STATUS REPORT - PROTECTIVE COATING SYSTEMS FOR REPAIRED CARBON STEEL SURFACES - 18 MONTH EXPOSURE

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SUBJECT: STATUS REPORT - PROTECTIVE COATING SYSTEMS FOR REPAIRED CARBON STEEL SURFACES - 18-MONTH EXPOSURE

1.0 SUMMARY

Recent advances in protective coatings technology have developed materials that are intended for use over mechanically prepared surfaces. These materials promise satisfactory corrosion protection for the corroded carbon steel substrate with only cursory removal of loose, flaking rust to prevent premature adhesion loss. These products vary in composition from epoxies to polyurethanes to chemical conversion coatings. This study focused on techniques to rapidly screen many varied materials followed by conventional beachfront exposure testing of the successful candidate coatings. Data are presented on the performance characteristics of rust prevention of these coating systems and also gloss retention studies of the finish topcoats.

2.0 FOREWORD

2.1 In 1982, a test program was undertaken by the Materials Testing Branch (MTB) to evaluate protective coating systems applied to panels of carbon steel, aluminum alloys, and stainless steel. As a part of this program, testing was done to evaluate coating system performance on repaired carbon steel panels with various surface preparation techniques. The purpose of this testing was to determine if any mechanical cleaning techniques would be suitable for inorganic zinc primers to be applied over previously corroded carbon steel. Further, several other coating systems for use over mechanically cleaned carbon steel were tested. The results of this study provided valuable guidance in selecting appropriate coatings for protection of KSC structures in our severe marine and chemical environment.

2.2 The findings of this study were that repair procedures other than abrasive blasting were unacceptable when preparing corroded carbon steel surfaces for recoating with inorganic zinc primers. Also noted was that the repair coatings then available did not perform to the level required to be used in the corrosion control program for structures and ground support equipment at KSC. The repair coating materials used were the aluminum epoxy mastic formulations topcoated with aliphatic polyurethane products. The number of manufacturers and products tested in the study was limited so that a fair judgement of all coatings was not determined. Since that time, many more manufacturers and types of repair coatings have entered the market and no doubt improvements have been made to the coating technology employed to manufacture these type materials.

2.3 This present study focused on many more manufacturers and types of repair coatings now available. All materials under consideration are recommended to be applied to "tightly adhering rust - minimum surface preparation - no abrasive blasting required".

3.0 MATERIALS AND EQUIPMENT

3.1 Coating manufacturers were contacted to deliver the wet samples of coatings to KSC. The 47 different coatings applied during the course of this study were supplied by 23 different manufacturers. These coatings ranged from epoxy mastics and moisture cured urethanes to high build polyurethanes and chemical conversion coatings. The materials tested are listed in Table I.

3.2 In preparation for the testing program, test panels were prepared in the MTB coatings laboratory before installation in test racks for the salt fog chamber and beach exposure testing. The coatings application laboratory was equipped with a Binks Model 18 spray gun with graphite packings, various combinations of fluid needles, fluid nozzles, and air caps suited to spray materials of varying viscosities, and a l-quart DeVilbiss pressure cup.

3.3 For the surface'preparation of the rusty steel panels, several pneumatic tools manufactured by the Florida Pneumatic Corporation were used. These included an rotary sander/wire brush, rotary grinder, and a pneumatic needle scaler (needle gun) as shown in Figures l-4. The sandpaper used for

TABLE I

MATERIAL LIST

MANUFACTURER	PRIMER	TYPE	TOPCOAT	TYPE
Ameron	Amerlock 400	E. Mastic	Amershield	Urethane
AM-TEC	L1-P	M.C. Urethane	L1-C	Urethane
Carboline	CM 15 Low Odor	E. Mastic	D834	Urethane
Con-Lux	81 Series	E. Mastic	200 Series	Urethane
Devoe #1	Pre-Prime 167 235HS	Epoxy E. Mastic	359	Urethane
Devoe #2	235HS	E. Mastic	359	Urethane
DuPONT #1	62ZF	Epoxy Zinc	326	Urethane
DuPONT #2	25P	E. Mastic	326	Urethane
Elite	7510	E. Mastic	4040	Urethane
Engard	473	E. Mastic	428HS	Urethane
Hempel #1	4514	H.B. Epoxy	508U	Urethane
Hempel #2	4515	E. Mastic	5528	Urethane
Loctite Devoe	EXTEND	Converter	 359	 Urethane
Momar Devoe	Protect-Al	M.C. Urethane	 359	 Urethane

TABLE I (cont.)

MANUFACTURER	PRIMER	TYPE	TOPCOAT	TYPE
Coulter	MP-7	Converter		
Devoe	235HS	E. Mastic	359	Urethane
Neutra-Rust	661	Converter		
Devoe			359	Urethane
Plasite	C-720	E. Mastic	2089	Urethane
Porter Int'l	7900	E. Mastic	XP91-556A	Urethane
PPG	DTR 97-149	E. Mastic	97-812	Urethane
Packard	RENEW	Converter		
Devoe			359	Urethane
Chesterton	NR-763	Converter		
Devoe	235HS	E. Mastic	359	Urethane
Sherwin-Williams	B58	E. Mastic	B65	Urethane
Sigma	7476	E. Mastic	5523	Urethane
Southern Coatings	645	E. Mastic	270	Urethane
Tnemec #1	135	E. Mastic	74	Urethane
Tnemec #2	50-330	M.C. Urethane	74	Urethane
Corrostabil	CS-2985			
Xymax			C-4-100	Urethane
Xymax	PUR-PR	M.C. Urethane	PUR-COVER	Urethane

Note:
E. - Epoxy
H. B. - High Build
M. C. - Moisture Cured

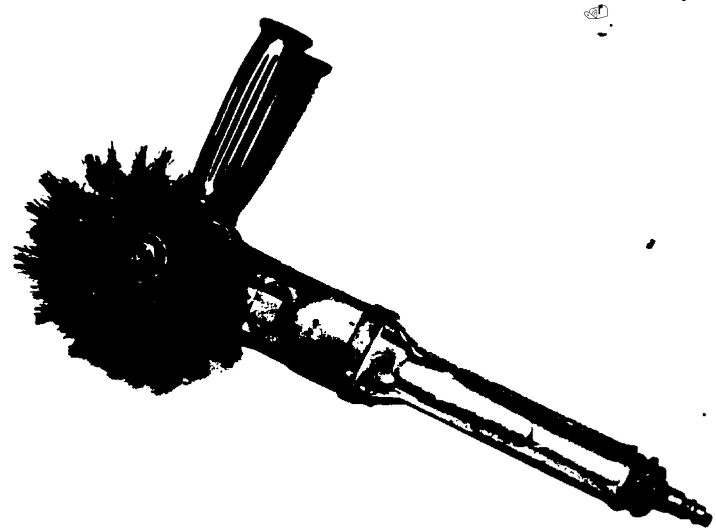

FIGURE 1

STAINLESS STEEL WIRE BRUSH USED FOR PANEL PREPARATION.

FIGURE 2

PNEUMATIC NEEDLE SCALER USED FOR PANEL PREPARATION.

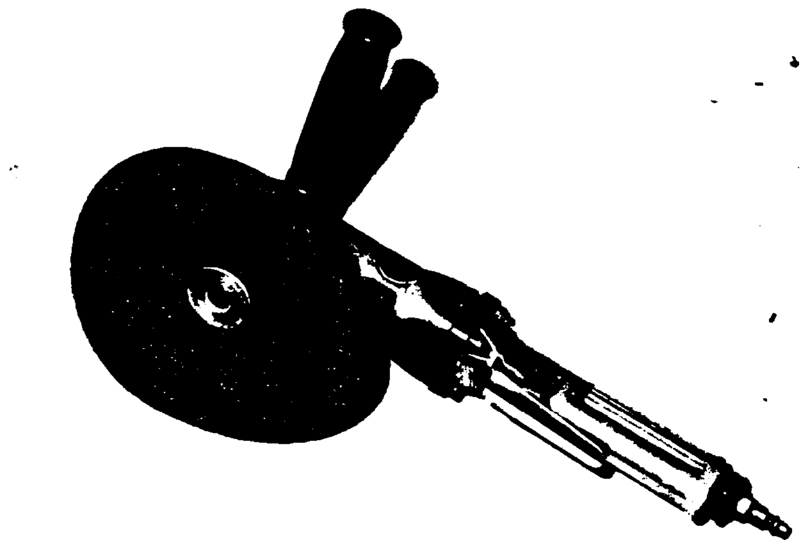

FIGURE 3

PNEUMATIC SANDING DISK USED FOR PANEL PREPARATION.

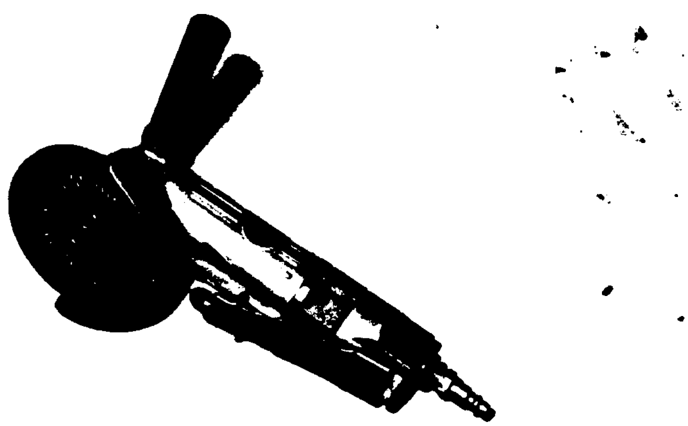

FIGURE 4

COARSE GRINDING WHEEL TOOL USED FOR PANEL PREPARATION.

the surface preparation was 18 grit and the wire brush was stainless steel.

3.4 Coating dry film thickness (DFT) was measured in mils (0.001") with a calibrated Mikrotest IV magnetic pull-off gauge and a Positector 2000 digital magnetic gauge calibrated with plastic shims.

3.5 The test panels used in this study were 4 inch by 6 inch by 1/8 inch flat carbon steel panels with a 2 inch weld bead in the center of the panel. They were abrasive blasted to white metal (SSPC-SP-5) to remove any mill scale and weld slag prior to the two pre-rusting procedures.

3.6 Topcoat gloss testing was conducted using a portable, multi-angle glossmeter manufactured by BYK Chemie GmbH. All gloss measurements were conducted at the 60° angle.

3.7 Salt fog exposure was conducted in a Corrosive Fog Exposure System Model SF-2000 manufactured by the Atlas Electric Devices Company, Inc.

4.0 TEST PROCEDURES

4.1 Panel Preparation and Exposure

4.1.1 The coating of the test panels was accomplished under relatively controlled conditions in the Materials Science Laboratory Coatings Lab by Mr. Edwin V. Tier, a journeyman painter under Contract to NASA.

4.1.2 Panels to be used for coating operations were pre-rusted prior to mechanical cleaning. The test panels were abrasive blasted to white metal (SSPC-SP-5) before the two rusting procedures.

4.1.2.1 For the first procedure, the blasted panels were placed in an Atlas Electric Devices Corrosive Fog System and exposed to the ASTM B117 salt fog test for two weeks (336 hours). This procedure produced a heavily scaled steel surface contaminated with salt for the subsequent mechanical cleaning. A representative panel from this procedure is shown in Figure 5. This procedure will also be

FIGURE 5

REPRESENTATIVE 4" X 6" PANEL PRE-RUSTED IN THE SALT FOG CHAMBER PRIOR TO CLEANING PROCEDURES.

reproducible if more panels are required for further tests in the future.

4.1.2.2 The second procedure placed the abrasive blasted panels in racks at the KSC Beach Corrosion Test Site for a period of 6 months as shown in Figure 6. This site is located approximately 100 feet from the high tide line on the Atlantic Ocean at Kennedy Space Center, Fl. This procedure produced corroded steel panels in the naturally occurring conditions of seacoast exposure.

4.1.2.3 By starting with both conditions, any differences in performance of the coating systems could be traceable to the pre-rusting procedures. If no differences in performance are noted, then future test panels may be pre-rusted in the salt fog chamber for convenience and time savings.

4.1.3 It was intended to compare the performance of previously rusted panels mechanically prepared using four methods and two different initial conditions. The four mechanical methods are power wire brush, pneumatic needle gun, sanding disk, and coarse grinder wheel. The two initial conditions were to prepare the rusted panels direct from the salt fog chamber or Beach Site and to prepare the rusted panels after water washing with a 3000 psi pressure cleaner. This provided information about water washing prior to surface preparation to reduce salt concentration on steel surfaces and possibly affecting coating performance. Typically, high salt concentrations on steel surfaces degrade coating performance due to the hydroscopic nature of sodium chloride. This may increase moisture permeation through the coating film and lead to premature blistering or corrosion. However, data is scarce as to how this effects the performance of the coatings evaluated in this study.

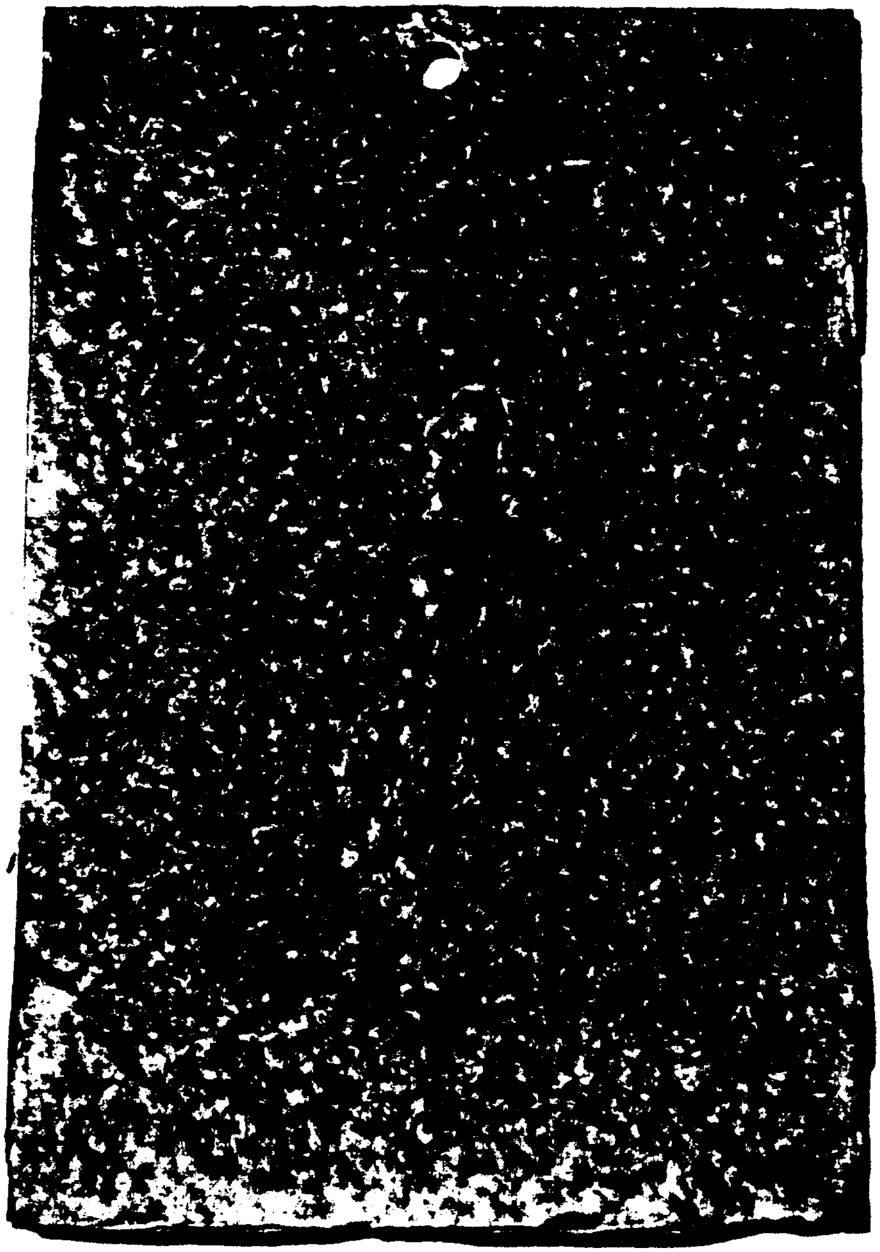

FIGURE 6

REPRESENTATIVE 4" X 6" PANEL PRE-RUSTED AT THE BEACH CORROSION SITE PRIOR TO CLEANING PROCEDURES.

4.1.4 The salt fog exposure portion of the repair program consisted of four mechanical methods and two initial conditions that produced eight different sets of coated test panels. Photographs of the surfaces produced by the four mechanical preparation methods are shown in Figures 7-10. The various combinations of test panel preparation are identified as follows.

SALT FOG EXPOSURE

WB-SFUNW - Power wire brush on unwashed rusted panels

NG-SFUNW - Needle gun on unwashed rusted panels

SD-SFUNW - Sanding disk on unwashed rusted panels

CG-SFUNW - Coarse grinder on unwashed rusted panels

WB-SFWASH - Wire brush on washed rusted panels

NG-SFWASH - Needle gun on washed rusted panels

SD-SFWASH - Sanding disk on washed rusted panels

CG-SFWASH - Coarse grinder on washed rusted panels

4.1.5 Initial screening of coating materials was conducted by exposing prepared panels in the salt fog chamber. The test panels were mounted in plastic racks with the surfaces inclined approximately 15° from vertical. The chamber was started using the standard conditions of ASTM B117. The panels were monitored for coating performance at regular intervals of 24, 48, 72, 168 (1 week), 336 (2 weeks), 504 (3 weeks), 672 (4 weeks), 1008 (6 weeks), 1344 (8 weeks), 1620 (10 weeks), and 2016 hours (12 weeks). The panels were rated according to ASTM D610 for rusting and ASTM D714 for blistering. This procedure produced relative performance of generic coating systems (e.g. epoxy mastics) and reduced the number of coatings that were used in the final round of beach testing.

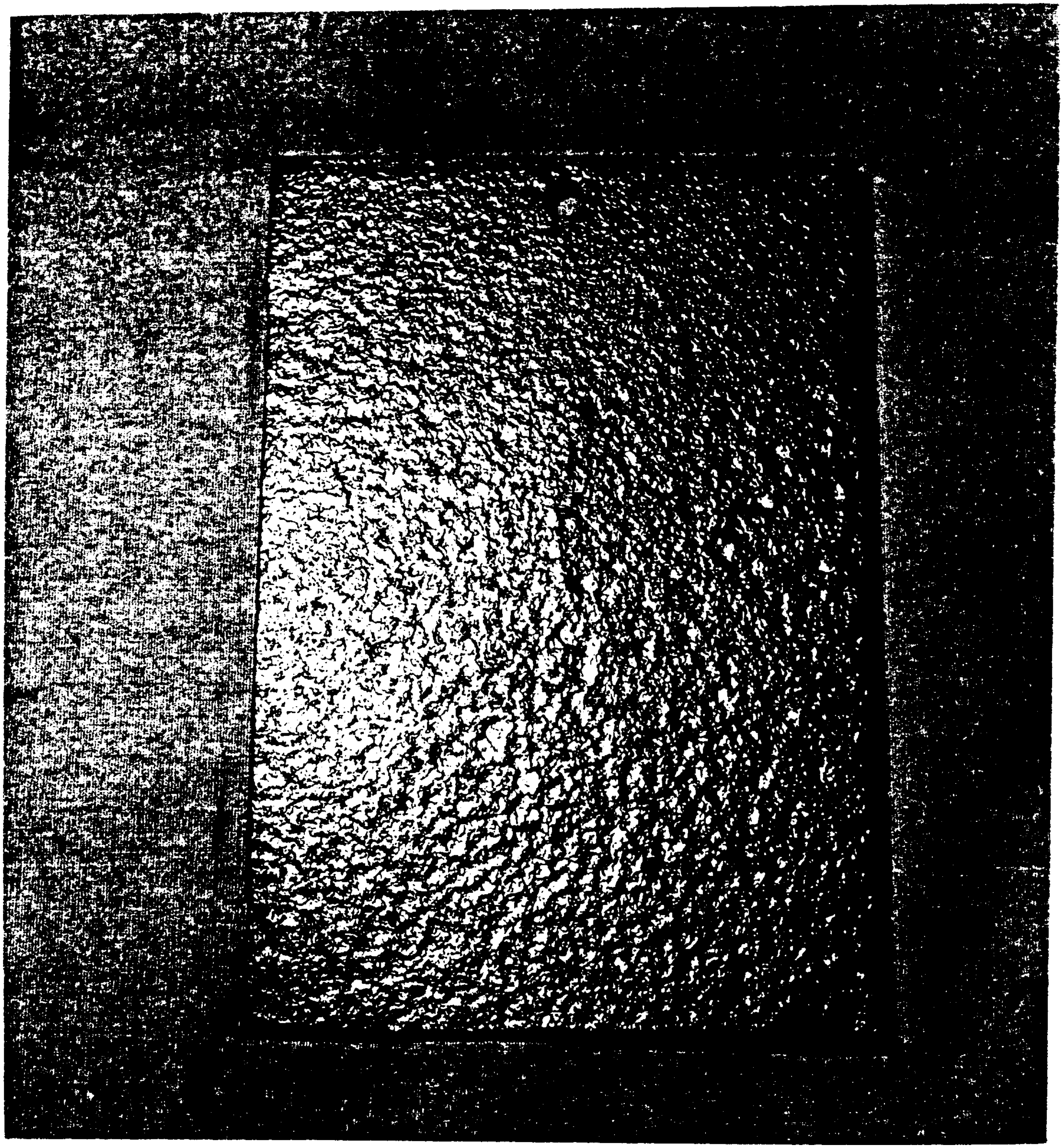

FIGURE 7

SURFACE PRODUCED USING THE PNEUMATIC STAINLESS STEEL WIRE BRUSH PREPARATION METHOD ON SALT FOG RUSTED PANEL.

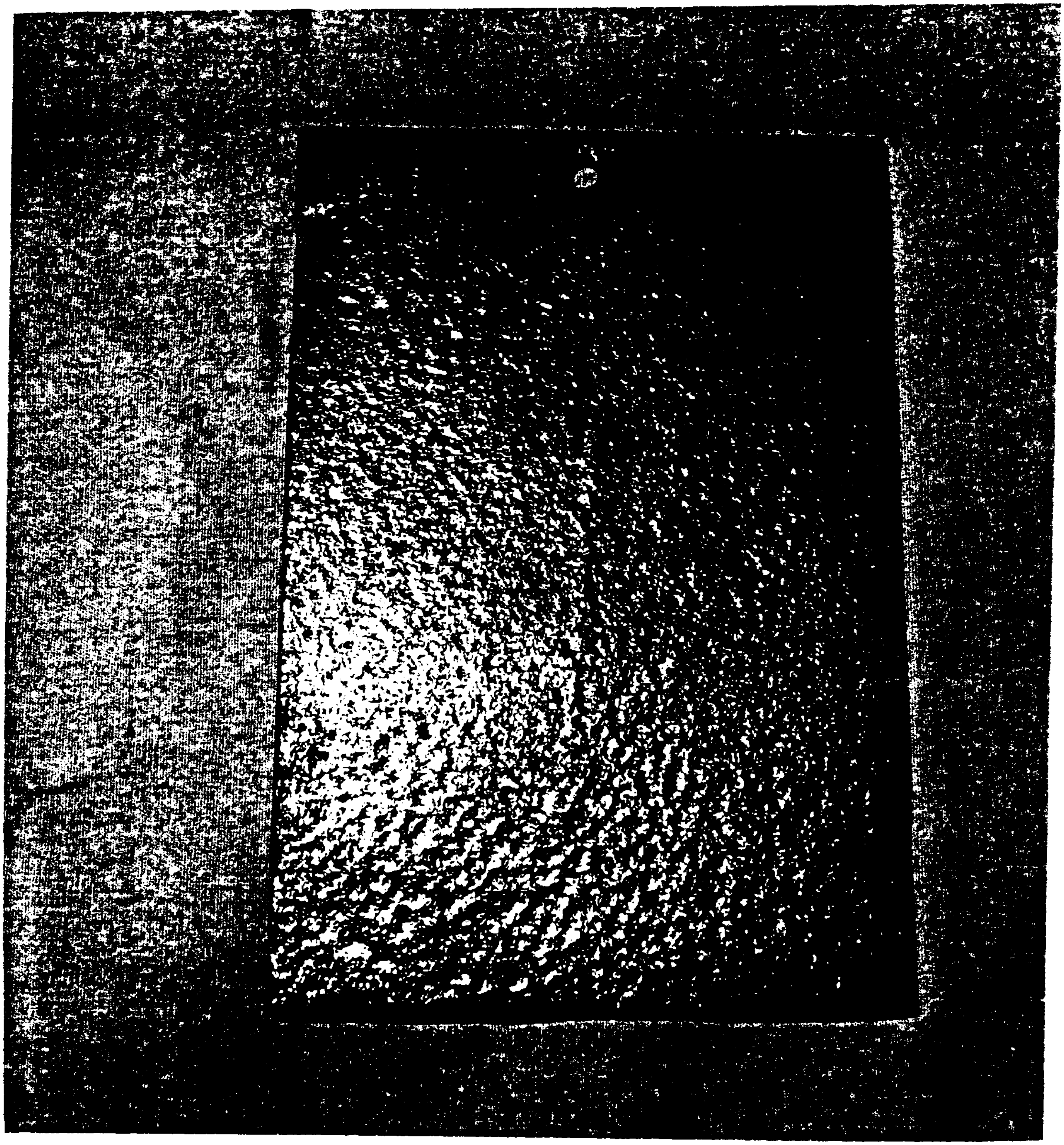

FIGURE 8

SURFACE PRODUCED USING THE PNEUMATIC NEEDLE SCALER (NEEDLE GUN) PREPARATION METHOD ON SALT FOG RUSTED PANEL.

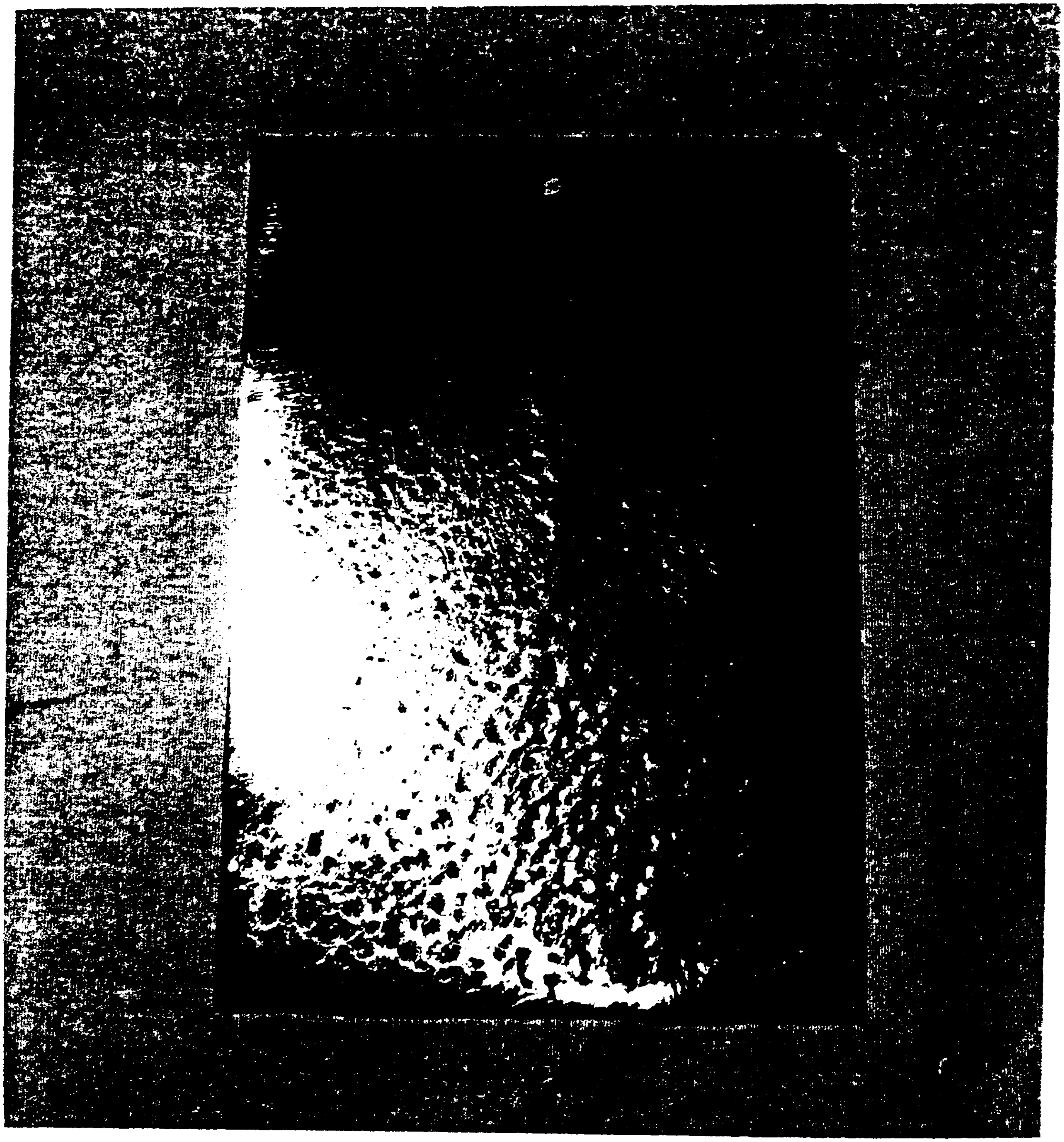

FIGURE 9

SURFACE PRODUCED USING THE PNEUMATIC SANDING DISK PREPARATION METHOD ON SALT FOG RUSTED PANEL.

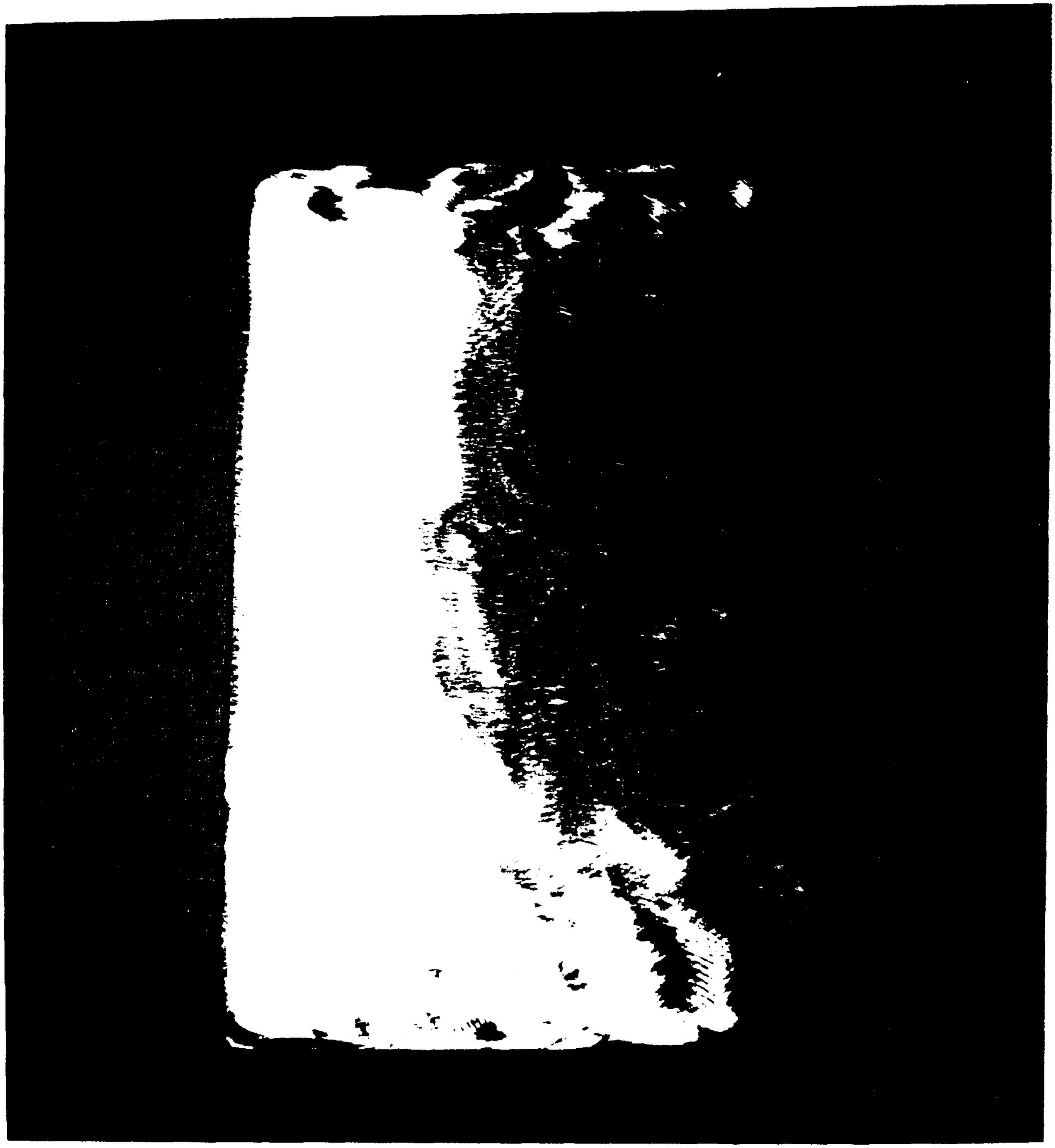

FIGURE 10

SURFACE PRODUCED USING THE PNEUMATIC COARSE WHEEL GRINDER PREPARATION METHOD ON SALT FOG RUSTED PANEL.

4.1.6 Panels were prepared by the four different methods previously described to determine if all preparation methods were required in the final testing. Following the screening procedure, the material list and preparation methods were evaluated and a decision was made as to which were included in the final beach exposure sequence.

4.1.7 Based on results from the salt fog exposure program, the beach exposure portion of the repair program consisted of two mechanical methods and two initial conditions that produced four different sets of test panels. Due to the poor performance of the wire brushed surfaces and the similarity of the sanding disk to the coarse grinder results, the two methods chosen for the beach testing were needle gun and coarse grinder. This reduction in methods helped to conserve the limited supply of beach site rusted panels. As an additional condition, some materials were tested over surfaces that have had no surface preparation before coating. These panels were prepared by applying coatings directly over the rust and scale present after removal from the beach. The various combinations of test panel preparation are identified as follows.

BEACH CORROSION SITE EXPOSURE

NG-BSUNW - Needle gun on unwashed rusted panels

CG-BSUNW - Coarse grinder on unwashed rusted panels

NG-BSWASH - Needle gun on washed rusted panels

CG-BSWASH - Coarse grinder on washed rusted panels

UNCLEAN - No surface preparation

4.1.8 The exposure testing for this study was conducted at the KSC Beach Corrosion Test Site. This site is located approximately 1.5 miles South of Launch Complex 39A. The coated test panels were installed on a stainless steel rack that uses porcelain insulators as standoffs. Each rack can hold up to 25 panels; however, not all racks were completely filled. The racks were installed on galvanized pipe test stands at a 30° angle facing the ocean. The distance of the test stands from the mean high-tide line was approximately 100 feet. Views of the test site are shown in Figures 11 and 12.

4.1.9 Panels at the Beach Site were inspected periodically at 1, 3, 6, 12, and 18 months and the degree of corrosion was judged on a scale of 0 to 10, with 10 being the highest rating. This rating system is described in ASTM D610 as follows.

RATING	DESCRIPTION
10	No rusting or less than 0.01% of surface rusted.
9	Minute rusting, less than 0.03% of surface rusted.
8	Few isolated rust spots, less than 0.1% of surface rusted.
7	Less than 0.3% of surface rusted.
6	Extensive rust spots, but less than 1% of surface rusted.
5	Rusting to the extent of 3% of surface rusted.
4	Rusting to the extent of 10% of surface rusted.
3	Approximately 1/6 of the surface rusted.
2	Approximately 1/3 of the surface rusted.
1	Approximately 1/2 of the surface rusted.
0	Approximately 100% of the surface rusted.

The panels used for coating testing have approximately 24 square inches of exposed area. This calculates to 0.0072 square inches for a rating of "9", 0.024 square inches for a rating of "8", 0.072 square inches for a rating of "7", and so on for the other area amounts. When the coating performance dropped below a value of 6, the panels were no longer rated due to the perceived failure of the coating system. The

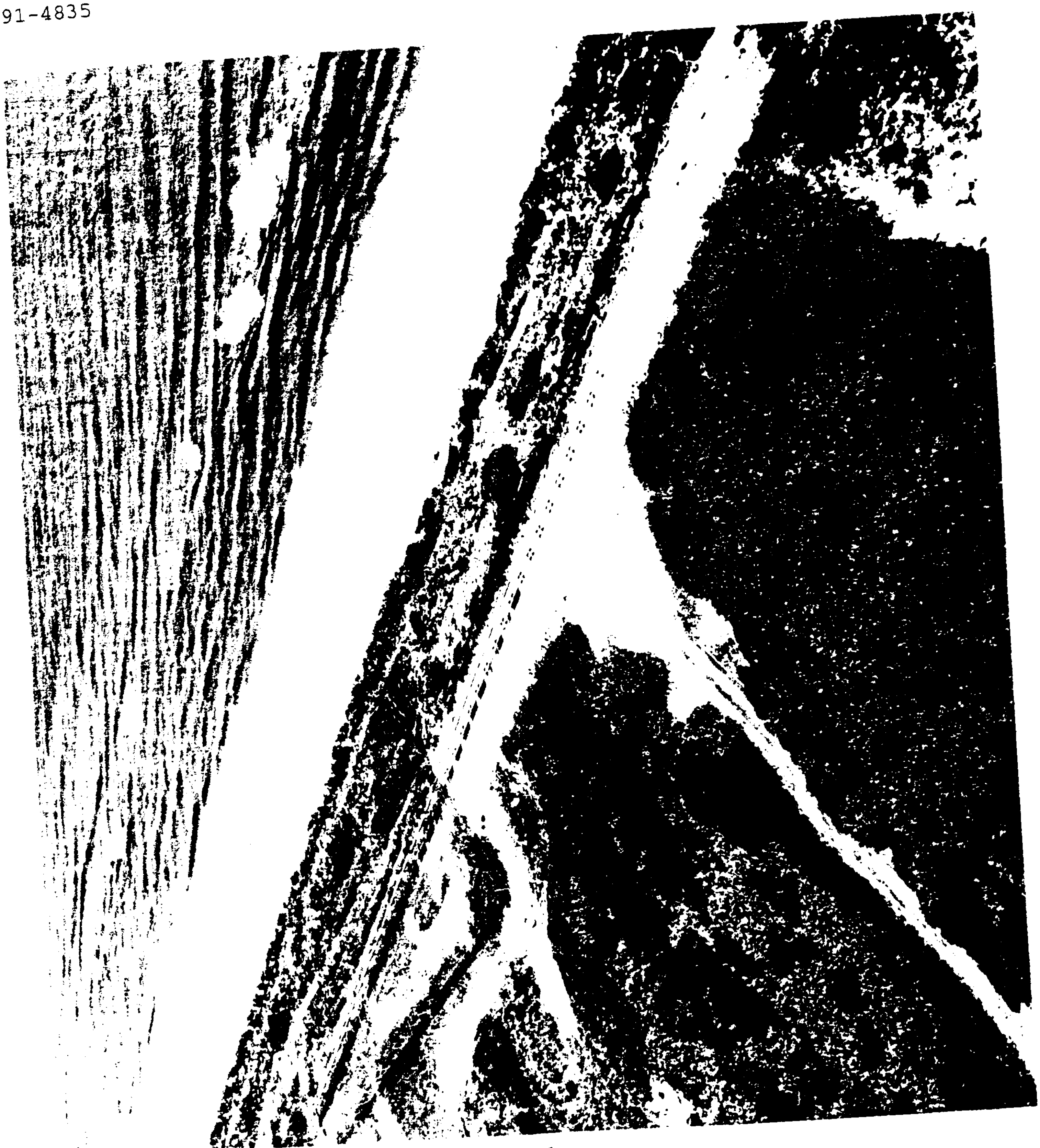

FIGURE 11

AERIAL VIEW OF KSC BEACH CORROSION SITE

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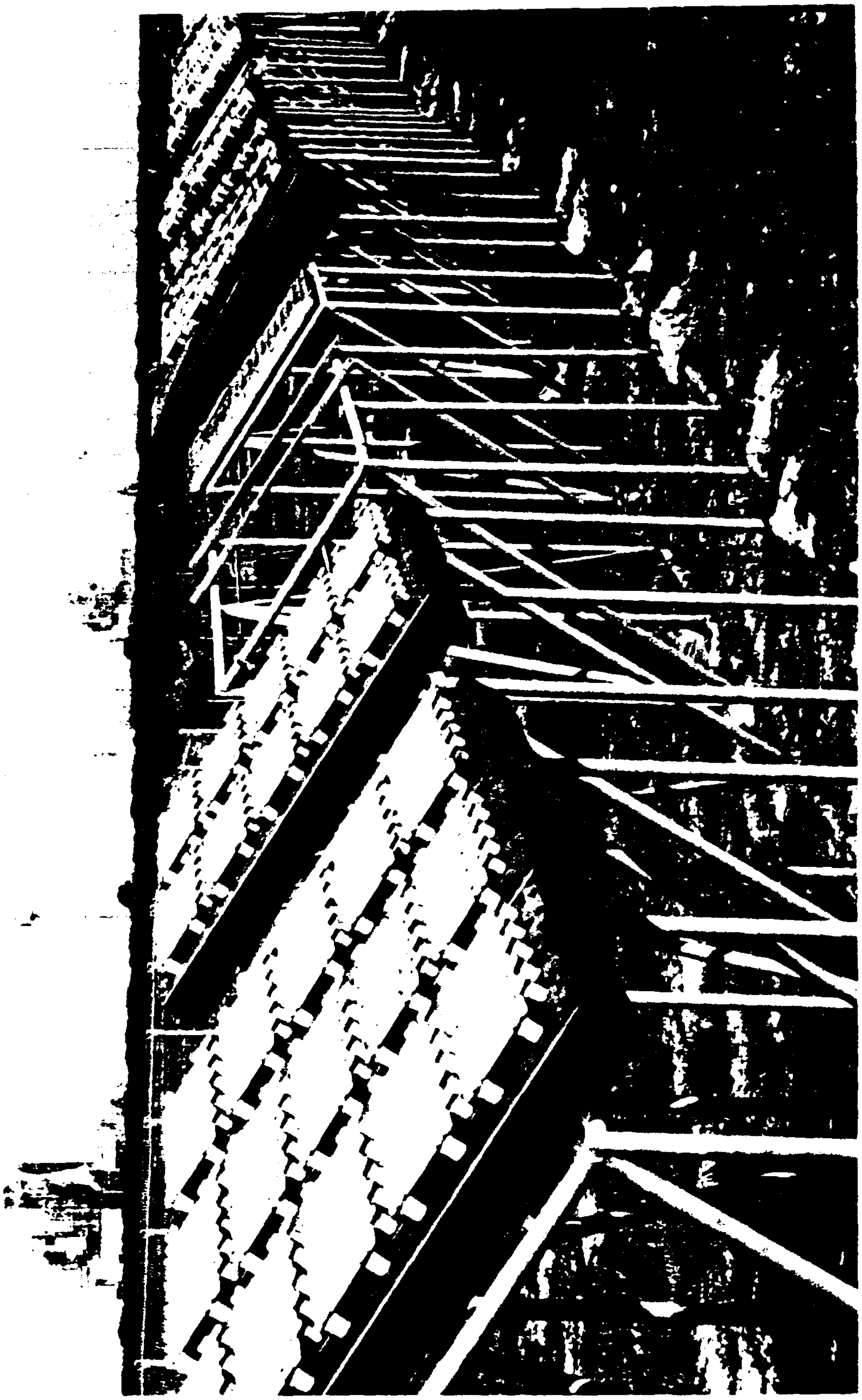


FIGURE 12

GROUND LEVEL VIEW OF KSC BEACH CORROSION SITE.

continued performance will be listed only as <6 for these materials.

4.1.10 Due to the various levels of performance of polyurethane topcoats in several recent studies at KSC, topcoat gloss testing was conducted to determine the gloss retention of the materials included in this study. The designated panels were chosen at random during the initial installation on the test racks. They were located near the rack edge to make removal and replacement easier for subsequent gloss measurements. The panels were measured for initial gloss before exposure at the Beach Corrosion Test Site. The gloss readings were made on the topcoats in the final coating system configuration. The gloss readings were determined using the properly calibrated BYK Tri-Gloss multi-angle gloss meter at the 60° angle. Every 6 months, the designated panels were removed from the exposure rack, rinsed with deionized water to remove surface residues, allowed to dry, measured for gloss retention, and replaced in the exposure rack.

5.0 RESULTS AND DISCUSS

5.1 Salt Fog Test Results

5.1.1 The results of the salt fog exposure testing are presented in Table II. All rating values presented in the tables are an average of two panels prepared and exposed at the same time. Where the ratings differed from panel to panel, a simple arithmetic mean is reported. The simple arithmetic averaging system can be misleading. It should be noted that a value of "8.75" merely means that the performance lies somewhere closer to a 9 than 8. The numerical rating does not have the significance of a weight change or thickness change that could be used for kinetic or mechanistic study. The blistering ratings are based on ASTM D714 with the numerical part of the rating denoting the size of the blister and the letter part of the rating indicating the frequency. The size of the blisters are based on a numerical scale from 10 to 0 with the number 10 designating no blistering. Blistering rating of 8, 6, 4, and 2 indicate a progressive increase in size. The frequency of the blisters is reported in four steps with the letter "D" designating dense, "MD" designating medium dense, "M" designating medium, and "F" designating few. For more information about this procedure and for

TABLE II

SALT FOG CHAMBER RESULTS (RUST GRADES/BLISTER RATINGS)

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336 HRS (2 WKS)	504 HRS (3 WKS)	672 HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
AMERON	WB-SFUNW	10/10	10/10	9/10	8.8/10	8.8/10	8.5110	8.5/10	8.5/10	8.5/10	8.5/10	8.5/10
400 EPOXY	NG-SFUNW	10/10	10/10	10110	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10110
AMERSHIELD	SD-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
	CGSFUNW	10/10	10/10	10/10	10/10	10/10	10110	10/10	10/10	10/10	10/10	10/10
	WB-SFWASH	10/10	10/10	9/10	9/10	8.8/10	8.5/10	8/10	8/8F	8/6F	8/6F	8/6F
	NGSFWASH	10/10	10/10	10/10	10/10	10/10	10/8F	10/8F	10/8M	10/6F	10/6F	10/6F
	SD-SFWASH	10/10	10/10	10/10	10/10	10110	10/10	10/10	10/10	10/10	10/10	10/10
	CG-SFWASH	10/10	10/10	10/10	10/10	10/10	9.8/10	9.5/10	9.5110	9.5/10	9.5/10	9.5/10

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336 HRS (2 WKS)	504 HRS (3 WKS)	672 HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	162O HRS (10 WKS)	2016 HRS (12 WKS)
AM-TEC	WB-SFUNW	10/10	9.5110	9.5/10	9.5110	9.5/6M	9.5/6M	9.5/4M	9.5/4M	9.5/4M	9.5/4M	9.5/4M
LI-P M.C. URETHANE	NG-SFUNW	10/10	9.5110	9.5110	9.5110	9.5/10	9.5/10	9.5/8F	9.5/8F	9.5/8F	9.5/8F	9.3/8F
LI -C TOPCOAT	SD-SFUNW	10/10	10/10	9.8/10	9.8/10	9.8/6F	9.8/6F	9.8/6F	9.8/6F	9.8/6F	9.5/6F	9.5/6F
	CG-SFUNW	10/10	9.8110	9.5110	9.5/10	9.3110	9.3110	9.3/10	9.3110	9.3/10	9.3/10	9/10
	WB-SFWASH	10/10	10/10	10/10	9.5110	9.5/8F	9.5/6M	9.5/6M	9.5/6M	9.5/6M	9.5/6M	9.5/6M
	NG-SFWASH	10/10	10/10	10110	10/10	10/10	10110	9.8110	9.8/10	9.8/10	9.8/10	9.5110
	SD-SFWASH	10/10	10/10	10/10	9.8/10	9.5110	9.5/10	9.5/10	9.5/10	9.5/10	9.5/10	9.5110
	CG-SFWASH	10/10	10/10	9.8/10	9.8/10	9.8/10	9.8/10	9.8/10	9.8/10	9.8/10	9.8/10	9.5/10

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336 HRS (2 WKS)	504 HRS (3 WKS)	672 HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
CARBOLINE	WB-SFUNW	10110	9.5/6F	8.5/6F	8.3/6F	7.5/6F	7.5/6F	6.8/6F	6.8/6F	< 6	< 6	< 6
CARBOMASTIC 15 LO.	NG-SFUNW	10/10	10/10	10/10	10/10	9.5110	9.5/2F	9/2F	9/2F	8/2F	7.3/2F	7RF
D834 TOPCOAT	SD-SFUNW	10110	9.8/10	9.8/10	9.5/10	9.5110	9/4F	8.8/4F	8.3/4F	7.5/4F	7.5/4F	7.5/4F
	CGSFUNW	10/10	10/2F	10/2F	9.3/2F	9.3/2F	8.5/2F	8/2F	8/2F	7.3/2F	< 6	< 6
	WB-SFWASH	10/10	9.5/2F	9.5/2F	8.8/2F	8.8/2F	8.3/2F	7.8/2F	7.5/4M	7/4M	6.8/4M	< 6
	NG-SFWASH	10/10	10/2F	10/2F	9.5/2F	9.5/2F	9/2F	9/2F	8.8/2F	8/2F	7.5/2F	< 6
	SD-SFWASH	10/10	9.8/2F	9.8/2F	9.3/2F	9.3/2F	8.8/2F	8.5/2F	8.5/2F	8/2F	7.5/2F	6.8/2F
	CG-SFWASH	10110	9 . w	9.8/2F	9.3/2F	9.3/2F	8.8/2F	8.3/2F	8.3/2F	7.8/2F	7.5/2F	< 6

TABLE II (cont.)

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672 HRS (4WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620HRS (10 WKS)	2016 HRS (12 WKS)
CON-LUX	W-B-SFUNW	10/10	10/10	10/8M	9.3/8M	8.5/4MD	8.5/4MD	8.3/4MD	8.3/4MD	8.3/4MD	8.3/4MD	8.3/MD
81 EPOXY	NG-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/8F	9.5/8F	9.5/8F	9.5/8F	9.5/8F
200 TOPCOAT	SD-SFUNW	10/10	10/10	10/10	10/10	10/6F	10/6F	9.5/6F	9.5/6F	9.5/6F	9.5/6F	9.5/6F
	CG-SFUNW	10/10	10/10	10/10	10/10	10/10	10/8F	10/8F	10/8F	10/8F	10/8F	10/8M
	WB-SFWASH	10/10	10/10	9.8/8F	9.5/8F	9.5/6F	9.3/6M	8.8/6MD	8.5/4MD	8.5/4MD	8.5/4MD	8.5/4MD
	NG-SFWASH	10/10	10/10	10/10	10/10	10/8F	10/8F	9.5/8M	8.8/8M	8.8/8M	8.8/8M	8.8/8M
	SD-SFWASH	10/10	10/10	10/10	10/10	9.5/8M	9.5/6M	9/6M	8.5/4M	8.5/4M	8.5/4M	8.5/4M
	CG-SFWASH	10/10	10/10	10/10	10/10	9.8/6F	9.8/6F	9.8/6M	9.5/6M	9.5/6M	9.5/6M	9.5/6M

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
DEVOE	WB-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
467 PRE-PRIME	NG-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
235 EPOXY	SD-SFUNW	10/10	10/10	10/10	10/10	10/6F	10/6F	10/6F	10/6F	10/6F	10/6F	10/6F
359 TOPCOAT	CG-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/8F	10/6F	10/6F	10/6F
	WB-SFWASH	10/10	10/10	10/10	10/10	10/10	10/4F	10/4F	10/4F	10/4F	10/4F	10/2F
	NG-SFWASH	10/10	10/10	10/10	10/10	9.8/10	9.8/4F	9.8/4F	9.5/4F	9.5/4F	9.5/4F	9.5/4F
	SD-SFWASH	10/10	10/10	10/10	10/10	10/10	10/4F	10/4F	10/4F	10/4F	10/4F	10/4F
	CG-SFWASH	10/10	10/10	10/10	10/10	10/10	10/4F	10/4F	10/4F	10/2F	10/2F	10/2F

MANUFACTURER	PREPARATION	24 HRS	48HRS	72 HRS	168HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
DEVOE	WB-SFUNW	10/10	10/10	9/10	9/10	8.5/10	8.5/10	8.5/8F	8.5/8M	8.5/8M	8.5/8M	8.5/8M
235 EPOXY	NG-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10110	10/10	10/10
359 TOPCOAT	SD-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/8F	10/8F	10/8F	10/8F
	CG-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
	WB-SFWASH	10/10	10/10	8/10	8/10	8/10	7.5/10	7.5110	7.5/8M	7.5/8M	7.5/8M	7.5/8M
	NG-SFWASH	10/10	10/10	10/10	9.8/10	9.5/10	9.5/10	9.5/10	9.5/10	9.5/10	9.5/10	9.3/10
	SD-SFWASH	10/10	10/10	10/10	10/10	9.8/10	9.8/10	9.8110	9.5110	9.5/10	9.5/8F	9.5/8F
	CG-SFWASH	10/10	10/10	9.8/10	9.5/10	9.5/10	9.5/10	9.3/10	9/10	9/10	9/10	9/10

TABLE II **(cont.)**

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620HRS (10 WKS)	2016 HRS (12 WKS)
DUPONT	WB-SFUNW	10/8M	9.25/8M	8.5/8M	8.5/6M	7.5/4F	7.5/4F	7.5/4M	7.3/4M	7.3/4M	7.3/4M	7.3/4M
62ZF EPOXY ZINC	NG-SFUNW	10/8F	10/8F	10/8F	9.8/8F	9.8/8M	9.3/8M	9.3/8M	9.3/8M	9.3/8M	9/8M	8.8/8M
326 TOPCOAT	SD-SFUNW	10/8M	10/8M	10/8M	9.5/8M	9.5/6M	9.5/6MD	9.5/6MD	9.5/6MD	9.5/6MD	9.5/6MD	9.3/6MD
	CG-SFUNW	10/8M	9.8/8M	9.8/8M	9.8/8M	9.8/6M	9.5/6MD	9.5/6MD	9.5/6MD	9.5/6MD	9.5/6MD	9.3/6MD
	WB-SFWASH	10/8F	9.8/8F	9.3/8F	9.3/8M	9/6M	8.5/6M	8.5/4M	8.5/4M	8.5/4M	8.5/4M	8.5/4M
	NG-SFWASH	10/8M	9.3/8M	8.8/8M	8.8/8M	8.8/6M	8.8/6M	8.8/6M	8.8/6M	8.8/6M	8.8/6M	8.5/6M
	SD-SFWASH	9.8/8MD	9.5/8MD	9/8MD	9/8MD	8.5/8MD	8.5/8MD	8.5/6M	8.5/6M	8.5/6M	8.5/6M	8.5/6M
	CG-SFWASH	10/8M	9.8/8MD	9.8/8MD	9.8/8MD	9.8/8MD	9.8/8MD	9.8/8MD	9.8/8MD	9.8/8MD	9.8/8MD	9.8/8MD

MANUFACTURER	PREPARATION	24HRS	48 HRS	72 **HRS**	168HRS **(1 WK)**	336HRS (2 WKS)	**504 HRS** (3 WKS)	672HRS (4WKS)	1008 HRS **(6 WKS)**	1344 **HRS** (8 WKS)	1620 HRS (10 WKS)	2016 **HRS** (12 WKS)
DUPONT	WB-SFUNW	10/10	10/10	10/10	10/10	9.8110	9.8/8F	9.8/6M	9.8/6MD	9.8/4MD	9.8/4MD	9.8/2MD
25P EPOXY	NG-SFUNW	10/10	10/10	10/10	9.8/10	9.8110	9.8110	9.75110	9.8/6M	9.8/6MD	9.8/6MD	9.8/4MD
326 TOPCOAT	**SD-SFUNW**	10/10	10/10	10/10	10/10	10/10	10/10	10/8M	10/6M	10/6MD	10/6MD	10/6MD
	CG-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/6M	10/6M	10/4M
	WB-SFWASH	10/10	10/10	10110	9.8/10	9.8/10	9.8/10	9.8110	9.8/2F	9.8/2F	9.75/2F	9.8/2F
	NG-SFWASH	10/10	9.8/10	9.8/10	9.8/10	9.5110	9.5/10	9.5110	9.5110	9.5110	9.5/10	9.5110
	SD-SFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9.8110	9.8/10	9.8110	9.8110
	CG-SFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9.8110	9.8/10

MANUFACTURER	PREPARATION	24HRS	48 **HRS**	72 HRS	168HRS (1 WK)	336HRS (2 **WKS)**	**504 HRS** (3 **WKS)**	672HRS **(4 WKS)**	1008 HRS **(6 WKS)**	1344 **HRS** (8 WKS)	1620 **HRS** (10 WKS)	2016 HRS (12 WKS)
ELITE	WB-SFUNW	10/10	10/10	10/10	10/10	9.8/10	9.8110	9.5110	9.5110	9.3/8F	9/8F	8.8/6M
7510 EPOXY	NG-SFUNW	10/10	10/10	10/10	10/10	9.8110	9.8/10	9.8/10	9.5/10	9.5110	9.5/8F	9.5/8F
4040 TOPCOAT	SD-SFUNW	10/10	10/10	10/10	9.8110	9.8110	9.5/10	9.3110	9.3110	9/10	9/10	8.8/10
	CG-SFUNW	10/10	10/10	10/10	9.8110	9.8/10	9.8110	9.8110	9.5/10	9.5110	9.3/10	9.3/10
	WB-SFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9.5110	9.5/10	9.5110
	NG-SFWASH	10/10	10/10	10/10	10/10	10/10	9.8110	9.8110	9.5/10	9.5110	9.3/10	93110
	SD-SFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9.8110	9.8110	9.5/10	9.3/10
	CGSFWASH	10/10	10/10	10/10	9.8110	9.8110	9.5/10	9.5110	9.5/10	9.5110	9.5/10	9.3110

TABLE II (cont.)

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672 HRS (4 WKS)	1008 HRS (6 WKS)	1344HRS (8 WKS)	1620HRS (10 WKS)	2016HRS (12 WKS)
ENGARD	WB-SFUNW	10/10	9.5110	9.5110	9.8110	9.8110	8.3/8F	8/8F	8/8F	8/8F	8/8F	7.8/8F
473 EPOXY	NG-SFUNW	10/10	9.5110 9.8110	9.8110	9.8110			8.8110	8.8110	8.5110	8.25/10	8.3110
428HS TOPCOAT	SD-SFUNW	10/10	10/10	10/10	9.5110	9.5/10	9.8110	9.5/8M	9.3/8M	9.3/8M	9.3/8M	9.3/8M
	CG-SFUNW	10/10	9.110	9.5110	9.5110	9.5110	9.5110	9.3/6M	9/6M	9/6M	9/6M	8.5/6M
	WB-SFWASH	10/10	10/10	10/10	10/10	10/10	9/10	8.5110	8.5110	8.3110	8.3110	7.5/2F
	NG-SFWASH	10/10					9.8110	9.8110	9.5110	9.5110	9.5110	9/10
	SD-SFWASH	10/10	10/10	10/10	10/10	10/10	9.8110	9.8110	9.8110	9.8110	9.5110	9.5110
	CG-SFWASH	10/10	10/10	10/10	9.3110	9.5110	9.5110	9.5110	9.5/10	9.5110	9.5110	9.5/10

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336 HRS (2 WKS)	504 HRS (3 WKS)	672 HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
HEMPEL #1	WB-SFUNW	10/10	9/6F	9/6F	8/6F	8/6F	8/6M	8/6MD	8/6MD	7.3/6MD	7.3/6MD	7/6MD
4514 EPOXY	NG-SFUNW	10/10	9.5110	9.5110	8.8/8F	8.8/8F	8.3/8F	8.3/8M	8/8M	7.3/8M	7.3/8M	< 6
508U TOPCOAT	SD-SFUNW	10/10	9.8110	9.5/10	9/8F	9/8F	9/8F	8.8/8F	8.8/8F	8.5/8F	8.3/8F	8/8F
	CG-SFUNW	10/10	9.5110	9.5110	8.5/8F	8.5/8F	8/8F	8/8F	8/8F	8/8F	7.5/8F	7/8F
	WB-SFWASH	10/10	9.8/6F	9.5/6F	8.8/6M	8.3/6M	8.2/6M	7.8/6M	7.3/6M	7/6M	< 6	< 6
	NG-SFWASH	10/10	9.8110	9.5110	8.5/8F	8.8/8F	8.8/6F	8.5/6M	8.5/6M	8.5/6M	8.3/6M	7.8/6M
	SD-SFWASH	10/10	9.5110	9.5110	9.5110	9.5/10	9.5/8M	9.5/8M	9.5/8M	9.3/8M	9.3/8M	8.8/8M
	CG-SFWASH	10/10	9.3110	9.3110	8.8/8F	8.8/8F	8.5/8F	8.5/8M	8.5/8M	8.3/8M	8.3/8M	8/8M

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4 WKS)	1008 HRS (6 WKS)	1344HRS (8 WKS)	1620HRS (10 WKS)	2016 HRS (12 WKS)
HEMPEL #2	WB-SFUNW	10/10	9.5110	9/10	8.8110	8.5/10	8.5/4F	8.5/4F	8/4F	7.5/4F	6.8/4F	6.8/4F
4515 EPOXY	NG-SFUNW	10/10	9.5110	9.3110	9/8M	9/8M	8.5/8M	8/8M	7.5/8M	7.3/8M	6.8/8M	< 6
5528 TOPCOAT	SD-SFUNW	10/10	9.5/10	9.5110	9/10	9/10	8.8/6M	8.8/6M	8.5/6M	8.3/6M	8/6M	7.8/6M
	CG-SFUNW	10/10	9.8110	9.8/10	9.5/4F	9.5/4F	9/4M	8.8/4M	8.8/4M	8.3/4M	7.5/4M	7/4M
	WB-SFWASH	10/10	9.8110	9.8110	9.5/4F	9/4F	9/4M	8.5/4M	8.5/4M	8/4M	7.8/4M	7/4M
	NG-SFWASH	10/10	9.8110	9.8110	9.5/8F	9.3/8F	9.3/8M	9/8M	8.8/8M	8.5/8M	8/8M	7.8/8M
	SD-SFWASH	10/10	10/10	10/10	9.5/8M	9.5/8M	9.3/8M	9/6M	9/6M	8.8/6M	8.8/6M	8.5/6M
	CG-SFWASH	10/10	10/10	9.8110	9.8/6M	9.8/6M	9.3/6M	9/6M	8.8/6M	8.5/6M	8.5/6M	8.3/6M

TABLE II (cont.)

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336 HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620HRS (10 WKS)	2016 HRS (12 WKS)
LOCTITE EXTEND CONVERTER WITH DEVOE 359	WB-SFUNW	10/8M	8.8/8M	8.5/8M	8.5/4F	8.5/4F	8.5/6M	8.5/6M	8.5/6M	8.3/6M	7.8/6M	7.5/6M
	NG-SFUNW	10/8M	9.3/8M	9/8M	9/6M	9/6M	9/6M	9/6M	8.8/6M	8.3/6MD	7.8/6MD	7.5/6MD
	SD-SFUNW	10/8M	9/8M	9/8M	9/6M	9/6M	9/6M	8.8/6M	8.5/6M	7.8/6MD	7.3/6MD	7/6D
	CG-SFUNW	10/8M	8/8M	8/8M	8/6M	8/6M	8/6M	8/6M	8/6M	7/6MD	6/6MD	6/6D
	WB-SFWASH	10/8M	9/8M	8.8/8M	8.8/8M	8.8/8M	8.8/8M	8.8/8M	8/8M	7.5/8M	7.5/8M	7/8M
	NG-SFWASH	10/8M	9.5/8M	9.3/8M	9.3/8M	9.3/8M	9/8M	9/8M	8/8M	7.5/6M	7/6M	6.3/6M
	SD-SFWASH	10/8M	9/8M	8.8/8M	8.5/8M	8.5/8M	8.5/8M	8.5/8M	8.5/8M	8/6M	7.5/6M	7/6M
	CG-SFWASH	10/8M	9.8/8M	9.8/8M	9.8/8M	9.5/8M	9.3/8M	9.3/8M	9/8M	8.3/8M	7.5/8M	7/8M

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
MOMAR PROTECT-AL M.C. URETHANE DEVOE 359	WB-SFUNW	10/10	9/8F	8/8M	7.8/8M	7/6M	7/6M	7/6M	7/6M	< 6	< 6	< 6
	NG-SFUNW	10/10	8.5/8F	8/8M	8/8M	7/6M	7/6M	6.8/6M	6.8/6M	< 6	< 6	< 6
	SD-SFUNW	10/10	10/8F	9.5/8F	9.5/8F	8.3/6M	8.3/6M	8.3/6M	8/6M	< 6	< 6	< 6
	CG-SFUNW	10/10	9.5/8F	9/8F	9/8F	8.5/6M	8.5/6M	8.5/6M	8/6M	< 6	< 6	< 6
	WB-SFWASH	10/10	10/10	9.8110	9.8/10	9.3110	9.3110	9.3/8F	8.3/8F	< 6	< 6	< 6
	NG-SFWASH	10/10	10/10	9.8110	9.8/10	9.3110	9.3110	9/8F	8.3/8F	< 6	< 6	< 6
	SD-SFWASH	10/10	10/10	10/10	10/10	9.5/10	9.5/10	9.5/8F	8.5/8F	< 6	< 6	< 6
	CG-SFWASH	10/10	10/10	10/8F	10/8F	9.5/8F	9.5110	9.5110	9/8F	< 6	< 6	< 6

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
MP-7 CONVERTER DEVOE 235HS/359	WB-SFUNW	10/10	10/8F	10/8F	10/8F	9.8/8F	9.8/8F	9.8/8F	9.5/6F	9/6MD	8.5/6MD	8/6MD
	NG-SFUNW	10/10	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F	9.3/8F	9/8F	9/8F
	SD-SFUNW	10/10	10/8F	10/8F	10/8F	9.8/8F	9.8/8F	9.5/8F	9.5/8F	9/6F	8.8/4F	8.8/F
	CG-SFUNW	10/10	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F	10/6F	9.5/6F	9.5/6F	9.3/6F
	WB-SFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9.8110	9.5/8F	9/8F
	NG-SFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9.5110	9.3/10	9/10
	SD-SFWASH	10/10	10/10	10/10	10/10	10/10	10/10	9.8110	9.5110	9/8F	9/8F	8.8/8F
	CGSFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9/8F	9/8F	9/8F

TABLE II (cont.)

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336 HRS (2 WKS)	504 HRS (3 WKS)	672 HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
NEUTRA-RUST	WB-SFUNW	10/8M	7.5/8M	6.8/8M	6.8/8M	6.8/8M	6.3/8M	c 6	< 6	< 6	< 6	< 6
CONVERTER	NG-SFUNW	10/8M	7.3/8M	6.8/8M	6.8/8M	6/8M	< 6	< 6	< 6	< 6	< 6	< 6
WITH DEVOE 359	SD-SFUNW	10/8M	7.3/8M	7/8M	7/8M	6.5/8M	6.3/8M	< 6	< 6	< 6	< 6	< 6
	CG-SFUNW	10/8M	7.8/8M	7.5/8M	7.5/8M	7.5/8M	7/8M	< 6	< 6	< 6	< 6	< 6
	WB-SFWASH	10/8M	7/8M	6.5/8M	6.5/8M	6.5/8M	6.3/8M	< 6	< 6	< 6	< 6	< 6
	NG-SFWASH	10/8M	7.3/8M	6.8/8M	6.5/8M	6.5/8M	6.5/8M	< 6	< 6	< 6	< 6	< 6
	SD-SFWASH	10/8M	7.3/8M	6.8/8M	6.8/8M	6.8/8M	6.3/8M	< 6	< 6	< 6	< 6	< 6
	CG-SFWASH	10/8M	7.8/8M	7.5/8M	7.5/8M	7.5/8M	7.3/8M	< 6	< 6	< 6	< 6	< 6

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72HRS	168HRS (1 WK)	336 HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
PLASITE	WB-SFUNW	10/10	9.5110	9/10	8/10	8/10	7/10	< 6	< 6	< 6	< 6	< 6
C-720 EPOXY	NG-SFUNW	10/10	9.8110	9.8110	9.8110	9.8110	9.3/4F	8.8/4F	8/4F	7.3/4F	6.8/4F	6.8/4F
2089 TOPCOAT	SD-SFUNW	10/10	9.5/10	9.5110	9/10	9/10	8/2F	7.5/2F	7/2F	< 6	< 6	< 6
	CG-SFUNW	10/10	10/10	10/10	9.5110	9.5110	9.3/6M	9/6M	8.8/6M	8.3/6M	8.3/6M	7.5/6M
	WB-SFWASH	10/10	9.5110	9.3110	8.8110	8.78/10	8/8M	7.8/8M	7.8/8M	7.5/8M	7.5/8M	7/6M
	NG-SFWASH	10/10	10/10	10/10	10/2F	10/2F	9.5/2F	9.5/2F	9.5/2F	9.3/2F	9.3/2F	9.3/2F
	SD-SFWASH	10/10	10/10	10/10	9.8/8MD	9.8/8MD	9.5/8MD	9.3/8MD	9.3/8MD	9/8MD	9/8MD	8.5/6MD
	CG-SFWASH	10/10	10/10	10/10	9.8/8MD	9.8/8MD	9.8/8MD	9.5/8MD	9.5/8MD	9.5/8MD	9.5/8MD	9.5/8MD

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672 HRS (4WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
PORTER	**WB-SFUNW**	10/10	9.5110	9.3110	9/10	8.5110	8.3/6F	8.3/6F	8/6F	7.5/6F	6.8/6F	6.8/6F
7900 EPOXY	NG-SFUNW	10/10	10/10	9.8110	9.5110	9.3110	9/10	9/10	8.8110	8.5110	8.5/10	7.8/8F
XP91-556A TOPCOAT	SD-SFUNW	10/10	10/10	10/10	9.8110	9.5/10	9.5/8F	9.3/8F	9/10	9/8F	9/8F	9/6M
	CG-SFUNW	10/10	10/10	10/10	9.5110	9.5/10	9.3/10	9/6F	9/6F	9/6F	9/6F	8.8/6F
	WB-SFWASH	10/10	9.3110	9.3110	8.8110	8.8110	7.5/10	7/10	< 6	< 6	< 6	< 6
	NGSFWASH	10/10	10/10	10/10	10/10	10/10	9.8110	9.3110	8.8110	8.3/10	8.3/10	7.3/8F
	SDSFWASH	10/10	9.8/10	9.8110	9.5/10	9.5/10	9.5/4F	9.5/4F	9.3/4F	9/4F	9/4F	8.5/4F
	CG-SFWASH	10/10	10/10	10/10	9.8110	9.8110	9.3/6M	9.3/6M	9.3/6M	8.8/6M	8.8/6M	8.5/6M

TABLE II (cont.)

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72HRS	168HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620HRS (10 WKS)	2016 HRS (12 WKS)
PPG	WB-SFUNW	10/10	10/10	10/10	9.8110	9.8110	9.8/10	9.8110	9.5110	9.5110	9.5110	9.5110
97-149 DTR EPOXY	NG-SFUNW	10/10	10/10	9.8110	9.5110	9.5110	9.3110	9/10	9/10	9/6F	9/4F	9/4F
97-812 TOPCOAT	SD-SFUNW	10/10	10/10	10/10	10/10	10/10	9.8/10	9.8110	9.8110	9.8110	9.8/6F	9.8/6F
	CG-SFUNW	10/10	10/10	10/10	10/10	9.8110	9.8110	9.8110	9.8110	9.8/10	9.8110	9.8/10
	WB-SFWASH	10/10	10/10	9.8110	9.5110	9.5110	9.5110	9.5110	9.5/4F	9.3/4F	9.3/2F	9/2F
	NGSFWASH	10/10	10/10	10/10	10/10	9.8110	9.8110	9.8110	9.3110	9.3110	9.3/10	9.3110
	SD-SFWASH	10/10	10/10	10/10	10/10	9.8110	9.8/10	9.8/4F	9.8/4F	9.8/2F	9.8/2F	9.8/2F
	CG-SFWASH	10/10	10/10	10/10	10/10	10/10	10/2F	10/2F	10/2F	10/2F	10/2F	9.8/2F

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
RENEW CONVERTER	WB-SFUNW	10/10	8.3/8M	8/8M	8/8M	8/8M	8/8M	8/8M	7.8/8M	7/6M	< 6	< 6
WITH	NG-SFUNW	10/10	8.3/8M	8.3/8M	8/8M	8/8M	8/8M	8/8M	7.8/8M	7.3/8M	< 6	< 6
DEVOE 359	SD-SFUNW	10/10	8.3/8M	8/8M	7.8/8M	7.5/8M	7.5/8M	7.5/8M	7.3/8M	7/8M	< 6	< 6
	CG-SFUNW	10/10	8/8M	7.8/8M	7.8/8M	7.8/8M	7.8/8M	7.8/8M	7.3/8M	7/8M	< 6	< 6
	WB-SF-WASH	10/10	8.5/8M	8.5/8M	8/8M	8/8M	8/8M	8/8M	8/8M	7/4MD	< 6	< 6
	NG-SFWASH	10/10	8/8M	8/8M	8/8M	8/8M	8/8M	8/8M	7.5/8M	7/6M	< 6	< 6
	SD-SFWASH	10/10	8/8M	8/8M	8/8M	8/8M	8/8M	8/8M	7.5/8M	7/8M	< 6	< 6
	CG-SFWASH	10/10	8.5/8M	8/8M	8/8M	8/8M	8/8M	8/8M	8/8M	7.5/8M	< 6	< 6

MANUFACTURER	PREPARATION	24HRS	48 HRS	72 HRS	168 HRS (1 WK)	336 HRS (2 WKS)	504 HRS (3 WKS)	672 HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
RUST TRANSFORMER	WB-SFUNW	10/10	10/10	10/10	10/10	10/10	10/8F	10/6F	10/4F	9.5/6M	9.3/6M	9/6MD
WITH	NG-SFUNW	10/10	10/10	10/10	10/10	10/10	10/8F	10/6F	9.8/6F	9.3/6M	9/6M	8.8/6MD
DEVOE 235HS/359	SD-SFUNW	10/10	10/10	10/10	10/10	10/10	10/8F	10/8F	10/8F	9.5/8F	9.3/8F	8.8/8MD
	CG-SFUNW	10/10	10/10	10/10	10110	10/10	10/8F	10/8F	10/6F	9.5/6F	9/6F	8.5/6MD
	WB-SFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9.5110	9.5/8F	9/8F
	NG-SFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9.3110	9/10	9/10
	SD-SFWASH	10/10	10/10	10/10	10/10	10/10	10110	10/10	10/10	9.5110	9.5/10	9.3/10
	CGSFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9.5110	9.5/10	9.3/10

TABLE 11 (cont.)

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4WKS)	1008 HRS (6 WKS)	1344HRs (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
SHERWIN-WILLIAMS	WB-SFUNW	10/10	10/10	10/10	9.8/10	9.5/10	9.3/10	9.3/6F	9.3/4F	9.3/4F	9.3/4M	9.3/4M
B58 EPOXY	NG-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/8F	9.8/8F	9.8/8F	9.8/8M	9.8/8M
B65 TOPCOAT	SD-SFUNW	10/10	10/10	10/10	10/10	9.8/10	9.8/10	9.8/8F	9.5/8F	9.5/6F	9.5/6M	9.5/6M
	CG-SFUNW	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	9.8/10	9.8/2F	9.8/2F
	WB-SFWASH	10/10	10/10	10/10	10/10	9.8/6F	9.5/6M	9.3/4M	9.3/4MD	9/2MD	9/2MD	8.5/2MD
	NG-SFWASH	10/10	10/10	10/10	10/10	10/10	10/6F	10/6F	10/6M	9.8/6MD	9.5/6MD	9.5/6MD
	SD-SFWASH	10/10	10/10	10/10	10/10	10/10	10/6F	9.8/6M	9.8/4M	9.8/4MD	9.5/4MD	9.5/4MD
	CG-SFWASH	10/10	10/10	10/10	10/10	10/10	10/4F	10/2F	10/2F	10/2F	10/2F	10/2F

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
SIGMA	WB-SFUNW	10/10	10/8F	10/8F	10/8F	10/4F	10/2F	10/2F	10/2F	10/2F	10/2F	10/2F
7476 EPOXY	NG-SFUNW	10/10	10/8F	10/8F	10/8F	10/6F	10/4F	10/2F	10/2F	10/2F	10/2F	10/2F
5523 TOPCOAT	SD-SFUNW	10/10	10/8F	10/8F	10/8F	10/4F	10/4F	10/2F	10/2F	10/2F	10/2F	10/2F
	CG-SFUNW	10/10	10/8F	10/8F	10/8F	10/6F	10/4F	10/2F	10/2F	10/2F	10/2F	10/2F
	WB-SFWASH	10/10	10/10	10/10	10/10	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F
	NG-SFWASH	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
	SD-SFWASH	10/10	10/10	10/8F	10/8F	10/8F	10/6F	10/6F	10/6F	10/6F	10/6F	10/6F
	CG-SFWASH	10/10	10/10	10/10	10/10	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4 WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
SOUTHERN COATINGS	WB-SFUNW	10/10	10/10	9.5/10	9.5/8F	9.5/4F	9.5/2M	9.5/2M	9.5/2M	9.3/2M	9.25/2M	9.3/al
645 EPOXY	NG-SFUNW	10/10	10/10	10/10	10/10	10/6F	10/4F	10/4F	10/4F	10/4F	10/4F	9.8/4F
270 TOPCOAT	SD-SFUNW	10/10	10/10	10/8F	9.8/8F	9.8/4M	9.8/4M	9.8/4M	9.8/4M	9.5/4M	9.5/4M	9.5/4M
	CG-SFUNW	10/10	10/10	10/8F	10/8F	10/6F	10/6M	10/6M	9.8/6M	9.8/6M	9.8/6M	9.8/6M
	WB-SFWASH	10/10	10/10	9.5/8F	9/8F	9/8F	9/8M	9/8M	9.3/6M	9.3/6M	9.3/6M	9.3/6M
	NG-SFWASH	10/10	10/10	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F	10/6F	10/6F
	SD-SFWASH	10/10	10/10	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F	10/6F	10/6F	10/6F
	CG-SFWASH	10/10	10/10	10/8F	10/8F	10/8F	10/8F	10/8F	10/8F	10/6F	10/6F	10/6F

TABLE II (cont.)

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4WKS)	loos HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
TNEMEC #1	WB-SFUNW	10/10	9.8/10	9.5110	9.3110	9.3/8M	9.3/8M	9.3/8M	9.3/6F	8.8/6F	8.5/4F	8.5/4F
135 EPOXY	NG-SFUNW	10/10	10/10	10/10	9.5110	9.3/8F	9/8F	9/8MD	9/8MD	8.8/8MD	8.8/8MD	8.8/8MD
74 TOPCOAT	SD-SFUNW	10/10	9.8/10	9.5110	9.3110	9.3110	9.3110	9.3/8M	9.3/8M	9/8M	9/8M	8.5/8M
	CG-SFUNW	10/10	9.8/10	9.8/10	9.8110	9.5/10	9.3110	9.3/8MD	9.3/8MD	9/8MD	8.5/8MD	8.3/8MD
	WB-SFWASH	10/10	9.8110	9.5/10	9.3110	9.3110	9.3/10	9.3/8MD	9.3/8MD	9/8MD	8.8/8MD	8.3/8MD
	NG-SFWASH	10/10	10/10	9.8/10	9.8/10	9.8/10	9.8/10	9.5/8M	9.5/8M	9/8M	8.75/8M	8.3/8M
	SD-SFWASH	10/10	9.8110	9.8/10	9.5110	9.5/10	9.3110	9.3/8F	9.3/6F	9/6F	9/6F	8.5/6F
	CG-SFWASH	10/10	10/10	9.8/10	9.5110	9.5/10	9.3/10	9.3/8F	9.3/8F	8.8/8F	8.5/8F	8.3/8F

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336 HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4 WKS)	loo8 HRS (6 WKS)	1344 HRS (8 WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
TNEMEC #2	WB-SFUNW	10/10	9.8/10	9.5110	9.3/6M	9/4M	8.8/4M	8.3/4M	7.3/4M	< 6	< 6	< 6
50-330	NG-SFUNW	10/10	9.5110	9.5/10	9.3/8M	9/8M	8.5/8M	8/8M	6.8/8M	< 6	< 6	< 6
M.C. URETHANE	SD-SFUNW	10/10	9.8/10	9.8/10	9.5/8M	9.5/8M	9/8M	8.5/6M	7.3/6M	< 6	< 6	< 6
74 TOPCOAT	CG-SFUNW	10/10	9.8110	9.5/10	9.5/8F	9.3/8F	8.8/8F	8.5/8M	8/8M	7.3/8M	< 6	< 6
	WB-SFWASH	10/10	10/10	10/10	10/6F	9.8/6F	9.5/6F	9/6F	8.3/6F	7.5/6F	< 6	< 6
	NG-SFWASH	10/10	10/10	10/10	10/8M	9.5/8M	9.5/8M	9.3/8M	8.8/8M	7.5/8M	< 6	< 6
	SD-SFWASH	10/10	10/10	9.8/10	9.8/10	9.3110	9/10	9/10	8.5/10	7.5/8M	6.8/8M	< 6
	CG-SFWASH	10/10	10/10	10/10	10/10	9.3110	9.25/10	9.3/8F	8.8/8F	8.3/8F	7.8/6F	7.3/6F

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72HRs	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672HRS (4WKS)	1008 HRS (6 WKS)	1344 HRS (a WKS)	1620 HRS (10 WKS)	2016 HRS (12 WKS)
XYMAX #1	WB-SFUNW	10/10	10/6F	10/6F	9/6F	9/6M	9/6M	9/6M	8.5/6M	8/6M	7/6M	< 6
CORROSTABIL PRIMER	NG-SFUNW	10/10	9.5/10	9.5110	8.8/10	8.3/10	8.3/8M	8.3/8M	7.5/8M	6.8/8M	< 6	< 6
C-4-100 TOPCOAT	SD-SFUNW	10/10	9.8/6F	9.8/6F	9.3/6F	9.3/6F	9.3/6F	9/6M	8.5/6M	8/6M	7.3/6M	6.8/6M
	CG-SFUNW	10/10	9.5/10	9.5110	8.8/6F	8.8/6F	8.8/6F	8.5/6M	8.5/6M	7.5/6M	7/6M	6.8/6M
	WB-SFWASH	10/10	9.8/6F	9.8/6F	9.5/6F	9.3/6F	9.3/6F	9/6M	8.8/6M	8/6M	7.3/6M	6./6M
	NG-SFWASH	10/10	9.8/10	9.8/10	8.5/10	8.5/10	8.3/10	8/8M	7.8/8M	7/8M	< 6	< 6
	SD-SFWASH	10/10	10/10	10/10	9.5/8F	9.3/8F	9.3/8F	9/8F	8.8/8F	8.5/8F	7.8/8F	7.5/8F
	CG-SFWASH	10/10	10/10	10/10	9.8/8M	9.3/8M	8.8/8M	8.8/8M	8.8/8M	8.3/8M	7.3/8M	6.8/8M

TABLE II (cont.)

MANUFACTURER	PREPARATION	24 HRS	48 HRS	72 HRS	168 HRS (1 WK)	336HRS (2 WKS)	504 HRS (3 WKS)	672 HRS (4WKS)	1008 HRS (6 WKS)	1344 HRS (8 WKS)	1620HRS (10 WKS)	2016 HRS (12 WKS)
XYMAX #2	WB-SFUNW	10/10	9/2F	8.8/2F	7.5/2M	7.5/2M	7.5/2M	7.3/2M	7.3/2M	6.8/2M	6.8/2M	< 6
PUR-PR-PRIMER	NG-SFUNW	10/10	9.5110	9.5110	9/6F	9/6F	9/6F	9/6F	9/6F	9/6F	8.5/6F	8.5/6F
PURCOVER TOPCOAT	SD-SFUNW	10/10	10/4F	10/4F	9.5/4F	9.5/4F	9.3/4F	9/4F	9/4F	8.5/4F	8.3/4F	8.3/4F
	CG-SFUNW	10/10	9.3/4F	9.3/4F	8.8/4F	8.8/4F	8.8/4F	8.8/4F	8.8/4F	8.5/4F	8.5/4F	8.5/4F
	WB-SFWASH	10/10	9.3/6M	9.3/6M	8.8/6M	8.8/6M	8.5/6M	8.3/6M	8.3/6M	8/6M	7.5/6M	7/6M
	NG-SFWASH	10/10	10/10	10/10	10/8M	9.8/8M	9.8/8M	9.8/8M	9.3/8M	9.3/8M	8.8/8M	8.8/8M
	SD-SFWASH	10/10	10/8D	10/8D	10/8D	10/8D	9.5/8D	9.3/8D	9.3/8D	9.3/8D	9.3/8D	9.3/8D
	CG-SFWASH	10/10	10/8D	10/8D	9.5/8D	9.5/68D	9.5/8D	9.5/8D	9.5/8D	9.5/8D	9.3/8D	9/6D

Note: Example of rating - **9.5/6F**
9.5 - Corrosion Rating
6 - Medium Size Blisters
F - Few Blisters

the pictorial representation of the various steps, refer to the complete ASTM Standard.

5.1.2 The performance of the coating systems can be broken down to the generic types of materials and separately discussed.

5.1.2.1 Epoxy Mastic/Urethane - This generic class of coating system dominated the overall percentage of material combinations submitted for testing. Of the 28 coating systems tested, 16 systems consisted of the epoxy mastic type primer followed by a high build aliphatic polyurethane topcoat. As the salt fog exposure data shows, these high build, thick film (10-15 mils DFT) materials display good corrosion protection over marginally prepared carbon steel surfaces. Most notably the Ameron 400/Amershield, Devoe 467/235/359, DuPont 25P/326, Sigma 7476/5523, and Southern 645/270 systems exhibited excellent protection with all panels rating higher than a "9" for all surface preparations after over 2000 hours in the salt fog chamber. However, several materials such as the Carboline Carbomastic 15 Low Odor/D834, Hempel 4515/5528, and Plasite C-720/2089 systems displayed unacceptable performance with many panels rating <6 after the salt fog exposure. This result shows that the performance of this class of materials is product specific and they must be chosen carefully to obtain the higher performing materials required for long term protection of KSC launch structures and ground support equipment.

5.1.2.2 Chemical Conversion Products - As a class, these materials performed poorly in the salt fog testing and most did not qualify for testing at the KSC Beach Corrosion Site. The three common tannate conversion/primer materials such as Loctite EXTEND, Neutra-Rust 661, and Packard RENEW did not provide acceptable performance in the 2000 hour salt fog screening test with most of the panels rating <6 after exposure. However, two materials, Coulter MP-7 and Chesterton

NR-763, did perform well enough to be included in the beach exposure testing. The MP-7 material is a thin, acid based material used to prepare the rusted substrate for further coating. The Chesterton NR-763, more commonly known as "Rust Transformer", is a thin, tannic acid based conversion coating used to form iron tannates on the rusted steel surface to provide reported corrosion protection. Both of these products allowed the application of a epoxy mastic/urethane system that may have contributed a great deal to the overall performance of the system in the salt fog exposure.

5.1.2.3 Moisture Cured Urethane - In recent years, this class of material has gained recognition in the maintenance coating field due to their single package formulation and ease of application. The urethane formulation requires relatively thin application thicknesses (3 mils DFT) per coat to prevent foaming of the wet coating film. Therefore, the two coat systems had DFT's of 4-6 mils for the total coating thickness. These thinner coating systems did not generally perform as well as the thicker epoxy mastic materials. However, one system, Am-Tee L1-P/L1-C, performed very well in the salt fog testing and was considered for beach exposure.

5.1.3 Overall, the salt fog exposure testing provided excellent information about the ability of a coating system to protect marginally prepared carbon steel surfaces from the effects of moisture and salt. It allowed rapid screening of many products and reduced the final number to an acceptable cross section of materials.

5.2 Beach Exposure Results

5.2.1 The results of the beach exposure testing are presented in Table III. Again, the values represent the arithmetic average of two panels exposed at the same time. Blistering data per ASTM D714 were taken only at the 18-month point and are included in the Table.

BEACH EXPOSURE RESULTS (RUST GRADES/BLISTER RATING @ 18 MONTHS)

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
AMERON	CGWASH	10	10	10	10/6F
400 EPOXY	NGWASH	10	10	10	10/6F
AMERSHIELD	CGUNW	10	10	10	9.8/6F
	NGUNW	10	10	10	10/10
	UNCLEAN	10	10	10	10/10

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
DEVOE	CGWASH	10	9.5	9.5	8.8/6F
467 PRE-PRIME	NGWASH	10	10	10	9.5/10
235 EPOXY	CGUNW	10	10	10	9/6F
359 TOPCOAT	NGUNW	10	10	9.75	9.8/10
	UNCLEAN	10	10	10	9/10

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
DuPONT	CGWASH	10	10	10	10/6F
25P EPOXY	NGWASH	10	9.75	9.5	9.5/6F
326 TOPCOAT	CGUNW	10	9.75	9.5	9.5/4F
	NGUNW	10	9.75	9.75	9.8/4M

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
ELITE	CGWASH	10	10	9.75	9/10
7510 EPOXY	NGWASH	10	10	9.75	9.8/6F
4040 TOPCOAT	CGUNW	10	10	9.5	9/6F
	NGUNW	10	10	10	9.3/6F

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
ENGARD	CGWASH	10	10	10	10/8F
473 EPOXY	NGWASH	10	10	10	9.8/6F
428HS TOPCOAT	CGUNW	10	10	10	10/6F
	NGUNW	10	10	10	9.8/6F

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
MP-7 CONVERTER	CGWASH	9.75	9.25	9	6.5/4F
DEVOE 235HS/359	NGWASH	9.25	8.75	8.5	7/10
	CGUNW	9.25	9.25	9	6/4M
	NGUNW	9	8.5	8	7/4F
	UNCLEAN	9.5	8.5	8.5	6/4F

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
PORTER	CGWASH	10	10	9.75	9.8/8F
7900 EPOXY	NGWASH	9.75	9.5	9.5	9.5/10
XP9 1-556A TOPCOAT	CGUNW	10	10	9.75	9.8/8F
	NGUNW	10	9.75	9.75	9.8/10

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
PPG	CGWASH	10	9.5	9.5	9/6F
97-149 DTR EPOXY	NGWASH	10	9.75	9.5	8.5/6F
97-8 12 TOPCOAT	CGUNW	10	9.5	9.25	9/6F
	NGUNW	9.75	9.5	9.25	8/6F

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
RUST TRANSFORMER WITH	CGWASH	10	9.75	9	7.5/2M
	NGWASH	9.5	9.5	8.5	6/2MD
DEVOE 235HS/359	CGUNW	10	9.75	9	8/4F
	NGLJNW	9.25	8.5	8	4.5/4MD
	UNCLEAN	9.5	9.5	8.5	6/4M

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
SHERWIN-WILLIAMS	CGWASH	10	10	10	**10/6MD**
B58 EPOXY	NGWASH	10	10	9.75	**9.8/6M**
B65 TOPCOAT	CGUNW	10	10	10	**10/6MD**
	NGUNW	10	10	10	**10/6M**

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
SIGMA	CGWASH	10	10	10	**10/4M**
7476 EPOXY	NGWASH	9.75	9.5	9.5	**9.5/6M**
5523 TOPCOAT	CGUNW	10	10	10	**10/4M**
	NGUNW	10	10	10	**10/6M**

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
SOUTHERN COATINGS	CGWASH	10	10	10	**9.5/6F**
645 EPOXY	NGWASH	10	10	10	**10/6F**
270 TOPCOAT	**CGUNW**	10	10	10	**10/6F**
	NGUNW	10	9.75	9.5	**9.5/6F**

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
TNEMEC #1	CGWASH	10	10	9.25	**9.3/6F**
135 EPOXY	NGWASH	10	10	9.75	**9.8/6F**
74 TOPCOAT	CGUNW	10	9.25	9	**9/6F**
	NGUNW	9.75	9.5	9	**9/6F**

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
TNEMEC #2 50 330	CGWASH	9	8.5	8	**7/6M**
	NGWASH	9	8.25	8	**6/8M**
M.C. URETHANE 74 TOPCOAT	CGUNW	9	8.25	8	**6/8MD**
	NGUNW	9	8.5	8	**6/8MD**

MANUFACTURER	PREPARATION	3 MON.	6 MON.	12 MON.	18 MON.
XYMAX #2	CGWASH	9.75	9	9	**9/6F**
PUR-PR-PRIMER	NGWASH	9.75	9.25	9.25	**9/6F**
PUR-COVER TOPCOAT	CGUNW	9.75	9.25	9	**8.8/8M**
	NGUNW	9.5	9	8.75	**8.8/6M**

Note: Example of Rating - **9.5/6F**
9.5 - Corrosion Rating
6 - Medium Size Blisters
F - Few Blisters

5.2.2 The performance of the coating systems can be broken down to the generic types of materials and separately discussed.

5.2.2.1 Epoxy Mastic/Urethane - Due to the overall better performance of this class of coating system in the salt fog portion of this study, a higher percentage of these materials were included in the beach exposure testing. As can be seen from Table III, these materials continued to outperform the other classes of materials included in this study. Although the panel ratings of these products were relatively close, the varying performance of similar products in this class confirmed that the performance of these materials is product specific and should be considered when choosing materials for use on KSC structures. Continued exposure of these materials at the KSC Beach Corrosion Test Site should reveal more definitive results on the higher performing materials. The results of the totally uncleaned panels was surprising and shows the ability of these coatings to protect the carbon steel substrate from continued rusting even in the severe marine environment at KSC. These coatings should continue to be used at KSC and will enhance the maintenance effort on corroded surfaces that cannot be properly cleaned with abrasive blasting. However, they are not a substitute for the exceptional performance of the inorganic zinc systems used at KSC for long term protection of carbon steel surfaces.

5.2.2.2 Chemical Conversion Products - While two of these products provided acceptable performance in the salt fog chamber testing, the beach exposure testing revealed unacceptable results. It is interesting to note that these chemical conversion products were topcoated using a particular epoxy mastic/urethane combination that provided excellent protection to panels that did not receive the chemical pretreatment. These conversion products may continue to remain acidic and chemically active under the coating film attacking the steel substrate and possibly deteriorating the protective qualities of the topcoat materials.

5.2.2.3 Moisture Cured Urethane - Due to the limited success in the salt fog exposure testing, only two of this class of materials were exposed in the beach site test sequence. The Am-Tee L1-P/L1-C system materials used in the salt fog testing had gelled in the cans when the beach panels were being prepared, so the similar coating system, Xymax PUR-PR/PUR-COVER, was substituted for beach testing. As can be seen from Table III, the performance of these materials was better than the chemical conversion products, but not as good as the epoxy mastic coating systems. The thin film nature of these systems (5-6 mils DFT total) may not provide sufficient coverage over the asperities associated with the heavily pitted and scaled carbon steel surfaces. The Tnemec 50-330/74 system provided unacceptable performance at the 18 month period but the Xymax system did perform better. Continued exposure of these panels at the beach site will more clearly define the performance characteristics of the Xymax system in relation to the higher build coating systems.

5.2.3 The results of the topcoat gloss retention testing are presented in Table IV, V, and VI for exposure of 6, 12, and 18 months respectively. The data are presented as percent loss of gloss. To find percent gloss retention subtract the value from 100 (i.e., 100 - % loss = % gloss retention). The time of year corresponding to the different exposure times were 7/90 - 1/91 for the first six months, 1/91 - 7/91 for the second six months, and 7/91 - 1/92 for the final six months. All of the materials were aliphatic polyurethane formulations with some variation in blending between acrylic and polyester resins.

5.2.4 As reported in a previous topcoat gloss investigation (MTB 268-86B, February 1988), the materials performed well for the first 6 months (Florida summer/fall) except for the Porter XP91556A, which lost over 50 percent gloss. Except for the Porter material, most of the materials displayed little or no loss of gloss.

TABLE IV
6 MONTH TOPCOAT GLOSS DATA

MATERIAL NAME	INITIAL GLOSS	6 MONTH GLOSS	% LOSS (6 MO.)
AMERON AMERSHIELD	89%	79%	11
DEVOE 359	68%	68%	0
DUPONT 326	69%	68%	1
ELITE 4040	75%	75%	0
ENGARD 428HS	59%	59%	0
PORTER XP91556A	71%	32.8%	53.8
PPG 97-812	74%	74%	0
PURE COAT C-4-100	89%	69.7%	21.7
SHERWIN WILLIAMS B60V2	72%	63%	13
SIGMA 5523	78%	78%	0
SOUTHERN 270	54%	51.2%	5.2
TNEMEC 74 ENDURASHIELD IV	75%	75%	0

TABLE V
12 MONTH TOPCOAT GLOSS DATA

MATERIAL NAME	INITIAL GLOSS	12 MONTH GLOSS	% LOSS (12 MO.)
AMERON AMERSHIELD	89%	49.6%	44.3
DEVOE 359	68%	46.3%	31.9
DUPONT 326	69%	42.5%	38.4
ELITE 4040	75%	52.5%	30.0
ENGARD 428HS	59%	28.6%	51.5
PORTER XP91556A	71%	15.8%	77.7
PPG 97-812	74%	51.2%	30.8
PURE COAT C-4-100	89%	44.1%	50.4
SHERWIN WILLIAMS B60V2	72%	50.8%	29.4
SIGMA 5523	78%	45.4%	41.8
SOUTHERN 270	54%	30.3%	43.9
TNEMEC 74 ENDURASHIELD IV	75%	55.3%	26.3

TABLE VI
18 MONTH TOPCOAT GLOSS DATA

MATERIAL NAME	INITIAL GLOSS	18 MONTH GLOSS	% LOSS (18 MO.)
AMERON AMERSHIELD	89%	24.9%	72.0
DEVOE 359	68%	26.7%	60.7
DUPONT 326	69%	27.9%	59.6
ELITE 4040	75%	30.4%	59.5
ENGARD 428HS	59%	15.1%	74.4
PORTER XP91556A	71%	13.1%	81.5
PPG 97-812	74%	33.9%	54.2
PURE COAT C-4-100	89%	24.6%	72.4
SHERWIN WILLIAMS B60V2	72%	44.4%	38.3
SIGMA 5523	78%	40.8%	47.7
SOUTHERN 270	54%	20.3%	62.4
TNEMEC 74 ENDURASHIELD IV	75%	47.8%	36.3

The second six months (Florida winter/spring) produced more measurable reductions in percent gloss with the Tnemec 74 providing the highest gloss with the lowest percent loss of gloss. As was found in the previous referenced study, the final six month period of Florida summer/fall produced significant deterioration of topcoat gloss values. The best performers were revealed during this period and were clearly the Sherwin Williams B60V2, Sigma 5523, and the Tnemec 74 with the coating retaining over 40 percent topcoat gloss. Due to the level of gloss reduction at 18 months and general deterioration of the test panels, no further gloss testing will be conducted on these products.

5.2.5 Several of the manufacturers of topcoat products included in this study provided the same or similar products for evaluation in the MTB 268-86 study. These manufacturers coating products and their 18 month gloss retention data are shown in Table VII for comparative purposes. The materials submitted for the MTB 268-86 study were received in 1985 and were applied and exposed in 1986. The materials submitted for this study were received in 1989 and were applied and exposed in 1990. Most of the products submitted for this study displayed improved gloss retention properties over the 1986 counterparts. However, the overall performance of the aliphatic polyurethanes in the high intensity UV environment at KSC is considered only marginally acceptable.

5.2.6 Photographs of the panels exposed for 18 months at the KSC Beach Corrosion Site with the product identification key can be found in Appendix A.

5.3 Beach Exposure versus Salt Fog Exposure

5.3.1 As part of the data acquisition process, comparisons of the different exposure conditions could be investigated to determine any correlation of performance between particular material/preparation combinations. All the materials exposed at the Beach Exposure Site could be compared to the exposure at various times for the same materials in the salt fog chamber. The panels exposed at the beach were compared to the NGUNW, CGUNW, NGWASH, and CGWASH panels that were exposed in the chamber.

TABLE VII
TOPCOAT GLOSS COMPARISON DATA

MANUFACTURER	INITIAL GLOSS	18 MO. GLOSS	% LOSS
AMERON AMERSHIELD (1986)	82%	18%	78
AMERON AMERSHIELD (1990)	89%	25%	72
DEVOE 359 (1986)	76%	35%	54
DEVOE 359 (1990)	68%	27%	61
DuPONT 326 (1986)	79%	53%	33
DuPONT 326 (1990)	69%	28%	60
ENGARD 428 (1986)	51%	15%	71
ENGARD 428 (1990)	59%	15%	74
PORTER 8610 (1986)	37%	6%	84
PORTER XP91556A (1990)	71%	13%	82
PPG 97-812 (1986)	65%	15%	77
PPG 97-812 (1990)	74%	34%	54
SHERWIN WILLIAMS Hi Bild (1986)	71%	17%	76
SHERWIN WILLIAMS B60V2 (1990)	72%	44%	38
SIGMA 7523 (1986)	81%	15%	81
SIGMA 5523 (1990)	78%	41%	48
TNEMEC 70 (1986) *	85%	65%	24
TNEMEC 73 (1986)	85%	32%	62
TNEMEC 74 (1990)	75%	48%	36

* - Polyester formulation

5.3.2 Since blistering was not recorded on the beach exposed panels until the 18 month point, this will be the baseline for comparison to the panels in the salt fog chamber.

5.3.3 Analysis of this data will require significant statistical work and will not be presented in this report. A separate report will be written in the future comparing the different exposure of the similarly prepared panels.

6.0 CONCLUSIONS

6.1 Based on the results of the salt fog and beach exposure testing, the epoxy mastic primers with polyurethane topcoats produced the best performance as a generic class of coating materials. These materials should be considered for use on Kennedy Space Center facilities and ground support equipment including launch structures.

6.2 Chemical conversion coatings tested as a part of this study produced unacceptable results and should not be used for corrosion control operations at Kennedy Space Center.

6.3 Salt fog testing procedures conducted during this investigation provided extremely useful information about relative performance of surface preparation and coating system performance. However, salt fog testing should not be considered an absolute replacement technique for actual outdoor exposure. This was an expected result and reaffirms the need to conduct protective coating and corrosion studies in the real world to obtain the true performance of the materials in the intended use environment. Accelerated testing is still a useful tool but should be considered just a tool and not a definitive answer.

6.4 Topcoat gloss testing revealed some improved results over similar products tested several years ago. In general, the overall performance of the polyurethane formulations showed enhanced gloss retention for the first 12 months but the final 6 months produced significant reductions in specular gloss. However, several materials, such as Sherwin Williams B60V2 and Tnemec 74, displayed excellent results. The combination of intense UV light from the Florida sun, settlement of dirt and dust on the coating surface, possible abrasion from wind blown sand, and high surface temperatures during the summer months produces an extremely harsh environment for topcoat gloss retention.

6.5 Of the four mechanical preparation methods used during this study, the most effective overall method for the higher build coating systems was the pneumatic needle scaler or needle gun. This device produced a significant profile in the metal surface resulting in better adhesion of the coatings and reduced blistering. It allowed better preparation of uneven surfaces making it a more suitable choice for complex shapes such as bolt heads, splice plates, or other structural connections.

6.6 For the thinner coating systems such as the moisture cured urethanes, the coarse grinding wheel produced the best results. The deep surface profile of the needle gun was not fully covered by the thinner films and displayed some pinpoint rusting. The grinding wheel produces a smaller profile and better overall cleanliness. This allowed the thinner moisture cured systems to provide acceptable results.

6.7 The removal of surface salts by high pressure water washing did not produce any significant improvements to the overall coating performance at the 18-month rating period. The materials that displayed excellent corrosion protection did not show diminished performance over the higher salt panels. However, this was not true for some of the poorer performing materials. Higher salt concentrations on the prepared surfaces did display increased blistering of these coating products.

INVESTIGATOR: ______________________________

L. G. MACDOWELL, III, NASA, DM-MSL-22

APPROVED: ______________________________

C. J. BRYAN, CHIEF, MATERIALS SECTION

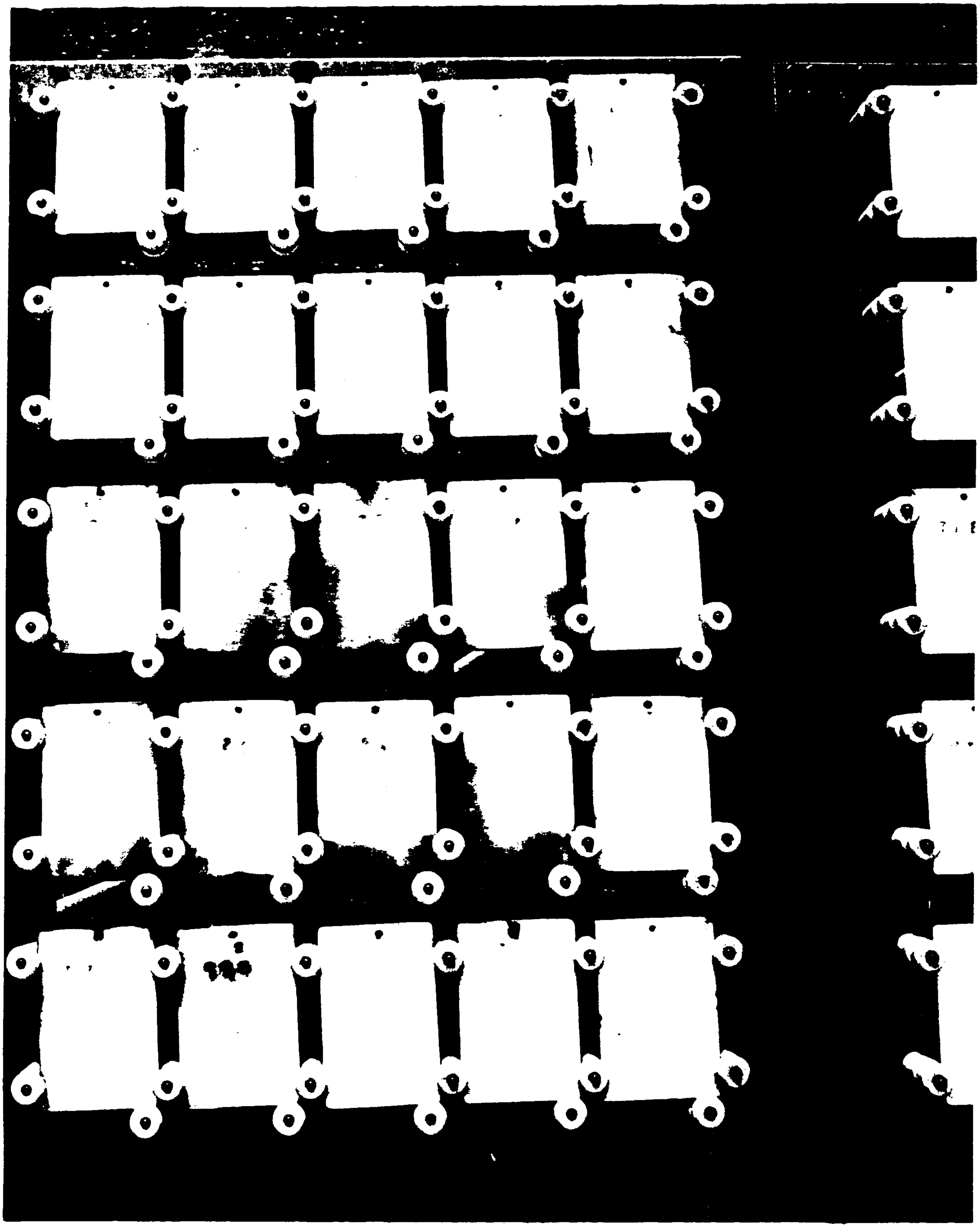
APPENDIX A

91-4835 A-l

STUDY NO.: 144-88 RACK NO.: A-l DATE : 7/90 EXPOSURE: NORMAL

	A	B	C	D	E
5	SIGMA 7476 5523 CGWASH	SIGMA* 7476 5523 CGWASH	SIGMA 7476 5523 NGWASH	SIGMA 7476 5523 NGWASH	DEVOE 467 235HS 359 CGUNW
4	SIGMA 7476 5523 CGUNW	SIGMA 7476 5523 CGUNW	SIGMA 7476 5523 NGUNW	SIGMA 7476 5523 NGUNW W-S	DEVOE 467 235HS 359 CGUNW
3	PPG* DTR 97-812 CGWASH	PPG DTR 97-812 CGWASH S-W	PPG DTR 97-812 NGWASH	PPG DTR 97-812 NGWASH	DEVOE 467 235HS 359 NGUNW
2	PPG DTR 97-812 CGUNW	PPG DTR 97-812 CGUNW	PPG DTR 97-812 NGUNW	PPG DTR 97-812 NGUNW	DEVOE 467 235HS 359 NGUNW
1	DEVOE* 467 235HS 359 CGWASH	DEVOE 467 235HS 359 CGWASH	DEVOE 467 235HS 359 NGWASH	DEVOE 467 235HS 359 NGWASH	DEVOE 467 235HS 359 UNCLEAN

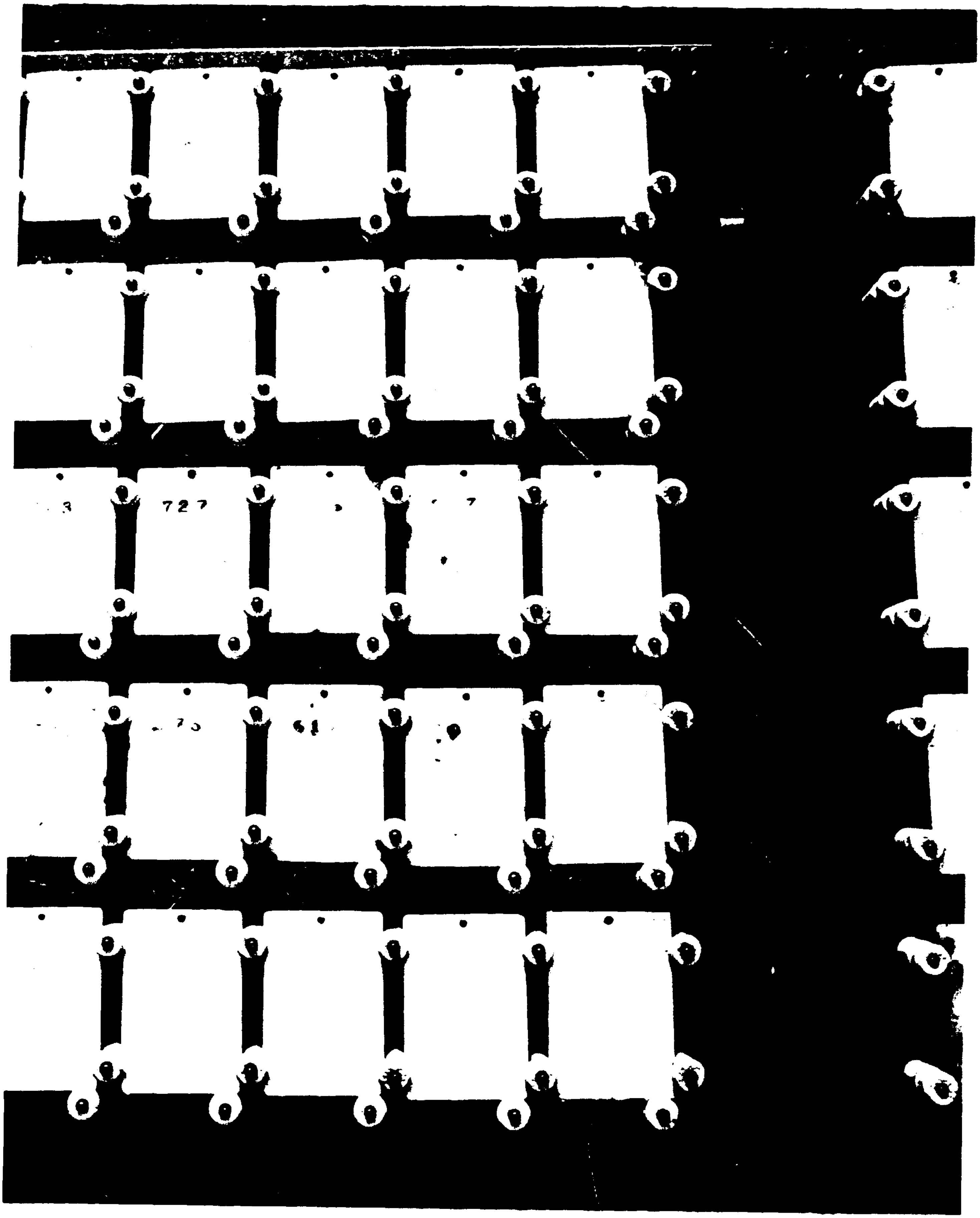
* - PANELS USED FOR GLOSS TESTING



STUDY NO.: 144-88 RACK NO.: A-2 DATE : 7/90 EXPOSURE: NORMAL

	A	B	C	D	E
5	ENGARD* 473 428HS CGWASH	ENGARD 473 428HS CGWASH	ENGARD 473 428HS NGWASH	ENGARD 473 428HS NGWASH	AMERON 400 AMER-SHIELD CGUNW
4	ENGARD 473 428HS CGUNW	ENGARD 473 428HS CGUNW	ENGARD 473 428HS NGUNW	ENGARD 473 428HS NGUNW	AMERON 400 AMER-SHIELD CGUNW
3	XYMAX PUR-PR C4-100 CGWASH	XYMAX* PUR-PR C4-100 CGWASH	XYMAX PUR-PR C4-100 NGWASH	XYMAX PUR-PR C4-100 NGWASH	AMERON 400 AMER-SHIELD NGUNW
2	XYMAX PUR-PR C4-100 CGUNW	XYMAX PUR-PR C4-100 CGUNW	XYMAX PUR-PR C4-100 NGUNW	XYMAX PUR-PR C4-100 NGUNW	AMERON 400 AMER-SHIELD NGUNW
1	AMERON* 400 AMER-SHIELD CGWASH	AMERON 400 AMER-SHIELD CGWASH	AMERON 400 AMER-SHIELD NGWASH	AMERON 400 AMER-SHIELD NGWASH	AMERON 400 AMER-SHIELD UNCLEAN

* - PANELS USED FOR GLOSS TESTING

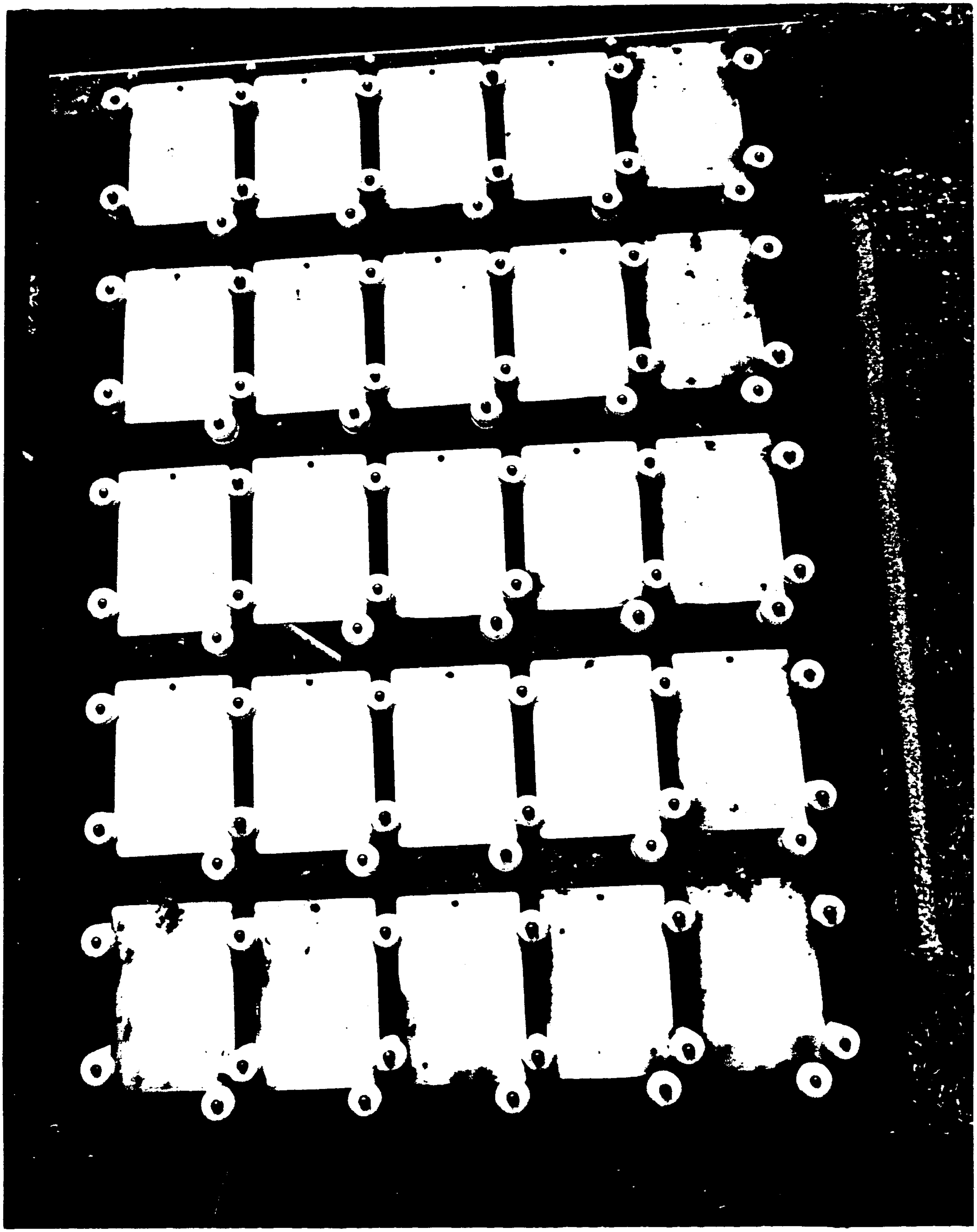


91-4835
STUDY NO.: 144-88 RACK NO.: A-3 DATE : 7/90

A-5
EXPOSURE: NORMAL

	A	B	C	D	E
5	DUPONT* 25P 326 CGWASH	DUPONT 25P 326 CGWASH	DUPONT 25P 326 NGWASH	DUPONT 25P 326 NGWASH	COULTER MP-7 235HS 359 CGUNW
4	DUPONT 25P 326 CGUNW	DUPONT 25P 326 CGUNW	DUPONT 25P 326 NGUNW	DUPONT 25P 326 NGUNW	COULTER MP-7 235HS 359 CGUNW
3	SHERWIN WILLIAMS B58 EM B60V2	SHERWIN* WILLIAMS B58 EM B60V2	SHERWIN WILLIAMS B58 EM B60V2	SHERWIN WILLIAMS B58 EM B60V2	COULTER MP-7 235HS 359
2	SHERWIN WILLIAMS B58 EM B60V2 CGUNW	SHERWIN WILLIAMS B58 EM B60V2 CGUNW	SHERWIN WILLIAMS B58 EM B60V2 NGUNW	SHERWIN WILLIAMS B58 EM B60V2 NGUNW	COULTER MP-7 235HS 359 NGUNW
1	COULTER MP-7 235HS 359 CGWASH	COULTER MP-7 235HS 359 CGWASH	COULTER MP-7 235HS 359 CGWASH	COULTER MP-7 235HS CGWASH	COULTER MP-7 235HS 359 UNCLEAN

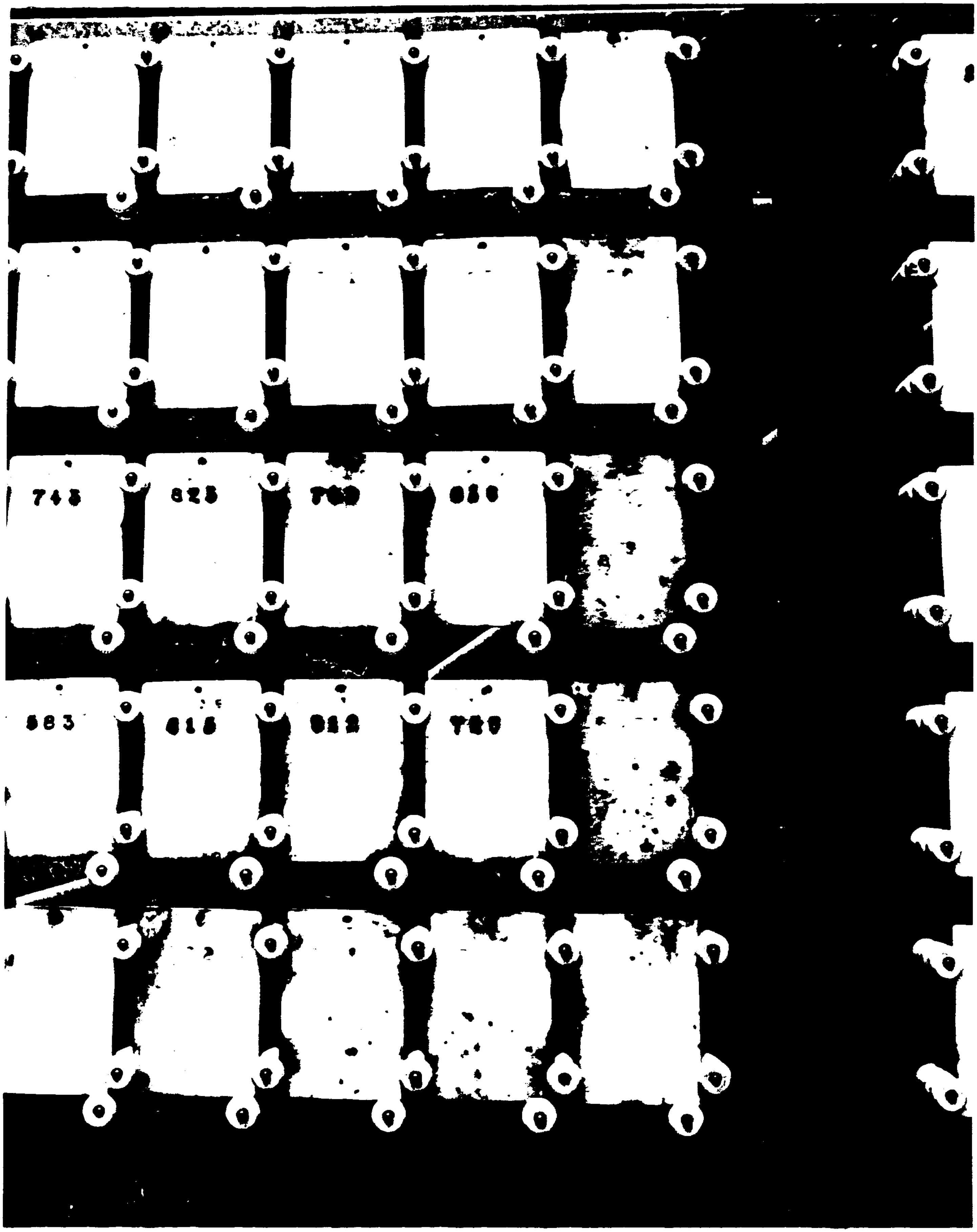
* - PANELS USED FOR GLOSS TESTING



91-4835
STUDY NO.: 144-88 RACK **NO.: B-1** **DATE : 7/90** A-7
EXPOSURE: NORMAL

	A	B	C	D	E
5	TNEMEC* 135 EM 74 CGWASH	TNEMEC 135 EM 74 CGWASH	TNEMEC 135 EM 74 NGWASH	TNEMEC 135 EM 74 NGWASH	RUSTRANS NR-763 235HS 359 CGUNW
4	TNEMEC 135 EM 74 CGUNW	TNEMEC 135 EM 74 CGUNW	TNEMEC 135 EM 74 NGUNW	TNEMEC 135 EM 74 NGUNW	RUSTRANS NR-763 235HS 359 CGUNW
3	TNEMFC SO-330 74 CGWASH	TNEMEC SO-330 74 CGWASH	TNEMEC SO-330 74 NGWASH	TNEMEC SO-330 74 NGWASH	RUSTRANS NR-763 235HS 359 NGUNW
2	TNEMEC 50-330 74 CGUNW	TNEMEC SO-330 74 CGUNW	TNEMEC SO-330 74 NGUNW	TNEMEC SO-330 74 NGUNW	RUSTRANS NR-763 235HS 359 NGUNW
1	RUSTRANS NR-763 235HS 359 CGWASH	RUSTRANS NR-763 235HS 359 CGWASH	RUSTRANS NR-763 235HS 359 NGWASH	RUSTRANS NR-763 235HS 359 NGWASH	RUSTRANS NR-763 235HS 359 UNCLEAN

*** - PANELS USED FOR GLOSS TESTING**



91-4835

A-9

STUDY NO.: 144-88 RACK NO.: B-2 DATE : 7/90 EXPOSURE: NORMAL

	A	B	C	D	E
5	e-w- ELITE* 7510 4040 CGWASH m---s-	ELITE 7510 4040 CGWASH	ELITE 7510 4040 NGWASH	ELITE 7510 4040 NGWASH	SOUTHERN 645 270 CGUNW
4	ELITE 7510 4040 CGUNW	ELITE 7510 4040 CGUNW	ELITE 7510 4040 NGUNW	ELITE 7510 4040 NGUNW	SOUTHERN 645 270 CGUNW
3	w--e-- PORTER* 7900 XP91556 CGWASH	PORTER 7900 XP91556 CGWASH	me- PORTER 7900 XP91556 NGWASH	PORTER 7900 XP91556 NGWASH	SOUTHERN 645 270 NGUNW
2	PORTER 7900 XP91556 CGUNW we--	PORTER 7900 XP91556 CGUNW	PORTER 7900 XP91556 CGUNW	PORTER 7900 XP91556 CGUNW	SOUTHERN 645 270 NGUNW
1	SOUTHERN 645 * 270 CGWASH	SOUTHERN 645 270 CGWASH	SOUTHERN 645 270 NGWASH	SOUTHERN 645 270 NGWASH	SOUTHERN 645 270 UNCLEAN

* - PANELS USED FOR GLOSS TESTING