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MATERIALS AND CHEMICAL ANALYSIS BRANCH
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FEBRUARY 3, 1997

REPORT 96-1M0167

SUBJECT: Inorganic Coating Systems for Carbon Steel Exposed to the Space Transportation System (STS) Launch Environment: 18-Month Exposure Results

RELATED DOCUMENTATION: KSC-STD-C-0001

1.0 ABSTRACT

This report is to document the 18-month performance of several inorganic coating systems for carbon steel exposed to the STS launch environment. This evaluation program was initiated in 1994 to identify alternative inorganic topcoat coating materials for use at KSC and to study the performance of a new high-gloss polysiloxane topcoat for inorganic zinc-rich primers. KSC-STD-C-0001 requires an evaluation at the 18-month exposure period for material evaluation for initial approval of products. This report provides information for the revision of approved coating systems listed in KSC-STD-C-0001.

2.0 FOREWORD

The intent of this report is to document the 18-month performance of coating systems initially exposed on June 10, 1994. This evaluation program was started to identify inorganic coating systems to prevent corrosion of carbon steel structures in the STS launch environment. These systems include inorganic zinc primers coated with inorganic topcoats; and high-gloss polysiloxane finish coats. KSC-STD-C-0001 requires an evaluation at the 18-month exposure period for material evaluation for initial approval of products. This report provides information for the revision of approved coating systems listed in KSC-STD-C-0001.

3.0 INVESTIGATIVE PROCEDURES

3.1 A list of the materials tested as part of this study is shown in Table I. The three inorganic topcoats (Ameron 741, Devoe Devram 701, and Sherwin Williams

L03 inorganic) are ethyl silicate liquid binders with various pigmentation to produce the desired colors and heat resistance. The polysiloxane coating (Ameron PSX 700) is a proprietary material based on a silicone and epoxy resin combination to produce a high-gloss topcoat product. For more information regarding theses products, please contact the different manufacturers' technical representatives.

3.2 The exposure of the test panels for these studies was conducted at the KSC Beach Corrosion Test Site. This site is located approximately 2 kilometers South of Launch Complex 39A and is approximately 30 meters from the mean high tide line of the Atlantic Ocean. The panels were installed on stainless steel racks that use porcelain insulators as standoffs. The racks were mounted on zinc-coated test stands at a 30° angle facing the ocean. A view of the test site is shown in Figure 1.

3.3 Two different conditions were used in the field exposure testing: (1) inorganic topcoats over zinc exposed to normal seacoast conditions, and (2) inorganic topcoats over zinc exposed to normal seacoast conditions plus Al_2O_3 (alumina) slurry applications. The slurry was produced by combining 0.3 micron Al_2O_3 particles in a 10% (by volume) hydrochloric acid solution. This slurry was periodically applied to the lower 2/3 of the panels using a polyethylene squeeze bottle.

FIGURE 1
KSC Beach Corrosion Test Site

3.4 The test panels with the inorganic topcoats and polysiloxane coating were examined on December 14, 1995, making the exposure period of these materials just over 18 months. During the exposure period, there were 10 applications of the acid slurry. Photographs of the panels after 18 months of exposure with the product identification key can be found in the Appendix. The rating results of the seacoast exposure of the materials listed in Table I are shown in Table II. The degree of corrosion was judged on a scale of 0 to 10, with 10 being the highest rating. The 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 the 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 32 square inches of exposed area on the side that is rated. This calculates to 0.0032 square inches or less for a rating of "10," 0.0096 square inches for a rating of "9," 0.032 square inches for a rating of "8," and so on for the other area amounts.

3.5 According to the regulations stated in KSC-STD-C-0001, a topcoated inorganic zinc primer must receive an ASTM corrosion rating of 8 or better after 18 months of normal seacoast exposure to be initially approved. This coating system must continue to perform at this level for 5 years (60 months) to remain on the approved topcoat list in KSC-STD-C-0001.

3.6 The acronyms used for the material identification in the tables are as follows:

KEY TO TEST MATERIALS

Carbon Steel Coatings:

VEN-IO Vendor's inorganic zinc + same vendor's inorganic topcoat

TABLE I

4 INORGANIC COATING SYSTEMS (VEN-IO)

MANUFACTURER	PRIMER	TOPCOAT
AMERON	D-21-9	741
AMERON	D-21-9	PSX-700
DEVOE	304V	DEVRAM 701
SHERWIN WILLIAMS	ZC II	L03 INORGANIC

3.7 The polysiloxane panel was measured for initial gloss prior to exposure at the Beach Site and at intervals of 6, 12, and 18-month exposure. The gloss readings were conducted on the topcoat in the final coating system configuration and not panels specifically produced for gloss measurements. The panels were removed from the exposure rack at the Beach Site, rinsed with deionized water to remove surface contaminants, allowed to dry, measured for gloss, and replaced in the exposure rack. The polysiloxane material was measured for gloss retention at the Beach Corrosion Test Site using a portable, multi-angle gloss meter manufactured by BYK Chemie GmbH. All gloss measurements were performed at the 60° angle.

4.0 RESULTS

4.1 All rating values presented in the tables are an average of four panels prepared and exposed at the same time. Where the ratings differed from panel to panel, a simple arithmetic mean is reported.

TABLE II

RUST GRADE EVALUATIONS AFTER 18-MONTH SEACOAST EXPOSURE

	ASTM D-610-68(74) RUST GRADES	
VEN-IO COATING SYSTEM	NORMAL EXPOSURE	ACID TREATED
D-21-9/741	10.00	10.00
D-21-9/PSX-700	10.00	9.63
304V/DEVRAM 701	10.00	10.00
ZC II/L03 INORGANIC	10.00	10.00

4.2 All the coating materials are above the rating of "9," and most are rated as "10," even after ten applications of the acid slurry. These materials display excellent corrosion protection and are virtually unaffected by the high ultraviolet radiation levels typical of the Florida environment.

4.3 Topcoat gloss performance has been a concern at KSC for many years. Due to variations in gloss retention performance of polyurethanes in many studies, the Ameron PSX-700 polysiloxane material was tested to determine the gloss retention of this new material during this study. Table III presents the data for the gloss loss and retention information for the Ameron PSX-700 polysiloxane material. The time of year corresponding to the various exposure times were 5/94 - 11/94 for the first 6 months, 11/94 - 5/95 for the second 6 months, and 5/95 - 11/95 for the final 6 months.

TABLE III

Exposure Time	% Gloss	% Gloss Loss	% Gloss Retention
Initial	61.7	0.0	0.0
6 Months	54.6	11.5	88.5
12 Months	54.5	11.7	88.3
18 Months	54.2	12.2	87.8

5.0 CONCLUSIONS

5.1 The panels coated with the inorganic and polysiloxane topcoats performed very well, with all materials rating a perfect "10" after 18 months of normal exposure. These topcoat materials do not produce the same localized failure mode as seen with the organic topcoats.

5.2 The inorganic and polysiloxane topcoats also performed very well after 18 months of exposure with the acid slurry treatments. These topcoat materials would be excellent choices for use in the STS launch environment.

5.3 The gloss testing of the polysiloxane topcoat material showed excellent gloss retention after 18 months of exposure at the KSC Beach Corrosion Test Site.

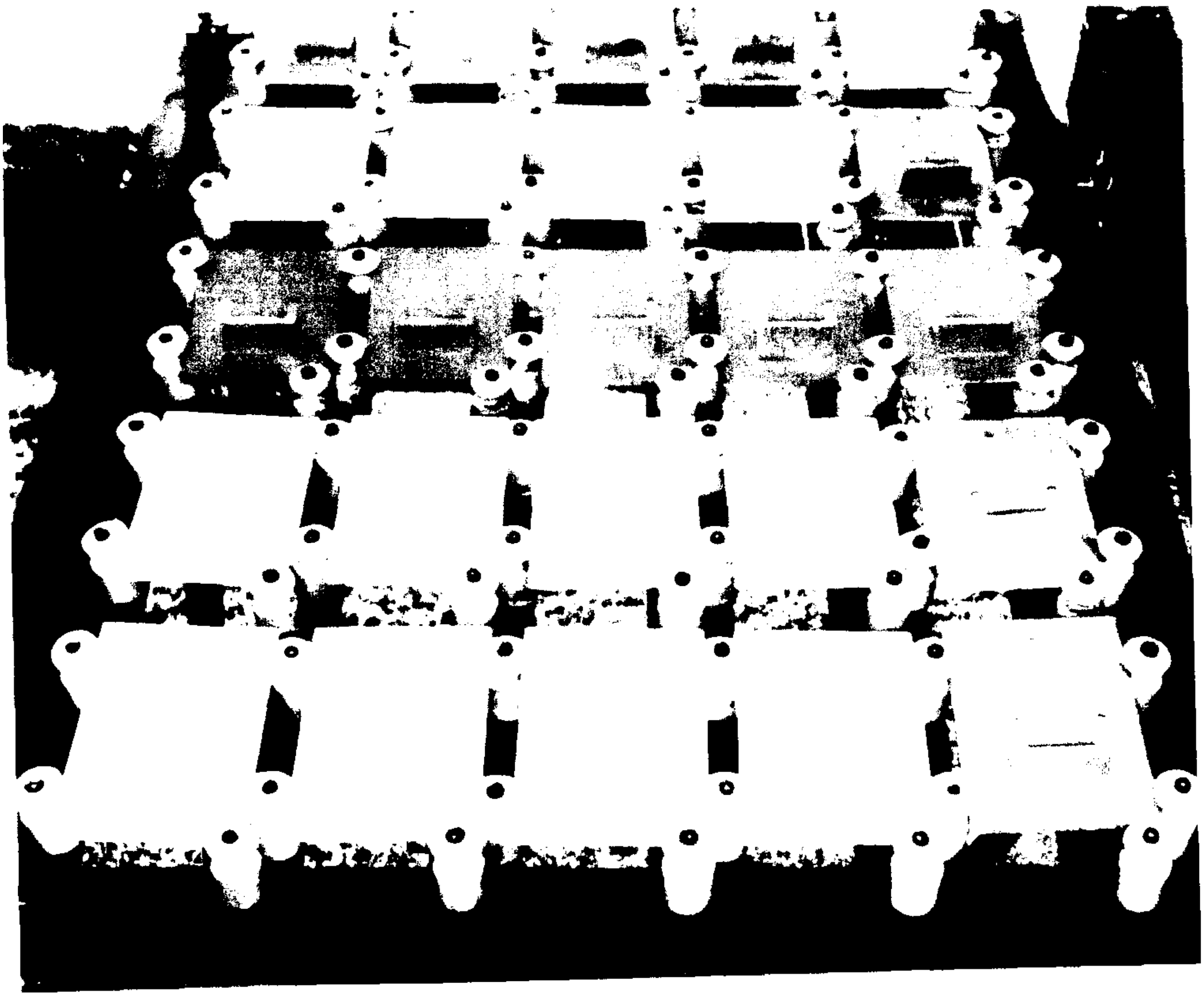
INVESTIGATOR: Louis G MacDowell for LGM

L. G. MacDowell

APPROVED: Scott Murray

S. H. Murray, ead Engineer, Materials

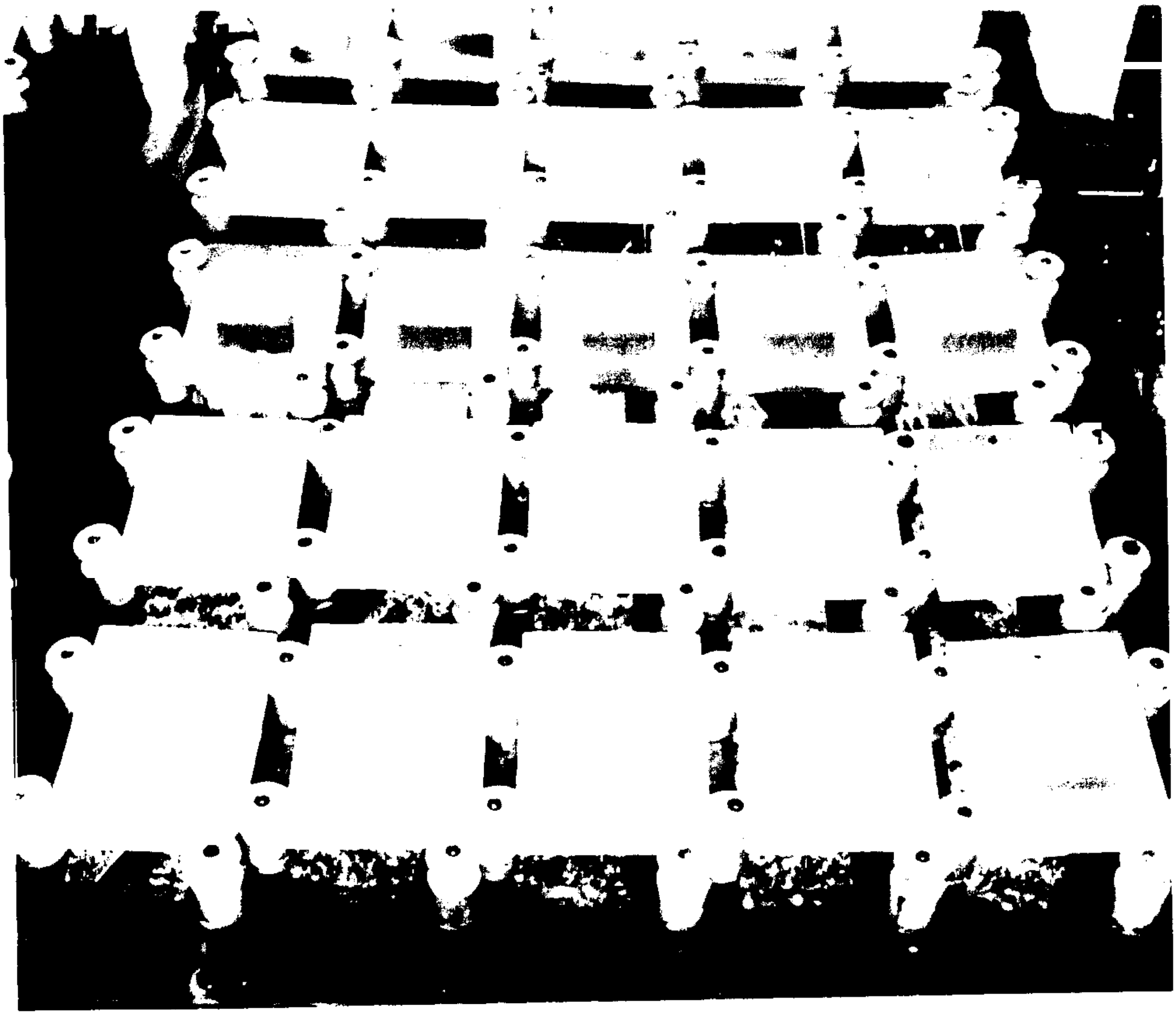
APPENDIX



RACK NUMBER: IO-1

STUDY NO. : IO TOPCOAT RACK NO. : IO-1 DATE : 12/14/95 EXPOSURE : NORMAL

	A	B	C	D	E
5	DEVOE 304V DEVOE 701 INORGANIC	DEVOE 304V DEVOE 701 INORGANIC	DEVOE 304V DEVOE 701 INORGANIC	DEVOE 304V DEVOE 70 1 INORGANIC	ZINC-CLAD II LO3 INORGANIC
4	AMERON D-21-9 AMERON PSX-700	AMERON D-21-9 AMERON PSX-700	AMERON D-21-9 AMERON PSX-700	AMERON D-21-9 AMERON PSX-700	DEVOE 304V DEVOE 701 INORGANIC
3	AMERON D-21-9 AMERON 741	AMERON D-21-9 AMERON 741	AMERON D-21-9 AMERON 741	AMERON D-2 l-9 AMERON 741	AMERON D-21-9 AMERON 741
2	SHERWIN WILLIAMS zc-u LO3 INORGANIC	SHERWIN WILLIAMS zc-u LO3 INORGANIC	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	DEVOE 304V DEVOE 701
1	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	SHERWIN WILLIAMS zc-11 LO3 INORGANIC	SHERWIN WILLIAMS zc-II LO3 INORGANIC	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	AMERON D-21-9 AMERON 741



RACK NUMBER: IO-2

STUDY NO. : IO TOPCOAT RACK NO. : IO-2 DATE : 12/14/95 EXPOSURE ACID

	A	B	C	D	E
5	DEVOE 304V DEVOE 701 INORGANIC	DEVOE 304V DEVOE 701 INORGANIC	DEVOE 304V DEVOE 701 INORGANIC	DEVOE 304V DEVOE 70 1 INORGANIC	ZINC-CLAD II LO3 INORGANIC
4	AMERON D-21-9 AMERON PSX-700	AMERON D-21-9 AMERON PSX-700	AMERON D-21-9 AMERON PSX-700	AMERON D-21-9 AMERON PSX-700	DEVOE 304V DEVOE 701 INORGANIC
3	AMERON D-21-9 AMERON 741	AMERON D-21-9 AMERON 741	AMERON D-21-9 AMERON 741	AMERON D-21-9 AMERON 741	AMERON D-21-9 AMERON 741
2	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	DEVOE 304V DEVOE 701
1	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	SHERWIN WILLIAMS ZC-II LO3 INORGANIC	AMERON D-21-9 AMERON 741

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