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Evaluation Of Thermal Sprayed Metalic Coatings For Use On The Structures At Launch Complex 39

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DM-MSL-2, ROOM 1218, O&C BUILDING
KENNEDY SPACE CENTER, FLORIDA 32899
JANUARY 25, 1990

MTB-1058-89

SUBJECT: EVALUATION OF THERMAL SPRAYED METALLIC COATINGS FOR USE ON THE STRUCTURES AT LAUNCH COMPLEX 39

RELATED DOCUMENTATION:

MTB-781-89 (Addendum A), Test of Thermal Sprayed Coatings on Launch Complex 40.
MTB-195-87, Test of Thermal Coatings on Launch Complex 17.
MTB-379-86 Study Plan, Evaluation of Thermal Sprayed Metallic Coatings for use on the Structures at Launch Complex 39.
ASTM G82-83, Development and Use of a Galvanic Series for Predicting Galvanic Corrosion Performance, Standard Guide for

1.0 INTRODUCTION

1.1 This is an interim report of the evaluation of thermal sprayed coatings (TSC). The final objective is to select materials and application methods (flame, arc, or plasma) to protect the structures at Launch Complex 39 (LC-39). In many areas at LC-39, the exhaust from the Shuttle Transportation System (STS) Solid Rocket Boosters (SRB's) destroys the protective coatings on the structures during every launch. The SRB exhaust products contains hydrochloric acid, aluminum oxide, and other materials. The heat and exhaust products from the SRB's cause erosion/corrosion of the structure.

1.2 First, Launch Complex 17 (LC-17) and then Launch Complex 40 (LC-40) was selected for these tests because at the time of the earlier testing, they were the only active launch sites that utilized solid rocket motors (SRM's) on the launch vehicle. At LC-40 the Titan III launch vehicle utilizes two SRM's which are ignited at lift off.

1.3 In addition to the launch environment testing, some of the TSC panels received by early 1987 were exposed to periodic rinses with an aluminum oxide (Al_2O_3)-hydrochloric acid (HCl) slurry at the beach corrosion test site.

2.0 TEST PROCEDURE

2.1 Eleven new thermal spray coating (TSC) composite test panels, a strain isolation barrier, and 6 reference panels were secured to a mount plate which was attached to the Titan transporter at LC-40, at the same location described in MTB-781-88.

2.2 The mount plate was secured to the transporter several weeks before the Titan III launch on September 4, 1989, and returned to the MTB on September 7, 1989 (see Figures 1 and 2).

2.3 A group of TSC test panels were set out at the beach corrosion test site on April 15, 1987. Periodically the panels were rinsed with a slurry of Al_2O_3 powder and HCl to simulate the effects of the SRB exhaust residue.

3.0 RESULTS

3.1 A comparison of reference panels from the subject Titan launch and the previous test on November 30, 1987, indicates that this most recent test environment was less severe than the previous one.

3.1.1 The silicone rubber ablative reference panels from the most recent test lost less material than during the first test. The comparison is shown in Table I.

TABLE 1

LOSS OF ABLATIVE MATERIAL

MATERIAL	LAUNCH DATE	
	NOV 30, 1987	SEPT. 4, 1989
Q3-6077	0.034"	0.021"
SEA 200	0.046"	0.035"

3.1.2 Panel S/N 83203 with the D-6 inorganic zinc paint experienced only slight erosion on the edge of the channel.

3.1.3 The three reference TSC panels, S/N's 12358, 77127, and 82947, all experienced significantly less damage than panels on the earlier launch from the same batches.

3.1.3.1 Panel S/N 12358 with Hastelloy-C and a top coat of tungsten carbide-cobolt (WC-Co) experienced only microcracks on the panel. However, on the previous Titan launch, panel S/N 12351 with the WC-Co contained numerous cracks.

3.1.3.2 The panel S/N 77127 with TSC of nickel-chromium-tungsten-molibdium (Ni-Cr-W-Mo) experienced some debonding of the coating from the base of the channel. On the previous launch, a similar TSC panel, S/N 79959, was cracking and debonding on the flat panel section, and suffered extensive exfoliation on the channel section.

3.1.3.3 Panel S/N 82947 with iron-chromium-aluminum-yitrium (Fe-Cr-Al-Y) TSC experienced some cracking and corrosion bleed through on the panel section, and showed some evidence of exfoliation and bleed through on the channel section. The panel from the previous test exhibited significantly worse degradation.

3.2 The strain isolation barrier, which consists of a tightly packed layer of stainless steel wire mesh brazed to the panel with a ceramic TSC topcoat, was not noticeably damaged.

3.3 Of the eleven new TSC panels only S/N 83127 showed no noticeable damage (see Figure 3). It was coated with aluminum. The results of all the panels are presented in Table II.

4.0 DISCUSSION

4.1 Inorganic zinc paint is the standard protective coating for steel structures at Kennedy Space Center (KSC). In some applications inorganic zinc is utilizied with epoxy and urethane based top coats. The zinc paint provides cathodic protection for the steel. As shown in the galvanic series (see Figure 5) zinc is more active than mild steel and low alloy steel; therefore, as a coating it corrodes sacrificially and provides a protective oxide barrier over the steel structure.

TABLE II

RESULTS OF

THE SECOND TEST OF THERMAL SPRAYED COATINGS

ON LAUNCH COMPLEX 40, CCAFS

I.D. LTR	SERIAL NUMBER/ MATERIAL	APPLY TECH/ THICKNESS	COMMENTS
*I	83203 D6 INORGANIC Zn	PAINT SPRAY 3-4 mils	COATING ERODED AT TWO SPOTS OF CHANNEL BASE
*J	259 Q3-6077	PAINT SPRAY 1/2-inch	AVERAGE LOSS 0.021"
*K	251 SEA 200	PAINT SPRAY 1/4-inch	AVERAGE LOSS 0.035"
*M	12358 Hast-C (NiCrWMo) /(TC) WC-Co	HYPER FLAME 7-10 mil ea.	MICROCRACKS ON PANEL
*O	77127 NiCrWMo	PLASMA 15-20 mils	CRACKS, BLEEDTHROUGH, AND EXFOLIATION
*P	82947 FeCrAlY	PLASMA 17-22 mils	CRACKS, BLEEDTHROUGH, AND EXFOLIATION
S	82945 TiN	PLASMA 15-20 mils	EXFOLIATION/BLEEDTHROUGH ON PANEL AND CHANNEL
T	82994 (BC)NiAl/ (TC)Al2O3	PLASMA BC 1-2 mils TC 8-10 mil	BLEEDTHROUGH AND SOME DAMAGE ON THE CHANNEL
U	83110 CrC + CoCrAlY	PLASMA 8-10 mils	CRACKS AND BLEEDTHROUGH ON THE BASE OF CHANNEL
V	83128 WC-Co	PLASMA 8-10 mils	BLEEDTHROUGH AROUND THE WELD AND ON THE CHANNEL
W	82924 CoCrMo	HYPER FLAME 15-20 mils	SOME BLEEDTHROUGH
X	83218 WC-Co	HYPER FLAME 15-20 mils	MICROCRACKING ON THE BASE OF THE CHANNEL
Y	83212 CrC-NiCr	HYPER FLAME 15-20 mils	BLEEDTHROUGH ON CHANNEL
Z	83127 Al	ARC 7-10 mils	NO NOTICEABLE DAMAGE
AA	83007 Zn	ARC 7-10 mils	COATING ERODED AT FACE OF CHANNEL
AB	82932 Al-Zn	ARC 7-10 mils	COATING ERODED AT FACE OF CHANNEL
AC	STRAIN ISOLATION BARRIER	N/A	NO NOTICABLE DAMAGE
AD	83122 CrNiTi	ARC 15-20 mils	BLEEDTHROUGH ON INNER WALLS OF CHANNEL

NOTES: BC = Bond Coat, TC = Top Coat

4.2 Most of the TSC alloys applied by either plasma or hypersonic flame spray processes are more noble than the low alloy steels. In the case of these exotic, noble alloys, the carbon steel structure becomes the sacrificed cathode which corrodes. This undesirable phenomena was illustrated in the beach exposure tests.

4.3 The testing in the launch environment has illustrated the problems of porosity and exfoliation due to thermal shock. The use of the exotic TSC's to protect launch structure appears impractical.

5.0 CONCLUSIONS

Only the relatively low cost aluminum TSC which provides some cathodic protection for steel appears to be a practical candidate for further investigation.

6.0 FUTURE PLANS

The aluminum TSC panel with several of the other materials will be subjected to the Al_2O_3-HCl slurry rinse at the beach corrosion test site.

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FIGURE 1

THE MOUNT PLATE WITH TSC COMPOSITE TEST PANELS IS SHOWN MOUNTED ON THE TITAN TRANSPORTER PRIOR TO THE TITAN LAUNCH ON SEPTEMBER 5, 1989.

ORIGINAL PAGE
COLOR PHOTOGRAPH

FIGURE 2

THE MOUNT PLATE WITH TSC COMPOSITE TEST PANELS IS SHOWN MOUNTED ON THE TITAN TRANSPORTER AFTER THE TITAN LAUNCH ON SEPTEMBER 5, 1989.

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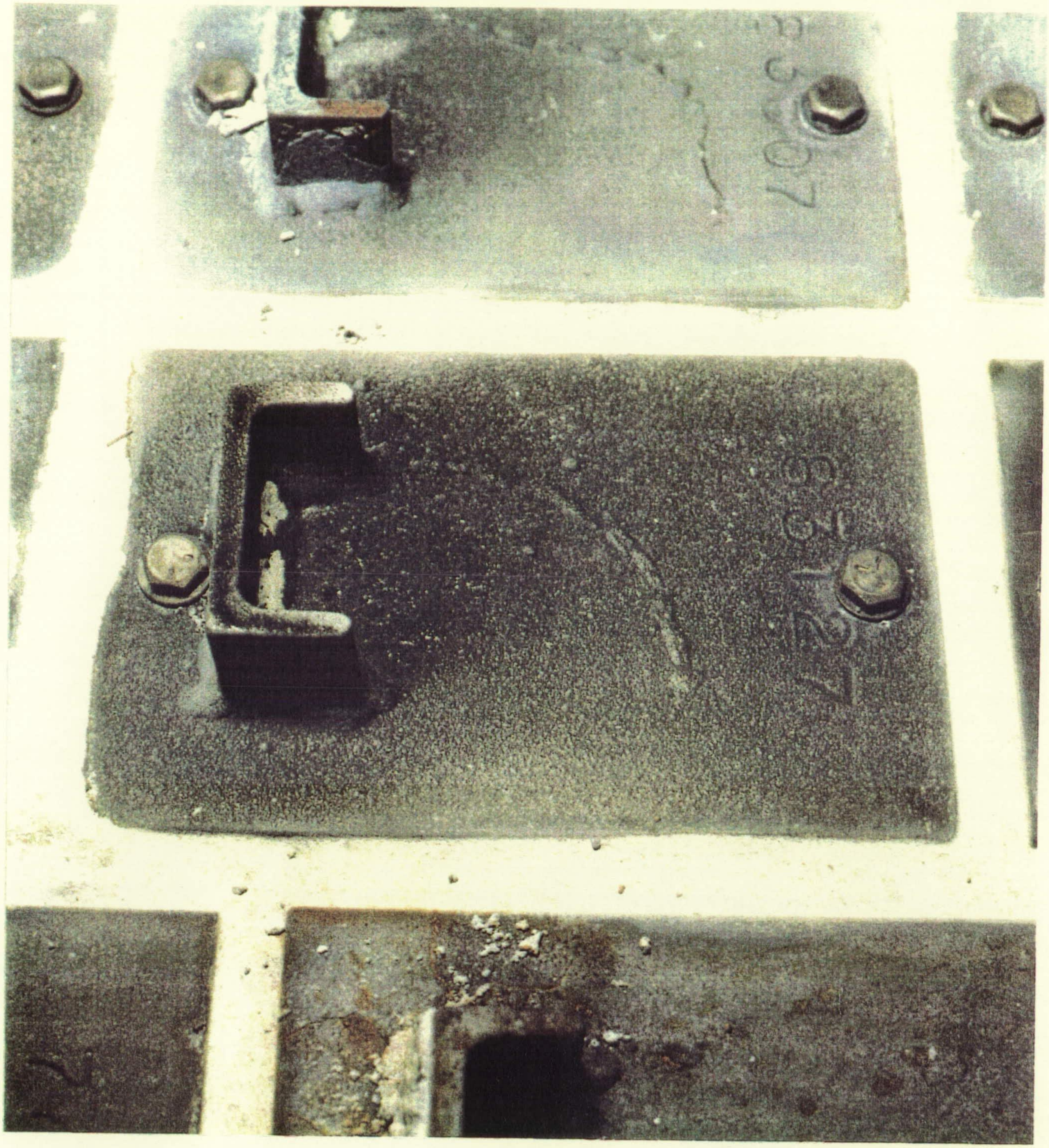

FIGURE 3

THE ALUMINUM TSC TEST PANEL, S/N 83127, WAS THE ONLY TSC PANEL WHICH DID NOT APPEAR TO SUSTAIN ANY DANAGE FROM THE TITAN LAUNCH ENVIRONMENT.

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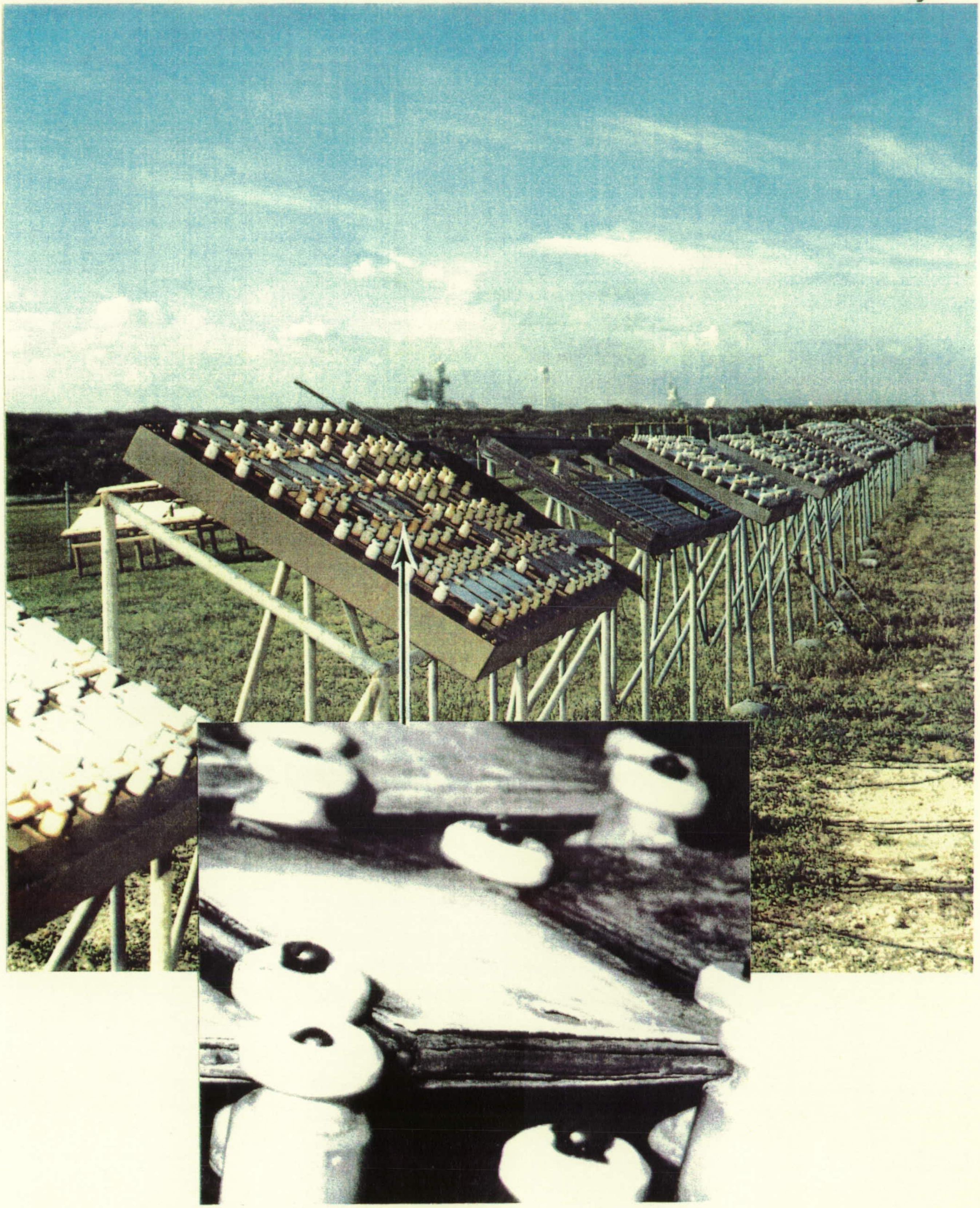

FIGURE 4

TSC TEST PANEL S/N 12342 WHICH WAS EXPOSED TO THE Al_2O_3-HCl SLURRY AT THE BEACH CORROSION TEST SITE IS SHOWN AFTER 2-1/2 YEARS OF BEACH EXPOSURE. THE TSC WAS A Ni-Cr-W-Mo ALLOY.

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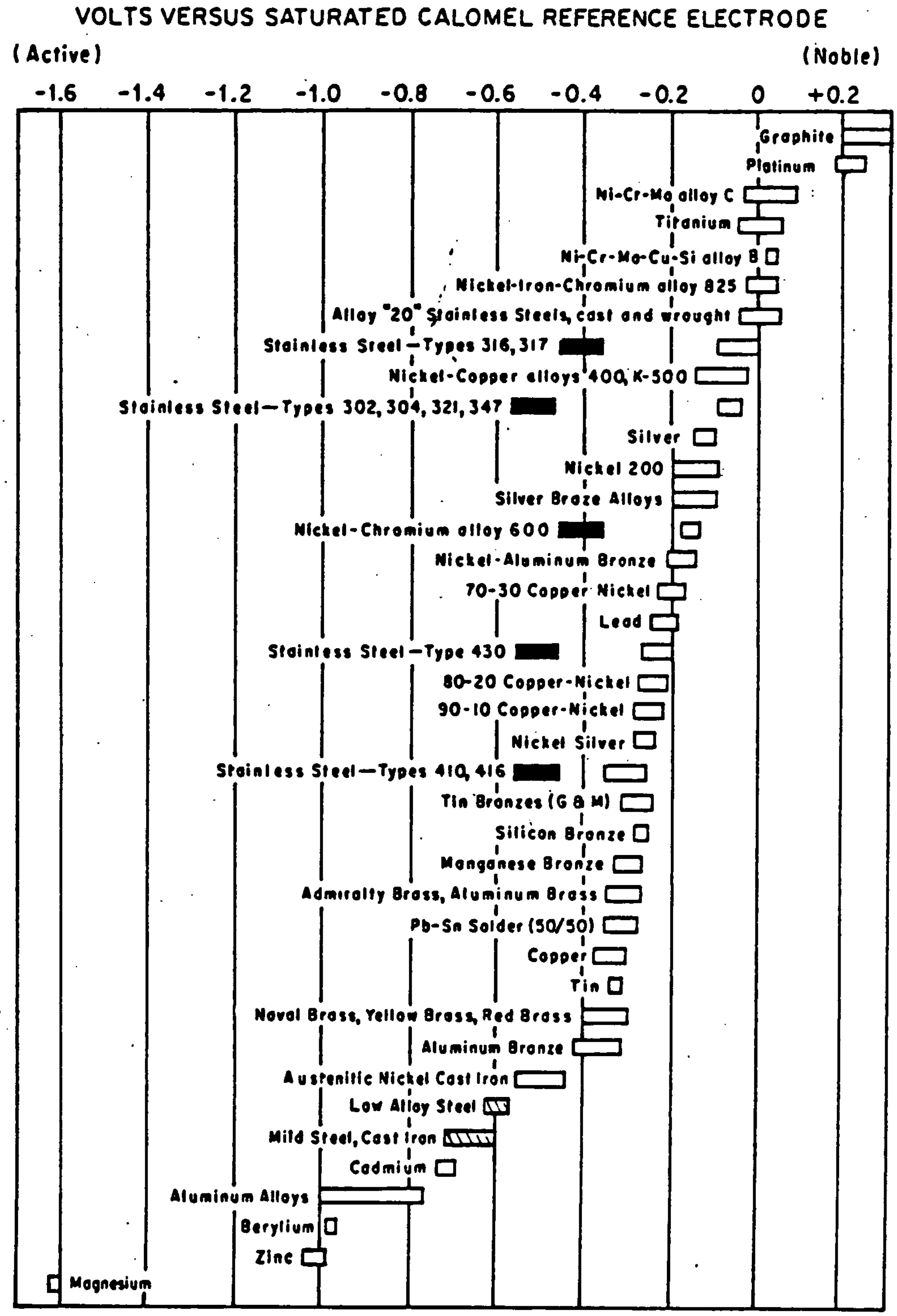

NOTE—Dark boxes indicate active behavior of active-passive alloys.

FIGURE 5

GALVANIC SERIES OF VARIOUS METALS IN FLOWING SEAWATER (REFERENCE ASTM G 82-83).

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16. Abstract

The report provides the current status of the evalution program. The objective was to evaluate the applicability of thermal sprayed coatings to protect the structures in the high temperature acid environment produced by the exhaust of the Solid Rocket Boosters during the launches of the Shuttle Transportation System at Kennedy Space Center, Florida.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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