CORROSION OF GALFAN IN SOIL AND CONCRETE
PROJECT #ZM-428

2001 PROGRESS REPORT

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EXECUTIVE SUMMARY

A total of 121 specimens have been removed from the three test sites (Montreal, Canada; Weirton, WV; and Newark, DE) following an approximately eight (8) year exposure.

The corrosion characteristics of each test site are evidenced by the individual data sets. In the full soil exposure, Montreal continues to be the most corrosive site followed by Newark and then Weirton. The Weirton Site is the least corrosive site in all exposure categories evaluated at this time.

Generally, corrosion rates for the coating systems decreased over time, and in aggressive environments, Galfan shows a significantly lower rate of corrosion on flat surfaces. The performance margin between Galfan and galvanizing becomes less distinct when soil conditions become less aggressive. Corrosion rates, while measurable, remain low at the Weirton site.

Galvanizing has a significant advantage over Galfan when forming angles. The Galfan seems to crack on formed corners especially at the GF200 level. This was not as pronounced at the GF115 thickness. As with the previous paragraph, this advantage diminishes, as soil conditions become less aggressive.

Both the Magni and Plastisol coatings show a propensity to blister at the cut edges on nearly all specimens, particularly for Magni on Galfan. When blisters form they seem to be larger under Plastisol than under Magni. Magni seems to spall more readily from the galvanized specimens when blisters form.

Bar graphs of the average corrosion rates after one, two and eight years of exposure for unpainted specimens are shown in Appendix D. Additionally, bar graphs for this most recent data set of corrosion rates allow a site by site corrosivity comparison for each exposure category.

Partially buried specimens from Weirton, WV and specimens cast in full and partial concrete are currently being evaluated and their data was not available for this report.

TEST PROGRAM CONCEPT AND DESIGN

In 1990, Weirton Steel Corporation (Weirton, WV) contracted with Corrosion Testing Laboratories, Inc. (CTL) to conduct a long-term corrosion study of Galfan and hot dipped galvanized steel in soil and concrete. This testing program was undertaken following short-term laboratory electrochemical tests performed by CTL, which indicated that Galfan performed better than galvanizing.

Six test sites were chosen to represent a wide variety of soil and climate types. Various sizes and shapes of unpainted and painted Galfan and galvanized specimens were completely or partially buried at each site. In addition, sets of specimens were also partially embedded in two different types of concrete and either completely buried or left unburied.

Sets of specimens were retrieved from each site after exposures of six, twelve, eighteen, and twenty-four months, and evaluations made of coating system performance via weight loss measurement and corrosion rate calculations as well as visual and microscopic assessments. Detailed surface morphology studies and electrochemical tests were also performed on exposed specimens to determine possible corrosion mechanisms and to evaluate coating integrity.

At the end of two years, although the Galfan coatings (three Galfan and two galvanized coatings were included in the study) performed best at each test site, a review of the data could not establish a clear indication of which coating system outperformed the others. Part of the reason for this could be the termination of the program before definite trends had developed, i.e.; the test program was too short. Furthermore, direct comparisons between coating systems were made difficult or impossible by the fact that too many variables had been introduced, from system to system, in such important areas as coating thickness and steel surface preparation.

The current effort was undertaken to continue the corrosion study of Galfan and hot-dip galvanizing in soil and concrete, while limiting the number of variables between coating systems by using test specimens with a standardized coating thickness. In addition, the test program was envisioned to continue for five years to determine if clear trends in coating performance could be discerned after a longer exposure. The number of test sites was limited to three, including the site, which had produced the worst corrosion in the initial study.

To date, three sets of specimens were retrieved from each of the three sites. Specimens were retrieved and evaluated after one year of exposure. The results of the first evaluation were reported previously under CTL REF #9042-10 dated March 1994 to the North American Galfan Development Association (NAGDA). Upon the completion of two years of exposure, the second set of results were reported to the International Lead Zinc Research Organization (ILZRO) under CTL REF #9042-11 dated April 1995. The most recent set was retrieved after eight years of continuous exposure.

INITIAL CHARACTERIZATION OF TEST SPECIMENS

Eight coating systems, specimens of which were supplied by either Weirton Steel Corporation (W) or Wheeling Pittsburgh (WP), were included in the test program. In the following list of the coating systems, "CT" refers to the application of a passivating chemical treatment to the steel matrix prior to the coating application; "G" or "GF" refers to either a galvanized or Galfan coating; the number refers to the coating thickness/weight per square foot; and "Plastisol" or "Magni" refer to painting systems. Specifications (except for fence posts) regarding the metal coating thickness and chemical analysis, metal coating microstructure, paint systems, chemical pretreatment, and surface characterization are found in Tables 1 through 5, respectively.

- Galvanized, CT, G115
- Galvanized, CT, G200
- Galfan, CT, GF115
- Galfan, CT, GF200
- Painted Galvanized, G90, Plastisol
- Painted Galfan, GF90, Plastisol
- Painted Galvanized, G90, Magni
- Painted Galfan, GF90, Magni

In addition, Galfan and galvanized rolled "C"-Form fence posts were supplied by Gregory Galvanizing & Metal Processing.

TABLE 1
METAL COATING THICKNESS AND CHEMICAL ANALYSIS

Identification	Location	Size (in^2)	Coating ($oz./ft^2$)	Al	Fe	Pb	Sb	Ce	La
WG 115	Top	4.0	0.73	0.200	0.390	0.040	0.023	---	---
	Bottom		0.69						
	Total		1.42						
WPG 200	Top	4.0	1.03	0.179	0.114	0.011	<0.003	---	---
	Bottom		1.17						
	Total		2.20						
Magni WG90	Top	7.76	0.43	0.204	0.590	0.060	0.012	---	---
	Bottom		0.47						
	Total		0.90						
WGF 115	Top	4.0	0.58	4.550	0.085	0.009	<0.005	0.007	0.004
	Bottom		0.64						
	Total		1.22						
WPGF 115	Top	4.13	0.62	3.690	0.105	0.011	<0.004	0.008	0.003
	Bottom		0.93						
	Total		1.55						
WPGF 200	Top	3.88	1.82	4.030	0.090	0.009	<0.002	0.012	0.004
	Bottom		1.02						
	Total		2.84						
Magni WGF90	Top	7.76	0.39	4.630	0.133	0.013	<0.004	0.008	0.005
	Bottom		0.48						
	Total		0.87						

TABLE 2
COATING MICROSTRUCTURE

SPECIMEN CODE	DESCRIPTION
WG115	Typical hot dipped galvanize zinc coating. Very thin iron-zinc intermetallic layer at the steel coating interface with some intermetallic alloy bursts into the coating.
WGF115	Typical Galfan coating eutectic microstructure with numerous zinc globules scattered throughout. There were no iron-aluminum intermetallics found at the steel coating interface.
WPGF115	Typical Galfan coating eutectic microstructure with numerous zinc globules scattered throughout. There were some particles of intermetallic dross in the coating. There were no iron-aluminum intermetallics found at the steel coating interface.
WPG200	Typical hot dipped galvanize zinc coating. No discernible iron-zinc intermetallic layer at the steel coating interface.
WPGF200	Typical Galfan coating eutectic microstructure with numerous zinc globules scattered throughout. There were some particles of intermetallic dross in the coating. There were no intermetallics found at the steel coating interface.
GALVANIZED-MAGNI	Typical hot dipped galvanize zinc coating. Very thin iron-zinc intermetallic layer at the steel coating interface with some intermetallic alloy bursts into the coating.
GALFAN-MAGNI	Typical Galfan coating eutectic microstructure with numerous zinc globules scattered throughout. There were no iron-aluminum intermetallics found at the steel coating interface.

TABLE 3
PAINT COATING SYSTEMS

DESIGNATION	COATING SYSTEM INFORMATION	
PLASTISOL	Manufacturer:	Valspar
	Primer:	561Y007 (0.10 mils)
	Topcoat:	DGA0009 quality Plastisol (4.5 mils)
	Topcoat thickness:	4-6 mils (Topcoat was applied to only one side of specimens)
MAGNI	Manufacturer:	Magni Industries
	Pretreatment:	Parker + Amchem 14115A
	Primer:	Dorrlflex G (725-PT92C)(aluminum and nickel pigmented)
	Film thickness:	Top 0.55 to 0.60 mils; Bottom approx. 1.0 mils

TABLE 4
CHEMICAL PRETREATMENTS FOR GALFAN AND GALVANIZED SPECIMENS
(Supplied by Weirton Steel Corporation)

WG115:	Okemcoat F1, 7.0 g/in, mill applied
WGF115:	Okemcoat F1, 5.1 g/in (3.1 to 8.4 range), laboratory applied

TABLE 5
SURFACE CHARACTERIZATION OF GALFAN AND GALVANIZED SPECIMENS
(Supplied by Weirton Steel Corporation)

WG115:	Minimized Spangle (Steam minimized; not temper rolled)
WGF115:	Minimized Grain Structure (Steam minimized; not temper rolled)
WGF90M:	Extra Smooth (Steam minimized and temper rolled)
WG90M:	Extra Smooth (Steam minimized and temper rolled)

TEST SPECIMEN PREPARATION AND IDENTIFICATION

Test specimens were supplied to CTL in five different forms:

- 3" x 3" squares (full burial) for standard soil corrosion tests.
- 6" x 6" "Z"-forms (full burial) for investigating the reported "crack-healing" properties of as-formed Galfan products.
- 1" x 4" strips for either full or partial embedment in concrete and subsequent full burial in soil, used to study corrosion effect of concrete. The concrete exposure reflects conditions which are significant in certain applications such as playground equipment and sign posts.
- 2" x 8" strips (partial burial) for investigating the "water-line" corrosion effects at the soil/atmosphere interface.
- 2' long, "C"-form fence posts (partial burial) to assess the performance of an actual product line.

Three identical sets of specimens were prepared, one for each site. Each set included five subsets slated for retrieval at yearly intervals over five years. A limited number of spare specimens were also included to cover any specimen losses due to damage on retrieval or for special investigations.

Each specimen was given a unique identification by using combinations of colored plastic coated wires threaded through a small hole drilled in each specimen.

Specimen preparation consisted of degreasing with acetone and methanol, weighing and measuring, and noting any outstanding features, such as mechanical damage, on each specimen. Half of each set of square Plastisol-painted specimens was scored with an "X" pattern to assess the paint integrity at damage sites; Magni-painted specimens were not scored. Fence posts were cut to two-foot (2') lengths for testing.

Specimens exposed to concrete (Portland Type 1) were either fully embedded or embedded to half their length.

INSTALLATION OF SPECIMENS AT TEST SITES

Three test sites were chosen for the test program:

Montreal, Quebec, Canada - This site was chosen because it was the most corrosive venue in the initial testing program. Specimens were exposed to numerous freeze/thaw cycles and acid rain conditions.

Weirton, West Virginia - This site represented an industrial environment, it ranked as moderately corrosive in the first study, and was convenient since it was located on the property of Weirton Steel.

Newark, Delaware – This site represented a suburban/rural environment. It was not used in the first study; however, a nearby site was included in an earlier (1956) NBS/NIST study on underground corrosion. Since the Newark, DE test site was located on the property of CTL, it was therefore convenient.

The specimens were installed during the winter of 1992 and spring of 1993. Installation involved carefully delineating plots for each projected year of retrieval. Fully buried specimens were buried at a depth of approximately 18". Each specimen was carefully spaced from each other to avoid contact during burial. Fence post specimens were driven into the ground to a depth of 18" using a sledgehammer, thus simulating actual installation methods. Partially buried specimens were buried to approximately half of their length. All concrete-embedded specimens were fully buried.

SOIL CHARACTERIZATION

Various characteristics of soil specimens retrieved from the three sites were measured and are shown in Table 6. The results of the analyses could be used in making correlations between prospective product use locations and possible product corrosion behavior characteristics.

TABLE 6
SOIL CHARACTERIZATION
CORROSION OF GALFAN IN SOIL AND CONCRETE

	Montreal PQ	Weirton, WV	Newark, DE
pH (1:1 Water/soil)	5.3	4.1	6.7
Resistivity ρ/cm^3 (as received)	9,100	6,500	13,000
Resistivity ρ/cm^3 (water saturated)	8,400	6,400	7,800
Redox-vs-Platinum (mv)	+390	+460	+295
Particle Size % Sand	64.6	37.6	63.7
Particle Size % Silt	26.7	35.8	24.4
Particle Size % Clay	8.7	26.6	11.9
Soil Classification	Loam	Loam	Loam
Water Saturation	36%	41%	30%
Free Carbonates?	No	No	No
Chlorides (ppm)	Trace	Trace	Trace
Sulfates (ppm)	0	136	32
Sulfides (ppm)	0.032	0	0.176
% Moisture (as received)	20.8	16.6	11.4
Acidity (ppm as $CaCO_3$)	40.0	44.0	14.0
Alkalinity (ppm as $CaCO_3$)	28.8	0	140.0
Hardness Ca as $CaCO_3$ (ppm)	5.48	0.80	97.2
Hardness Mg as $CaCO_3$ (ppm)	8.28	9.44	43.6

SPECIMEN CONDITION ASSESSMENT AFTER EIGHT YEARS OF EXPOSURE

In the current specimen assessment, the set of specimens originally scheduled for retrieval after three years exposure were recovered after approximately eight years of exposure. Some of the specimens were not available for recovery having been removed previously for various reasons.

The retrieved specimens were first visually examined for mechanical damage or any unusual characteristics. Next, the specimens were cleaned using detergent, a non-abrasive cleanser, and water. An intermediate weighing was taken, and corrosion rates were calculated (Tables 7, 8, and 9). All unpainted specimens, excluding the fence posts, were then chemically cleaned in 20 weight percent chromic acid at room temperature to remove oxidized zinc. This step was taken to investigate the amount of tenacious corrosion product, which adhered to the test specimens; in the case of Galfan, it has been speculated that this corrosion product, which was hard, dark gray, and reflective, may offer protection to the steel matrix. After chemical cleaning, the specimens were again weighed and a second set of corrosion rates were calculated (Tables 7, 8, and 9). Presented in Tables 10, 11, and 12 are the specimen weight loss per unit area after the two cleaning methods is The weight loss purely as a result of chemical cleaning versus mechanical scrubbing was obtained by subtracting respective values in Tables 10, 11, and 12.

Montreal Site

The partially buried specimens (2” × 8” strips) and fence posts, of both Galfan and galvanizing, were not available for evaluation.

The specimens were cleaned with detergent and non-abrasive cleanser, photographed, acid cleaned (20% Chromic Acid) and photographed again. The photographs of the specimens are presented in Appendix A.

3×3’s
In general, the Galfan-coated specimens appeared less corroded than the galvanized specimens retaining 70–90% of the GF115 coating and 85-95% of the GF200, however the GF200 coating appeared to have areas that had pitted (Figure 1). The galvanized 3” × 3” specimens had a heavily corroded appearance with large patches of red rust and only traces of galvanizing left on the G115 specimens and 35-40% of the coating on the G200 specimens.

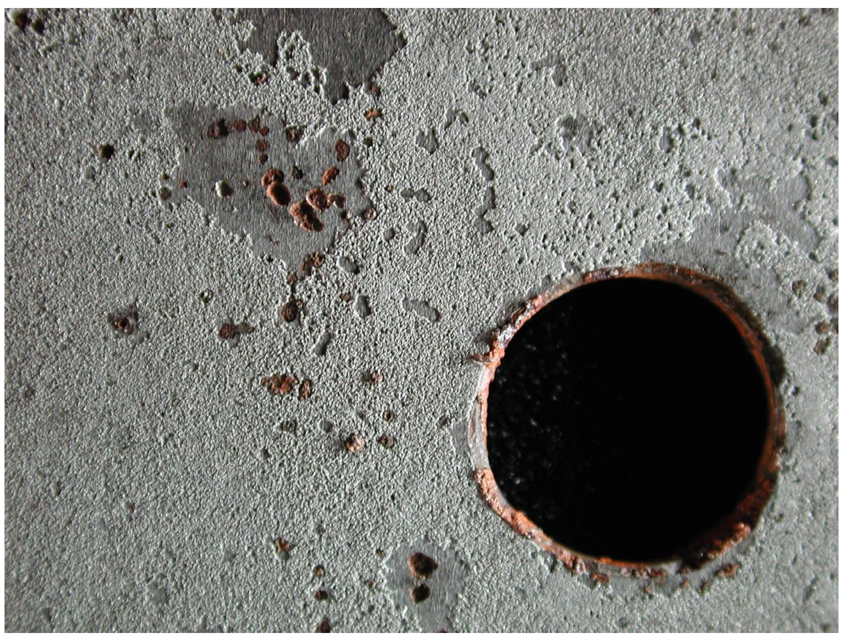

Figure 1 Pitting observed on a 3” × 3” Galfan 200 specimen removed from the Montreal Site after approximately eight years of soil exposure

The Plastisol-coated GF90 (no Plastisol-coated specimens were pre-scored, and only one side of each specimen was painted) developed blisters concentrated near the cut edges. The unpainted side showed some deterioration of the Galfan coating, however, this affected portion of the specimen accounts for about 10% of the unpainted surface. The Plastisol-coated G90 specimen had many large blisters; the unpainted side had deteriorated with 40-50% of its surface showing red rust.

The Magni-coated GF90 (no Magni-coated specimens were pre-scored, and both sides of each specimen were painted) developed blistering at all cut edges. Blisters covered approximately

15% of the surface area of the specimen. Larger, and more numerous, blisters developed at the edges of the G90 that covered nearly 25% of the surface. The coating had spalled in some sections of the G90 Magni coated specimen. The portion of the specimens exposed to concrete did not blister.

6 × 6 Z's

The Galfan-coated specimens had some patches of red rust concentrated near bent and cut edges. Although both GF200 and GF115 showed similar corrosion rates, the GF200 specimens performed better visually than the GF115 specimens. The bends appeared to be more susceptible to corrosion due to cracks (Figure 2) observed in the coating.

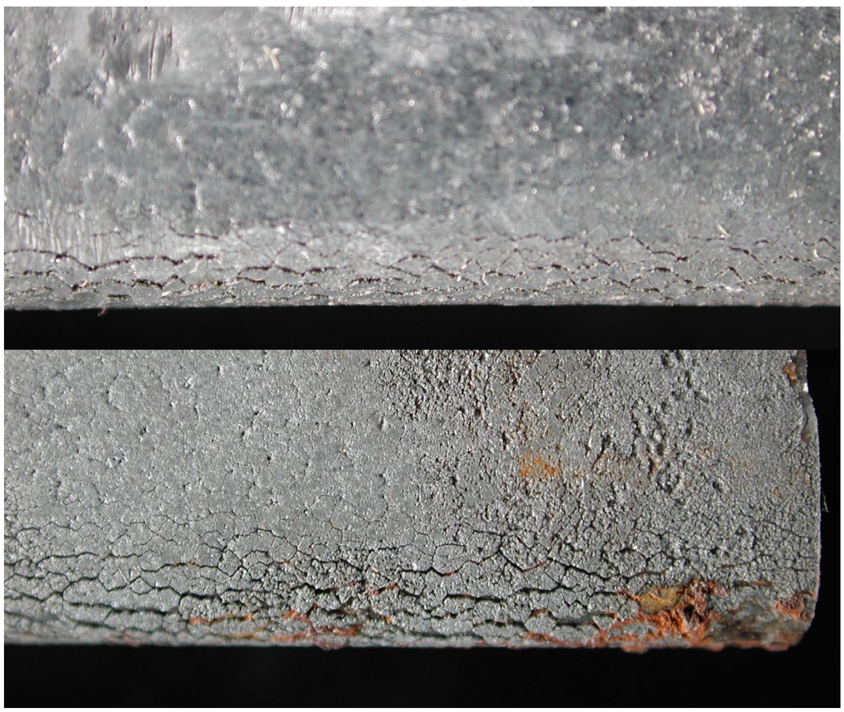

Figure 2 Cracking observed on outside radius of Galfan 200 Z-Form specimens. The top photo is an unexposed specimen, the bottom was removed from the Montreal Site following approximately eight years of soil exposure

The galvanized specimens with the G200 coating faired well compared to their thinner coated G115 complement. The G200 showed light attack at the cut and bent edges while retaining nearly the entire original coating on the remaining flat surfaces. The G115 specimens showed severe attack and a general loss of coating over much of the surface except on the inside radius of the bends.

1" × 4" Strips in Concrete

The 1" × 4" strips have not been evaluated at this time.

Newark Site

The partially buried specimens, of both Galfan and galvanizing, were not available for evaluation.

The specimens were cleaned with detergent and non-abrasive cleanser, photographed, acid cleaned (20% Chromic Acid) and photographed again. The photographs of the specimens are presented in Appendix B.

3×3's
The Galfan coated specimens performed very well evidencing almost no visual attack on the GF200 specimens and 85-90% coating retention on the GF115 specimens. With respect to corrosion rates, the Galfan specimens performed equally well. However, the GF115 specimens showed deterioration localized at the edges and a few isolated areas of the specimens as opposed to the general loss of Galfan on the GF200 specimens.

The galvanized specimens seem to have replicated the corrosion patterns of the Galfan specimens in that the G200 showed a general loss of coating and the G115 had concentrated corrosion near edges and isolated spots. The G115 specimens showed an average loss of coating equal to about 10%.

Both Plastisol-coated specimens at this site performed similarly to the ones reported for Montreal with blisters near the cut edges. The unpainted sides of both showed a similar deterioration as the Montreal specimens with ~50% loss of galvanizing and ~10% loss of Galfan. The Plastisol-coated G90 specimen had larger more numerous blisters than the GF90 specimen.

The Magni-coated specimens showed blisters at all cut edges. The blisters covered approximately 15% of the surface area of both specimens. The specimens were similar to each other except that the Magni-coated G90 had spalled areas where white corrosion product and red rust were visible on the base material.

6 × 6 Z's
The Galfan GF200 specimens performed very well despite cracks at the bends. A few patches of bare steel became exposed on GF115 specimens. No significant loss of coating was noted on any of the Galfan coated specimens.

The galvanized G200 specimens performed well showing no loss of coating and no patches of red rust or bare steel. The G115 however, had several areas of coating loss concentrated near the bent and cut edges. The remaining surfaces exhibited very little corrosion.

1" × 4" Strips in Concrete
The 1" × 4" strips have not been evaluated at this time.

Fence Posts
The fence posts were removed in 1998, after approximately six years exposure. They have not been evaluated at this time

Weirton Site

The specimens were cleaned with detergent and non-abrasive cleanser, photographed, acid cleaned (20% Chromic Acid) and photographed again. The photographs of the specimens are presented in Appendix C.

3×3's
The Galfan coated specimens showed no areas of any significant attack and had a mottled dark gray appearance with areas retaining their original luster. Similar to the Galfan specimens, the galvanized specimens showed no signs of significant deterioration and looked mottled with dull gray areas mixed with areas retaining their original luster.

The Plastisol-coated GF90 evidenced some light blistering near the cut edges, while the G90 specimen did not show any sign of blistering. The unpainted side of both specimens showed some deterioration of the coating, however, no significant loss of coating was observed and no red rust was visible.

Both Magni-coated specimens developed light blistering at all cut edges. The blisters covered approximately 20% of the surface area of the GF90 specimen and <10% of the G90 specimen.

6 × 6 Z's
Both Galfan and galvanized-coated specimens performed extremely well showing no significant signs of degradation. The specimens in general evidence a mottled appearance with some areas retaining their original luster.

1" × 4" Strips in Concrete
The 1" × 4" strips have not been evaluated at this time.

2" × 8" Strips (Partial Immersion)
The 2" × 8" strips have not been evaluated at this time.

2' C Form Fence Posts
The fence posts have not been evaluated at this time.

COMMENTS AND DISCUSSION

The corrosion rates shown in Tables 7, 8, and 9 were made assuming uniform weight loss on the surfaces of the specimens; however, in some cases where localized corrosion occurred, this rate may be much higher. The data presented also assumes that all of the corrosion/weight loss occurred to the coating.

Corrosion rate data for painted specimens may not reflect actual paint coat thickness loss. As previously mentioned, in the case of Plastisol, most weight appears to have been lost on the primed but unpainted side of the specimens and, at Montreal and Newark, on the sheared specimen edges. Weight loss on the Magni-coated specimens appears to have occurred mainly as a result of paint flecks chipping off at sheared specimen edges.

TABLE 7
MONTREAL SITE
EIGHT-YEAR EXPOSURE DATA

MATERIAL	SPECIMEN TYPE	CORROSION RATE (mils/year)			
		Detergent + Cleanser		Chromic Acid	
		Specimen #1	Specimen #2	Specimen #1	Specimen #2
		SOIL EXPOSURE			
W-G-115	3x3	0.36	0.37	0.37	0.39
W-GF-115	3x3	0.19	0.18	0.22	0.22
WP-GF-115	3x3	0.20	0.14	0.24	0.19
WP-G-200	3x3	0.29	0.29	0.34	0.34
WP-GF-200	3x3	0.22	0.13	0.27	0.19
W-G-115	"Z"	0.20	0.22	0.34	0.28
W-GF-115	"Z"	0.07	0.07	0.14	0.16
WP-GF-115	"Z"	0.08	0.10	0.16	0.16
WP-G-200	"Z"	0.16	0.17	0.18	0.20
WP-GF-200	"Z"	0.11	0.06	0.17	0.19
W-G-90	Plastisol 3x3	0.21	-	-	-
W-GF-90	Plastisol 3x3	0.13	-	-	-
W-G-90	Magni 3x3	0.03	-	-	-
W-GF-90	Magni 3x3	0.03	-	-	-

Notes: "s" indicates a pre-scored Plastisol-coated specimen.
W = Weirton Steel Corporation G = galvanized
WP = Wheeling Pittsburgh GF = Galfan
- = Either only one specimen was tested or chromic acid cleaning was not performed.

TABLE 8
NEWARK, DE SITE
EIGHT-YEAR EXPOSURE DATA

MATERIAL	SPECIMEN TYPE	CORROSION RATE (mils/year)			
		Detergent + Cleanser		Chromic Acid	
		Specimen #1	Specimen #2	Specimen #1	Specimen #2
		SOIL EXPOSURE			
W-G-115	3x3	0.09	0.11	0.14	0.16
W-GF-115	3x3	0.16	0.10	0.24	0.15
WP-GF-115	3x3	0.10	0.09	0.16	0.14
WP-G-200	3x3	0.09	0.12	0.15	0.18
WP-GF-200	3x3	0.10	0.09	0.18	0.16
W-G-115	"Z"	0.08	0.08	0.13	0.13
W-GF-115	"Z"	0.09	0.05	0.16	0.11
WP-GF-115	"Z"	0.06	0.05	0.11	0.09
WP-G-200	"Z"	0.07	0.08	0.13	0.14
WP-GF-200	"Z"	0.05	0.05	0.11	0.11
W-G-90	Plastisol 3x3	0.28	-	-	-
W-GF-90	Plastisol 3x3	0.12	-	-	-
W-G-90	Magni 3x3	0.02	-	-	-
W-GF-90	Magni 3x3	0.02	-	-	-

Notes: "s" indicates a pre-scored Plastisol-coated specimen.
W = Weirton Steel Corporation G = galvanized
WP = Wheeling Pittsburgh GF = Galfan
- = Either only one specimen was tested or chromic acid cleaning was not performed.

TABLE 9
WEIRTON, WV SITE
EIGHT-YEAR EXPOSURE DATA

MATERIAL	SPECIMEN TYPE	CORROSION RATE (mils/year)			
		Detergent + Cleanser		Chromic Acid	
		Specimen #1	Specimen #2	Specimen #1	Specimen #2
		SOIL EXPOSURE			
W-G-115	3x3	0.02	0.03	0.07	0.08
W-GF-115		0.01	----	0.07	0.07
WP-GF-115		----	0.01	0.06	0.06
WP-G-200		0.02	0.02	0.06	0.07
WP-GF-200		0.02	0.02	0.07	0.08
W-G-115	"Z"	0.01	0.02	0.04	0.06
W-GF-115		0.00	0.00	0.07	0.06
WP-GF-115		----	----	0.05	0.04
WP-G-200		0.01	0.01	0.05	0.05
WP-GF-200		0.01	0.01	0.07	0.06
W-G-90	Plastisol 3x3	0.03	-	-	-
W-GF-90		0.01	-	-	-
W-G-90	Magni 3x3	0.00	-	-	-
W-GF-90		0.00	-	-	-

Notes: "s" indicates a pre-scored Plastisol-coated specimen.
W = Weirton Steel Corporation G = galvanized
WP = Wheeling Pittsburgh GF = Galfan
- = Either only one specimen was tested or chromic acid cleaning was not performed.

TABLE 10
MONTREAL SITE
EIGHT-YEAR EXPOSURE DATA

MATERIAL	SPECIMEN TYPE	WEIGHT LOSS in oz./sq.ft.			
		Detergent + Cleanser		Chromic Acid	
		Specimen #1	Specimen #2	Specimen #1	Specimen #2
		SOIL EXPOSURE			
W-G-115	3x3	1.59	1.65	1.64	1.71
W-GF-115		0.77	0.75	0.92	0.91
WP-GF-115		0.83	0.59	0.99	0.76
WP-G-200		1.30	1.30	1.49	1.50
WP-GF-200		0.83	0.53	1.11	0.76
W-G-115	"Z"	0.89	0.97	1.52	1.22
W-GF-115		0.30	0.29	0.59	0.64
WP-GF-115		0.32	0.40	0.67	0.67
WP-G-200		0.73	0.74	0.79	0.88
WP-GF-200		0.46	0.24	0.69	0.77
W-G-90	Plastisol 3x3	0.92	-	-	-
W-GF-90		0.52	-	-	-
W-G-90	Magni 3x3	0.15	-	-	-
W-GF-90		0.12	-	-	-

Notes: "s" indicates a pre-scored Plastisol-coated specimen.
W = Weirton Steel Corporation G = galvanized
WP = Wheeling Pittsburgh GF = Galfan
- = Either only one specimen was tested or chromic acid cleaning was not performed.

TABLE 11
NEWARK, DE SITE
EIGHT-YEAR EXPOSURE DATA

MATERIAL	SPECIMEN TYPE	WEIGHT LOSS in oz./sq.ft.			
		Detergent + Cleanser		Chromic Acid	
		Specimen #1	Specimen #2	Specimen #1	Specimen #2
		SOIL EXPOSURE			
W-G-115	3x3	0.37	0.47	0.60	0.68
W-GF-115	3x3	0.63	0.37	0.91	0.58
WP-GF-115	3x3	0.39	0.33	0.60	0.53
WP-G-200	3x3	0.36	0.49	0.63	0.76
WP-GF-200	3x3	0.39	0.35	0.71	0.60
W-G-115	"Z"	0.33	0.34	0.53	0.54
W-GF-115	"Z"	0.35	0.21	0.61	0.43
WP-GF-115	"Z"	0.23	0.19	0.43	0.36
WP-G-200	"Z"	0.30	0.35	0.54	0.58
WP-GF-200	"Z"	0.20	0.20	0.41	0.38
W-G-90	Plastisol 3x3	1.17	-	-	-
W-GF-90	Plastisol 3x3	0.46	-	-	-
W-G-90	Magni 3x3	0.07	-	-	-
W-GF-90	Magni 3x3	0.06			

Notes: "s" indicates a pre-scored Plastisol-coated specimen.
W = Weirton Steel Corporation G = galvanized
WP = Wheeling Pittsburgh GF = Galfan
- = Either only one specimen was tested or chromic acid cleaning was not performed.

TABLE 12
WEIRTON, WV SITE
EIGHT-YEAR EXPOSURE DATA

MATERIAL	SPECIMEN TYPE	WEIGHT LOSS in oz./sq.ft.			
		Detergent + Cleanser		Chromic Acid	
		Specimen #1	Specimen #2	Specimen #1	Specimen #2
		SOIL EXPOSURE			
W-G-115	3x3	0.09	0.15	0.31	0.35
W-GF-115		0.05	-0.01	0.30	0.28
WP-GF-115		0.00	0.03	0.25	0.25
WP-G-200		0.07	0.09	0.28	0.32
WP-GF-200		0.08	0.07	0.29	0.35
W-G-115	"Z"	0.03	0.08	0.19	0.26
W-GF-115		0.01	0.00	0.29	0.25
WP-GF-115		-0.01	-0.01	0.21	0.17
WP-G-200		0.04	0.06	0.22	0.23
WP-GF-200		0.05	0.04	0.27	0.24
W-G-90	Plastisol 3x3	0.13	-	-	-
W-GF-90		0.05	-	-	-
W-G-90	Magni 3x3	0.02	-	-	-
W-GF-90		0.02	-	-	-

Notes: "s" indicates a pre-scored Plastisol-coated specimen.
W = Weirton Steel Corporation G = galvanized
WP = Wheeling Pittsburgh GF = Galfan
- = Either only one specimen was tested or chromic acid cleaning was not performed.