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**GENERAL DYNAMICS**

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**402162**

Report No. 8926-127

Material - Stainless Steel - Type 410, Casting

Effect of Surface Preparation on Adhesive  
Bond Strengths

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H. Pearson, G. L. Picotte, E. E. Keller

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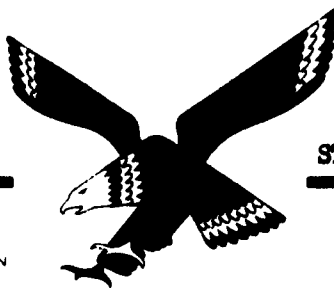
Abstract:

The comparative effectiveness of a sulfuric acid-sodium dichromate and a boiling hydrofluoric acid surface preparation in providing suitable structural adhesive bonds between Type 410 stainless steel castings, and 7075-T6 clad and 2024-T86 bare aluminum alloys was determined. The sulfuric acid-sodium dichromate cleaner consisted of distilled water, 2 per cent sulfuric acid and 2 per cent sodium dichromate used at room temperature. The hydrofluoric acid cleaner consisted of a 10 per cent aqueous hydrofluoric acid solution used at its boiling temperature for 5 minutes. The adhesives used to compare the adhesion characteristics of the different stainless steel surfaces were EC-1459 primer and AF-10 film (Minnesota Mining and Manufacturing Co.), and they were cured at 350°F for 2 hours under a pressure of 100 psi. Satisfactory adhesive bond strengths were obtained with both surface preparation methods. The hydrofluoric acid method generally provided the higher strengths, however. Pertinent results are tabulated below:

<u>Alloys (1)</u>	<u>Cleaner (2)</u>	<u>Bond Strength</u>			
		<u>R.T.</u>	<u>SS(3)</u>	<u>-67°F</u>	<u>300°F</u>
7075-410	1	3190	4080	2110	2275
7075-410	2	3635	3690	2945	1620
2024-410	1	2690	3910	1690	1670
	2	3320	4050	2480	1560
7075-7075	1	4015	4155	1610	2145
2024-2024	1	3890	4165	2115	2265

- (1) 7075-T6, 2024-T86 aluminum alloys, Type 410 stainless steel.
- (2) 1, sulfuric acid-sodium dichromate cleaner; 2, hydrofluoric acid cleaner.
- (3) Tested at room temperature after 30 days salt spray exposure.

Reference: Pearson, H., Picotte, G. L., Keller, E. E., "Aluminum to Stainless Steel Bond Tests," General Dynamics/Convair Report MP 57-603, San Diego, California, 30 December 1957 (Reference attached).



STRUCTURES-MATERIALS LABORATORIES

**CONVAIR**

A DIVISION OF GENERAL DYNAMICS CORPORATION

SAN DIEGO

REPORT 57-603

DATE 12-30-57

MODEL F-106A

TITLE

REPORT NO. 57-603  
ALUMINUM TO 410 STAINLESS  
STEEL BOND TESTS

MODEL: F-106A

CONTRACT: AF33(600) 30169

PREPARED BY H. Pearson  
H. Pearson

GROUP MATERIALS & PROCESSES LAB.

CHECKED BY: G. L. Picotte  
G. L. Picotte

REFERENCE \_\_\_\_\_

CHECKED BY E. E. Keller  
E. E. Keller

APPROVED BY E. F. Strong  
E. F. Strong,  
Chief of Test Laboratories

CHECKED BY W. M. Sutherland NO. OF PAGES 7

W. M. Sutherland NO. OF DIAGRAMS 5  
W. M. Sutherland, Grp. Engr.

REVISIONS

NO.	DATE	BY	CHANGE	PAGES AFFECTED
1	3-5-58	HP	20 minutes at 200°F to 30 minutes at 250°F	2
2	3-5-58	HP	additional detail on fig 7	7

ACCESS NO.

Title: MATERIAL - STAINLESS STEEL - TYPE 410, CASTING. EFFECT OF SURFACE PREPARATION ON ADHESIVE BOND STRENGTHS.

Authors: Pearson, H., Picotte, G. L., Keller, E. E.

Report No. 8926-127

Date: 30 December 1957

Contract: AF 33(600)-30169

Contractor: General Dynamics/Convair

ABSTRACT: The comparative effectiveness of a sulfuric acid-sodium dichromate and a boiling hydrofluoric acid surface preparation in providing suitable structural adhesive bonds between Type 410 stainless steel castings, and 7075-T6 clad and 2024-T86 bare aluminum alloys was determined. The sulfuric acid-sodium dichromate cleaner consisted of distilled water, 2 per cent sulfuric acid and 2 per cent sodium dichromate used at room temperature. The hydrofluoric acid cleaner consisted of a 10 per cent aqueous hydrofluoric acid solution used at its boiling temperature for 5 minutes. The adhesives used to compare the adhesion characteristics of the different stainless steel surfaces were EC-1459 primer and AF-10 film (Minnesota Mining and Manufacturing Co.), and they were cured at 350°F for 2 hours under a pressure of 100 psi. Satisfactory adhesive bond strengths were obtained with both surface preparation methods. The hydrofluoric acid method generally provided the higher strengths, however Pertinent results are tabulated below:

(see next card)

ACCESS NO. (Continued)

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(2) 1, sulfuric acid-sodium dichromate cleaner;  
2, hydrofluoric acid cleaner.

(3) Tested at room temperature after 30 days salt spray exposure.

ANALYSIS  
PREPARED BY Pearson/Picotte  
CHECKED BY Keller/Sutherland  
REVISED BY

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A DIVISION OF GENERAL DYNAMICS CORPORATION  
(SAN DIEGO)

PAGE 1  
REPORT NO. 57-603  
MODEL F-106A  
DATE 12-30-57

REPORT NO. 57-603  
ALUMINUM TO 410 STAINLESS  
STEEL BOND TESTS

INTRODUCTION:

In accordance with a letter from AMC, substantiation of the stainless steel surface treatment described in paragraphs 3.2.2.4 and 3.2.2.5 of Convair Specification 8-01318 was deemed necessary. The relative effect of cleaning with sulfuric acid-sodium dichromate type solutions and of hydrofluoric acid cleaners on bond strength was desired. The stainless steel alloy to be tested was Type 410 in cast form.

OBJECT:

To evaluate present stainless steel cleaning methods on Type 410 cast stainless steel in accordance with Convair Specification 8-01318.

CONCLUSION:

Satisfactory results were obtained with both the sulfuric acid-sodium dichromate and hydrofluoric acid surface treatment systems. The hydrofluoric acid method specified in 3.2.2.5 is the better of the two systems in regards to bond strength.

RECOMMENDATION:

Some thought should be given to the necessary strength requirements before establishing a production line surface treatment system on this type steel. Even though slightly higher tensile shear values are obtained by the alternate cleaning method, it would be considerably more hazardous in operation. The use of boiling hydrofluoric acid in the cleaning procedure would necessitate the use of special cleaning tanks and severe safety precautions. Possibly the loss in bond strength could be sacrificed to allow for ease in handling.

DESCRIPTION OF SPECIMENS:

The specimens were of the lapped tensile shear type. One half of each test specimen was aluminum and the other half steel. The aluminum half specimens consisted of two types. These were .064" 7075-T6 clad and .064 2024-T86 bare aluminum alloys. They were cut and subsequently milled to one by four inch dimensions. These will hereafter be referred to as type "A" and type "B" aluminum respectively.

The steel half of specimens were cut from four F-106 rudder horns. It was found that by making some of the samples slightly less than the desired one by

**ANALYSIS**

**PREPARED BY** Pearson/Picotte  
**CHECKED BY** Keller/Sutherland  
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MODEL F-106A

DATE 12-30-57

**DESCRIPTION OF SPECIMENS:** (Continued)

four inch size, forty-one pieces .051" thick could be obtained. During the milling operation both sides of the specimens were given a 125 microinch finish.

A duplicate set of aluminum to aluminum specimens were prepared for control purposes.

**TEST PROCEDURE:**

The aluminum half of test specimens were cleaned with dichromate-sulfuric acid cleaning solution as set forth in paragraph 3.2.2.1 of Specification 8-01318, oven dried for 20 minutes at 175° F, allowed to cool to room temperature and primed with EC 1459, LOT 16H6S. The specimens were then air dried for 15 minutes at room temperature and precured 30 minutes in a circulating air oven at 280° F, preparatory for bonding.

The steel half of test specimens were divided into two groups. One group was cleaned in accordance with paragraph 3.2.2.4 of Specification 8-01318 and shall be referred to as type 1. The other group was cleaned by the method specified in paragraph 3.2.2.5 of Specification 8-01318 and shall be called type 2. Both sets of specimens were then dried and primed in the same manner as were the aluminum specimens described above.

A special jig, see Figure 1, was fabricated to hold the specimens in place during the bonding operation. This fixture maintained the overlap distance as well as the alignment of the two half specimens. All specimens were bonded with AF 31, LOT 24 adhesive at 350° F ± 10° F for 2 hours ± 5 minutes and at a pressure of 100 psi ± 5, according to the procedure set forth in Convair Specifications 8-01318 and 0-03007.

The bonded specimens were of four kinds; type "A" aluminum bonded to type 1 and 2 steel and type "B" aluminum bonded to type 1 and 2 steel. Hereafter in this report these test specimens will be referred to by the following designations; A<sub>1</sub>, A<sub>2</sub>, B<sub>1</sub>, and B<sub>2</sub> respectively. Each type of specimen was tested as follows: room temperature, room temperature after thirty days exposure to salt spray, minus 67° F. and plus 300° F. The specimens subjected to salt spray exposure were tested within two hours after their removal from the environmental cabinet. The salt spray exposure was done in accordance with Specification QQ-M-151.

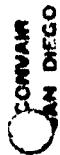
All testing was done on a Tinius Olsen testing machine with appropriate attachments.

**RESULTS:**

The results of tensile shear tests are recorded in Tables 1, 2, 3, and 4.

**NOTE:** Note; The 300° F tensile shear values given in Tables 1 and 2 are low due to a mechanical failure of the testing machine.

The data from which this report was prepared are recorded in Data Book No. 891.



FORM 33

TABLE 1

7075-T6 CLAD ALUMINUM - TYPE 1 AND TYPE 2 STEEL

SPEC	TEST TEMP	WIDTH INCH	LENGTH INCH	LOADS LBS	PSI	CHANGE	SPEC	TEST TEMP	WIDTH INCH	LENGTH INCH	LOADS LBS	PSI	FAILURE	
				ULTIMATE	ULTIMATE						ULTIMATE	ULTIMATE	MODE	
1A	RT	0.99	0.50	1270	2600	100	1A2	RT	0.99	0.50	1895	3710	25	75
2A	RT	0.99	0.50	1565	3160	75	2A2	RT	1.00	0.51	2090	3940	40	60
3A	RT	0.99	0.50	1560	3155	90	3A2	RT	0.97	0.51	1905	3950	50	50
4A	RT	1.00	0.50	1960	3840	100	4A2	RT	0.97	0.50	1520	3140	85	15
AVE					3190		AVE				3635			
5A	RT	0.99	0.52	2280	4438	95	5A2	RT	1.00	0.52	2100	4038	90	10
6A	RT	1.00	0.51	1825	3520	90	6A2	RT	1.00	0.52	1905	3660	65	35
7A	RT	0.99	0.51	2205	4360	90	7A2	RT	0.98	0.51	1805	3610	95	5
8A	RT	0.99	0.50	1945	3930	95	8A2	RT	1.00	0.53	1955	3690	50	50
AVE					4080		AVE				3750			
9A	-67°F	1.00	0.51	1170	2280	100	9A2	-67°F	1.00	0.51	1400	2800	100	-
10A	-67	1.00	0.51	1220	2380	100	10A2	-67	1.00	0.50	1310	2620	100	-
11A	-67	1.00	0.50	1060	2120	100	11A2	-67	1.00	0.51	1665	3262	100	-
12A	-67	1.00	0.50	780	1660	100	12A2	-67	1.00	0.51	1580	3100	100	-
AVE					2110		AVE				2945			
13A	300°F	1.00	0.50	1135	2270	100	13A2	300°F	0.98	0.50	750	1530	100	-
14A	300	1.00	0.50	1120	2240	100	14A2	300	0.97	0.50	730	1500	100	-
15A	300	1.00	0.50	1245	2490	100	15A2	300	0.98	0.51	835	1670	100	-
16A	300	1.00	0.50	1050	2100	100	16A2	300	1.00	0.51	915	1790	100	-
AVE					2275		AVE				1620			

\* RT - 79°F - TYPICAL OF ALL

ADH - ANNEALING TREATMENT

CON - CONCRETE FILLING

RT - TESTED AFTER SALT

SPRAY EXPOSURE



TABLE 2

2024-T86 BARE ALUMINUM - TYPE 1 AND TYPE 2 STEEL

SPEC	TEST TEMP	WIDTH INCH	LENGTH INCH	LBS	PSI	FAILURE	SPEC	TEST TEMP	WIDTH INCH	LENGTH INCH	LBS	PSI	FAILURE
				ULTIMATE	ULTIMATE	MODE					ULTIMATE	ULTIMATE	MODE
1B,	RT,	0.99	0.50	1235	2500	70	1B,	RT,	1.00	0.50	1545	3090	20
2B,	RT,	1.00	0.51	1505	2950	60	2B,	RT,	0.99	0.48	1240	2610	100
3B,	RT,	1.00	0.49	1360	2780	50	3B,	RT,	1.00	0.52	1960	3770	90
4B,	RT,	1.00	0.49	1210	2520	100	4B,	RT,	0.99	0.50	1730	3500	40
AVE					2690		AVE				3320		
5B,	RT	1.00	0.51	2040	4000	100	5B,	RT	0.99	0.50	2060	4160	75
6B,	RT	1.00	0.51	1955	3830	90	6B,	RT	0.99	0.53	1985	3780	95
7B,	RT	1.00	0.50	2000	4000	100	7B,	RT	0.99	0.53	2060	3920	100
8B,	RT	0.99	0.50	1890	3820	100	8B,	RT	1.00	0.50	2170	4340	85
AVE					3910		AVE				4050		
9B,	-67°F	1.00	0.51	1145	2240	100	9B,	-67°F	1.00	0.51	1605	3150	100
10B,	-67	1.00	0.48	700	1460	100	10B,	-67	1.00	0.50	1215	2430	100
11B,	-67	1.00	0.48	780	1630	100	11B,	-67	1.00	0.50	1105	2210	100
12B,	-67	0.98	0.52	730	1430	100	12B,	-67	0.99	0.50	1230	2480	100
AVE					1690		AVE				2555		
13B,	300°F	0.99	0.50	825	1670	100	13B,	300°F	0.98	0.48	790	1680	100
14B,	300	1.00	0.50	885	1770	100	14B,	300	1.00	0.50	815	1630	100
15B,	300	0.99	0.50	800	1620	100	15B,	300	1.00	0.50	820	1440	100
16B,	300	0.97	0.50	780	1610	100	16B,	300	0.97	0.50	620	1280	100
AVE					1670		AVE				1560		

TABLE 3

7075-T6 CLAD ALUMINUM CONTROL SPECIMENS

SPEC	TEST TEMP	WIDTH	LENGTH	LB5 ULTIMATE	PSI ULTIMATE	FAILURE	TEST TEMP	WIDTH	LENGTH	LB5 ULTIMATE	PSI ULTIMATE	FAILURE	
1A	RT	1.00	0.50	1920	3840	-	17A	-67°F	1.00	0.50	865	1730	100
2A	RT	1.00	0.50	2005	4010	-	18A	-67	1.00	0.49	860	1725	100
3A	RT	1.00	0.51	2115	4140	-	19A	-67	1.00	0.50	830	1660	100
4A	RT	1.00	0.50	1920	3840	5	20A	-67	1.00	0.50	940	1920	100
5A	RT	1.00	0.50	2045	4090	-	21A	-67	1.00	0.50	785	1570	100
6A	RT	1.00	0.51	2170	4340	-	22A	-67	1.00	0.50	600	1200	100
7A	RT	1.00	0.51	2155	4310	-	23A	-67	1.00	0.51	805	1595	100
8A	RT	1.00	0.50	1985	3970	-	24A	-67	1.00	0.50	760	1520	100
9A	RT	1.00	0.50	2005	4010	-	Ave				1610		
10A	RT	0.99	0.50	1825	3780	-	25A	300°F	1.00	0.49	960	1960	100
Ave					4015		26A	300	1.00	0.50	1090	2180	100
11A	RT	1.00	0.50	2005	4010	100	27A	300	1.00	0.51	1165	2380	100
12A	RT	0.98	0.51	1995	3990	100	28A	300	1.00	0.49	955	1950	100
13A	RT	1.00	0.50	2170	4340	100	29A	300	1.00	0.50	1170	2340	100
14A	RT	1.00	0.50	2180	4360	90	30A	300	1.00	0.50	1080	2160	100
15A	RT	1.00	0.50	2170	4340	95	Ave				2145		
16A	RT	1.01	0.50	1860	3880	100							
Ave					4155								

(SUNVAIR  
- JAN DIESEL)

TABLE 4

2024-T86 BARE ALUMINUM CONTROL SPECIMENS

SPEC	TEST TEMP	WIDTH INCH	LENGTH INCH	LB5 ULTIMATE	PSI ULTIMATE	FAILURE MODE	SPEC	TEST TEMP	WIDTH INCH	LENGTH INCH	LB5 ULTIMATE	PSI ULTIMATE	FAILURE MODE
17B	-67°F	1.00	0.48	1025	2138	100	17B	-67°F	1.00	0.48	1025	2138	100
18B	-67	1.00	0.48	1030	2144	100	18B	-67	1.00	0.48	1030	2144	100
19B	-67	1.00	0.49	1585	3238	100	19B	-67	1.00	0.49	1585	3238	100
20B	-67	1.00	0.50	900	1800	100	20B	-67	1.00	0.50	900	1800	100
21B	-67	1.00	0.50	1060	2120	100	21B	-67	1.00	0.50	1060	2120	100
22B	-67	1.00	0.50	1010	2020	100	22B	-67	1.00	0.50	1010	2020	100
23B	-67	1.00	0.49	705	1440	100	23B	-67	1.00	0.49	705	1440	100
24B	-67	1.00	0.50	1005	2010	100	24B	-67	1.00	0.50	1005	2010	100
AVE					2115		AVE					2115	
25B	300°F	1.00	0.50	1140	2280	100	25B	300°F	1.00	0.50	1140	2280	100
26B	300	1.00	0.50	1095	2190	100	26B	300	1.00	0.50	1095	2190	100
27B	300	1.00	0.52	1300	2500	100	27B	300	1.00	0.52	1300	2500	100
28B	300	1.00	0.50	1125	2250	100	28B	300	1.00	0.50	1125	2250	100
29B	300	1.00	0.50	1110	2220	100	29B	300	1.00	0.50	1110	2220	100
30B	300	1.00	0.50	1075	2150	100	30B	300	1.00	0.50	1075	2150	100
AVE					2265		AVE					2265	

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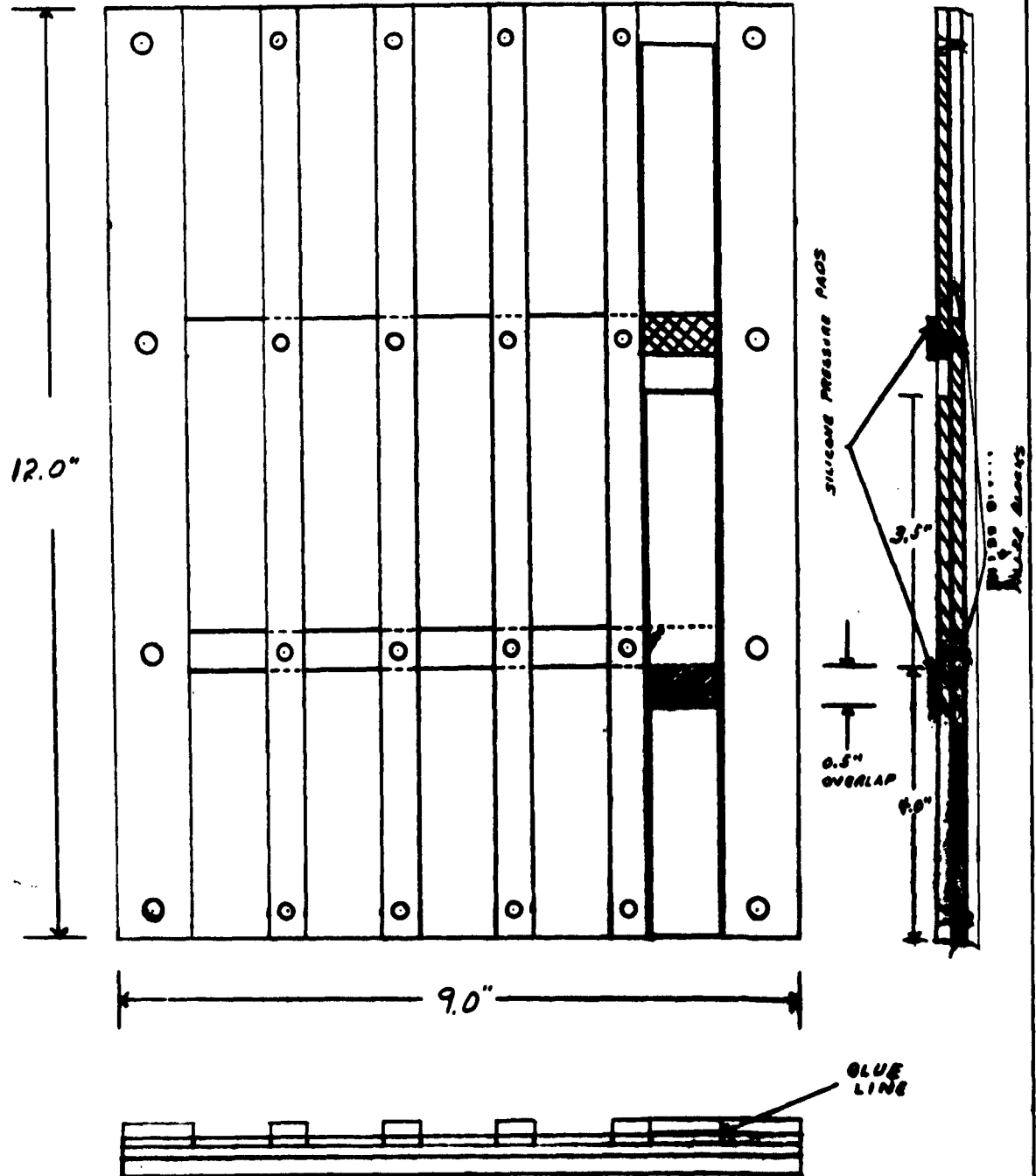


FIG. 1