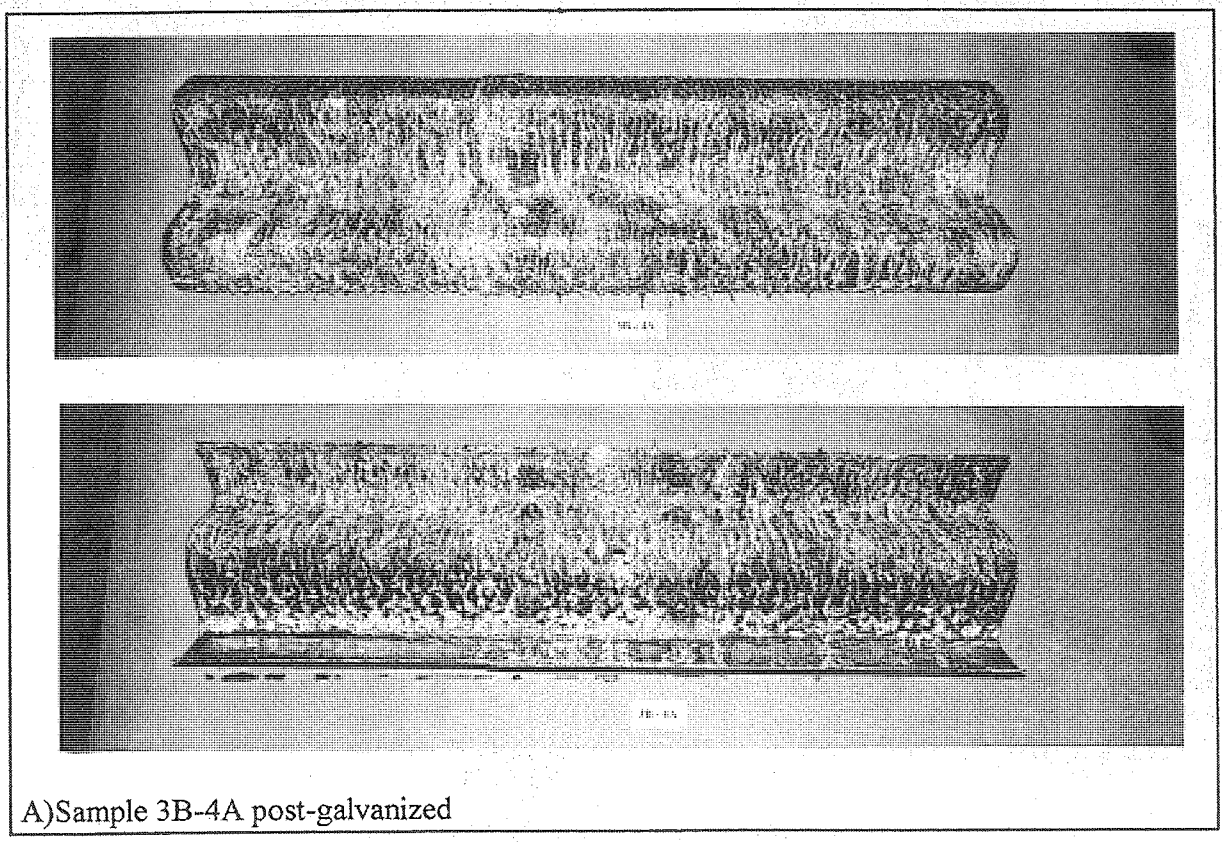


C)Sample 3A-4B post-galvanized

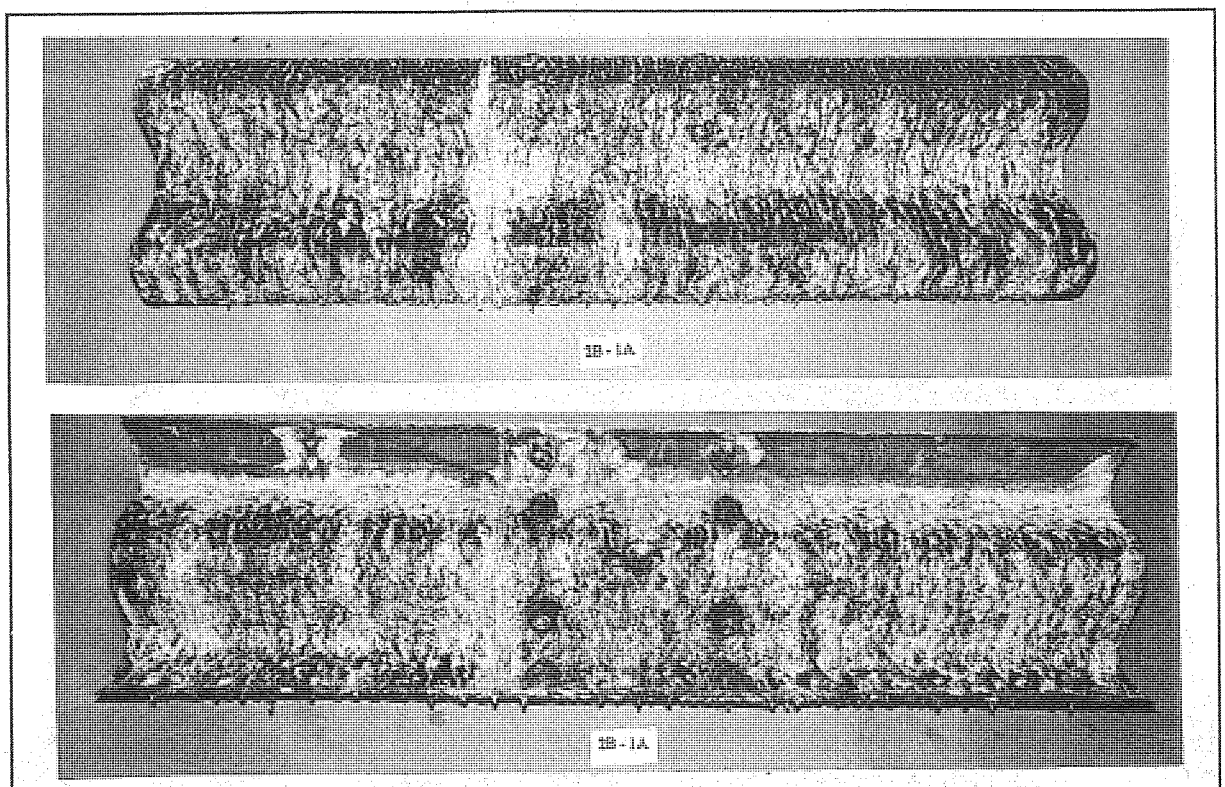


D)Sample 1B-2A pre-galvanized

Figure 7 Samples after 4000 hours

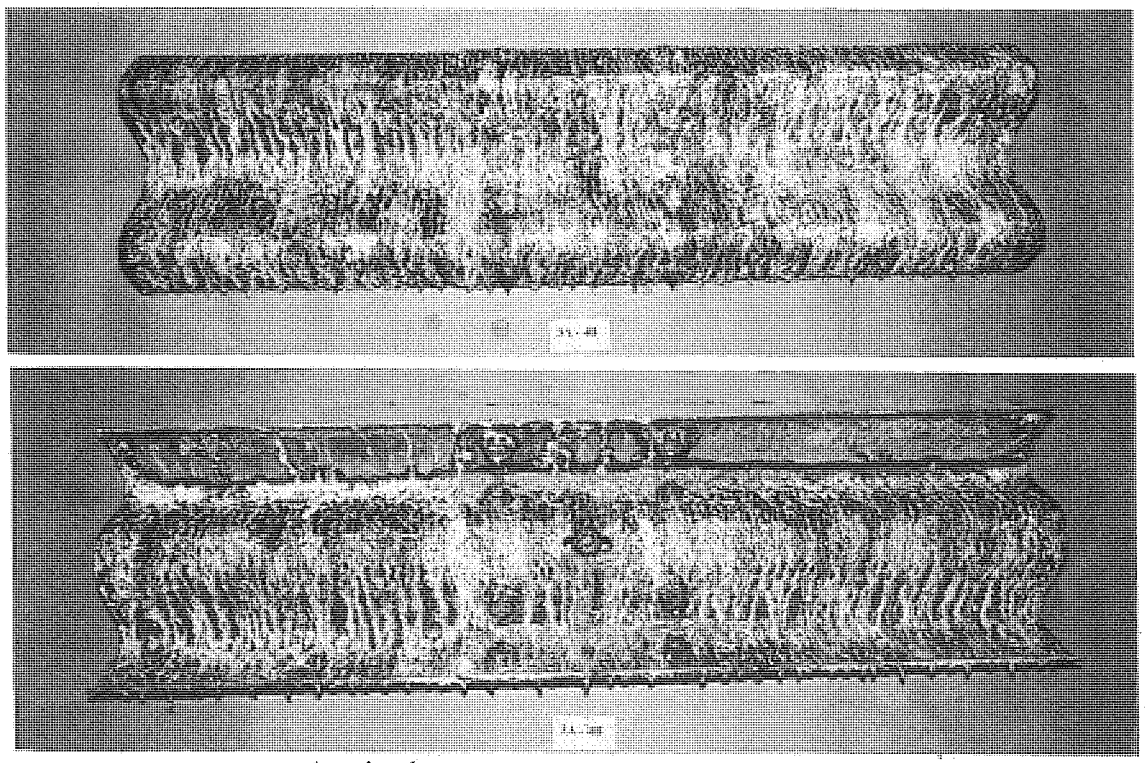


A)Sample 3B-4A post-galvanized

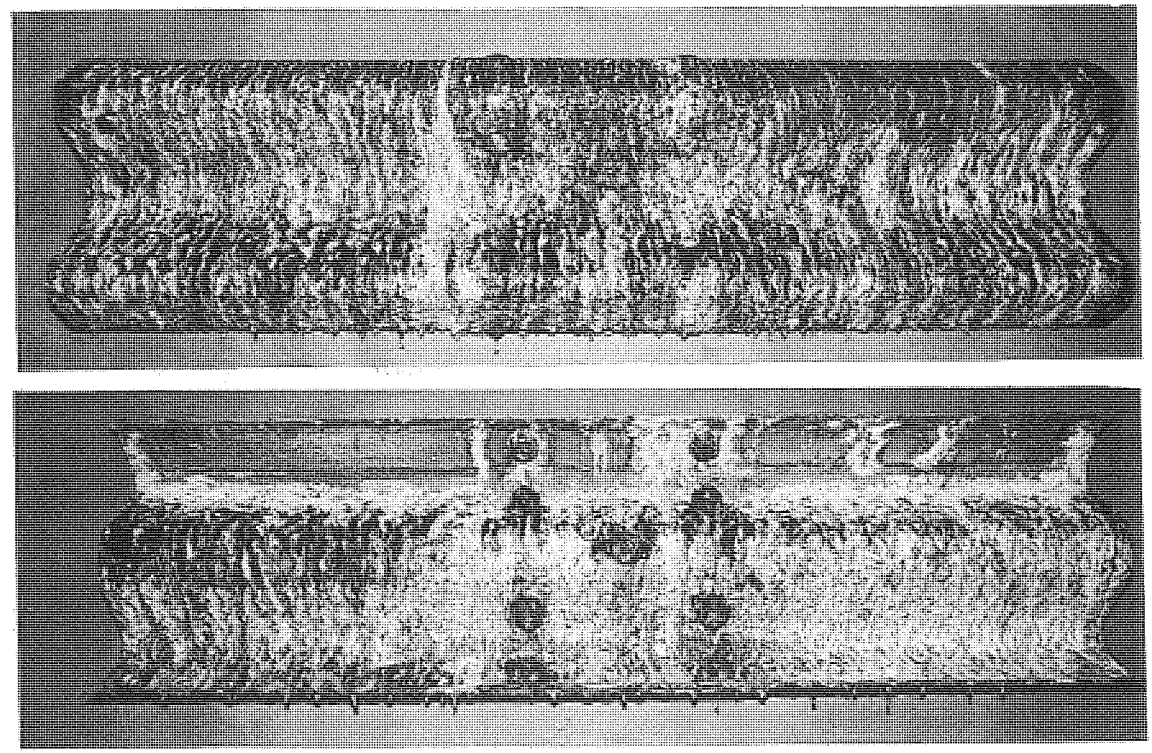


B)Sample 1A-2B pre-galvanized

Figure 8 Samples after 5000 hours

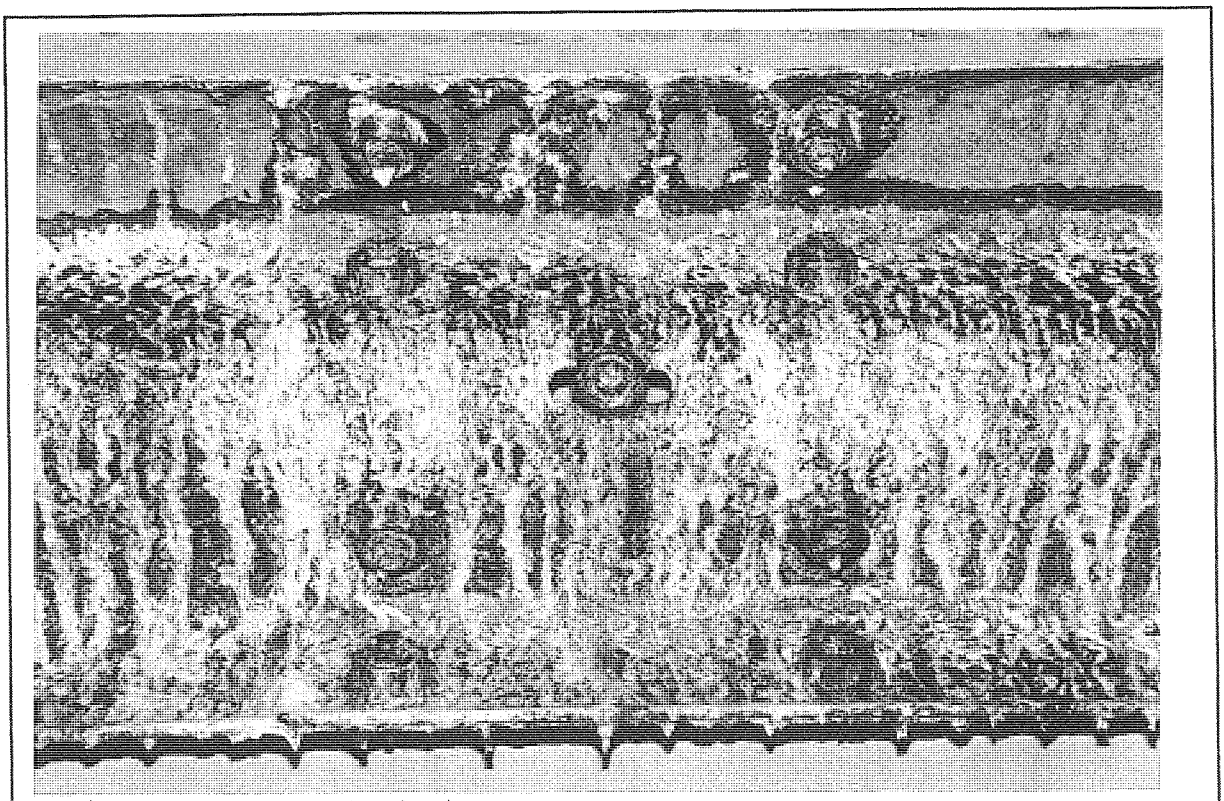


C)Sample 3A-4B post-galvanized

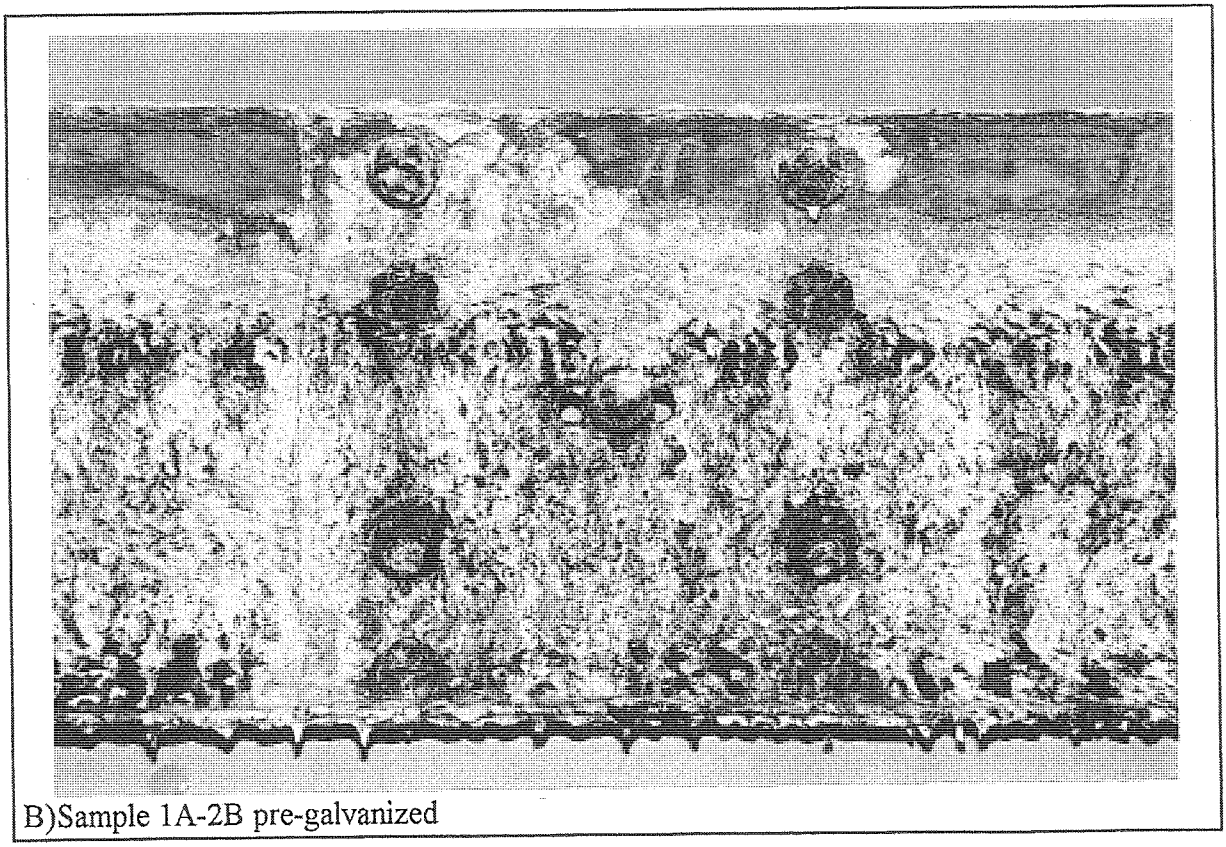


D)Sample 1B-2A pre-galvanized

Figure 8 Samples after 5000 hours

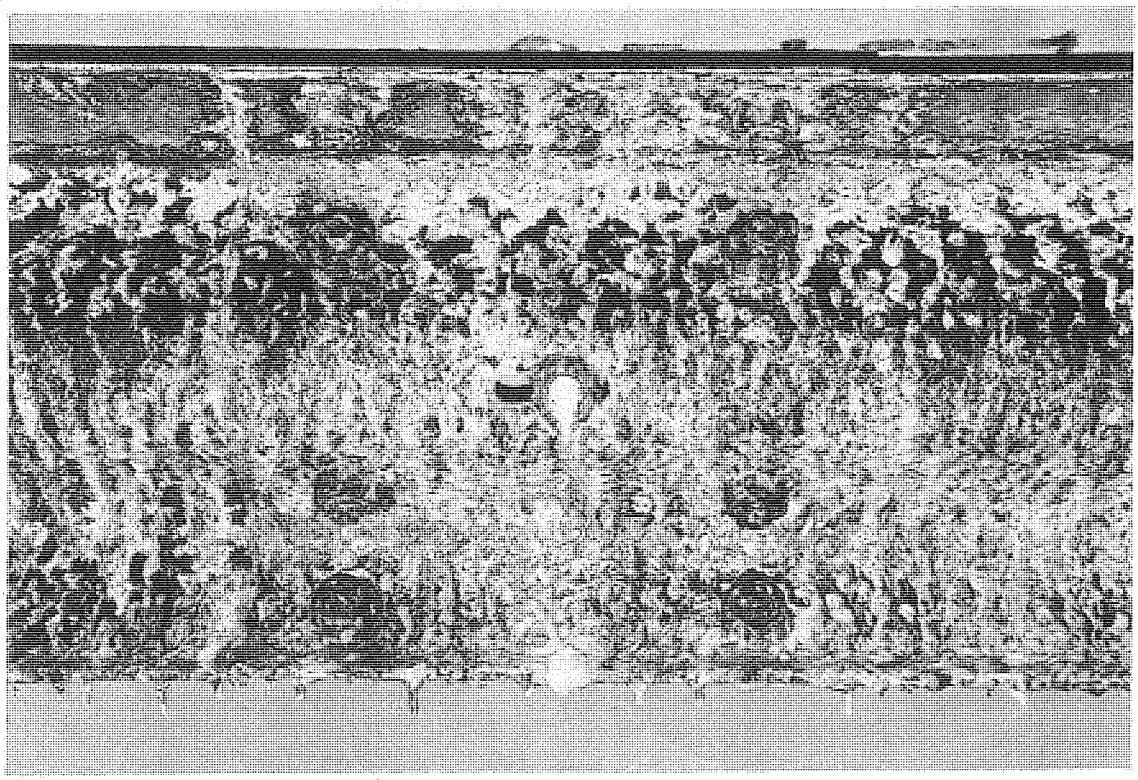


A)Sample 3B-4A post-galvanized

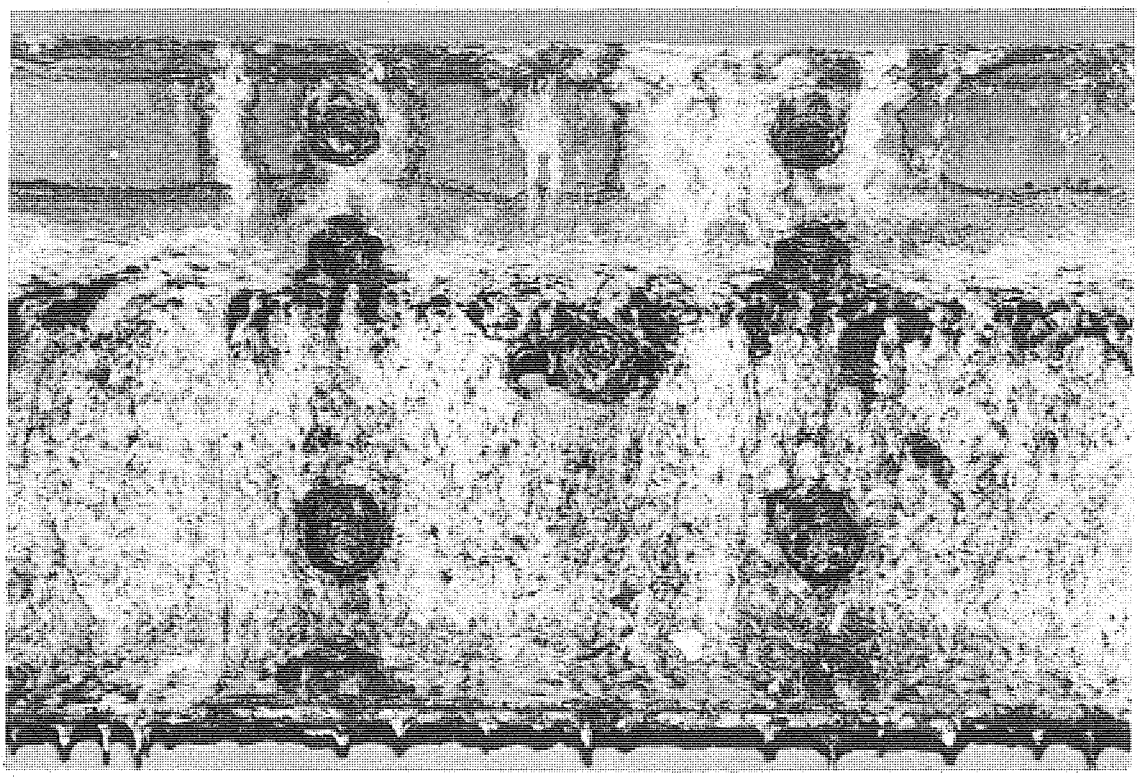


B)Sample 1A-2B pre-galvanized

Figure 9 Samples after 5000 hours. Closeup of the splice nuts

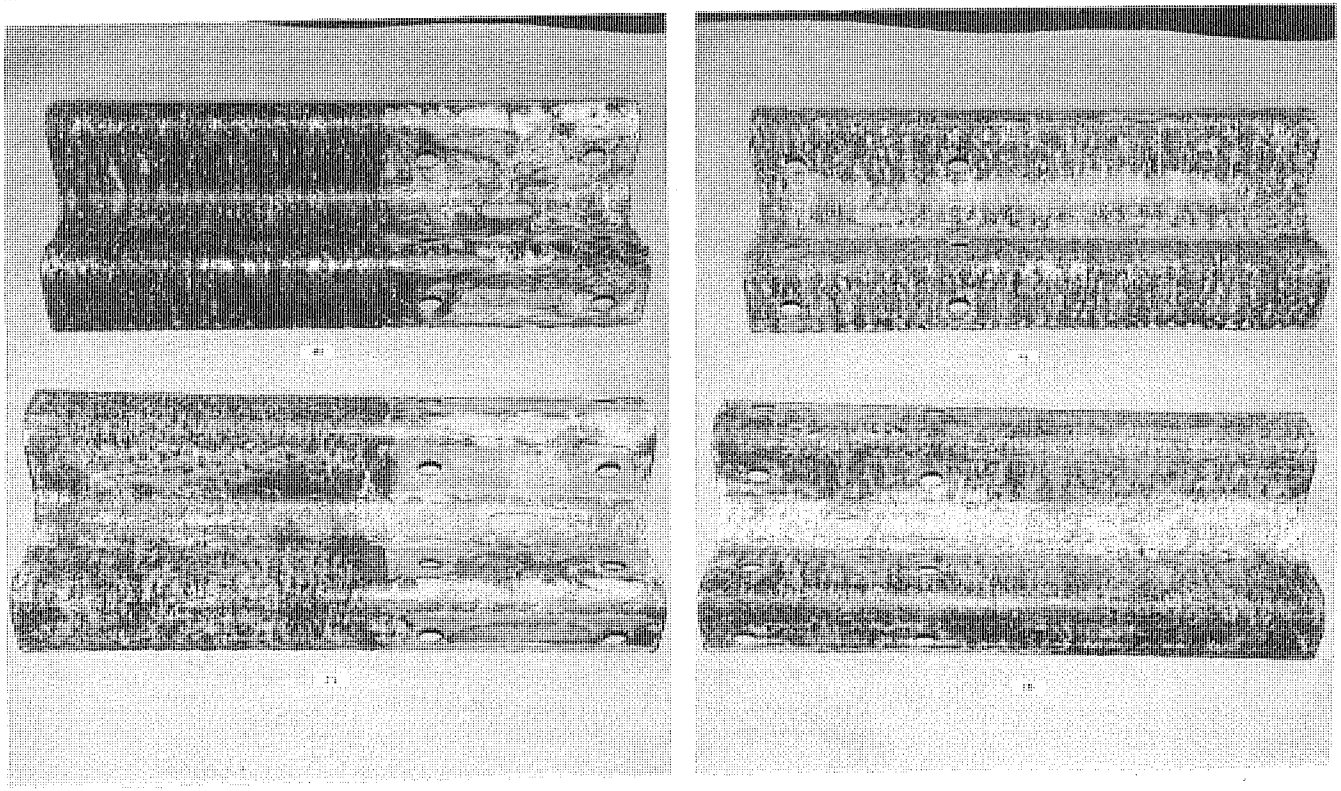


C)Sample 3A-4B post-galvanized



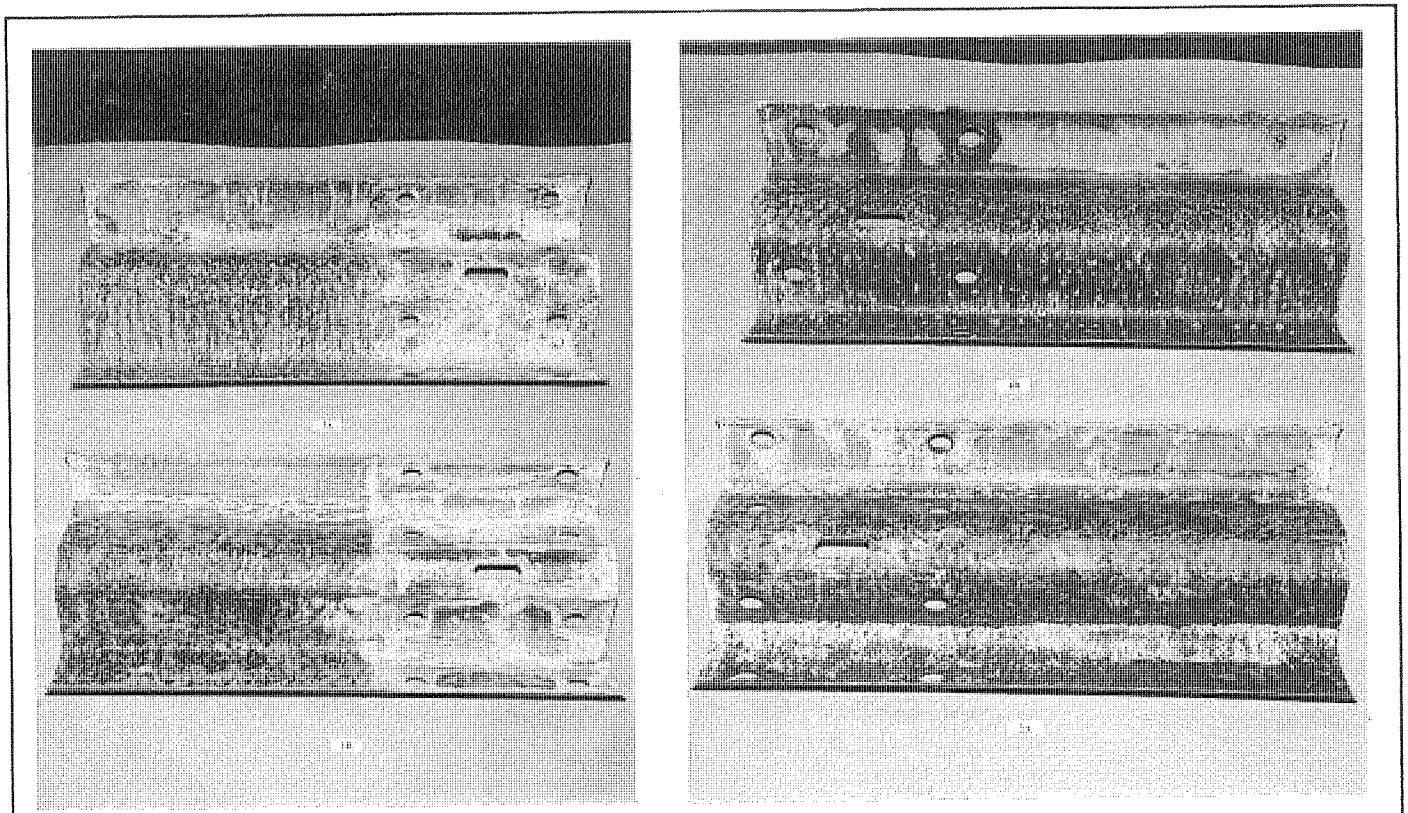
D)Sample 1B-2A pre-galvanized

Figure 9 Samples after 5000 hours. Closeup of the splice nuts



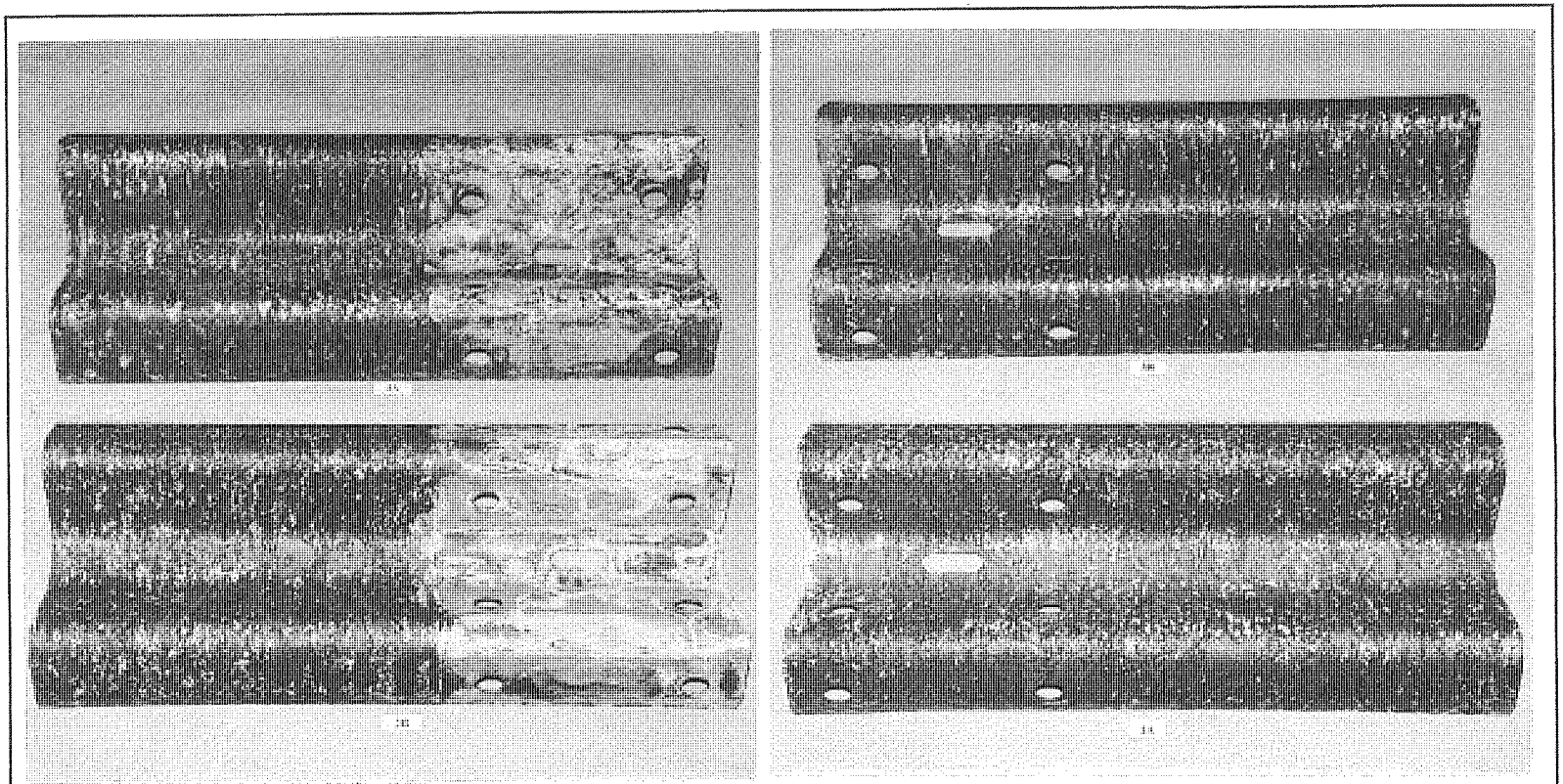
A) Sample 3A-4B is post-galvanized and sample 1B-2A is pre-galvanzied

Figure 10 Cleaned samples after 5000 hours



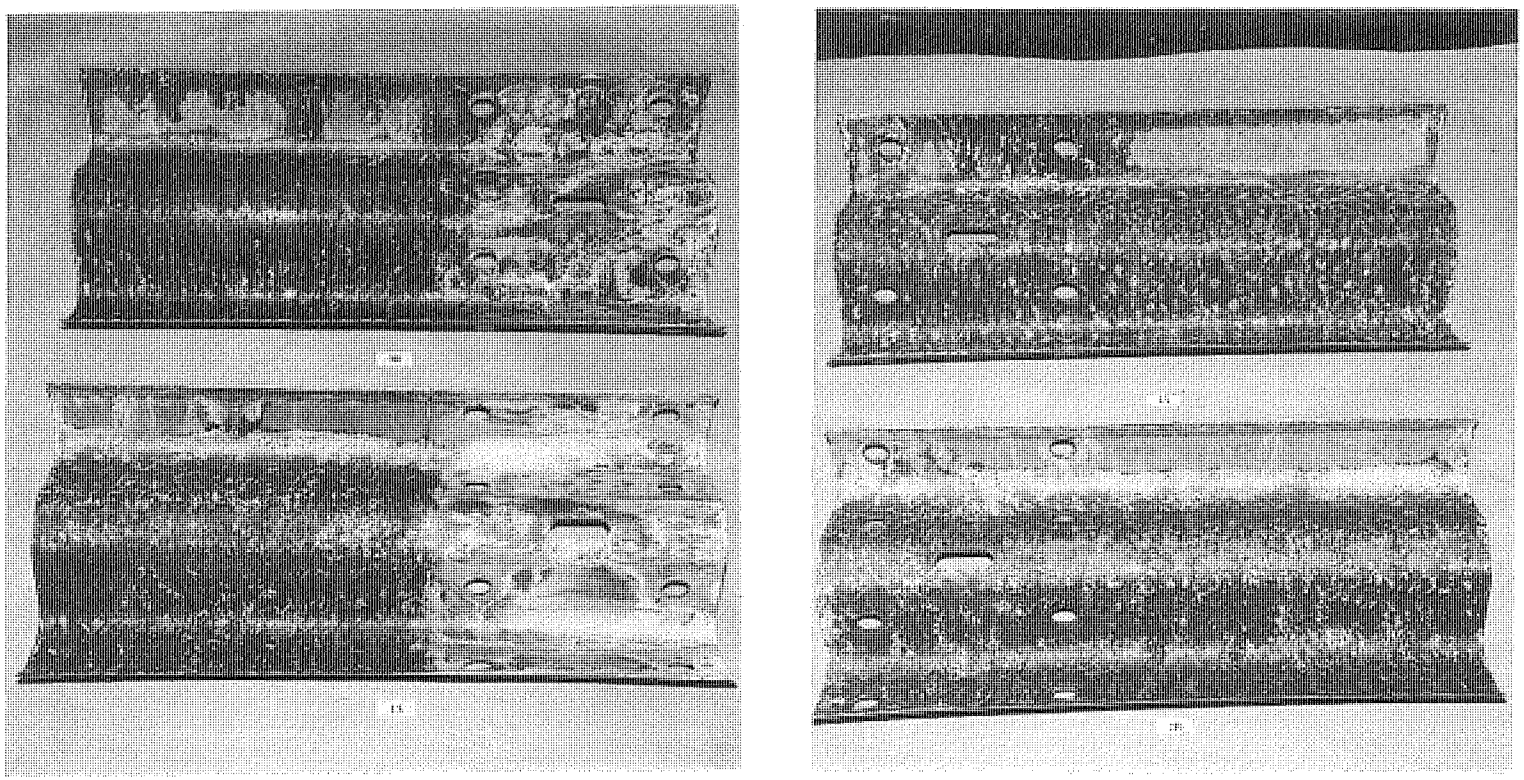
B) Sample 3A-4B is post-galvanized and sample 1B-2A is pre-galvanzied

Figure 10 Cleaned samples after 5000 hours



C) Sample 3B-4A is post-galvanized and sample 1A-2B is pre-galvanzied

Figure 10 Cleaned samples after 5000 hours



D) Sample 3B-4A is post-galvanized and sample 1A-2B is pre-galvanzied

Figure 10 Cleaned samples after 5000 hours

TABLES

Sample 1 Pre-Galvanized Heat # 1378

Piece 1A		Points			
		1	2	3	4
Region	A	157.5	94.0	139.7	99.1
	B	152.4	88.9	134.6	99.1
	C	132.1	101.6	124.5	94.0
Piece 1B		Points			
		1	2	3	4
Region	A	94.0	114.3	177.8	132.1
	B	106.7	101.6	127.0	129.5
	C	119.4	134.6	116.8	101.6

Sample 2 Pre-Galvanized Heat # 1378

Piece 2A		Points			
		1	2	3	4
Region	A	208.3	154.9	180.3	152.4
	B	152.4	172.7	198.1	221.0
	C	172.7	165.1	205.7	223.5
Piece 2B		Points			
		1	2	3	4
Region	A	114.3	101.6	106.7	111.8
	B	106.7	124.5	129.5	109.2
	C	101.6	101.6	99.1	116.8

Sample 3 Post-Galvanized Heat # 27612

Piece 3A		Points			
		1	2	3	4
Region	A	147.3	147.3	101.6	129.5
	B	88.9	96.5	88.9	129.5
	C	172.7	106.7	132.1	101.6
Piece 3B		Points			
		1	2	3	4
Region	A	81.3	76.2	152.4	101.6
	B	91.4	86.4	88.9	88.9
	C	81.3	86.4	101.6	129.5

Sample 4 Post-Galvanized Heat # 27612

Piece 4A		Points			
		1	2	3	4
Region	A	152.4	182.9	190.5	180.3
	B	116.8	96.5	88.9	111.8
	C	180.3	203.2	152.4	147.3
Piece 4B		Points			
		1	2	3	4
Region	A	203.2	213.4	147.3	139.7
	B	88.9	88.9	99.1	96.5
	C	147.3	177.8	157.5	139.7

Table 1
Zinc thickness of Pre-Galvanized and Post-Galvanized Guard Rail Splices.
The Zinc Thickness Test was conducted with Mikrotest Instrument # 85366
All values are microns.

Time Elapsed: 1000 hr.

Sample 1B/2A	Pre-Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	74.6	74.6	67.8	81.3	81.3	81.3	81.3	74.6	81.3
Sample 3B/4A	Post Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	88.1	81.3	81.3	108.5	81.3	101.7	81.3	94.9	94.9
Sample 3A/4B	Post Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	67.8	67.8	67.8	81.3	33.9	NG	81.3	81.3	94.9
Sample 1A/2B	Pre-Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	81.3	67.8	40.7	81.3	81.3	81.3	81.3	67.8	67.8

Time Elapsed: 2000 hr.

Sample 1B/2A	Pre-Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	94.9	94.9	88.1	101.7	122.0	115.2	101.7	122.0	94.9
Sample 3B/4A	Post Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	128.8	101.7	115.2	128.8	128.8	115.2	108.5	128.8	122.0
Sample 3A/4B	Post Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	81.3	81.3	40.7	88.1	74.6	94.9	108.5	101.7	115.2
Sample 1A/2B	Pre-Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	94.9	101.7	94.9	122.0	101.7	94.9	101.7	122.0	94.9

Time Elapsed: 3000 hr.

Sample 1B/2A	Pre-Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	101.7	94.9	81.3	94.9	122.0	88.1	94.9	88.1	94.9
Sample 3B/4A	Post Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	108.5	81.3	108.5	115.2	94.9	54.2	108.5	94.9	94.9
Sample 3A/4B	Post Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	94.9	67.8	40.7	74.6	74.6	88.1	101.7	94.9	94.9
Sample 1A/2B	Pre-Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	88.1	74.6	94.9	108.5	74.6	94.9	74.6	101.7	81.3

Time Elapsed: 4000 hr.

Sample 1B/2A	Pre-Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	94.9	88.1	81.3	94.9	94.9	67.8	101.7	81.3	81.3
Sample 3B/4A	Post Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	101.7	81.3	94.9	115.2	94.9	81.3	67.8	88.1	94.9
Sample 3A/4B	Post Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	88.1	74.6	40.7	67.8	74.6	88.1	101.7	94.9	61.0
Sample 1A/2B	Pre-Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	81.3	81.3	74.6	81.3	67.8	88.1	67.8	94.9	74.6

Time Elapsed: 5000 hr.

Sample 1B/2A	Pre-Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	88.1	81.3	81.3	67.8	94.9	61.0	122.0	81.3	81.3
Sample 3B/4A	Post Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	94.9	54.2	94.9	101.7	88.1	67.8	94.9	81.3	101.7
Sample 3A/4B	Post Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	88.1	81.3	27.1	61.0	81.3	94.9	94.9	67.8	54.2
Sample 1A/2B	Pre-Galvanized Specimen								
	Bolt #	1	2	3	4	5	6	7	8	9
	Torque	88.1	94.9	81.3	74.6	81.3	81.3	74.6	101.7	94.9

Table 2

Nut loosening torque values (N-m)

Torque values were soft converted from U.S. customary units