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STUDY OF INHIBITIVE PIGMENTS FOR IMPROVED CORROSION RESISTANCE IN LUSTRELESS ONE COAT AMMUNITION ENAMELS

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Army Coating and Chemical Laboratory

Prepared for:

Army Materiel Command

August 1972

AD750568

AD

CCL REPORT NO. 313

PROGRESS REPORT

STUDY OF INHIBITIVE PIGMENTS FOR IMPROVED CORROSION RESISTANCE IN LUSTRELESS ONE COAT AMMUNITION ENAMELS

BY

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AND

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AUGUST 1972

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U. S. ARMY
ABERDEEN RESEARCH & DEVELOPMENT CENTER
COATING & CHEMICAL LABORATORY

Aberdeen Proving Ground

Maryland

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY *(Corporate author)*

US Army Aberdeen Research & Development Center
Coating & Chemical Laboratory
Aberdeen Proving Ground, Md. 21005

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3 REPORT TITLE

STUDY OF INHIBITIVE PIGMENTS FOR IMPROVED CORROSION RESISTANCE IN LUSTRELESS ONE COAT AMMUNITION ENAMELS

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

Progress Report

5 AUTHOR(S) *(First name, middle initial, last name)*

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6 REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1972	~~30~~ 32	1

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
AMCMS Code No. 502E.11.29500	CCL #313
b. PROJECT NO. 1T062105A329	
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

10 DISTRIBUTION STATEMENT

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11 SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U.S. Army Materiel Command Washington, D. C. 20315

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DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED

Security Classification

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT

Security Classification

UNCLASSIFIED

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DEPARTMENT OF THE ARMY PROJECT NO.
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ABSTRACT

One coat ammunition enamels covered by Specification TT-E-516, "Enamel, Lustreless, Quick Drying, Styrenated Alkyd Type" were reformulated with white low tint strength inhibitive type pigmentations. The enamels were subjected to salt spray tests and exterior exposure at temperate and tropical zone sites. The data shows several of the experimental enamels will provide significantly improved corrosion resistance over the standard enamels.

TABLE OF CONTENTS

I. INTRODUCTION

During the past few years periodic reports from the field have indicated erratic performance of current specification one coat ammunition enamels conforming to Federal Specification TT-E-516 "Enamel, Lustreless, Quick Drying, Styrenated Alkyd Type". Most recently reported has been the occurrence of various degrees of corrosion on large caliber ammunition during shipment from the producer to the loading plant. This has further demonstrated the need to provide a higher degree of protection against atmospheric corrosion which may be encountered during the life cycle of such ammunition. A program was therefore undertaken to develop more corrosion resistant one coat ammunition enamels.

II. DETAILS OF TEST

In addition to providing corrosion resistance ammunition enamels are designed to meet production line requirements for ease of application and rapid drying characteristics. To avoid any change in these properties it was decided to initially concentrate on pigment modifications. Previous work at this laboratory had shown the use of zinc chromate as an inhibitive pigment in lustreless olive drab enamels appreciably improved salt spray resistance and exterior durability. However, since TT-E-516 includes seventeen colors and white, the use of colored inhibitive pigments would be precluded in the white and most of the other colors. Efforts were therefore directed toward the incorporation of white low tint strength or extender type pigments that have been reported to provide corrosion inhibitive properties. Those selected for the initial phase of this program were an experimental modified zinc molybdate (EZM), barium metaborate (BMB), tribasic lead phosphosilicate (TLP), and dibasic lead phosphite (DLP). Pigmentations for olive drab (OD) and white were formulated replacing a portion of the extender pigment with 15 and 30 percent concentrations of EZM, BMB, and TLP, by weight of total pigment. DLP was formulated at 10 percent of total pigment. Efforts to use higher amounts showed excessive viscosity increases with resultant tendencies toward gelation. Enamels (Tables A and B) were prepared substituting the revised pigmentations, at the same pigment volume concentration, in control olive drab and white enamels conforming to specification TT-E-516.

Salt spray testing was then conducted in accordance with the specification for up to 264 hours with daily examination for compliance. As can be seen in Tables C and D, EZM (Formulas A2 and A3) provided slight improvement in olive drab and none in white. All the others showed significantly improved corrosion resistance. Only the white enamel (B4) containing 15 percent BMB showing any failure at the end of 264 hours exposure compared to 48 hours for the control enamels (A1 and B1).

Test specimens were also placed on exterior exposure at Aberdeen Proving Ground (APG) and at breakwater and open field sites at Fort Sherman, Panama Canal Zone (1). All panels were scored, except for those at the Panama breakwater. Experience has shown this site to be extremely severe on scored areas of one coat enamels and the spread of corrosion from the score could interfere with an effective evaluation of differences in the inhibitive properties of the enamels since only semi-annual inspections could be made. After 6 months exposure the panels at all sites were examined for corrosion. In addition those at APG and the open field sites were examined for chalking and color change in accordance with specification requirements. In efforts to additionally distinguish differences, score condition was rated as in Table E, surface condition as in Table F, substrate condition in accordance with Photos 0-10, (Appendix B); and lightness index difference determined as in method 6122 of Federal Test Method Std. No. 141. The data is tabulated in Tables G and H.

At APG, except for the EZM pigmented white enamels (B2 and B3), there was no significant difference between the control and modified enamels in either the white or olive drab colors, with all meeting specification requirements at this time. The EZM modified white enamels showed a significant color change to a blue shade which was immediately obvious to the eye and further confirmed by the significant change in lightness index difference. Appearance of the enamels after 6 months at the APG site is shown in Photo 11. At the tropical sites, which provide a more aggressive environment, differences in the corrosion resistance of the enamels was shown. The open field site, as expected, was less severe than the breakwater but nevertheless was beginning to show differences between the white enamels with the white control exhibiting noticeable surface corrosion. All the experimental white enamels provided significantly better corrosion resistance (Photo 12). There was no surface corrosion evident with the olive drab enamels. The breakwater site further confirmed the improved corrosion resistance. The white enamels are shown in Photos 13 and 14. The same trends were also evident for the olive drab enamels.

III. SUMMARY

Overall the most effective enamels were those modified with tribasic lead phosphosilicate with 30% concentration showing only a trace of corrosion at the breakwater site after 6 months exposure. Although not quite as effective as TLP the enamels using dibasic lead phosphite and barium metaborate were comparable and significantly better than the experimental zinc molybdate. Exposure studies are continuing and additional work has been initiated to study the effectiveness of these inhibitive type pigments in other colors covered by the specification.

IV. REFERENCE

1. Teitell, Leonard, Report R-1888, "Studies of the Effects of Tropical Environments in Materials", 1. Description of Exposure Sites Pittman-Dunn Research Laboratories, Frankford Arsenal, Philadelphia, Pa., May 1968.

APPENDIX A

TABLE A

Olive Drab Formulations

Ingredient	A1	A2	A3	A4	A5	A6	A7	A8
Yellow iron oxide	133.1	134.7	135.6	136.4	138.6	141.5	134.7	138.8
Carbon black	4.0	4.0	4.0	4.1	4.1	4.2	4.0	4.1
Titanium dioxide	17.6	17.7	17.8	17.9	18.2	18.6	17.7	18.3
Acicular talc	79.9	60.2	39.3	61.0	40.2	64.2	39.1	69.3
Fibrous magnesium silicate	132.8	98.2	64.2	99.5	65.6	103.2	63.8	113.1
Zinc molybdate	--	55.6	111.8	--	--	--	--	--
Barium metaborate	--	--	--	56.3	114.4	--	--	--
Tribasic lead phosphosilicate	--	--	--	--	--	58.4	111.2	--
Dibasic lead phosphite	--	--	--	--	--	--	--	38.2
Styrenated alkyd resin (50%)	423.9	426.3	424.4	423.3	416.8	410.8	425.0	416.4
Xylene	238.0	237.6	239.7	241.1	248.5	255.4	239.2	249.0
Diethylamine	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cobalt naphthenate	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
Antioxidant	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0
Total Pounds	1032.7	1037.0	1039.5	1042.1	1048.9	1058.8	1037.2	1049.7
Total solids	56.3	56.3	56.3	56.3	56.2	56.2	56.2	56.2
Pigment on total paint, %	35.7	35.7	35.9	36.0	36.3	36.8	35.7	36.4
Vehicle solids on total paint, %	20.6	20.6	20.4	20.3	19.9	19.4	20.5	19.8
Pigment volume conc., %	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7
Pigment to binder, ratio	1.74/1	1.74/1	1.76/1	1.77/1	1.83/1	1.89/1	1.74/1	1.83/1
Inhibitor, %	0	15	30	15	30	15	30	10

TABLE B

White Formulations

Ingredient	Pounds/100 gallons							
	B1	B2	B3	B4	B5	B6	B7	B8
Titanium dioxide, rutile	197.5	198.7	199.7	201.3	204.8	209.5	223.7	205.3
Acicular talc	38.3	25.8	14.4	26.2	14.7	27.2	15.1	30.7
Fibrous magnesium silicate	147.4	103.4	57.4	104.7	58.9	109.0	64.3	122.8
Zinc molybdate	--	57.9	116.3	--	--	--	--	--
Barium metaborate	--	--	--	58.6	119.2	--	--	--
Tribasic lead phosphosilicate	--	--	--	--	--	61.0	130.3	--
Dibasic lead phosphite	--	--	--	--	--	--	--	39.9
Styrenated alkyd resin (50%)	423.1	420.9	418.0	417.5	410.5	405.4	381.7	411.5
Xylene	239.9	242.5	246.4	246.4	254.4	260.2	286.2	253.3
Diethylamine	0.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cobalt naphthenate, 6%	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Antioxidant	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total pounds	1048.9	1051.7	1054.7	1057.2	1065.0	1074.8	1104.8	1066.0
Total solids	56.7	56.7	56.6	56.7	56.6	56.7	56.6	56.7
Pigment on total paint, %	36.5	36.7	36.8	37.0	37.3	37.8	39.3	37.4
Vehicle solids on total paint, %	20.2	20.0	19.8	19.7	19.3	18.9	17.3	19.3
Pigment volume conc., %	33.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0
Pigment to binder, ratio	1.81/1	1.83/1	1.86/1	1.87/1	1.94/1	2.0/1	2.28/1	1.94/1
Inhibitor, %	0	15	30	15	30	15	30	10

TABLE C

5% Salt Spray Exposure

Olive Drab Formulations

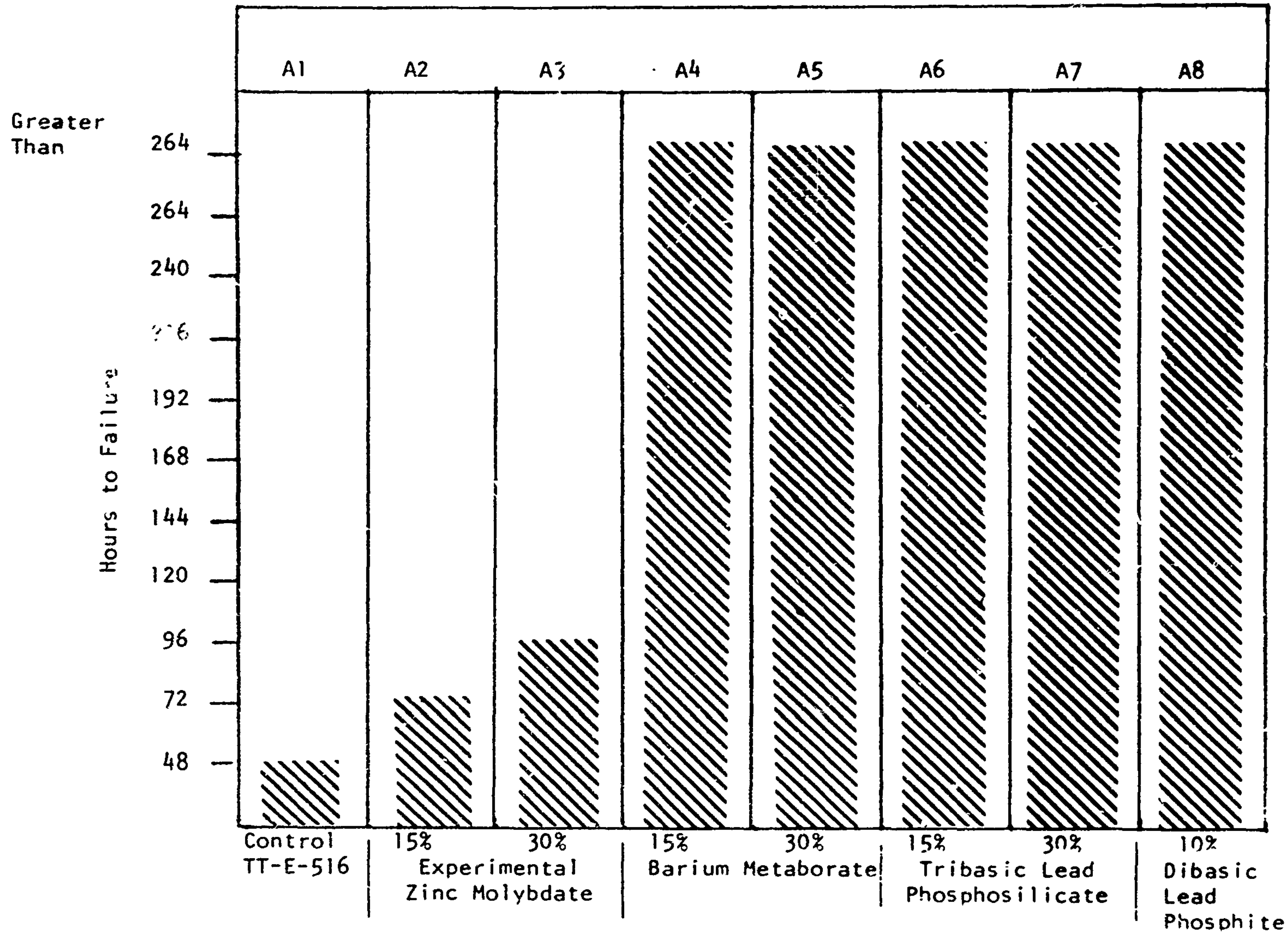


TABLE D

5% Salt Spray Exposure

White Formulations

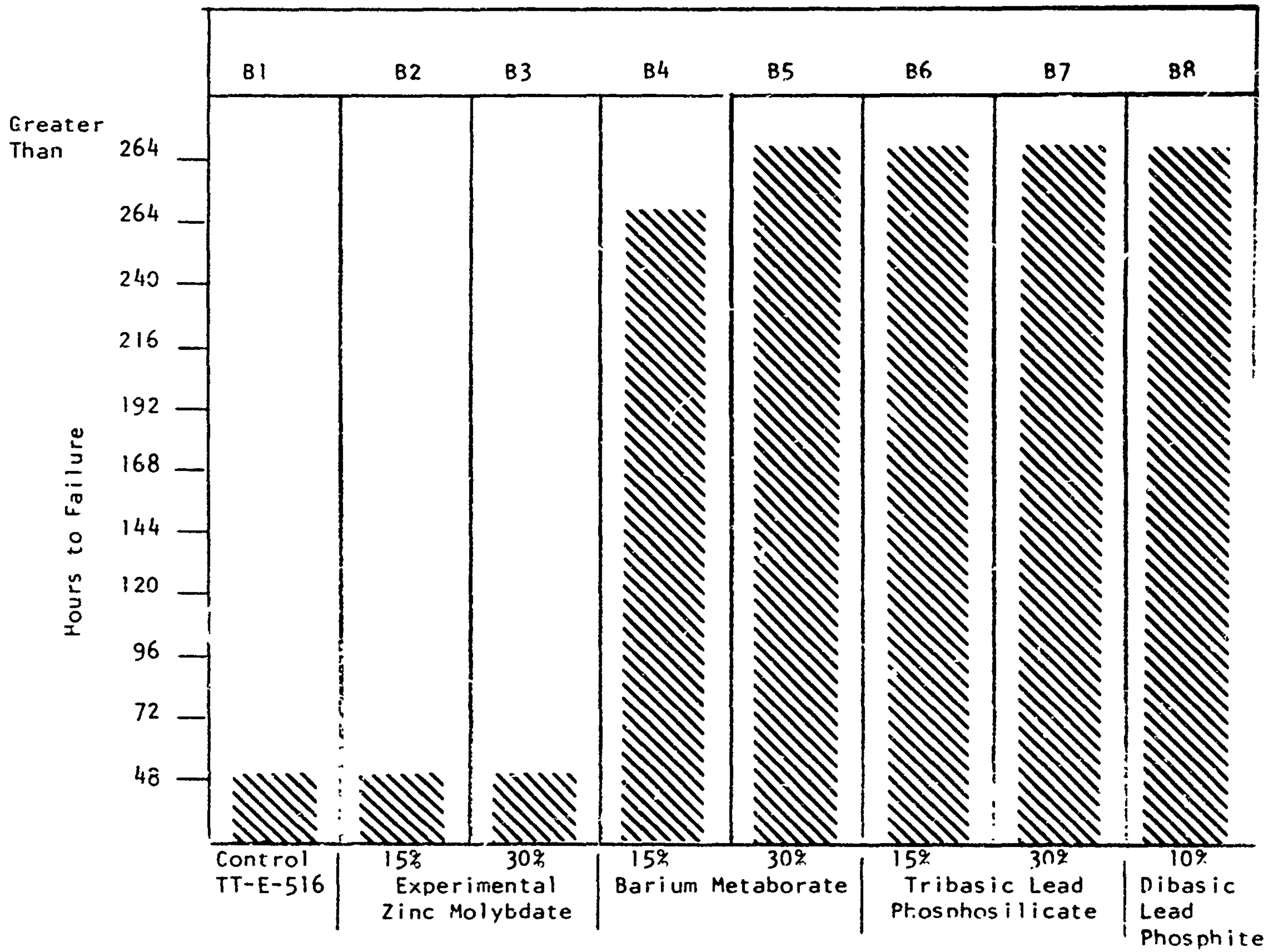


TABLE E

SCORE

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 F

Surface Condition*

Rating	A. Corrosion Alone
5	None
4	ASTM D610-43 Photo No. 10, Type I
3	ASTM D610-43 Photo No. 9, Type I
2	ASTM D610-43 Photo No. 8, Type I
1	ASTM D610-43 Photo No. 7, Type I
0	ASTM D610-43 Photo No. 6, Type I or worse

Rating	B. Corrosion Accompanied by Blistering
5	None
4	Trace, less than 5 defects on 4x12 inch panel
3	ASTM D610-43 Photo No. 8, Type 2
2	ASTM D610-43 Photo No. 7, Type 2
1	ASTM D610-43 Photo No. 6, Type 2
0	ASTM D610-43 Photo No. 4, Type 2 or worse

Rating	C. Blistering Alone
5	None
4	Trace ASTM D714-56 Size 2 on 4x12 inch panel - 2 max. ASTM D714-56 Size 4 on 4x12 inch panel - 4 max. ASTM D714-56 Size 6 on 4x12 inch panel - 6 max. ASTM D714-56 Size 8 on 4x12 inch panel - 8 max.
3	ASTM D714-56 Few - Record blister size
2	ASTM D714-56 Medium - Record blister size
1	ASTM D714-56 Med-Dense - Record blister size
0	ASTM D714-56 Dense - Record blister size

*Select applicable condition.

TABLE G

6 Months Exterior Exposure - Olive Drab

Formula No.	APG Score C/B	APG Score U	APG Sur.	APG Sub.	APG Chalk	APG ΔL	Panama Open Field Score C/B	Panama Open Field Score U	Panama Open Field Sur.	Panama Open Field Sub.	Panama Open Field Chalk	Panama Open Field ΔL	Panama Breakwater Sur.	Panama Breakwater Sub.
A1	5	5	5	10	7	+0.43	5	5	5	9	8	+0.66	B2	7
A2	5	5	5	10	8	+0.20	4	4	5	8	8	+1.71	B0	3
A3	5	5	5	10	8	-0.15	5	5	5	10	8	+1.33	B0	3
A4	5	5	A4	10	8	+0.55	5	5	5	10	8	+0.49	B3	8
A5	5	5	A4	10	8	+1.16	5	5	5	10	8	+1.64	B3	8
A6	5	5	5	10	8	-0.38	5	5	5	10	8	-0.46	B4	8
A7	5	5	5	10	8	-0.08	5	5	5	10	8	+0.45	5	8
A8	5	5	5	10	8	-0.96	5	5	5	10	8	-0.52	B3	8

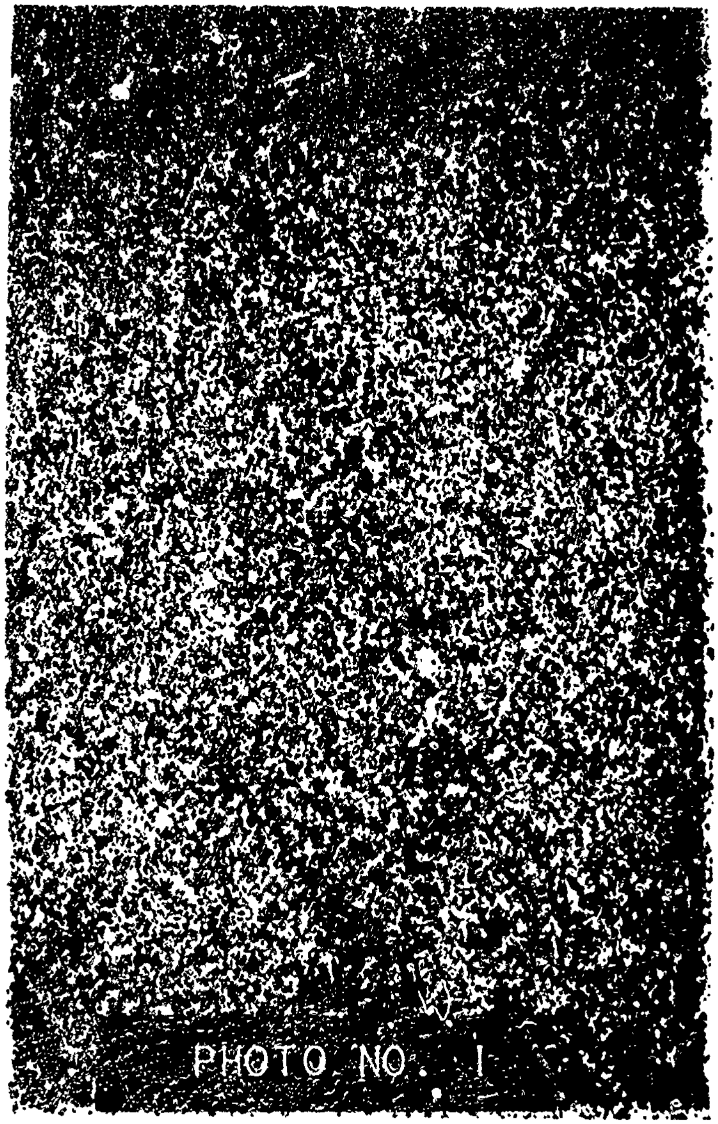
TABLE H

6 Months Exterior Exposure - White

Formula No.	APG Score C/B	APG Score U	APG Sur.	APG Sub.	APG Chalk	APG ΔL	Panama Open Field Score C/B	Panama Open Field Score U	Panama Open Field Sur.	Panama Open Field Sub.	Panama Open Field Chalk	Panama Open Field ΔL	Panama Breakwater Sur.	Panama Breakwater Sub.
B1	5	5	5	10	7	-1.56	4	4	B2	8	6	-0.23	B0	7
B2	5	5	5	10	7	-4.14	4	4	B3	10	6	-2.06	B0	7
B3	5	5	5	10	7	-6.52	4	4	B3	9	6	-2.91	B0	6
B4	5	5	5	10	7	-0.12	3	3	B4	10	6	-0.38	B1	8
B5	5	5	5	10	7	+0.48	3	3	5	10	6	+0.23	B1	8
B6	5	5	5	10	7	-0.93	5	5	5	10	6	-.125	B3	8
B7	5	5	5	10	7	-0.19	5	5	5	10	6	+0.11	B4	9
B8	5	5	5	10	7	-0.59	4	4	B4	10	6	-0.80	B1	7

APPENDIX B

SUBSTRATE CONDITION



SUBSTRATE CONDITION

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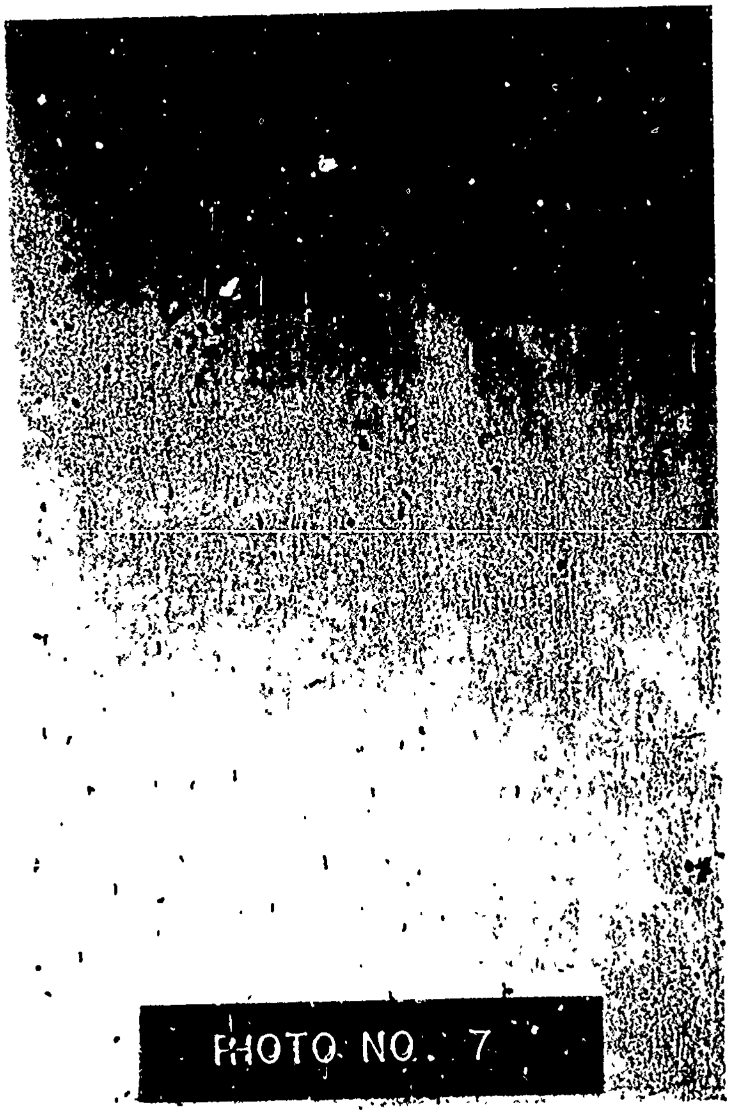

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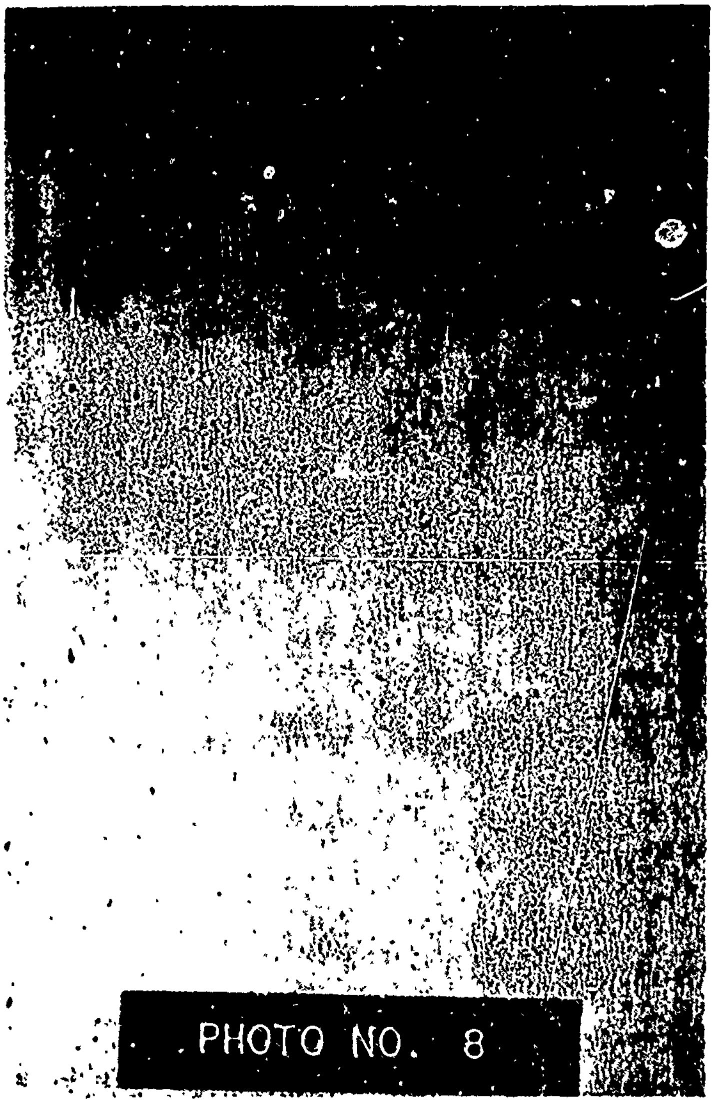

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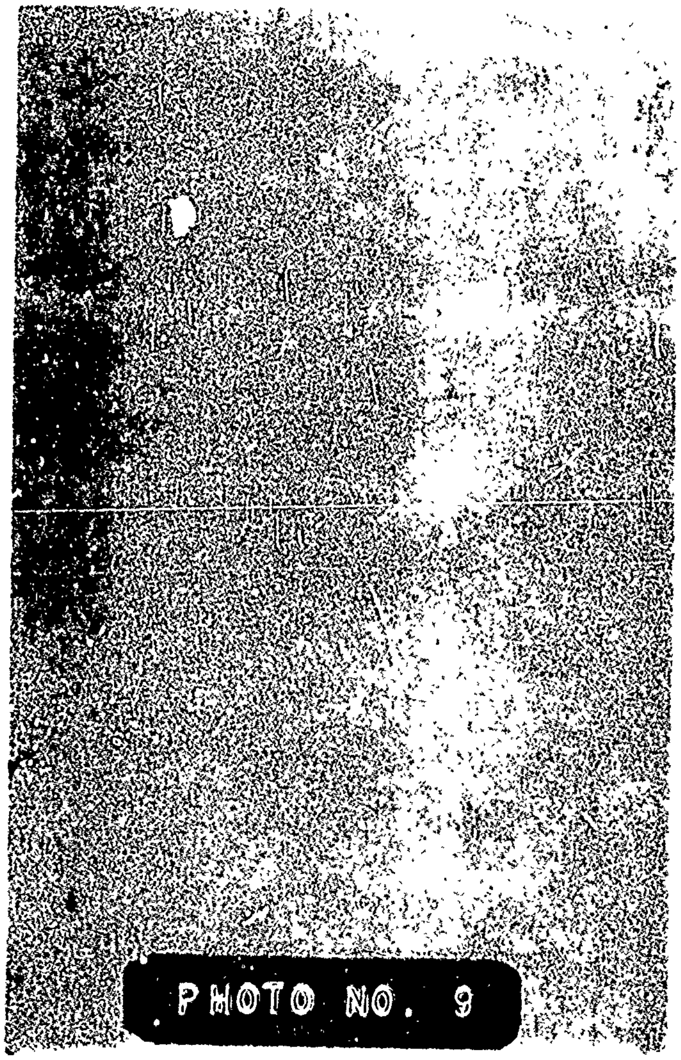

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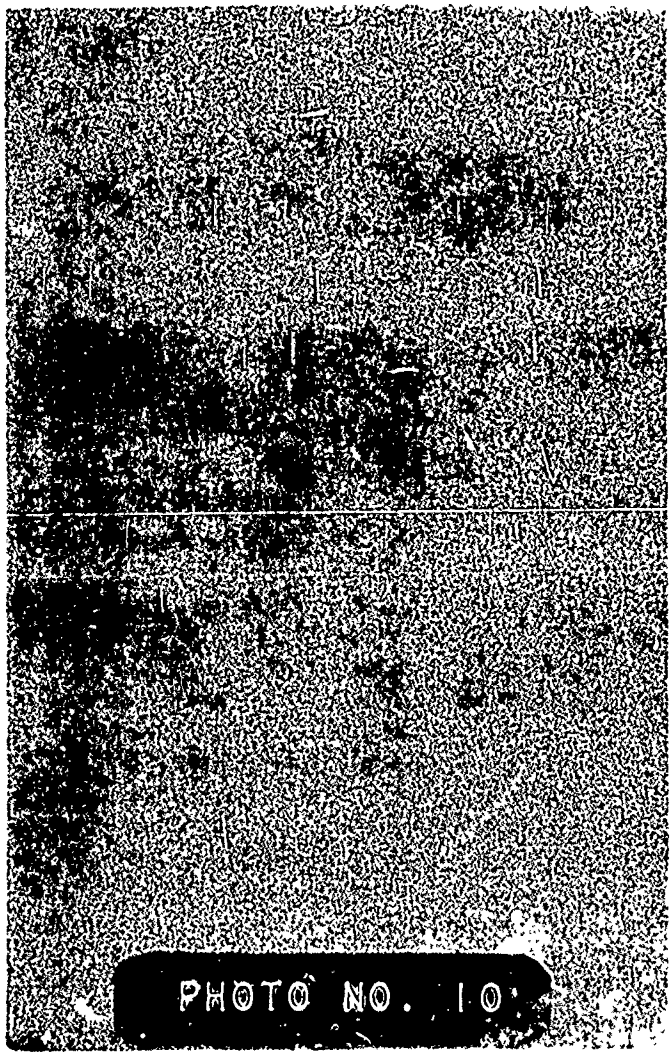
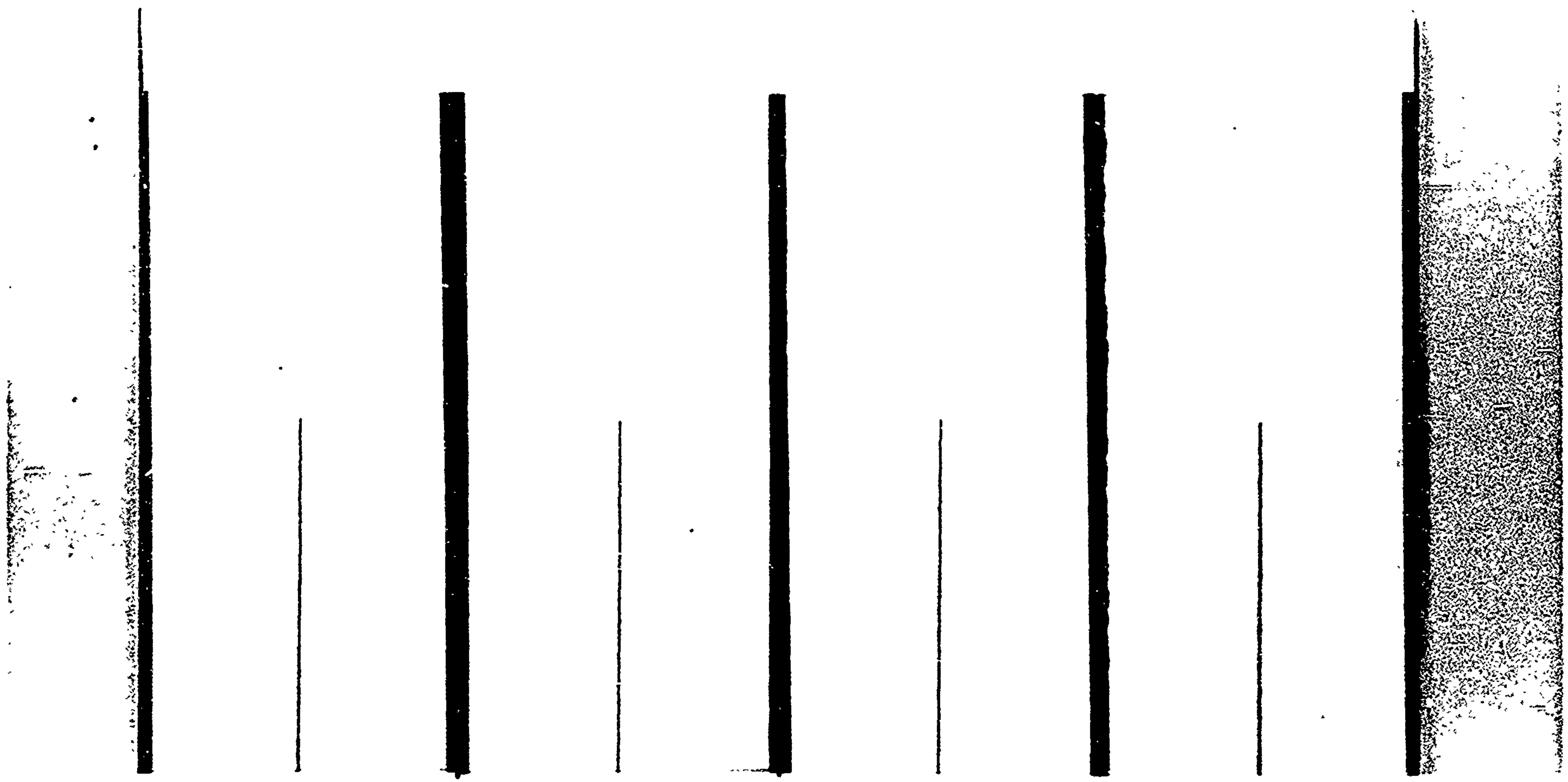


SUBSTRATE CONDITION

PHOTO 11

6 MONTHS APG EXPOSURE

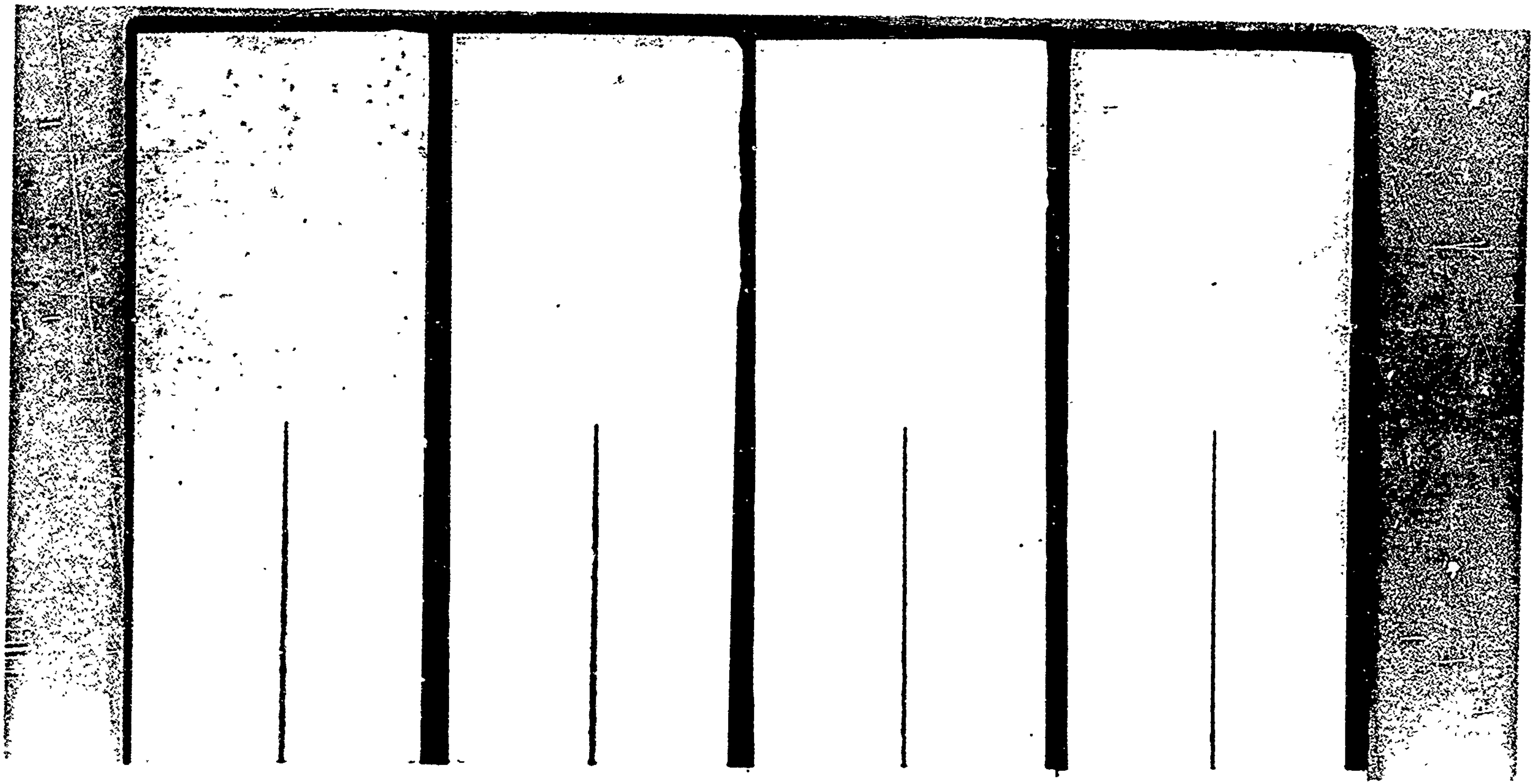


FORMULA B1	FORMULA B2	FORMULA B4	FORMULA B6
WHITE CONTROL	15% EXPERIMENTAL ZINC MOLYBDATE	15% BARIUM METABORATE	15% TRIBASIC LEAD PHOSPHOSILICATE

PHOTO 12

6 MONTHS PANAMA EXPOSURE

OPEN FIELD



FORMULA B1 — WHITE CONTROL

FORMULA B2 — 15% EXPERIMENTAL ZINC MOLYBDATE

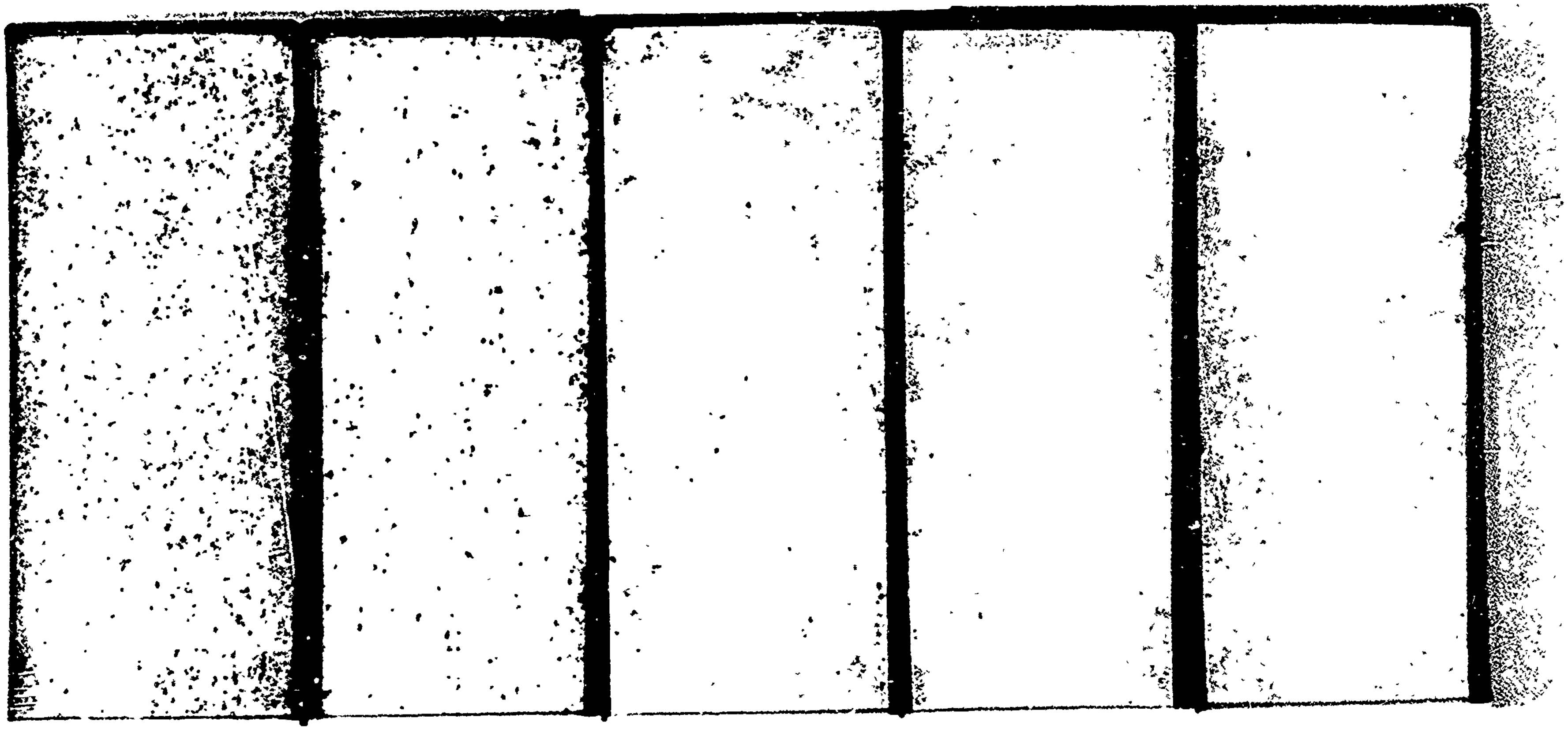
FORMULA B4 — 15% BARIUM METABORATE

FORMULA B6 — 15% TRIBASIC LEAD PHOSPHOSILICATE

PHOTO 13

6 MONTHS PANAMA EXPOSURE

BREAKWATER

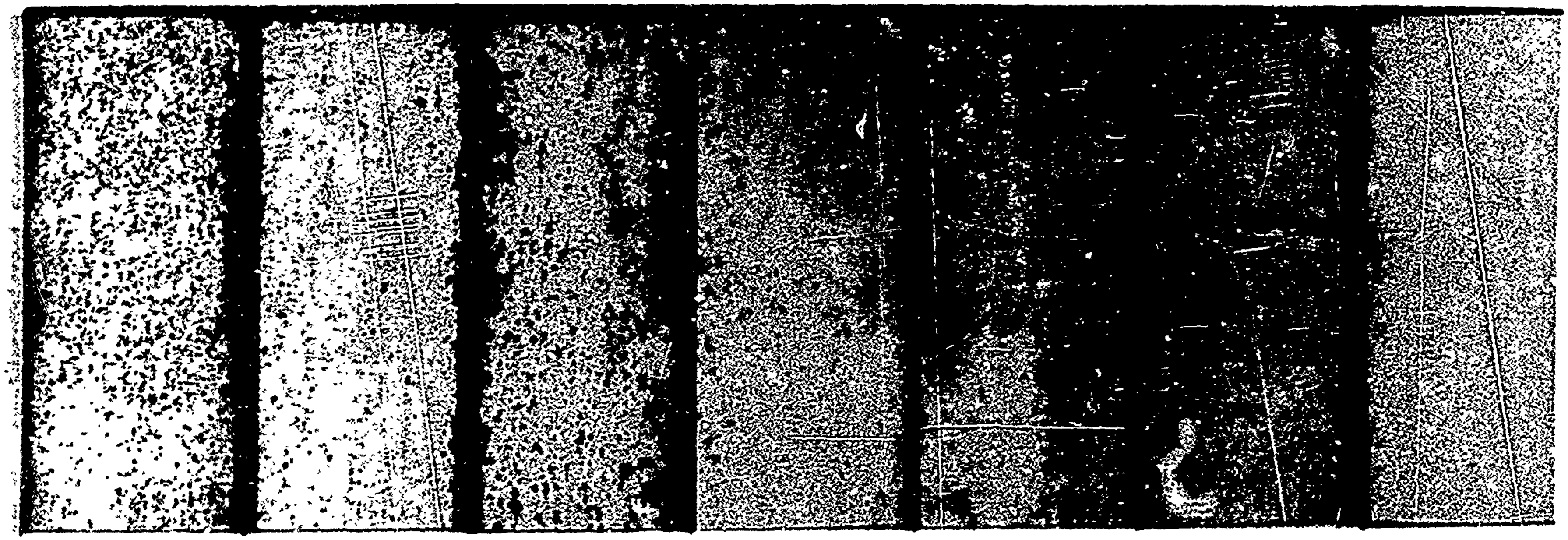


FORMULA B1	FORMULA B2	FORMULA B4	FORMULA B6	FORMULA B8
WHITE CONTROL	15% EXPERIMENTAL ZINC MOLYBDATE	15% BARIUM METABORATE	15% TRIBASIC LEAD PHOSPHOSILICATE	10% DIBASIC LEAD PHOSPHITE

PHOTO 14

6 MONTHS PANAMA EXPOSURE

BREAKWATER



FORMULA B1	FORMULA B2	FORMULA B3	FORMULA B4	FORMULA B5	FORMULA B6	FORMULA B
WHITE CONTROL	EXPERIMENTAL ZINC MOLYBDATE		BARIUM METABORATE		TRIBASIC LEAD PHOSPHOSILICATE	
	15%	30%	15%	30%	15%	30%