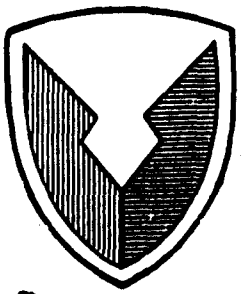

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CCL REPORT NO. 285

FINAL REPORT

EFFECT OF METALLIC COATINGS AND ZINC RICH PRIMERS ON THE PERFORMANCE OF FINISHING SYSTEMS FOR AUTOMOTIVE STEEL

BY

MELVIN H. SANDLER

SEPTEMBER 1970

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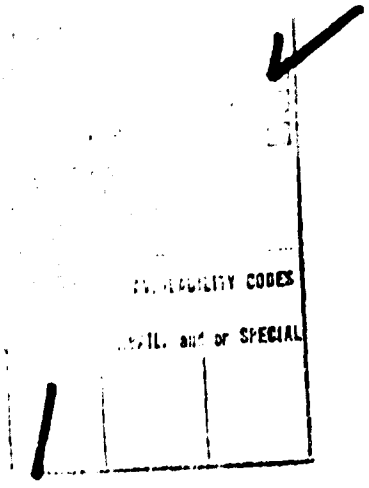
Aberdeen Proving Ground
Maryland



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ABERDEEN PROVING GROUND
MARYLAND 21005

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ABSTRACT

The effect of metallic coatings and zinc rich primers on the performance of finishing systems for automotive steel was investigated. Galvanized and aluminized type steels and zinc rich primed steels were coated with specification finishing systems and exposed to tropical and temperate environments. Data showed the hot dip galvanized steel properly finished will offer the most effective corrosion resistant system for severe environments such as salt atmosphere and sea coast exposure. This is followed in descending order by aluminized steel, zinc rich primer on cold rolled steel, electrolytic zinc and cold rolled steel. Differences between the metallic coated steels is much less pronounced under less severe exposure.

TABLE OF CONTENTS

I. INTRODUCTION

Military vehicles are exposed to a wide variety of corrosive climatic environments. Among the more severe exposures are salt atmospheres such as sea coast sites and humid tropical weather conditions. In recent years the automotive industry has increased the useage of galvanize steel and zinc rich primers on underbody components such as corner posts, box sections, rocker sections, etc. to reduce corrosion. As a result of the improved corrosion resistance obtained interest was expressed by the U.S. Army Tank-Automotive Center (ATAC) in the possibility of using metallic coated steels for vehicle bodies. In November 1965 the Coating and Chemical Laboratory was requested by ATAC to conduct an exposure program to determine the effect of metallic coated steels and zinc rich primers on the corrosion behavior of finishing systems for automotive steels exposed to severe climatic conditions.

The tropical sites selected were a breakwater marine (Photo 1) with very high atmospheric salt content, an open field (Photo 2) and a rain forest (Photo 3) located at Fort Sherman, Panama Canal Zone. For temperate zone exposure the test fence (Photo 4) at Aberdeen Proving Ground, Maryland was used. Panama is considered representative of most tropical environments, having consistently high but not extreme temperatures, high humidity, and abundant rainfall. The Fort Sherman area averages approximately 130 inches of rainfall a year with monthly means in the rainy season (May-December) from 12-22 inches and in the dry season (January-April) from 1.4-4 inches. The term dry season can be somewhat misleading since rain normally falls on about half the days. The monthly mean temperatures range from 80-82°F. with a daily range of 8-11°F. The monthly mean relative humidity ranges from 77-86 percent. Although the percentage of cloudiness is high, there are few days without some sunshine. Christobal, just across the bay from Fort Sherman, averages 6.3 hours per day with monthly totals ranging from about 5 hours per day in June, July, and November to about 8 hours per day in March.

The breakwater site is situated at the junction of Limon Bay and the Caribbean Sea and faces North in the direction of the prevailing trade winds. The specimens at this site are exposed to constant spray of salt water with a salt fall for 1 year being calculated as 4514 lb/acre (1). The open field site is approximately 1/2 mile inland from the breakwater and is subject primarily to rain and sun. The rain forest site is approximately 4 miles inland in the tropical evergreen forest composed basically of 3 tiers of tree growth ranging from 20-125 feet in height. The exposure here is primarily humidity and rain. More detailed information on the geography, climate, and description of the test sites is reported by Teitell (2), Chambers (3), McCoullough (4), and Wiley (5).

II. DETAILS OF TEST

A. Test Specimens - All test specimens were 4 x 12 inch panels of the following metals:

1. Cold rolled steel, No. 20 gage (Federal Specification QQ-S-698).

2. Hot dip galvanized cold rolled steel, 20 gage, commercial quality, 1.25 oz./sq. ft.

3. Electrolytic zinc coated cold rolled steel with 0.1 mil zinc plate on each side. Minimum coating weight 0.10 oz./sq. ft.

4. Aluminized steel, Type 1, 20 gage, hot dip coated on both sides with aluminum silicon alloy. Approximate coating weight per side 0.5 ounce per square foot (0.001 inch aluminum per side).

B. Surface Preparation and Finishing.

Metal preparation included solvent cleaning, chemical, and wash primer surface treatments. Four specification primers including an alkyd-phenolic, vinyl, epoxy, and organic zinc rich type and a proprietary inorganic zinc rich were used. The zinc rich types were used only on sand blasted cold rolled steel for comparison to the plated steels. The basic finish coats were olive drab semi-gloss enamel, Specification TT-E-529 and vinyl lacquer MIL-L-14486. A vinyl alkyd enamel, MIL-E-13515, was also used as a finish coat over the zinc rich primers. Surface preparation and finishing systems used are listed in Table I. The test panels were given the applicable pretreatments and the coatings spray applied using an automatic spray apparatus to assure film uniformity. Wash primer, MIL-C-15328, was applied to a dry film thickness between 0.3 and 0.5 mil; zinc rich primers between 2.0 and 2.5 mils; and all topcoats 0.9-1.1 mil except when applied over the proprietary zinc rich primer which required two coats or a thickness of 2.0 mils to obtain a uniform appearance, the first coat being heavily absorbed by the primer.

C. Exposure.

The specimens were placed on exterior exposure at the four test sites. The racks at the breakwater face north in the direction of the prevailing trade winds, those in the open field and rain forest face south. All were mounted at an angle of 30 degrees. The racks at APG face south at an angle of 45 degrees.

D. Evaluation.

At approximately 6 month intervals for up to 40 months the panels were examined for corrosion and/or blistering at the score, and for general surface condition and given a rating from 5 to 0 in accordance with Tables II and III. Examples of the score ratings are illustrated in

Photo 5. In general, ratings of 5 and 4 are considered to provide satisfactory protection. It is realized that panel evaluation cannot always be clearly defined by numerical rating, primarily when the condition of the specimen falls at the border of two possible ratings. Thus the number assigned is left to the judgement of the evaluator. For this reason in most cases the rating of a specimen was not considered complete until it received the same numerical rating for 2 consecutive rating periods. This is of particular concern in ratings of 4 and 3 since the former is considered satisfactory and the latter unsatisfactory. Therefore until two consecutive ratings were the same, the specimen was considered to have the higher rating.

III. DISCUSSION

Reproducibility among replicate specimens was excellent in most cases. Although there are occasional exceptions to be found in the data, it is believed the scope of the program was sufficiently broad to show general trends and to provide a meaningful guide for the selection of suitable finishing systems. Where detailed information on the performance of a specific system is desired, the rating Tables IV-VIII in the appendix may be consulted. Substrate and finishing system effectiveness at each site is illustrated in bar graphs, Figures 1-4, which cover the number of systems remaining with no rating less than 4 at the end of each exposure period. Figure 5 indicates the number of systems remaining at the end of each exposure period with no rating less than 4 at all sites. As expected, from previous exposure studies, the breakwater is by far the severest site with the major cause of failure being corrosion and/or blistering at the score. This is clearly shown in Table IX which lists the percent of systems with ratings less than 4 for each of the rating elements.

The data clearly indicates hot dip galvanize properly finished will offer the most effective corrosion resistant system for severe environments such as salt atmosphere and sea coast site (Figure 1). This is followed in descending order by aluminized steel, zinc rich primer on cold rolled steel, electrolytic zinc, and cold rolled steel. The differences between the metallic coated steels is much less pronounced under less severe exposure (Figures 2, 3, and 4), however, the general order of rating would be the same. This is further illustrated in Figure 5 which tabulates those systems with ratings of 4 or better at all sites. With regard to metal pretreatment prior to painting, wash primer was more effective with the hot dip galvanized steel than the chromate conversion coating under severe exposure of the sea coast whereas comparable performance was noted at the other sites. The reverse of this was true for the aluminum coated steel, i.e., MIL-C-5541 chromate film was more effective than wash primer at the sea coast site. However, as indicated earlier the hot dip galvanized substrate provided the most effective performance with 8 systems still rated 4 or better at all sites after 34 months exposure versus 4 systems utilizing aluminized steel. These systems are listed in Table X.

After 40 months exposure 5 of the galvanized systems and 2 aluminized systems were rated 4 or better with systems I - f, g, h and II - c, d,

of Table X having score ratings of 3 at the breakwater. However, these ratings will not be considered complete unless the rating is the same at the next evaluation period, as explained in paragraph II C "Evaluation" above. Regardless of this however, the noted trends have continued.

IV. REFERENCES

1. Brierly, W. B., "Atmospheric Sea-Salt Design Criteria", U.S. Army Natick Laboratories, April 1965.

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3. Chambers, J. V., "Representative Tropical Days", Special Report S-5 Earth Sciences Division, U.S. Army Natick Laboratories, November 1964.

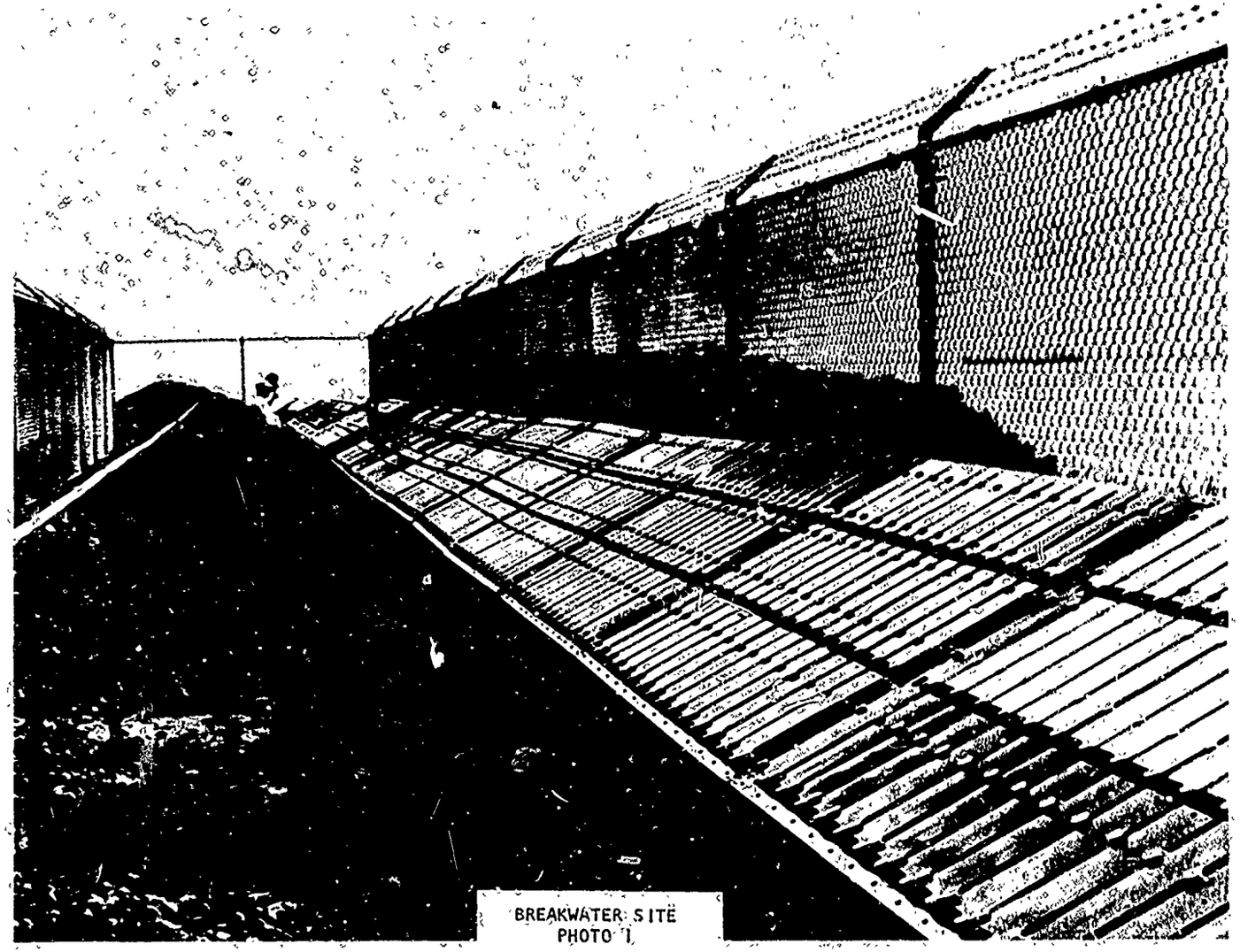
4. McCoullogh, C. R., Johnston, I. M., Parker, S. M. III, and Fadum, R. E., "Terrain Study of the Panama Canal Zone with Specific Reference to the Fort Sherman Area and Vicinity", Dept. Engineering Research, North Carolina State College, School of Engineering, Raleigh, N. C., July 1956.

5. Wiley, S. C., Dodd, A. V., and Chambers, J. V., "Environmental Handbook of Fort Sherman and Fort Gulick, Panama Canal Zone", Technical Report EP 17, Quartermaster Research and Development Center Environmental Protection Division, Natick, Mass., July 1955.

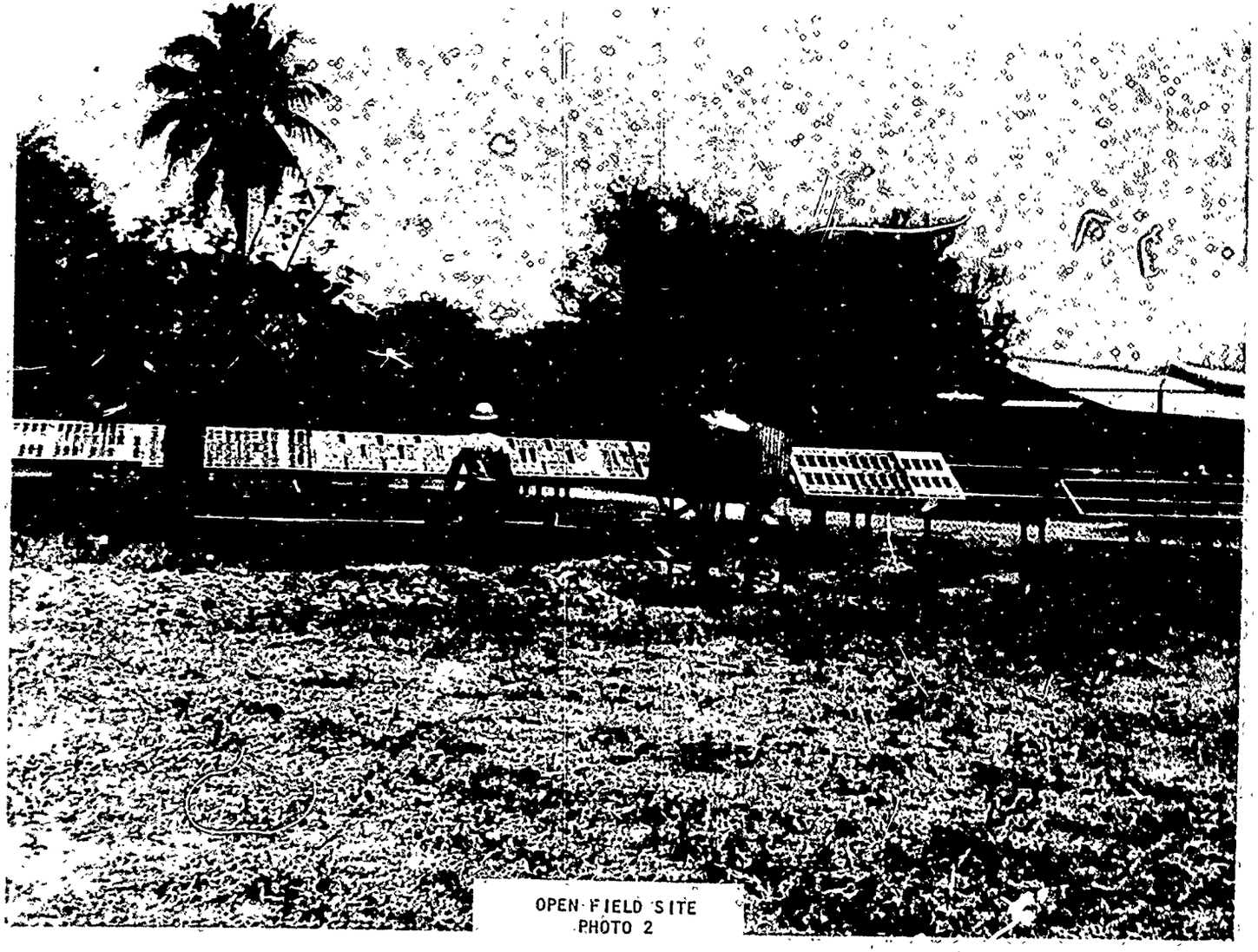
6. Sandler, Melvin H. CCL Report No. 197, "Tropical Exposure of Finishing Systems for Ferrous Metals, May 1966.

7. Sandler, M. H., and Cohen, M., CCL Report No. 233, "Tropical Exposure of Finishing Systems for Aluminum and Magnesium.

APPENDIX A

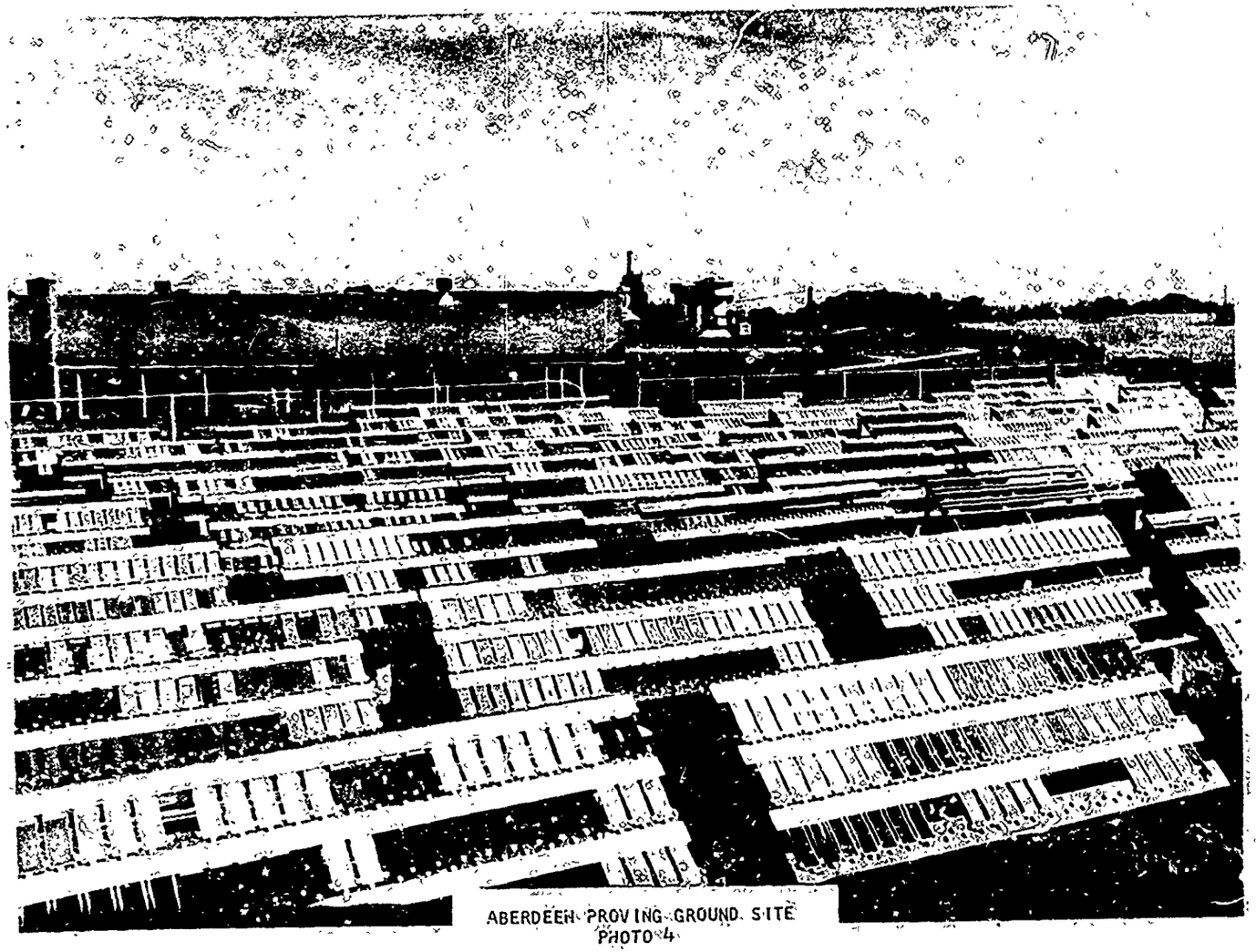


BREAKWATER SITE
PHOTO 1

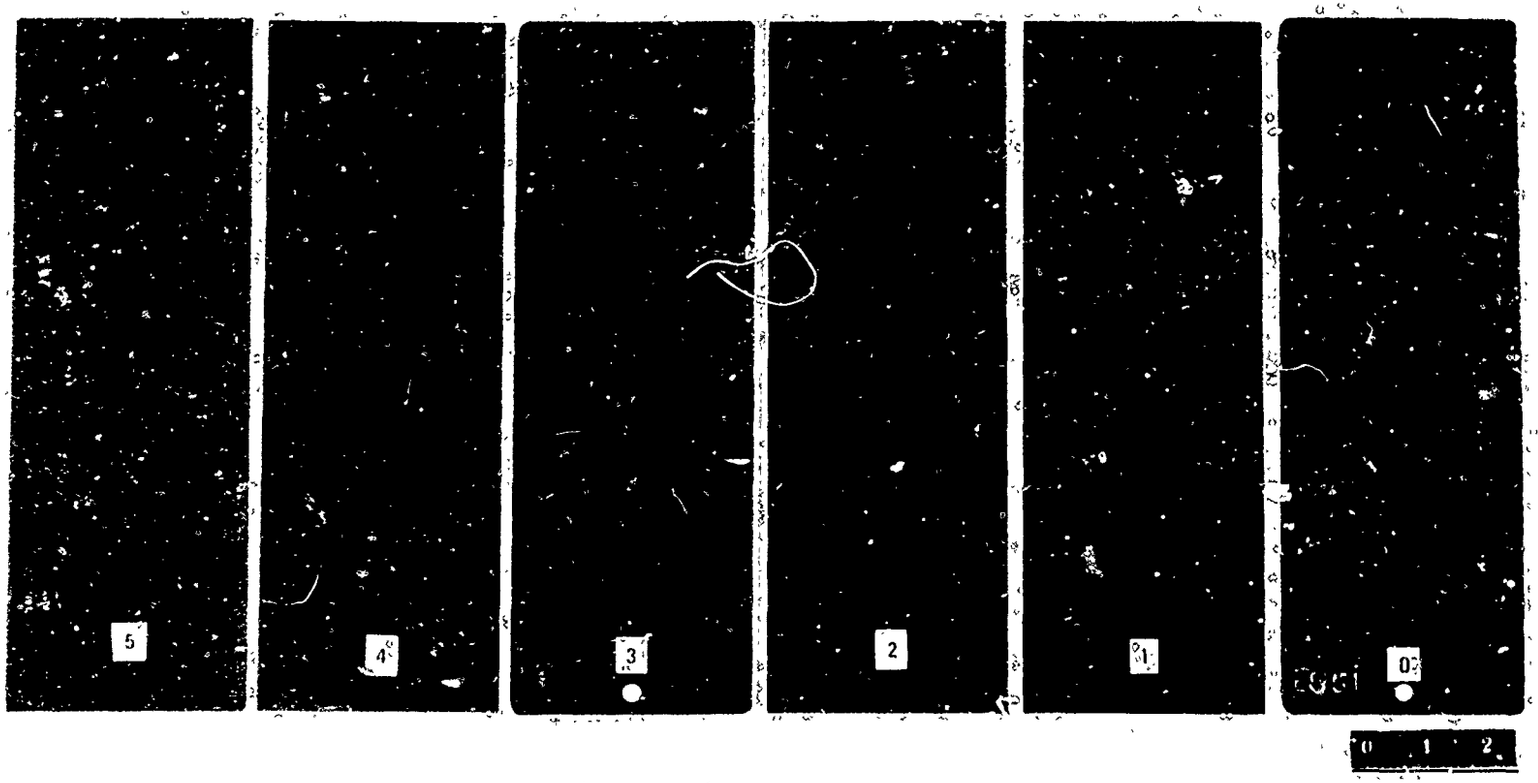


OPEN FIELD SITE
PHOTO 2

RAIN FOREST SITE
PHOTO 3



ABERDEEN PROVING GROUND SITE
PHOTO 4



SCORE CONDITION

PHOTO 5

APPENDIX B

LEGEND

BW = Breakwater Site

OF = Open Field

RF = Rain Forest

APG = Aberdeen Proving Ground

R = Combined with number indicates when panels were removed.

TABLE I - SURFACE PREPARATION - FINISHES

Surface Preparation

Solvent Clean - 1:1 by volume aliphatic naptha (TT-N-95) - ethylene glycol monoethyl ether (TT-E-781)
Sand blast -
MIL-P-15328 - Primer (wash) Pretreatment (Formula 117 for Metals).
MIL-C-5541 - Chemical Films and Chemical Film Materials for Aluminum and Aluminum Alloys, Type II, Grade C, Class 2.
Chromate Corrosion - Proprietary for Ganvanize.
TT-C-490 (Type I) - Cleaning Methods and Pretreatment of Ferrous Surfaces for Organic Coatings.

Primers

MIL-P-8585 - Primer Coating, Low Moisture Sensitivity.
MIL-P-15930 - Primer, Vinyl Zinc Chromate Type.
MIL-P-52192 - Primer Coating, Epoxy.
MIL-P-23377 - Primer Coating, Epoxy Polyamide, Chemical and Solvent Resistant.
MIL-P-46105 - Primer Coating; Weld-Trhough, Zinc Rich.
Inorganic Zinc Rich - Proprietary.

Finish Coats

TT-E-529 - Enamel, Alkyd, Semi-Gloss.
MIL-L-14486 - Lacquer, Vinyl Resin, Semi-Gloss.
MIL-E-13515 - Enamel, Vinyl Alkyd, Semi-Gloss.

TABLE II - SCORE RATINGS

I. Score Condition

Rating	Corrosion and/or Blistering
5	None - 1/32 inch
4	1/32 - 1/16 inch
3	1/16 - 1/8 inch
2	1/8 - 3/16 inch
1	3/16 - 1/4 inch
0	> 1/4 inch

II. Undercutting at Score

Rating	
5	None - intermittent
4	Continuous to 1/16 inch
3	Continuous to 1/16 - 1/8 inch
2	Continuous to 1/8 - 3/16 inch
1	Continuous to 3/16 - 1/4 inch
0	Continuous > 1/4 inch

TABLE I.II - SURFACE CONDITION* RATINGS

Rating	A. Corrosion Alone
5	None
4	ASTM Photo No. 10, Type 1
3	ASTM Photo No. 9, Type 1
2	ASTM Photo No. 8, Type 1
1	ASTM Photo No. 7, Type 1
0	ASTM Photo No. 6, Type 1 or worse

Rating	B. Corrosion Accompanied by Blistering
5	None
4	Trace, less than 5 defects on 4 x 12 inch panel
3	ASTM Photo No. 8, Type 2
2	ASTM Photo No. 7, Type 2
1	ASTM Photo No. 6, Type 2
0	ASTM Photo No. 4, Type 2 or worse

Rating	C. Blistering Alone
5	None
4	Trace ASTM Blister Size 2 on 4x12 inch panel - 2 max. ASTM Blister Size 4 on 4x12 inch panel - 4 max. ASTM Blister Size 6 on 4x12 inch panel - 6 max. ASTM Blister Size 8 on 4x12 inch panel - 8 max.
3	ASTM Few - Record blister size.
2	ASTM Medium - Record blister size.
1	ASTM Med-Dense - Record blister size
0	ASTM Dense - Record blister size

*Select applicable condition.

TABLE IV

EXPSOURE RATINGS.- HOT DIP GALVANIZE

Surface Prep.			Solvent Cleaned												MIL-P-15328											Chromate Conversion										
Exposure Site			BW			RF			OF			APG			BW			RF			OF			APG			BW			RF			OF			APG		
System No.	Coating System	Months Exposure	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface
1	MIL-P-8585 TT-E-529	7	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	4	4	5	5	4	5	4	4	5	5	4	5
		13	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	4	4	5
		22	2	2	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
		28	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
		34		R28		5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
		40		---		5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
2	MIL-P-8585 MIL-L-14486	7	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	3	3	5	4	4	C3-8	4	4	5	4	4	5
		13	4	4	C3-8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	C3-8	5	5	5	5	5	5
		22	0	0	C3-8	5	5	5	5	5	5	5	5	5	5	5	B4	5	5	5	5	5	5	5	5	3	3	5		R13		4	4	5	4	4	5
		28		R22		5	5	5	5	5	5	5	5	5	4	4	C4-8	5	5	5	5	5	5	5	5	3	3	5		---		5	5	5	4	4	5
		34		---		5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	3	3	C4-4		---		5	5	5	4	4	5
		40		---		5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	R34				---		5	5	5	4	4	5
3	MIL-P-52192 TT-E-529	7	5	5	C0-8	5	5	C0-8	5	5	C0-8	5	5	5	4	4	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		13		R7			R7			R7		5	5	5	4	4	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		22		---			---			---		5	5	C4-8	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
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		40		---			---			---		5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
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		40		---			---		5	5	C3-8		R34		4	4	B4	5	5	5	5	5	5	5	5	5		R34		5	5	5	5	5	5	5	5	5

TABLE IV - Continued

System No.	Coating System	Months Exposure	Solvent Cleaned												MIL-P-15328A												Chromate Conversion											
			BW			RF			OF			APG			BW			RF			OF			APG			BW			RF			OF			APG		
			Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface
5	MIL-P-15930 TT-E-529	7	4	4	5	5	5	5	5	5	5	5	4	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		13	3	3	C4	2	2	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		22	0	0	C4	3	3	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
		28		R22		3	3	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
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		40		---			R34		4	4	5	4	4	5	3	3	5	5	5	5	5	5	5	5	5	5	3	3	B4	5	5	5	5	5	5	5	5	5	5
6	MIL-P-15930 MIL-L-14486	7	0	0	5	5	5	5	3	3	5	2	2	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
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		28	1	1	B4	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		34		R28		5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		40		---		5	5	5	5	5	5	5	5	5	3	3	B4	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
8	MIL-P-23377 MIL-L-14486	7	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		13	3	3	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		22	3	3	B4	5	5	5	5	5	5	5	5	5	5	5	B4	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
		28	3	3	B4	5	5	5	5	5	5	5	5	5	3	3	B4	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
		34		R28		5	5	5	5	5	5	5	5	5	3	3	C4-4	5	5	5	5	5	5	5	5	5	2	2	C3-2	5	5	5	5	5	5	5	5	5
		40		---		5	5	5	5	5	5	5	5	5		R34		5	5	C3-6	5	5	5	5	5	5		P34		5	5	5	5	5	5	5	5	5

TABLE V

EXPOSURE RATINGS - ELECTROLYTIC ZINC

System No.	Surface Prep. / Exposure Site	Months Exposure	Solvent Cleaned BW Score	BW Undercut	BW Surface	Solvent Cleaned RF Score	RF Undercut	RF Surface	Solvent Cleaned OF Score	OF Undercut	OF Surface	Solvent Cleaned APG Score	APG Undercut	APG Surface	MIL-P-15328 BW Score	BW Undercut	BW Surface	MIL-P-15328 RF Score	RF Undercut	RF Surface	MIL-P-15328 OF Score	OF Undercut	OF Surface	MIL-P-15328 APG Score	APG Undercut	APG Surface	MIL-P-15328 BW Score	BW Undercut	BW Surface	Chromate Conversion RF Score	RF Undercut	RF Surface	Chromate Conversion OF Score	OF Undercut	OF Surface	Chromate Conversion APG Score	APG Undercut	APG Surface
1	MIL-P-8585 / TT-E-529	7	3	3	5	5	5	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	4	4	5
		13	3	3	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5	2	2	5	4	4	C3-8	5	5	5	4	4	5
		22	3	3	5	5	5	C4-8	5	5	5	4	4	5	1	1	5	5	5	5	4	4	5	4	4	5	0	0	B4	5	5	C3-8	4	4	5	3	3	5
		28	1	1	5	4	4	B3	3	3	5	4	4	5	0	0	5	4	4	C4-8	3	3	5	4	4	4	0	0	5	4	4	B3	3	3	5	3	3	5
		34	0	0	5	4	4	C3-8	4	4	5	4	4	5		R34		5	5	5	4	4	5	4	4	5		R28		4	4	C3-8	3	3	5	3	3	5
		40		R34			R34		3	3	5	4	4	5		---		4	4	5	4	4	5	4	4	5		---		4	4	C3-8	3	3	5	3	3	5
2	MIL-P-8585 / MIL-L-14486	7	3	3	5	5	5	C2-6	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	4	4	5
		13	3	3	5	5	5	C3-8	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	5	5	5	3	3	C4-6	5	5	5	5	5	5	4	4	5
		22	0	0	B4	5	5	C3-8	4	4	5	4	4	5	4	4	C4-8	5	5	5	5	5	5	4	4	5	0	0	C4-6	5	5	5	5	5	5	3	3	5
		28	0	0	B3	3	3	C3-6	4	4	5	4	4	5	2	2	B3	4	4	5	3	3	5	4	4	5	0	0	B3	4	4	B4	5	5	5	3	3	5
		34		R28			R28		4	4	5	4	4	5	2	2	C3-4	5	5	5	4	4	5	4	4	5		R28		5	5	5	4	4	5	3	3	5
		40		---			---		4	4	5	4	4	5		R34		4	4	5	4	4	5	4	4	5		---		4	4	C4-R	5	5	5	3	3	5
3	MIL-P-52192 / TT-E-529	7	3	3	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	4	4	5	3	3	5	5	5	5	5	5	5	5	5	5
		13	3	3	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
		22	0	0	5	5	5	5	4	4	5	3	3	5	0	0	5	5	5	5	4	4	5	3	3	5	0	0	5	4	4	5	4	4	5	2	2	5
		28	0	0	B4	4	4	C4-8	4	4	5	3	3	5	0	0	B4	4	4	C4-8	3	3	5	3	3	5	0	0	5	3	3	5	3	3	5	2	2	5
		34		R28		5	5	5	5	5	5	3	3	5	0	0	A3	5	5	5	4	4	5	3	3	5		R28		4	4	5	4	4	5	3	3	5
		40		---		5	5	C4-8	4	4	5	3	3	5		R34		3	3	5	4	4	5	3	3	5		---		4	4	5	4	4	5	2	2	5
4	MIL-P-52192 / MIL-L-14486	7	2	2	C2-8	5	5	C1-8	5	5	5	5	5	C2-8	4	4	5	5	5	5	4	4	5	5	5	5	3	3	5	4	4	5	5	5	5	4	4	5
		13		R7		5	5	C2-8	5	5	5	5	5	C3-8	3	3	5	5	5	5	5	5	5	4	4	C4-8	0	0	B3	5	5	5	5	5	5	3	3	5
		22		---			R13		5	5	5	4	4	C3-8	3	3	B4	5	5	5	5	5	5	3	3	C4-6	0	0	C3-8	5	5	5	5	5	5	2	2	C3-8
		28		---			R13		5	5	5	4	4	C2-6	0	0	B4	4	4	5	4	4	5	3	3	C4-6		R22		3	3	B4	5	5	B4	2	2	C1-8
		34		---			---		4	4	B4	4	4	C2-4	0	0	C3-6	4	4	5	4	4	5	2	2	C3-8		---		4	4	5	4	4	C4-8		R34	
		40		---			---		5	5	5		R34			R34		4	4	5	5	5	5		R34			---		4	4	5	4	4	B4		---	

TABLE V - Continued

System No.	Coating System	Months Exposure	Solvent Cleaned												MIL-P-15328A												Chromate Conversion											
			BV			RF			OF			APC			BV			RF			OF			APC			BV			RF			OF			APC		
			Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface
5	MIL-P-15930 TT-E 529	7	4	4	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	4	4	5
		13	3	3	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	3	3	C4-6	5	5	5	5	5	5	3	3	5
		22	0	0	5	5	5	5	4	4	5	4	4	5	0	0	5	5	5	5	4	4	5	3	3	5	0	0	B3	5	5	5	4	4	5	3	3	5
		28	0	0	B4	4	4	5	3	3	5	4	4	5	0	0	5	4	4	5	3	3	5	4	4	5		R22		4	4	5	3	3	B4	2	2	5
		34		R28		5	5	5	4	4	5	4	4	5	0	0	C3-6	5	5	5	4	4	5	3	3	5		---		4	4	5	3	3	5	3	3	5
		40		---		4	4	5	3	3	5	3	3	5		R34		4	4	5	4	4	5	4	4	5		---		4	4	5	3	3	B4	2	2	5
6	MIL-P-15930 MIL-L-14486	7	2	2	5	5	5	5	4	4	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	4	4	5
		13	2	2	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5	1	1	B3	5	5	5	5	5	5	3	3	5
		22	0	0	5	5	5	5	5	5	5	4	4	5	1	1	B4	5	5	5	4	4	5	4	4	5	0	0	C3-8	5	5	5	5	5	5	3	3	5
		28	0	0	B4	5	5	5	4	4	5	4	4	5	0	0	B4	4	4	5	3	3	5	4	4	5		R22		4	4	5	4	4	B4	2	2	5
		34		R28		5	5	5	3	3	5	4	4	5		R28		5	5	5	4	4	5	4	4	5		---		4	4	C4-8	3	3	C4-8	2	2	5
		40		---		4	4	5	3	3	5	3	3	5		---		4	4	5	4	4	5	4	4	5		---		4	4	5	3	3	5	2	2	5
7	MIL-P-23377 TT-E-529	7	3	3	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	4	4	5
		13	3	3	5	5	5	5	5	5	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	1	1	5	5	5	5	5	5	5	3	3	5
		22	0	0	5	5	5	5	3	3	5	4	4	5	1	1	5	5	5	5	2	2	5	4	4	5	0	0	B4	5	5	5	2	2	5	3	3	5
		28		R22		4	4	C4-8	3	3	5	4	4	5	1	1	B4	4	4	C4-8	2	2	5	4	4	5		R22		4	4	5	2	2	5	3	3	5
		34		---		5	5	5	2	2	5	4	4	5	1	1	C4-8	5	5	5	2	2	5	4	4	5		---		4	4	5	2	2	5	3	3	5
		40		---		4	4	5		R34		3	3	5		R34		4	4	5		R34		4	4	5		---		4	4	5		R34		2	2	5
8	MIL-P-23377 MIL-L-14486	7	4	4	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	3	3	3	5	5	5	5	5	5	5	5	5	5
		13	3	3	B4	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5	1	1	B4	5	5	5	5	5	5	4	4	5
		22	0	0	B4	5	5	5	4	4	5	3	3	5	0	0	B4	5	5	5	5	5	5	4	4	5	0	0	C4-6	5	5	5	4	4	5	3	3	5
		28	0	0	5	4	4	5	4	4	5	3	3	5	0	0	B4	4	4	5	3	3	B4	3	3	5	0	0	B3	4	4	5	3	3	B4	3	3	5
		34		R28		4	4	5	4	4	5	3	3	5		R28		5	5	5	3	3	C4-8	3	3	5		R28		5	5	5	3	3	5	3	3	5
		40		---		4	4	5	4	4	5	3	3	5		---		4	4	5	3	3	B4	3	3	5		---		3	3	5	3	3	B4	2	2	5

TABLE VI

EXPOSURE RATINGS - ALUMINIZED STEEL

Surface Prep.			Solvent Cleaned												MIL-P-15328												Chromate Conversion								
	Exposure Site		BW			RF			OF			APG			BW			RF			OF			APG			BW			RF			OF			APG		
System No.	Coating System	Months Exposure	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface
1	MIL-P-8585 TT-E-529	7	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5
		13	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5
		22	0	0	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	4	4	5	5	5	5	4	4	5	5	5	5	4	4	5	5	5	5
		28	0	0	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	4	4	5	5	5	5
		34		R28		5	5	5	4	4	5	5	5	5	3	3	5	5	5	5	4	4	5	5	5	5	4	4	5	5	5	5	4	4	5	5	5	5
		40		---		5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	4	4	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
2	MIL-P-8585 MIL-L-14486	7	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		13	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		22	2	2	5	5	5	5	5	5	5	5	5	5	4	4	C4-8	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		28	0	0	5	5	5	C4-8	4	4	5	5	5	5	2	2	B4	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		34		R28		5	5	5	4	4	5	5	5	5		R28		5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		40		---		4	4	5	4	4	5	5	5	C3-8		---		5	5	5	4	4	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5
3	MIL-P-52192 TT-E-529	7	4	4	5	2	2	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		13	0	0	B0	3	3	5	5	5	5	5	5	5	0	0	B0	5	5	5	4	4	5	5	5	5	2	2	B0	5	5	5	5	5	5	5	5	5
		22		R13		0	0	5	2	2	5	5	5	5		R13		5	5	5	0	0	5	5	5	5		R13		5	5	5	4	4	5	5	5	5
		28		---		0	0	5	2	2	5	5	5	5		---		5	5	5	0	0	5	5	5	5		---		4	4	5	4	4	5	5	5	5
		34		---			R28		3	3	5	5	5	5		---		5	5	5	0	0	B0	5	5	5		---		4	4	5	4	4	5	5	5	5
		40		---			---			R34		5	5	5		---		5	5	5		R34		5	5	5		---		4	4	5	4	4	5	5	5	5
4	MIL-P-52192 MIL-L-14486	7	0	0	B0	4	4	5	5	5	5	5	5	5	0	0	C0-8	4	4	5	5	5	5	5	5	5	2	2	5	5	5	5	5	5	5	5	5	5
		13		RZ		3	3	5	5	5	5	5	5	5	0	0	B0	3	3	5	5	5	5	5	5	5	2	2	5	5	5	5	5	5	5	5	5	5
		22		---		0	0	5	5	5	5	5	5	C4-8		R13		0	0	5	5	5	5	5	5	5	3	3	C3-8	5	5	5	5	5	5	5	5	C3-8
		28		---		0	0	5	5	5	5	5	5	C4-8		---		0	0	5	5	5	5	4	4	5	3	3	B4	3	3	C4-8	5	5	5	5	5	C3-8
		34		---			R28		5	5	C0-2	5	5	C3-8		---			R28		4	4	B0	5	5	5		R28		4	4	5	5	5	5	5	5	C3-8
		40		---			---			R34		5	5	C3-8		---			---			R34		5	5	5		---		3	3	5	5	5	5	5	5	C3-8

TABLE VI - Continued

System No.	Coating System	Months Exposure	Solvent Cleaned												MIL-P-15328												Chromate Conversion								
			BW			RF			OF			APG			BW			RF			OF			APG			BW			RF			OF			APG		
			Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface
5	MIL-P-15930 TT-E-529	7	3	3	5	4	4	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5
		13	2	2	5	4	4	5	5	5	5	5	5	5	1	1	B4	5	5	5	4	4	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5
		22	0	0	5	5	5	5	4	4	5	5	5	5	0	0	5	5	5	5	4	4	5	5	5	5	3	3	5	5	5	5	4	4	5	5	5	5
		28	0	0	B4	5	5	5	4	4	5	5	5	5	0	0	5	5	5	5	4	4	5	5	5	5	2	2	5	4	4	5	4	4	5	5	5	5
		34		R28		4	4	5	4	4	5	5	5	5		R28		5	5	5	4	4	5	5	5	5	3	3	5	4	4	5	4	4	5	5	5	5
		40		---		2	2	5	5	5	5	5	5	5		---		5	5	5	4	4	5	5	5	5	3	3	5	4	4	5	4	4	5	5	5	5
6	MIL-P-15930 MIL-L-14486	7	4	4	5	4	4	5	4	4	5	5	4	5	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		13	0	0	CO-8	5	5	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		22		R13		5	5	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		28		---		5	5	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		34		---		5	5	5	5	5	CO-2	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		40		---		5	5	5		R34		4	4	5	4	4	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
7	MIL-P-23377 TT-E-529	7	0	0	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		13	0	0	CO-8	5	5	5	3	3	5	5	5	5	3	3	5	5	5	5	4	4	5	5	5	5	3	3	5	5	5	5	5	5	5	5	5	5
		22		R13		0	0	5	0	0	5	5	5	5	0	0	5	5	5	5	4	4	5	5	5	5	3	3	5	5	5	5	4	4	5	5	5	5
		28		---		1	1	5	0	0	5	5	5	5		R22		5	5	5	4	4	5	5	5	5	2	2	5	5	5	5	3	3	5	5	5	5
		34		---		1	1	5		R28		5	5	5		---		5	5	5	4	4	5	5	5	5	2	2	5	5	5	5	4	4	5	5	5	5
		40		---			R34			---		5	5	5		---		4	4	5	4	4	5	5	5	5		R34		5	5	5	4	4	5	5	5	5
8	MIL-P-23377 MIL-L-14486	7	2	2	B3	4	4	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		13	0	0	CO-8	3	3	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	5	5	5	5	5
		22		R13		0	0	5	5	5	5	5	5	5	4	4	CO-1	4	4	5	5	5	5	5	5	5	4	4	5	5	5	5	3	3	5	5	5	5
		28		---		0	0	5	5	5	5	5	5	5		R22		4	4	5	5	5	5	5	5	5	3	3	5	5	5	C4-R	3	3	5	5	5	5
		34		---			R28		5	5	CO-2	5	5	5		---		4	4	5	5	5	5	5	5	5		R26		5	5	5	3	3	C4-8	5	5	5
		40		---			---			R34		5	5	5		---		3	3	5	5	5	5	5	5	5		---		4	4	5		R34		5	5	5

TABLE VII

EXPOSURE RATINGS - COLD ROLLED STEEL

System No.	Coating System	Months Exposure	Surface Prep.	MIL-P-15328												TT-C-490 Type I												Grit Blast											
			Exposure Site	BW			RF			OF			APG			BW			RF			OF			APG			BW			RF			OF			APG		
				Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface	Score	Undercut	Surface
1	MIL-P-8585 TT-E-529	7		3	3	5	4	4	5	5	5	5	3	3	5	2	2	5	4	4	5	5	5	5	4	4	5	3	3	5	4	4	5	5	5	5	4	4	5
		13		0	0	5	5	5	5	4	4	5	3	3	5	0	0	5	4	4	5	4	4	5	3	3	5	1	1	5	4	4	5	4	4	5	3	3	5
		22		0	0	5	5	5	5	4	4	5	2	2	5	0	0	5	4	4	5	4	4	5	2	2	5	0	0	5	5	5	5	3	3	5	3	3	5
		28			R22		4	4	5	3	3	5	2	2	5		R22		3	3	5	4	4	5	3	3	5	0	0	5	2	2	5	3	3	5	3	3	5
		34			---		4	4	5	4	4	5	2	2	5		---		4	4	5	4	4	5	3	3	5		R28		3	3	5	3	3	5	3	3	5
		40			--		4	4	5	3	3	5		R34			---		4	4	5	4	4	5	3		5		---			R34			R34		3	3	5
2	MIL-P-8585 MIL-L-14486	7		2	2	5	4	4	5	4	4	5	4	4	5	2	2	5	4	4	5	4	4	5	4	4	5	3	3	5	4	4	5	3	3	5	4	4	5
		13		1	1	5	4	4	5	4	4	5	2	2	5	2	2	5	3	3	5	4	4	5	3	3	5	0	0	5	4	4	5	3	3	5	3	3	5
		22		0	0	5	4	4	5	4	4	5	3	3	5	0	0	5	3	3	5	3	3	5	3	3	5	0	0	5	4	4	5	1	1	5	3	3	5
		28			R22		4	4	5	4	4	5	3	3	5	0	0	5	2	2	5	2	2	5	3	3	5	0	0	5	0	0	C4-8	1	1	5	3	3	5
		34			---		4	4	C4-8	3	3	5	3	3	5		R28		2	2	5	3	3	5	3	3	5		R28			R28			R28		3	3	5
		40			---		4	4	5	3	3	5		R34			---			R34			R34		3	3	5		---			---			---		3	3	5
3	MIL-P-52192 TT-E-529	7		3	3	5	4	4	5	5	5	5	2	2	5	3	3	5	5	5	5	5	5	5	4	4	5	3	3	5	4	4	5	5	5	5	4	4	5
		13		0	0	5	5	5	5	4	4	5	1	1	5	3	3	5	5	5	5	4	4	5	3	3	5	2	2	5	5	5	5	4	4	5	2	2	5
		22		0	0	5	5	5	5	4	4	5	0	0	5	0	0	5	4	4	5	4	4	5	2	2	5	0	0	5	5	5	5	2	2	5	3	3	5
		28			R22		4	4	5	4	4	5	1	1	5	0	0	B4	4	4	5	3	3	5	2	2	5	0	0	5	4	4	5	2	2	B4	3	3	5
		34			---		4	4	5	3	3	5	1	1	5		R28		4	4	5	3	3	5	2	2	5		R28		4	4	5	3	3	5	3	3	5
		40			---		4	4	5		R34			R34			---		4	4	C4-8	2	2	5	2	2	5		---		4	4	5		R34		3	3	5
4	MIL-P-52192 MIL-L-14486	7		2	2	5	4	4	5	4	4	5	2	2	5	3	3	5	4	4	CO-8	5	5	5	4	4	C2-8	3	3	C3-8	4	4	CO-8	3	3	C2-8	3	3	C2-8
		13		1	1	5	3	3	5	4	4	5	0	0	5	2	2	C3-8	5	5	CO-8	4	4	C3-8	3	3	C3-8	2	2	C2-8	5	5	CO-8	3	3	C2-8	3	3	C2-8
		22		0	0	C3-2	3	3	5	4	4	5	0	0	5	2	2	C4-8		R13			R13		2	2	C2-8		R13			R13			R13				
		28			R22		3	3	5	4	4	5	0	0	5	0	0	B4		---			---		3	3	C2-8		---			---			---				
		34			---		4	4	5	3	3	5	0	0	5		R28			---			---		3	3	C2-4		---			---			---				
		40			---		4	4	5	4	4	5		R34			---			---			---			R34			---			---			---				

TABLE VII - Continued

System No.	Coating System	Months Exposure	Surface Prep. / Exposure Site	MIL-P-15328 BW Score	BW Undercut	BW Surface	MIL-P-15328 RF Score	RF Undercut	RF Surface	MIL-P-15328 OF Score	OF Undercut	OF Surface	MIL-P-15328 APG Score	APG Undercut	APG Surface	TT-C-490 Type I BW Score	BW Undercut	BW Surface	TT-C-490 Type I RF Score	RF Undercut	RF Surface	TT-C-490 Type I OF Score	OF Undercut	OF Surface	TT-C-490 Type I APG Score	APG Undercut	APG Surface	Grit Blast BW Score	BW Undercut	BW Surface	Grit Blast RF Score	RF Undercut	RF Surface	Grit Blast OF Score	OF Undercut	OF Surface	Grit Blast APG Score	APG Undercut	APG Surface
5	MIL-P-15930 TT-E-529	7		2	2	5	4	4	5	4	4	5	3	3	5	2	2	5	4	4	5	5	5	5	3	3	5	3	3	5	4	4	5	5	5	5	4	4	5
		13		0	0	5	5	5	5	4	4	5	2	2	5	1	1	5	5	5	5	5	5	5	2	2	5	2	2	5	5	5	5	4	4	5	3	3	5
		22		0	0	5	4	4	5	3	3	5	2	2	5	0	0	5	4	4	5	4	4	5	2	2	5	0	0	5	5	5	5	2	2	5	3	3	5
		28			R22		4	4	5	4	4	5	1	1	5	0	0	5	3	3	5	4	4	5	3	3	5	0	0	B4	4	4	5	3	3	B4	3	3	5
		34			---		4	4	5	4	4	5	2	2	5		R28		4	4	5	4	4	5	3	3	5		R28		3	3	5	3	3	5	3	3	5
		40			---		4	4	5	3	3	5		R34			---		4	4	5	4	4	5		R34			---		4	4	5		R34		3	3	5
6	MIL-P-15930 MIL-L-14486	7		2	2	5	4	4	5	4	4	5	3	3	5	0	0	5	5	5	5	5	5	5	3	3	5	3	3	5	4	4	5	4	4	5	3	3	5
		13		0	0	5	3	3	5	4	4	5	2	2	5	1	1	5	5	5	5	4	4	5	1	1	5	3	3	C3-B	5	5	5	4	4	5	3	3	5
		22		0	0	5	3	3	5	2	2	5	2	2	5	0	0	5	5	5	5	3	3	5	2	2	5	0	0	5	4	4	5	0	0	5	2	2	5
		28			R22		3	3	5	2	2	5	2	2	5	0	0	5	4	4	5	3	3	5	2	2	5	0	0	5	4	4	5	0	0	5	2	2	5
		34			---		3	3	5	2	2	5	2	2	5		R28		4	4	5	3	3	5	1	1	5		R28		4	4	5		R28		2	2	5
		40			---			R34			R34			R34			---		4	4	5		R34			R34			---		4	4	5		---		2	2	5
7	MIL-P-23377 TT-E-529	7		3	3	5	4	4	5	4	4	5	3	3	5	2	2	5	4	4	5	5	5	5	2	2	5	3	3	5	5	5	5	4	4	5	4	4	5
		13		1	1	5	4	4	5	3	3	5	1	1	5	0	0	5	4	4	5	3	3	5	1	1	5	1	1	5	5	5	5	4	4	5	3	3	5
		22		0	0	B4	4	4	5	0	0	5	0	0	5	0	0	5	4	4	5	3	3	5	0	0	5	0	0	5	5	5	5	1	1	5	3	3	5
		28			R22		3	3	5	0	0	5		R22			R22		3	3	5	3	3	5	0	0	5	0	0	5	2	2	5	1	1	B4	3	3	5
		34			---		4	4	5		R28			---			---		4	4	5	3	3	5	0	0	5		R28		3	3	5	2	2	5	2	2	5
		40			---		4	4	5		---			---			---		4	4	5		R34			R34			---			R34			R34		2	2	5
8	MIL-P-23377 MIL-L-14486	7		0	0	5	4	4	5	3	3	5	2	2	5	2	2	5	4	4	5	4	4	5	3	3	5	3	3	5	4	4	5	3	3	5	2	2	5
		13		0	0	5	3	3	5	3	3	5	0	0	5	2	2	5	4	4	5	3	3	5	1	1	5	3	3	C3-B	4	4	5	4	2	5	2	2	5
		22		0	0	5	3	3	5	2	2	5	0	0	5	0	0	5	4	4	5	3	3	5	0	0	5	0	0	C4-4	4	4	5	0	0	5	2	2	5
		28			R22		2	2	5	2	2	5	0	0	5	0	0	5	3	3	5	2	2	5	0	0	5	0	0	B4	3	3	5	0	0	5	2	2	5
		34			---		3	3	5	2	2	5	0	0	5		R28		3	3	C4-B	3	3	5	1	1	5		R28		4	4	5		R28		2	2	5
		40			---			R34			R34			R34			---			R34			R34			R34			---		4	4	5		---			R34	

TABLE VIII

EXPOSURE RATINGS - COLD ROLLED STEEL - GRIT BLASTED

System No.	Coating System	Months Exposure	BW Score	BW Undercut	BW Surface	RF Score	RF Undercut	RF Surface	OF Score	OF Undercut	OF Surface	APG Score	APG Undercut	APG Surface
1	MIL-P-46105 TT-E-529	7	5	5	CO-8	5	5	5	5	5	5	5	5	5
		13	5	5	A0	5	5	5	5	5	5	5	5	5
		22		R13		5	5	5	5	5	5	5	5	5
		28		---		5	5	5	5	5	5	5	5	5
		34		---		5	5	5	5	5	5	5	5	5
		40		---		5	5	5	5	5	5	5	5	5
2	MIL-P-46105 MIL-P-15328 TT-E-529	7	4	4	5									
		13	5	5	B3									
		22	2	2	B0									
		28	2	2	B0									
		34		R28										
		40		---										
3	MIL-P-46105 MIL-E-13515	7	5	5	5	5	5	5	5	5	5	5	5	5
		13	5	5	B3	5	5	5	5	5	5	5	5	5
		22	5	5	A1	5	5	5	5	5	5	5	5	5
		28		R22		4	4	5	5	5	5	5	5	5
		34		---		5	5	5	5	5	5	5	5	5
		40		---		5	5	5	5	5	5	5	5	5
4	MIL-P-46105 MIL-C-15328 MIL-E-13515	7	5	5	5									
		13	5	5	B0									
		22		R13										
		28		---										
		34		---										
		40		---										
5	MIL-P-46105 MIL-L-14486	7	4	4	5	5	5	5	5	5	5	5	5	5
		13	5	5	A4	5	5	5	5	5	5	5	5	5
		22	4	4	B0	5	5	5	5	5	5	5	5	5
		28	4	4	B1	5	5	5	5	5	5	5	5	5
		34	4	4	B0	5	5	5	5	5	5	5	5	5
		40		R34		5	5	5	5	5	5	5	5	5

TABLE VIII - Continued

System No.	Coating System	Months Exposure	BW Score	BW Undercut	BW Surface	RF Score	RF Undercut	RF Surface	OF Score	OF Undercut	OF Surface	APG Score	APG Undercut	APG Surface
6	Inorganic Zinc (Self Cure) TT-E-529	7	4	4	5	5	5	5	5	5	5	5	5	5
		13	5	5	5	5	5	5	5	5	5	5	5	5
		22	1	1	5	5	5	5	4	4	5	4	4	5
		28	2	2	5	5	5	5	4	4	5	4	4	5
		34	0	0	5	5	5	5	5	5	5	4	4	5
		40	0	0	5	5	5	5	5	5	5	4	4	5
7	Inorganic Zinc (Self Cure) MIL-P-15328 TT-E-529	7	4	4	5									
		13	5	5	5									
		22	2	2	B2									
		28	0	0	B0									
		34		R28										
		40		---										
8	Inorganic Zinc (Self Cure) MIL-E-13515	7	5	5	5	5	5	5	5	5	5	5	5	5
		13	5	5	A4	5	5	5	5	5	5	5	5	5
		22	5	5	C3-4	5	5	5	4	4	5	5	5	5
		28	5	5	B0	5	5	5	5	5	5	5	5	5
		34	5	5	A3	5	5	5	5	5	5	5	5	5
		40	5	5	A3	5	5	5	5	5	5	5	5	5
9	Inorganic Zinc (Self Cure) MIL-P-15328 MIL-E-13515	7	5	5	5									
		13	5	5	5									
		22	4	4	C4-8									
		28	3	3	A4									
		34	3	3	5									
		40		R34										
10	7 Inorganic Zinc (Self Cure) MIL-L-14486	7	4	4	5	5	5	5	5	5	5	5	5	5
		13	5	5	5	5	5	5	5	5	5	5	5	5
		22	4	4	5	5	5	5	4	4	5	4	4	5
		28	4	4	B3	5	5	5	5	5	B4	4	4	5
		34	4	4	B1	5	5	5	5	5	5	3	3	5
		40		R34		5	5	5	5	5	5	3	3	5

TABLE IX

PERCENT OF SYSTEMS RATED LESS THAN 4
(Total Systems - 106)

Exposure Site	Months Exposure 7	13	22	28	34	40
Score Condition Only						
BW	42	47	56	57	55	58
RF	1	9	11	16	16	20
OF	4	8	22	26	29	32
APG	14	26	33	34	33	36
Score and Surface Condition Only						
BW	5	15	18	23	26	27
RF	0	0	0	0	1	1
OF	1	1	1	1	2	2
APG	1	2	3	3	4	4
Surface Condition Only						
BW	2	6	7	8	8	8
RF	7	8	8	8	8	9
OF	1	2	2	2	7	7
APG	3	22	3	3	3	4
Total All Conditions						
BW	49	68	81	88	89	93
RF	8	17	19	24	25	30
OF	6	11	25	29	38	41
APG	18	30	39	40	40	44

TABLE X

SYSTEMS RATED 4 OR BETTER AT ALL SITES - 34 MONTHS EXPOSURE

I. Hot Dip Galvanize

Pretreatment	Primer	Topcoat
MIL-P-15328	MIL-P-8585	TT-E-529
MIL-P-15328	MIL-P-8585	MIL-L-14486
MIL-P-15328	MIL-P-52192	TT-E-529
MIL-P-15328	MIL-P-52192	MIL-L-14486
Chromate Conversion	MIL-P-52192	TT-E-529
MIL-P-15328	MIL-P-15930	TT-E-529
MIL-P-15328	MIL-P-23377	TT-E-529
Chromate Conversion	MIL-P-15930	TT-E-529

II. Aluminized Steel

MIL-C-5541	MIL-P-8585	MIL-L-14486
MIL-P-15328	MIL-P-15930	MIL-L-14486
MIL-C-5541	MIL-P-8585	TT-E-529
MIL-C-5541	MIL-P-15930	MIL-L-14486

APPENDIX C

Figure 1

BREAKWATER - NO. SYSTEMS.NO RATING LESS THAN 4 - TOTAL SYSTEMS - 8*

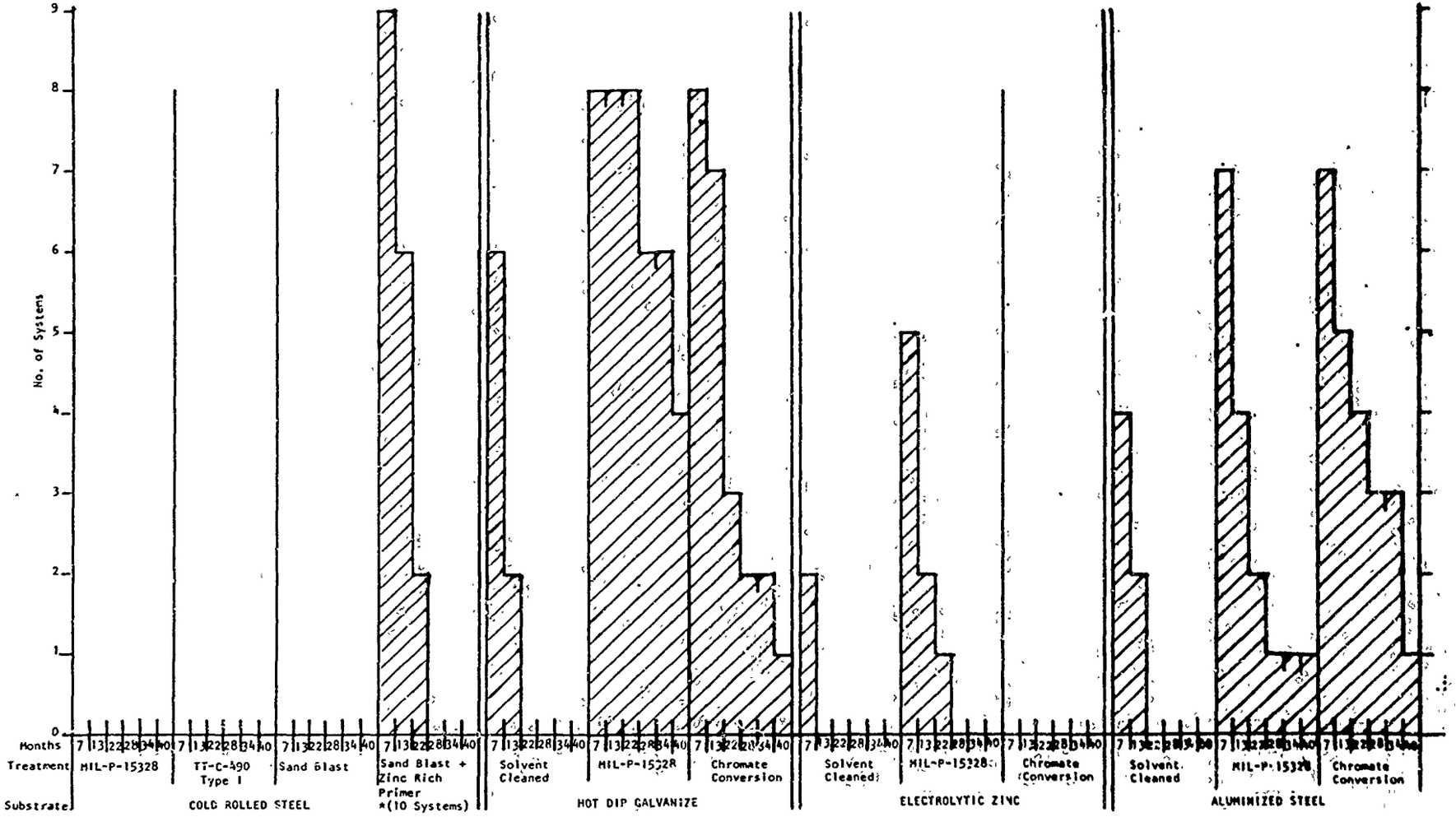


Figure 2

OPEN FIELD - NO. SYSTEMS WITH NO RATING LESS THAN 4 - TOTAL SYSTEMS - 8

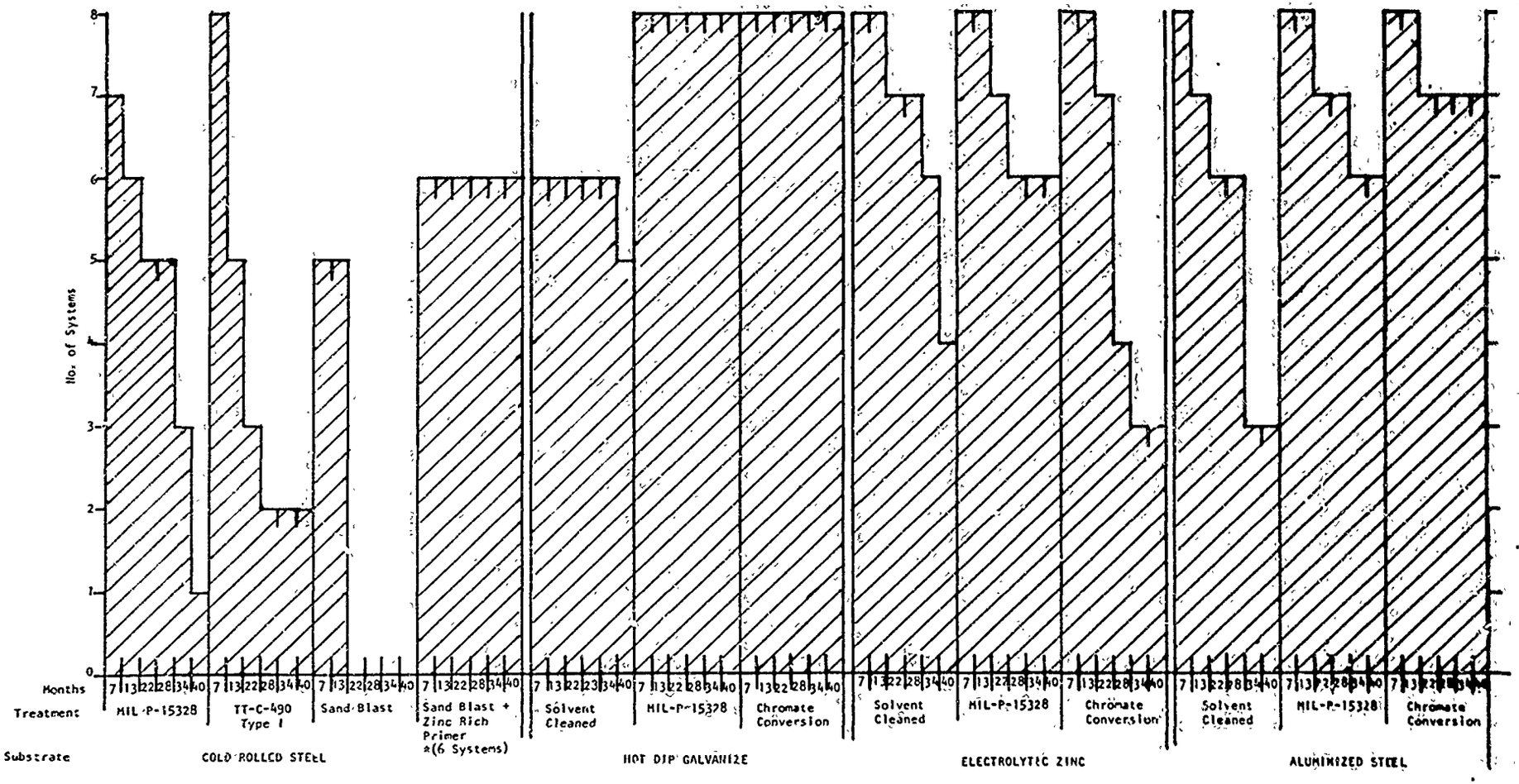


Figure 3

RAIN FOREST - NO. SYSTEMS WITH NO RATING LESS THAN 4 - TOTAL SYSTEMS - 84

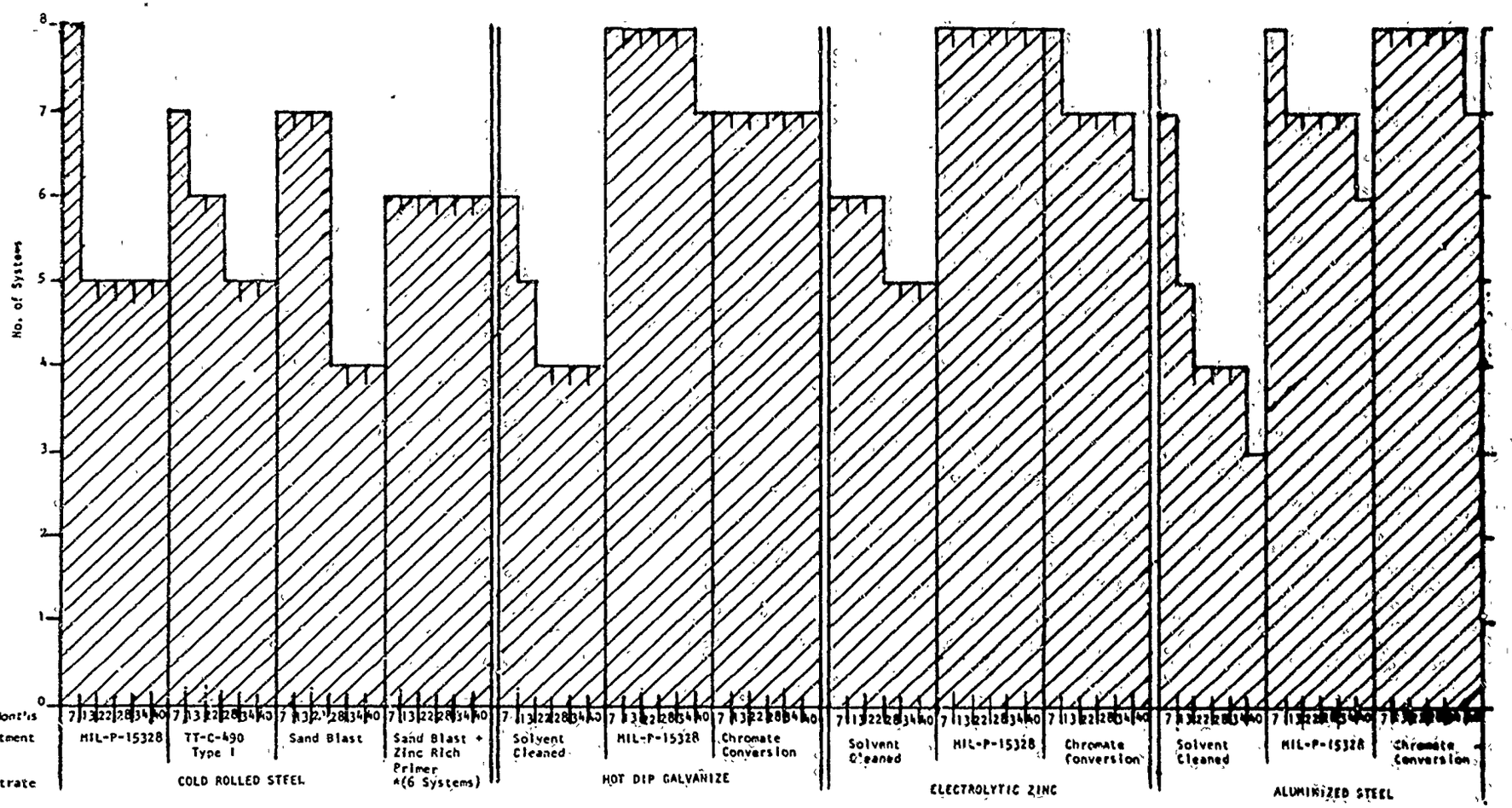


Figure 4

APG - NO. SYSTEMS WITH NO RATING LESS THAN 4 - TOTAL SYSTEMS 8*

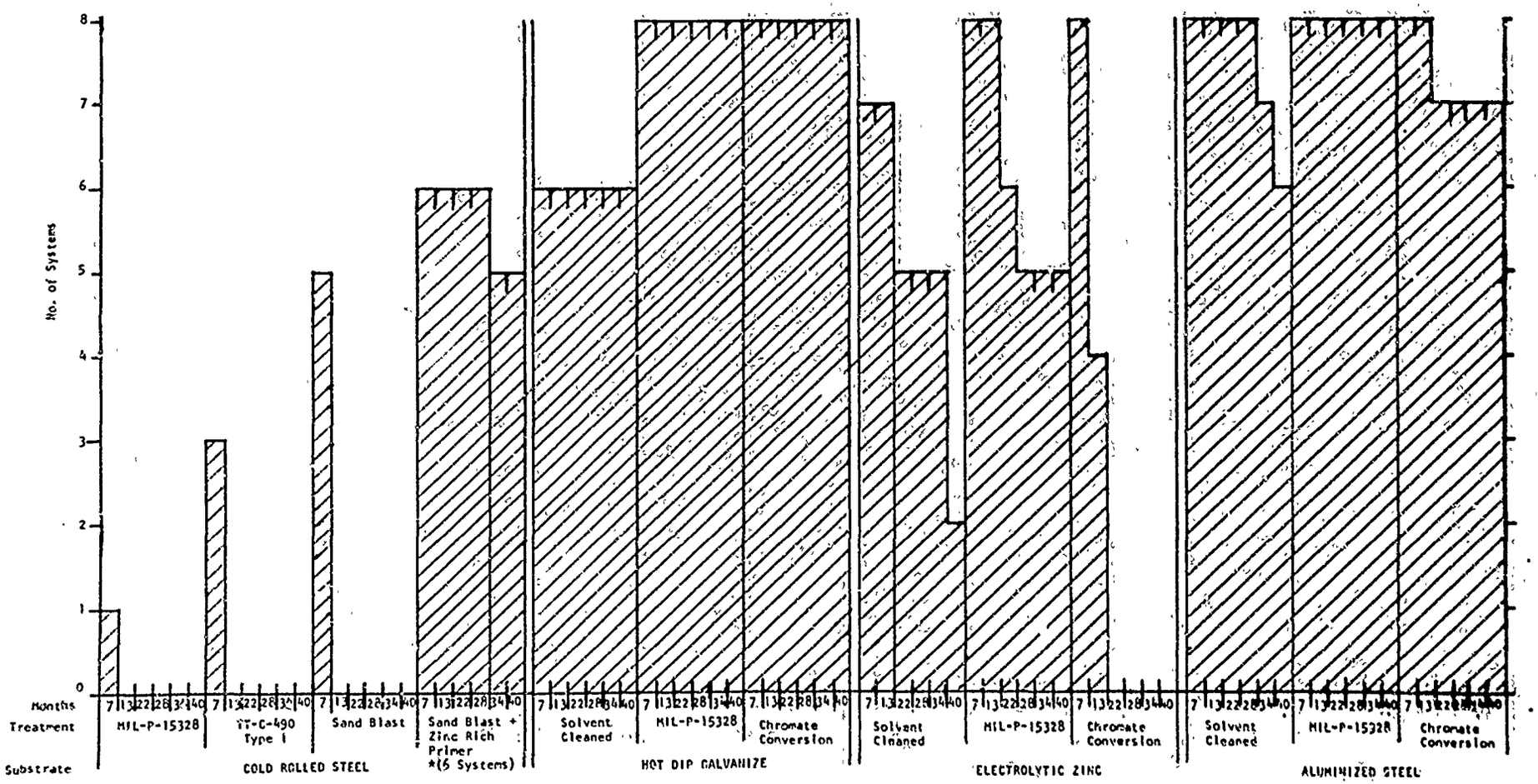
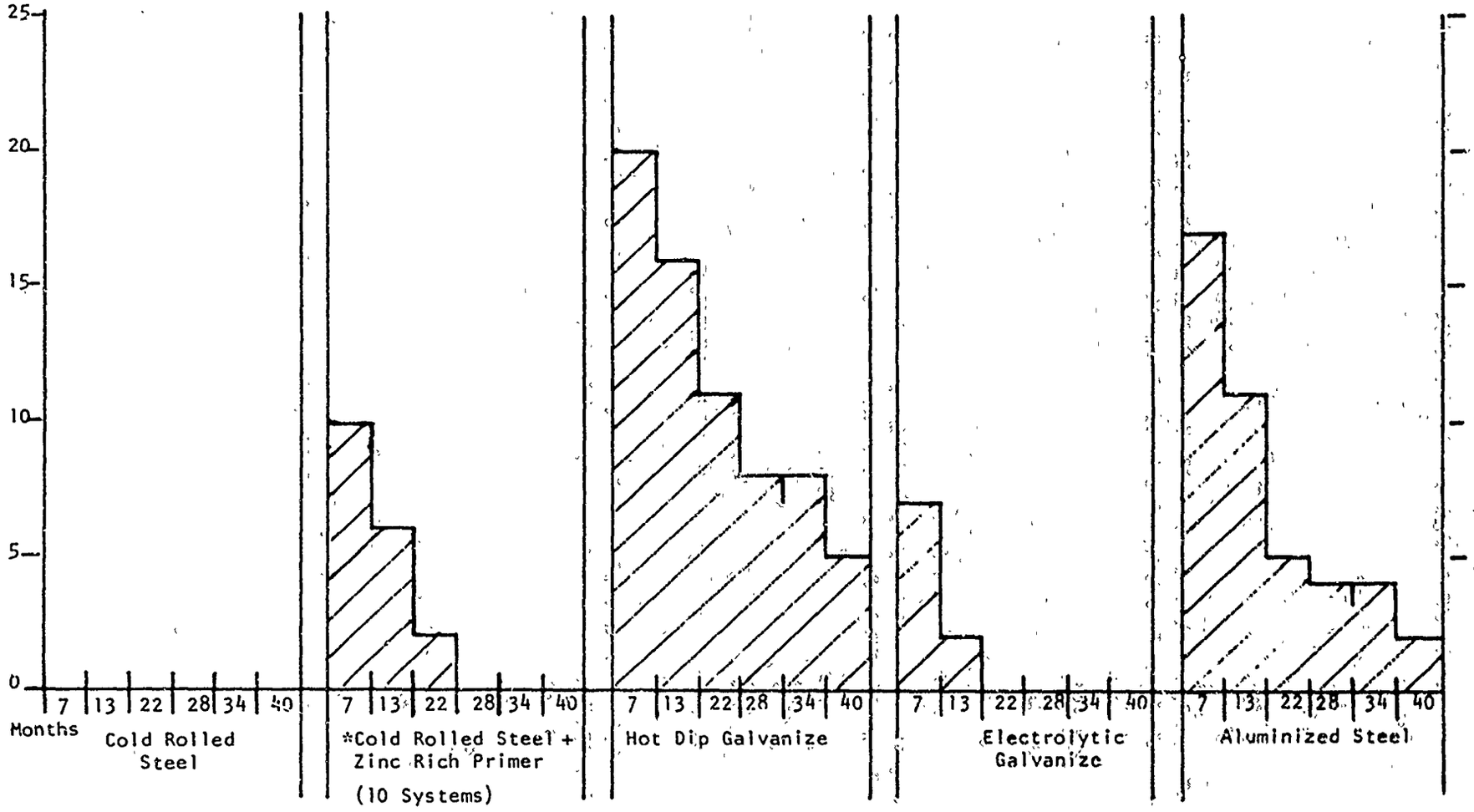


Figure 5

NO. SYSTEMS 4 OR BETTER AT ALL SITES

Total Systems 24*



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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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13. ABSTRACT

The effect of metallic coatings and zinc rich primers on the performance of finishing systems for automotive steel was investigated. Galvanized and aluminized type steels and zinc rich primer steels were coated with specification finishing systems and exposed to tropical and temperate environments. Data showed the hot dip galvanized steel properly finished will offer the most effective corrosion resistant system for severe environments such as salt atmosphere and sea coast exposure. This is followed in descending order by alumininzed steel, zinc rich primer on cold rolled steel, electrolytic zinc and cold rolled steel. Differences between the metallic coated steels is much less pronounced under less severe exposure.

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KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Tropical Exposure Galvanized Steel Aluminized Steel Primers Metal Pretreatments Finishing Systems						

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