

AD-A248 472



2

Report No. NADC-91078-60



IN-SERVICE EVALUATION OF 2090 ALUMINUM-LITHIUM ALLOY ON F/A-18 AIRCRAFT

J. Kozol, E.S. Tankins, J.J. Thompson, C.E. Neu
Air Vehicle and Crew Systems Technology Department (Code 606)
NAVAL AIR DEVELOPMENT CENTER
Warminster, PA 18974-5000

1 AUGUST 1991

INTERIM REPORT
Period Covering February 1988 to June 1991



Approved for Public Release; Distribution is Unlimited

Prepared for
NAVAL AIR SYSTEMS COMMAND
Washington, DC 20361-0001

82 4 07 038

92-08963



NOTICES

REPORT NUMBERING SYSTEM — The numbering of technical project reports issued by the Naval Air Development Center is arranged for specific identification purposes. Each number consists of the Center acronym, the calendar year in which the number was assigned, the sequence number of the report within the specific calendar year, and the official 2-digit correspondence code of the Command Officer or the Functional Department responsible for the report. For example: Report No. NADC-88020-60 indicates the twentieth Center report for the year 1988 and prepared by the Air Vehicle and Crew Systems Technology Department. The numerical codes are as follows:

CODE	OFFICE OR DEPARTMENT
00	Commander, Naval Air Development Center
01	Technical Director, Naval Air Development Center
05	Computer Department
10	AntiSubmarine Warfare Systems Department
20	Tactical Air Systems Department
30	Warfare Systems Analysis Department
40	Communication Navigation Technology Department
50	Mission Avionics Technology Department
60	Air Vehicle & Crew Systems Technology Department
70	Systems & Software Technology Department
80	Engineering Support Group
90	Test & Evaluation Group

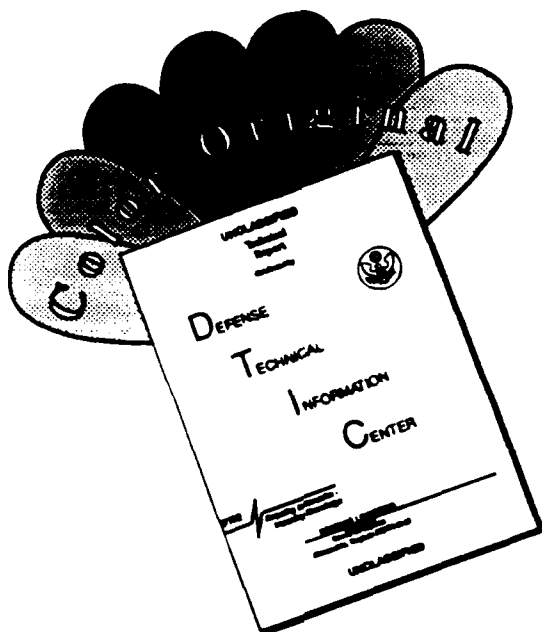
PRODUCT ENDORSEMENT — The discussion or instructions concerning commercial products herein do not constitute an endorsement by the Government nor do they convey or imply the license or right to use such products.

Reviewed By: Jeffrey Walburn Date: 10/18/91
Branch Head

Reviewed By: Shirley A. Smith Date: 10/23/91
Division Head

Reviewed By: J. H. Z. Ford Date: 24 OCT 91
Director/Deputy Director

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF COLOR PAGES WHICH DO NOT REPRODUCE LEGIBLY ON BLACK AND WHITE MICROFICHE.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 1 August 1991	3. REPORT TYPE AND DATES COVERED INTERIM 2/88 to 6/91	
4. TITLE AND SUBTITLE In-Service Evaluation Of 2090 Aluminum-Lithium Alloy On F/A-18 Aircraft			5. FUNDING NUMBERS	
6. AUTHOR(S) J. Kozol, E.S. Tankins, J.J. Thompson, C.E. Neu				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Vehicle and Crew Systems Technology Department (Code 606) NAVAL AIR DEVELOPMENT CENTER Warminster, PA 18974-5000			8. PERFORMING ORGANIZATION REPORT NUMBER NADC-91078-60	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) NAVAL Air Systems Command Washington, DC 20361-0001			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION AVAILABILITY STATEMENT Approved for Public Release; Distribution is Unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) Al-Li alloys can provide reduced weight and increased stiffness as replacements for conventional aluminum alloy aircraft components. A study was conducted to compare the performance of 2090 Al-Li and 7075 Al alloys in-service on Navy aircraft, during shipboard exposure and in laboratory accelerated tests. Results from this investigation indicated that no additional maintenance was required during in-service exposure and that the corrosion behavior of the two alloys in laboratory tests and during shipboard exposure was comparable.				
14. SUBJECT TERMS Aluminum Alloy Aircraft Components, 2090 Al, 7075 Al Alloys, F-18 Aircraft			15. NUMBER OF PAGES	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT SAR	

NADC-91078

CONTENTS

	Page
FIGURES	iv
TABLES	v
ACKNOWLEDGEMENTS	vi
INTRODUCTION	1
MATERIALS	1
PROCEDURES	1
IN-SERVICE EVALUATION	1
ACCELERATED CORROSION TESTING	1
SHIPBOARD CORROSION TESTING	2
RESULTS AND DISCUSSION	2
IN-SERVICE EVALUATION	2
ACCELERATED CORROSION TESTING	2
SHIPBOARD CORROSION TESTING	3
CONCLUSIONS	3
RECOMMENDATIONS FOR FUTURE WORK	3
REFERENCES	4

Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

NADC-91078-60

FIGURES

Figure		Page
1	Access Cover Installed On F/A-18 Aircraft	7
2	Access Cover Scribed For Corrosion Testing	9
3	Access Cover After Two Years Exposure On F/A-18 Aircraft	11
4	2090 Alloy Cover After Four Weeks In Cyclic Acidified Salt Spray, Wet Bottom Test	13
5	7075 Alloy Cover After Four Weeks In Cyclic Acidified Salt Spray, Wet Bottom Test	15
6	2090 Alloy Cover After Four Weeks In Cyclic Acidified Salt Spray, Dry Bottom Test	17
7	7075 Alloy Cover After Four Weeks In Cyclic Acidified Salt Spray, Dry Bottom Test	19
8	2090 Alloy Cover After Four Weeks In SO ₂ /Salt Spray Test	21
9	7075 Alloy Cover After Four Weeks In SO ₂ /Salt Spray Test	23
10	Access Covers Stripped After Cyclic Acidified Salt Spray/Wet Bottom Test	25
11	Access Covers Stripped After Cyclic Acidified Salt Spray/Dry Bottom Test	27
12	Access Covers Stripped After SO ₂ /Salt Spray Test	29
13	Access Covers After Shipboard Exposure	31

NADC-91078

TABLES

Table		Page
1	Identification Of Access Covers.	5
2	Ratings Of Failure At Scribed Lines	6

NADC-91078

ACKNOWLEDGEMENTS

The Cooperation and assistance of Mr. Ish Villalva, NAESU Detachment, Cecil Field, and Mr. Jim Spinks, NAESU Detachment, MCAS Beaufort, in installing and monitoring the access covers on F/A-18 aircraft is gratefully acknowledged.

The authors also wish to thank Mr. Peter Sabatini, NADC, for his assistance with the accelerated corrosion tests.

McDonnell Aircraft Company supplied the aluminum alloy access covers used in these tests and gratitude is expressed to Mr. D.W. Marquart and Dr. K.K. Sankharan for their assistance.

INTRODUCTION

Aluminum-lithium (Al-Li) alloys offer the potential for 8-10% reduction in structural weight on a gage-for-gage substitution for conventional high strength aluminum alloys, as well as enhanced elastic modulus and improved fatigue resistance. Extensive research and development efforts have been conducted on promising aluminum-lithium alloys (1). Several of the alloys are now commercially available and are important candidates for aerospace applications.

This test program represents the first application of an aluminum-lithium part on U.S. Navy aircraft. McDonnell Douglas Corporation identified a non-structural component (ALR-45 Detector Access Cover) for potential material substitution on F/A-18 aircraft for purposes of fleet evaluation. McDonnell Douglas fabricated 12 aluminum-lithium (2090-T8E41) covers and 12 conventional aluminum (7075-T6) covers, which they provided to the Navy for evaluation. The covers were manufactured under their IRAD program. The Naval Air Systems Command approved in-service evaluation of the Al-Li covers (2).

The purpose of this study was to conduct an in-service evaluation and to compare the performance of Al-Li and conventional aluminum covers during exposure aboard ship on a corrosion test rack and in laboratory accelerated corrosion tests.

MATERIALS

The alloys used in this evaluation were conventional 7075-T6 aluminum, which is the bill of materials for access covers currently on the F/A-18 aircraft, and 2090-T8E41 aluminum-lithium. Right side and left side covers of each alloy were fabricated and painted by McDonnell Aircraft Co., St. Louis, Mo. The paint system consisted of MMS 425 epoxy primer on the interior and exterior, followed on the exterior with one topcoat of MMS 420 polyurethane and one MIL-C-83286 topcoat.

PROCEDURES

IN-SERVICE EVALUATION

Access covers were installed on six F/A-18 aircraft at NAS Cecil Field, and on two F/A-18 aircraft at MCAS Beaufort. Two covers were installed on each aircraft, one made of conventional aluminum alloy 7075-T6 and one made of aluminum-lithium alloy 2090-T8E41. The aircraft at NAS Cecil Field were carrier deployed, and the aircraft at MCAS Beaufort were land based. Distribution and identification of the access cover panels on the aircraft is described in Table 1. Figure 1 illustrates the access cover installation on an F/A-18 aircraft.

ACCELERATED CORROSION TESTING

Three types of accelerated corrosion tests were conducted, each according to ASTM standards. One access cover of each alloy was exposed in each accelerated test environment. Sulfur dioxide (SO₂) salt spray testing was conducted per ASTM G85.A4. In this test, a 5% solution of sodium chloride was sprayed continuously in the chamber with SO₂ gas introduced for one hour, four times per day. Temperature in the chamber was maintained at 35°C (95°F). Cyclic acidified salt spray (MASTMAASIS) testing was conducted per ASTM G85.A2, with wet bottom and dry bottom. In these tests, pH of the 5% sodium chloride solution was maintained at 2.8-3.0 and a repetitive cycle of spray, dry air purge and high humidity soak was used. Temperature in the chamber was maintained at 49°C (120°F). For the wet bottom test, water was allowed to collect in the bottom of the salt spray chamber. For the dry bottom test, the exit valve was left open and water drained from the bottom of the chamber.

NADC-91078-60

Naval aircraft exterior surfaces are protected in service by an organic coating system designed to prevent and inhibit corrosion. The access covers subjected to accelerated corrosion testing were scribed with an "X" down to the bare substrate in order to determine the behavior of the bare substrate alloys in the event of loss of the environmentally protective coating. These panels were scribed initially on the left half with an "X" down to the bare substrate, as shown in Figure 2, and mounted in a rack at 15 degrees to the vertical. After two weeks exposure, the right half of each panel was scribed and the test continued for another two weeks. In this manner, the left half of each panel revealed the total effects of four weeks exposure and the right half simultaneously revealed the effects of two weeks exposure at the scribed areas.

SHIPBOARD CORROSION TESTING

One each of the 7075-T6 and 2090-T8E41 access covers were scribed on the left half as described above and exposed to the environment on an aircraft carrier. A rack containing the access covers was placed on the U.S.S. Independence and retrieved for examination after one deployment of the carrier.

RESULTS AND DISCUSSION

IN-SERVICE EVALUATION

After two years exposure on carrier based and land-based aircraft, all of the access covers were in good condition, with no visible evidence of corrosion or other damage. No special maintenance was required on any of the panels. A typical Al-Li access cover is shown in Figure 3. Extended exposure of the access covers on F/A-18 aircraft is being continued.

ACCELERATED CORROSION TESTING

Appearance of the 2090 and 7075 alloy access covers after three types of accelerated corrosion tests is shown in Figures 4 through 9. It can be seen that blistering occurred only along the scribe lines. Comparison of the two alloys after each test indicates more blistering for the 7075 alloy than for the 2090 aluminum-lithium alloy, especially after 4 weeks (672 hours) exposure. It is apparent that the greatest amount of blistering occurred for both alloys in the SO_2 /salt spray test, Figures 8 and 9. This test most closely simulates the carrier environment, specifically the acidified atmosphere resulting from jet engine and stack exhaust gases (3).

The corrosion tested access covers were stripped chemically, revealing the presence of corrosion along the scribe lines. There was no evidence of pitting corrosion or exfoliation. The panels are shown after stripping in Figures 10 through 12. For comparison, the 7075 and 2090 panels are shown side by side for each test.

The covers were evaluated according to ASTM D 1654, "Standard Methods of Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments". Scribed areas were rated as prescribed in Table 1 of ASTM D 1654, which assigns a rating number from 0 to 10 to each area of corrosion, depending on its mean creepage from the scribe line. A rating of 10 indicates no measurable attack. The percentage of the total length of scribe line assigned to each rating was determined and then multiplied by the rating. These factors were then added to obtain a cumulative rating of corrosion failure at the scribe for each specimen. Ratings of failure at the scribe lines are shown in Table 2.

In general, there were almost no measurable effects shown for either alloy in the cyclic acidified salt spray wet bottom test. This is reflected in the ratings of failure at the scribe lines, Table 2. In the cyclic acidified salt spray dry bottom test, the result is basically the same, with a slightly greater amount of

NADC-91078-60

corrosion occurring in the 7075 substrate as compared to the 2090 substrate after 4 weeks. The small amount of corrosion on the 7075 cover after 4 weeks exposure can be seen in Figure 11. According to ASTM D 1654, this resulted in a slightly lower rating of 9.6, compared to 9.9 for the 2090 alloy after 4 weeks exposure. For the two cyclic acidified salt spray tests, the differences in corrosion ratings at the scribe lines are minute and the two alloys are considered to have equivalent behavior.

The severity of the SO₂/salt spray test is reflected in the appearance of the covers, as shown in Figure 12. Corrosion in the 2090 substrate was more uniform than in the 7075, although it extended over a greater area of the scribe lines. This is reflected in the lower rating for the 2090 after 4 weeks exposure (Table 2). Numbers in parentheses next to the ratings for the SO₂/salt spray tests indicate the range of corrosion ratings along the scribe lines. These numbers show that greater individual areas of corrosion occurred for the 7075 alloy than for the 2090 alloy (as shown in Figure 12). For this test, as for the other accelerated corrosion tests, there were no distinct differences in the overall performance of both alloys.

SHIPBOARD CORROSION TESTING

In shipboard corrosion testing, 7075-T6 and 7075-T76 plate and cadmium plated 4130 steel sheet specimens are included as controls to permit assessment of the severity of the environment. The lack of corrosion of the controls after 6 months deployment on the U.S.S. Independence indicates the environment was not sufficiently severe for an accurate assessment of susceptibility to environmental degradation.

Appearance of the access covers exposed to the carrier environment is shown in Figure 13. The 7075 alloy cover shows a very slight effect at the scribe lines and the 2090 alloy cover shows no attack at all. Because of the lack of significant corrosion of either alloy, the covers were not stripped and will be redeployed aboard ship for further comparison of corrosion behavior. At this point, the performance of the two alloys appears to be equivalent.

CONCLUSIONS

1. In-service exposure of 2090-T8E41 aluminum-lithium alloy access covers on F/A-18 aircraft has resulted in no additional maintenance requirements.
2. Accelerated corrosion tests and shipboard exposure tests have shown that the corrosion behavior of the 2090-T8E41 alloy is comparable to that of the 7075-T6 alloy in sheet applications.

RECOMMENDATIONS FOR FUTURE WORK

It is recommended that in-service exposure testing continue on F/A-18 aircraft, along with shipboard corrosion tests, to confirm the results of laboratory accelerated tests.

REFERENCES

1. E.W. Lee, C.E. Neu and J. Kozol, "Al-Li Alloys and Ultra High -Strength Steels for U.S. Navy Aircraft," JOM, Vol. 42, No. 5, May, 1990.
2. NAVAIR LTR SER AIR5304 B4/7-0199, 6 Oct 88.
3. S.J. Ketcham and E.J. Jankowsky, "Developing an Accelerated Test: Problems and Pitfalls" Laboratory Corrosion Tests and Standards, ASTM Special Technical Publication 866, American Society for Testing and Materials, Philadelphia, 1985.

NADC-91078-60

Table 1. Identification Of Access Covers On F/A-18 Aircraft.

Custodian	Bureau Number	ACFT Side Number	Cover Material	Panel ID	Part Number	Side
VFA-82	163427	304	7075-T6 2090-T8E41	1 12	74A-313103-2003 SIA-313103-5004	L R
VFA-82	163438	302	7075-T6 2090-T8E41	11 1	74A-313103-2004 SIA-313103-5003	R L
VFA-82	163442	303	7075-T6 2090-T8E41	9 11	74A-313103-2003 SIA-313103-5004	L R
VFA-86	163437	401	7075-T6 2090-T8E41	6 10	74A-313103-2003 SIA-313103-5004	L R
VFA-86	163439	402	7075-T6 2090-T8E41	7 5	74A-313103-2004 SIA-313103-5003	R L
VFA-86	163443	400	7075-T6 2090-T8E41	8 2	74A-313103-2004 SIA-313103-5003	R L
VMFA-312	163173	09	7075-T6 2090-T8E41	2 9	74A-313103-2003 SIA-313103-5004	L R
VMFA-312	163171	07	7075-T6 2090-T8E41	10 6	74A-313103-2004 SIA-313103-5003	R L

NADC 91078-60

Table 2. Ratings Of Failure At Scribe Lines Per ASTM D 1654.

ASTM G85 Testing	2 WEEKS		4 WEEKS	
	2090	7075	2090	7075
Cyclic Acidified Salt Spray, Wet Bottom	10	9.9	10	9.9
Cyclic Acidified Salt Spray, Dry Bottom	10	9.9	9.9	9.6
SO ₂ /Salt Spray	9.0(8-10)	9.2(7-10)	8.1(7-10)	9.0(6-10)

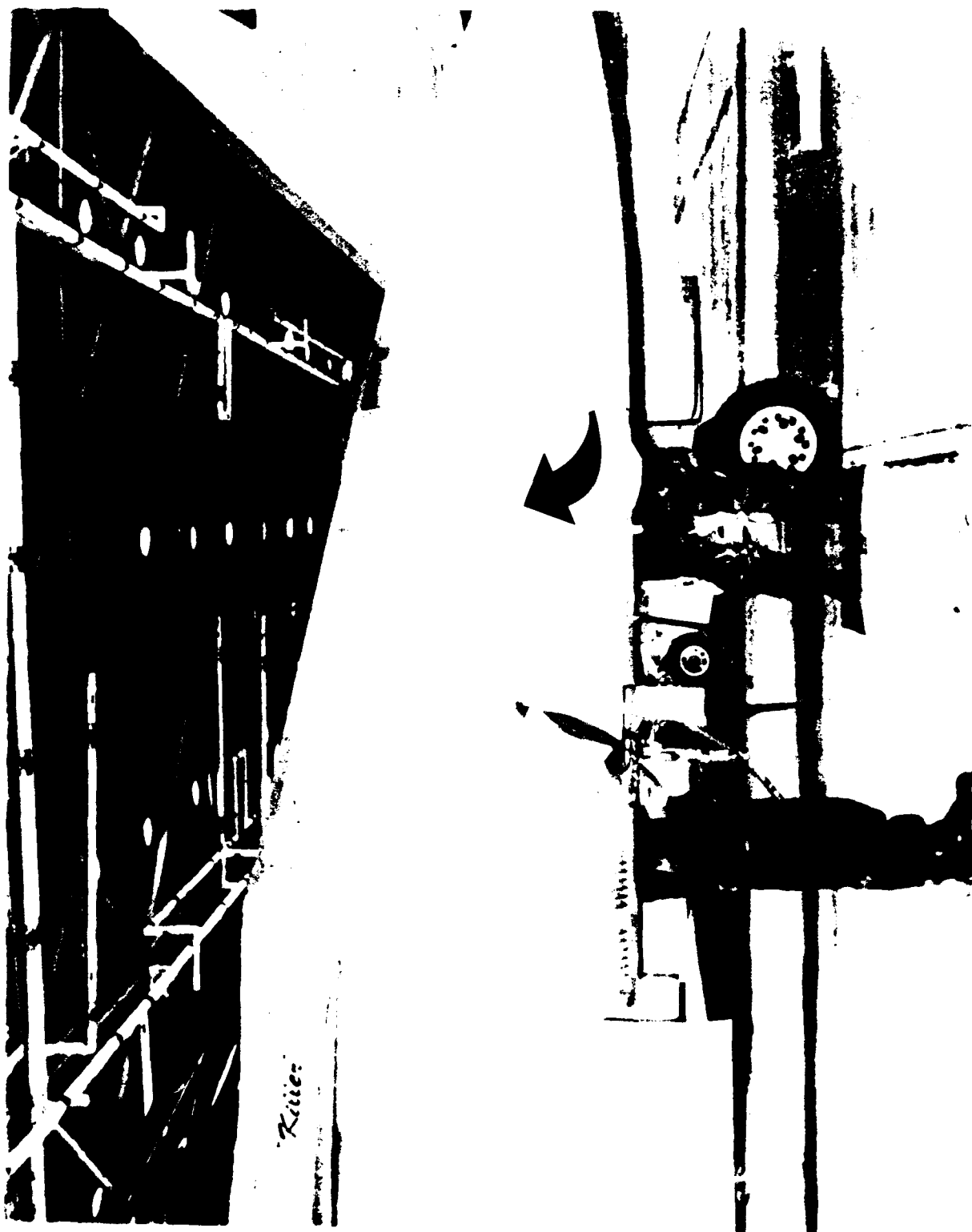
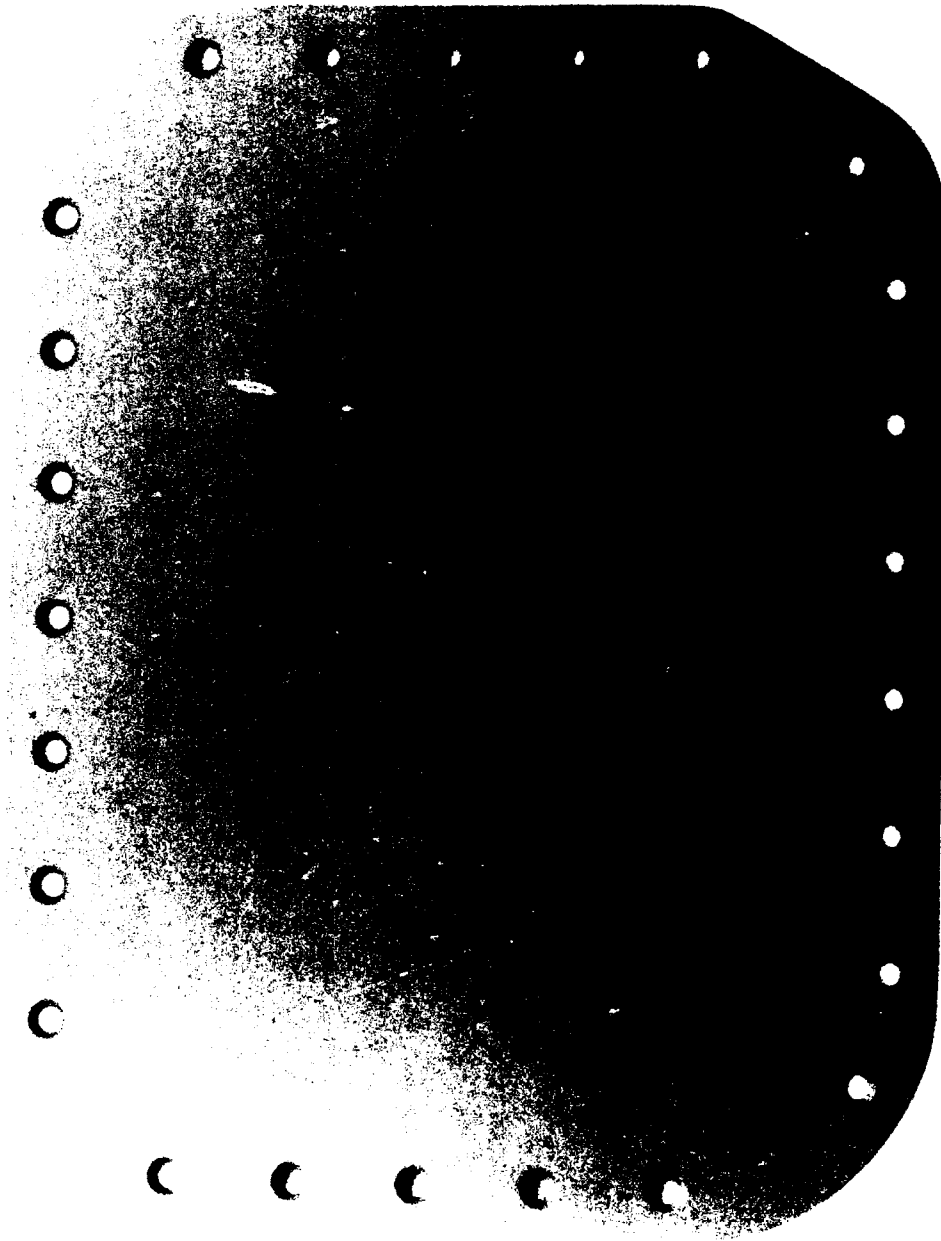


Figure 1. Access Cover Installed On F/A-18 Aircraft.



7075-3

Figure 2. Access Cover Scribed For Corrosion Testing.

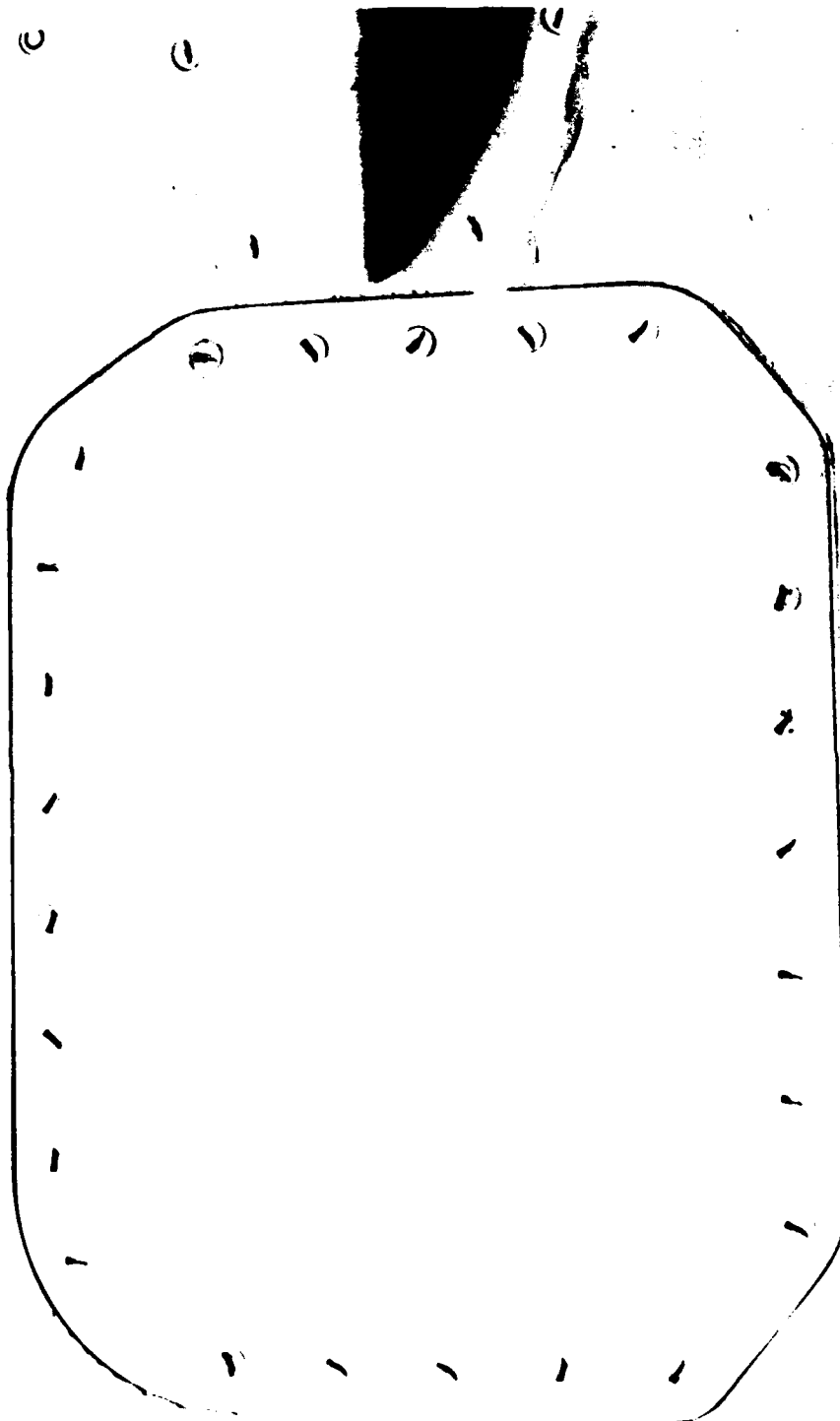


Figure 3 Access Cover After Two Years Exposure On F/A-18 Aircraft.

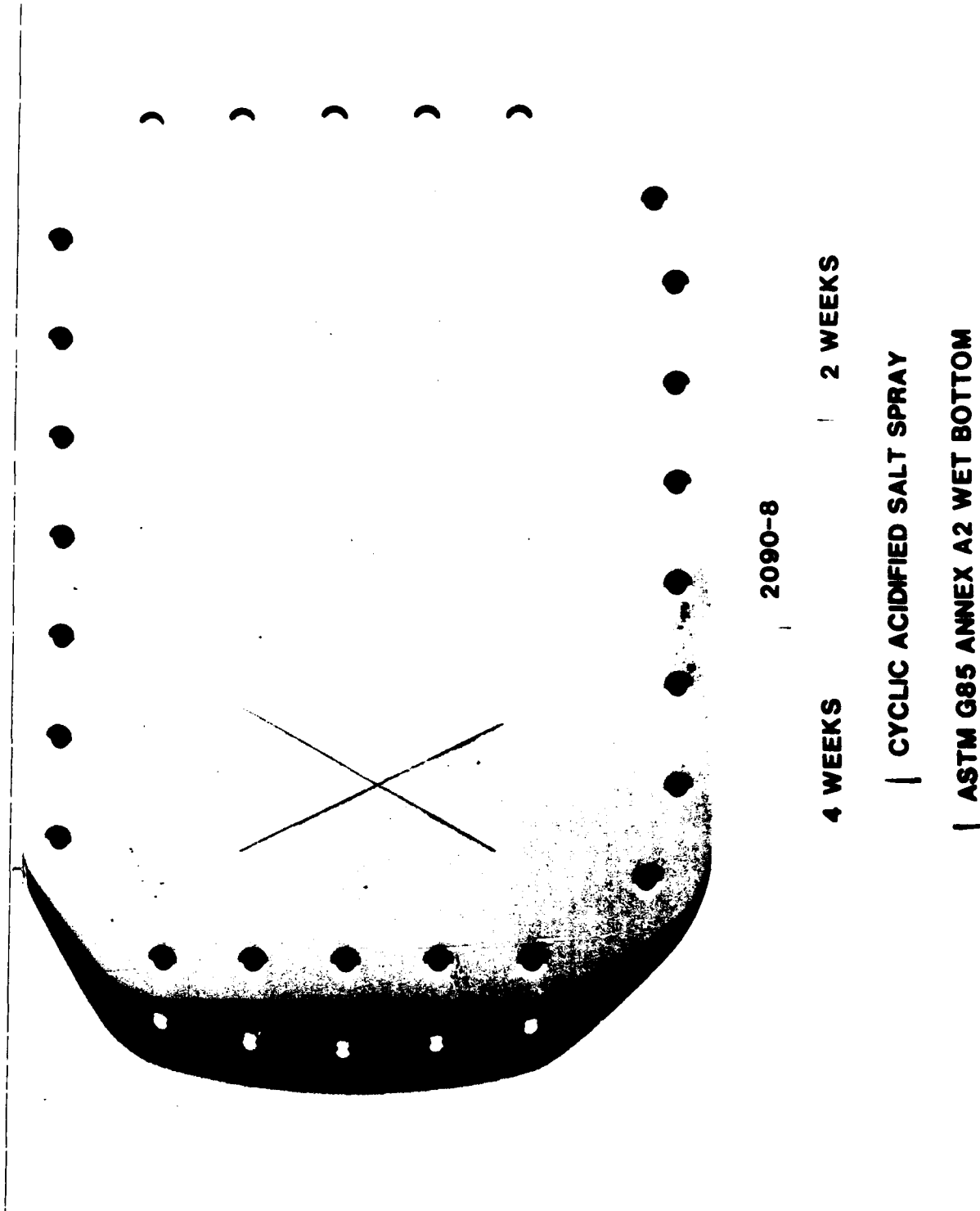
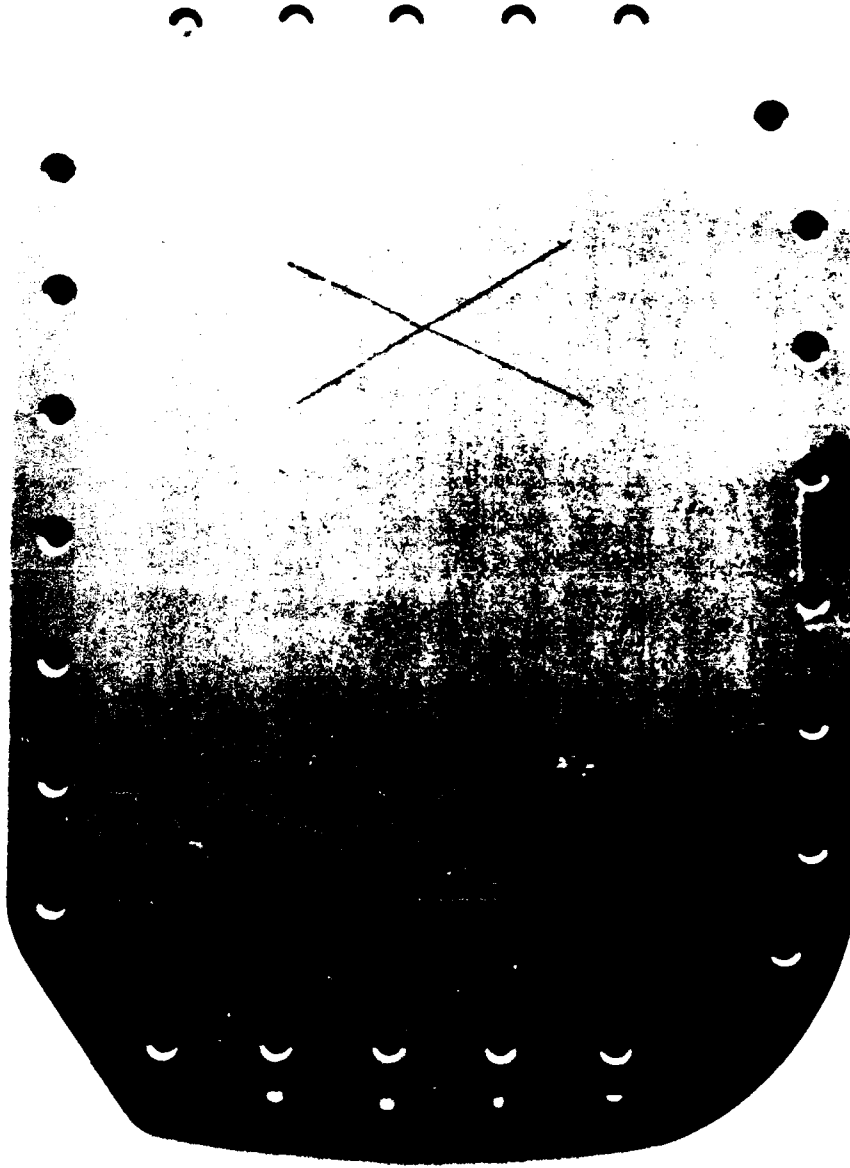


Figure 4. 2090 Alloy Cover After Four Weeks In Cyclic Acidified Salt Spray, Wet Bottom Test.



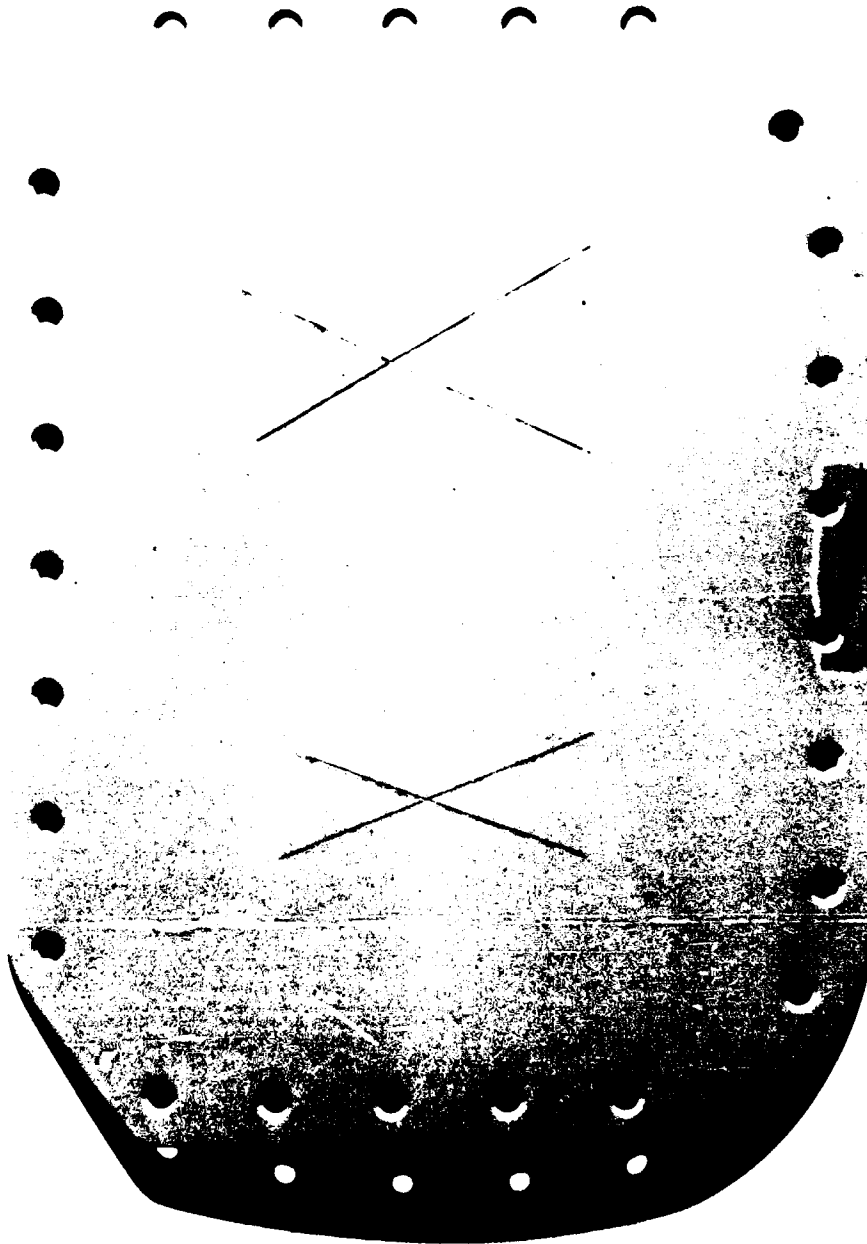
| 7075-3

| 4 WEEKS | 2 WEEKS

| CYCLIC ACIDIFIED SALT SPRAY

| ASTM G85 ANNEX A2 WET BOTTOM

Figure 5. 7075 Alloy Cover After Four Weeks In Cyclic Acidified Salt Spray, Wet Bottom Test.



2090-4

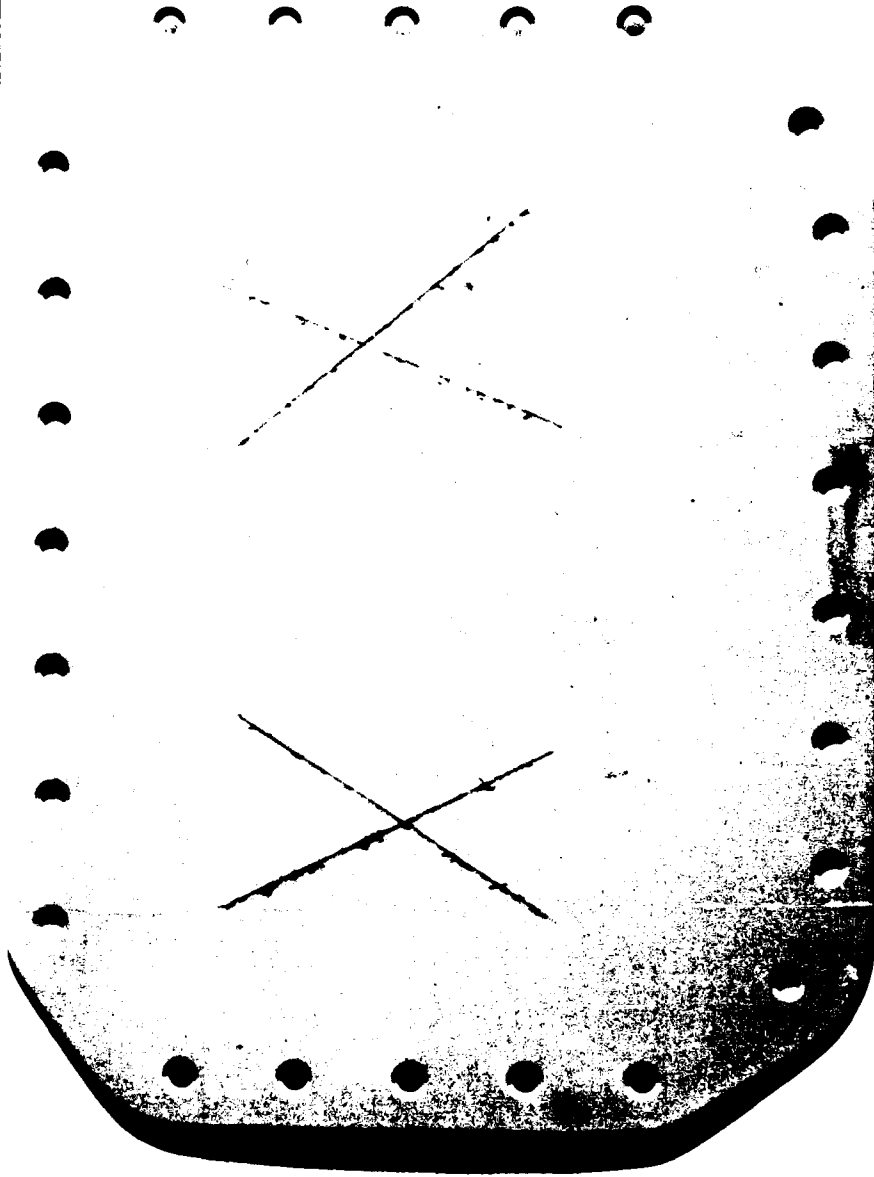
4 WEEKS

2 WEEKS

CYCLIC ACIDIFIED SALT SPRAY

ASTM G85 ANNEX A2 DRY BOTTOM

Figure 6. 2090 Alloy Cover After Four Weeks In Cyclic Acidified Salt Spray, Dry Bottom Test.



7075-5

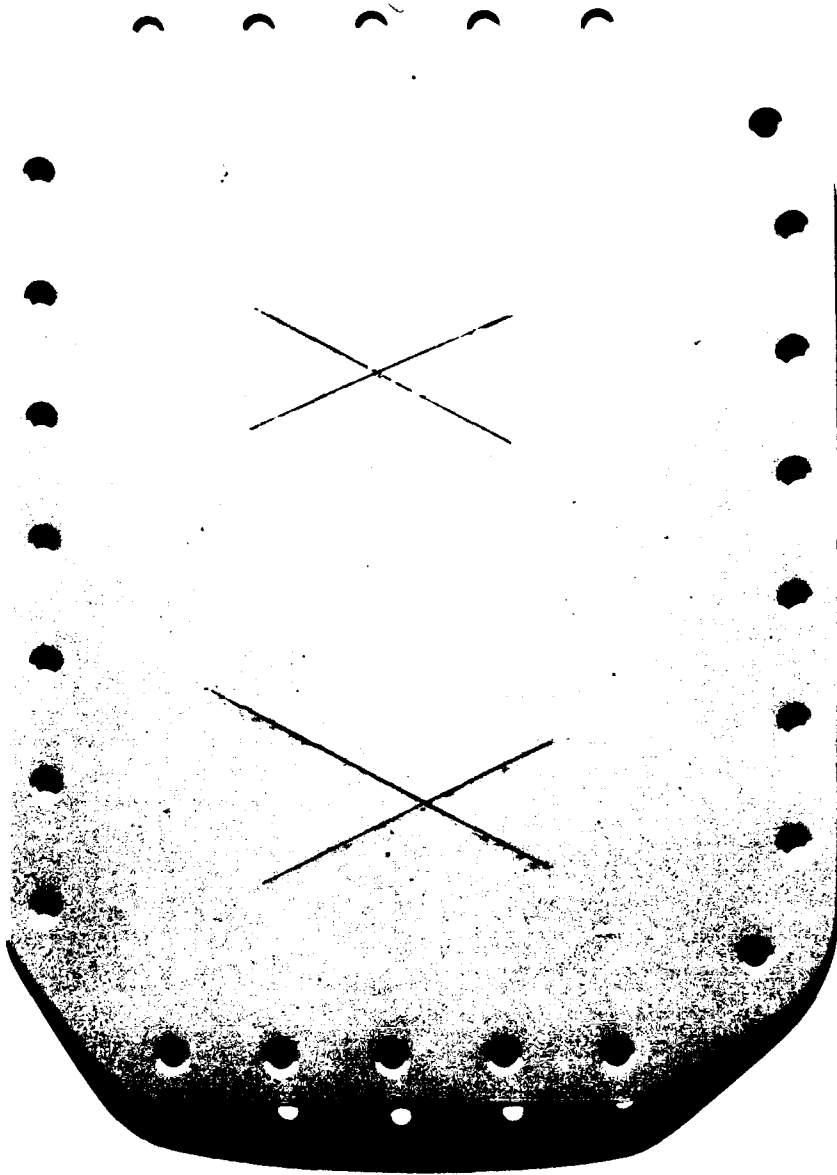
4 WEEKS

2 WEEKS

CYCLIC ACIDIFIED SALT SPRAY

ASTM G85 ANNEX A2 DRY BOTTOM

Figure 7. 7075 Alloy Cover After Four Weeks In Cyclic Acidified Salt Spray, Dry Bottom Test.



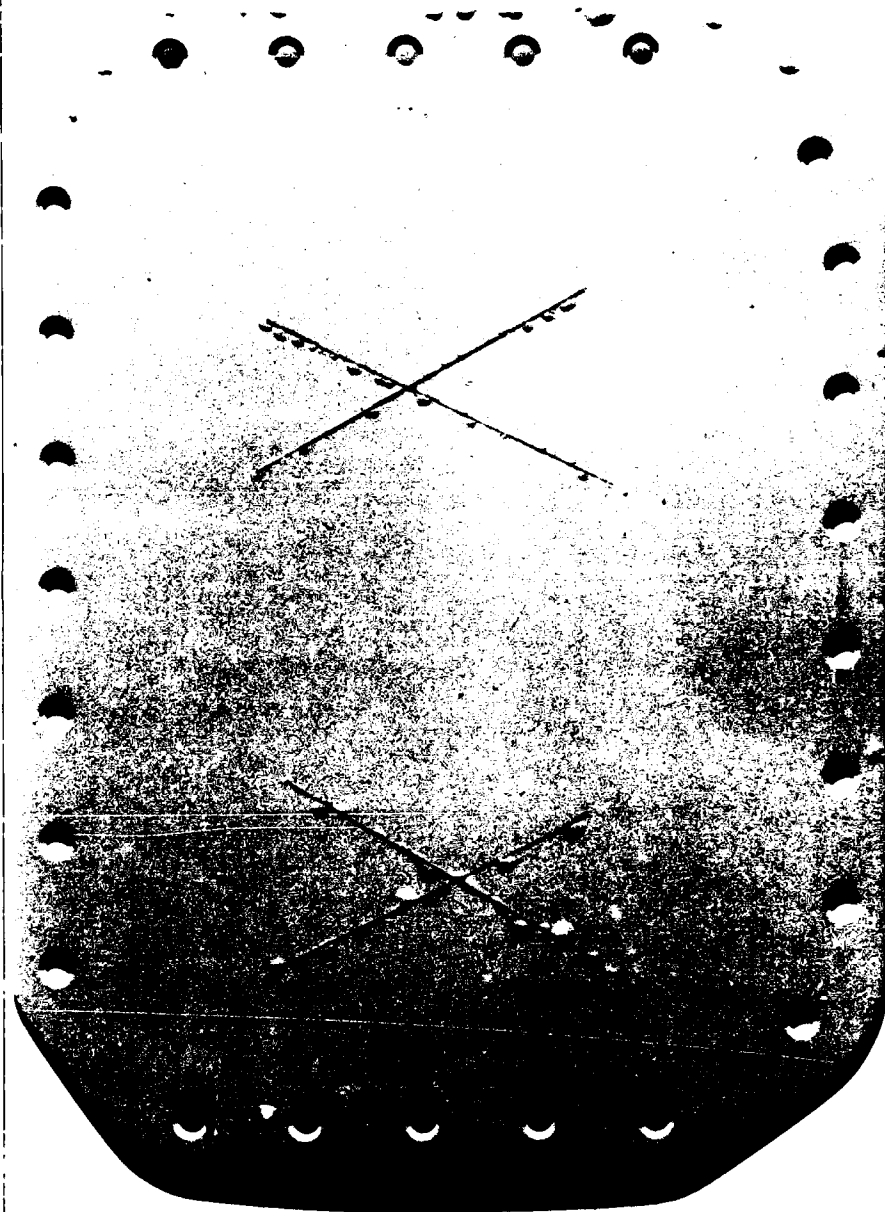
2090-7

4 WEEKS | 2 WEEKS

| SO₂/SALT SPRAY

| ASTM G85 ANNEX A4

Figure 8. 2090 Alloy Cover After Four Weeks In SO₂/Salt Spray Test.



7075-4

| 4 WEEKS

| 2 WEEKS

| SO₂/SALT SPRAY

ASTM G85 ANNEX A4

Figure 9. 7075 Alloy Cover After Four Weeks In SO₂/Salt Spray Test.

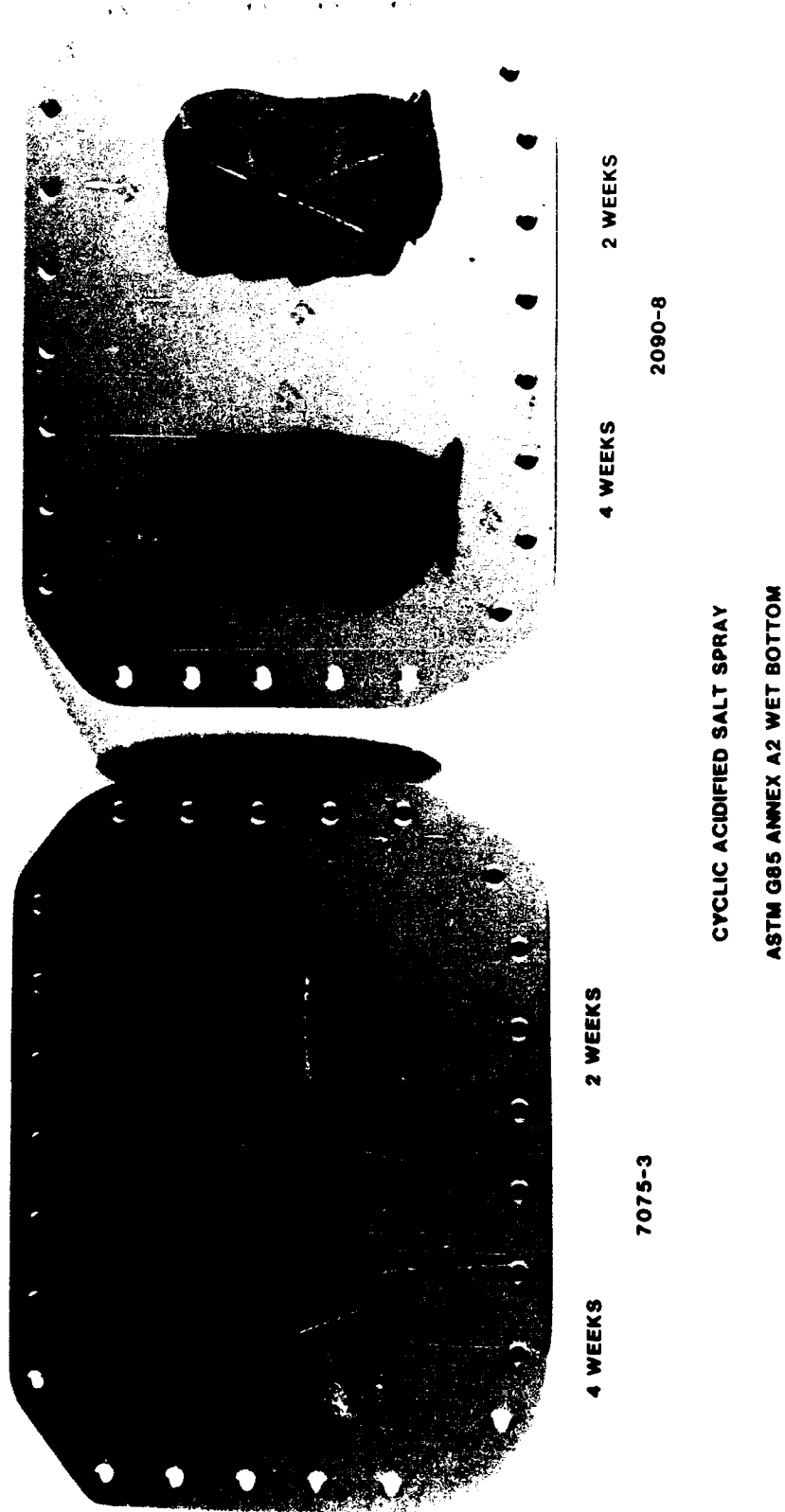


Figure 10. Access Covers Stripped After Cyclic Acidified Salt Spray/Wet Bottom Test.

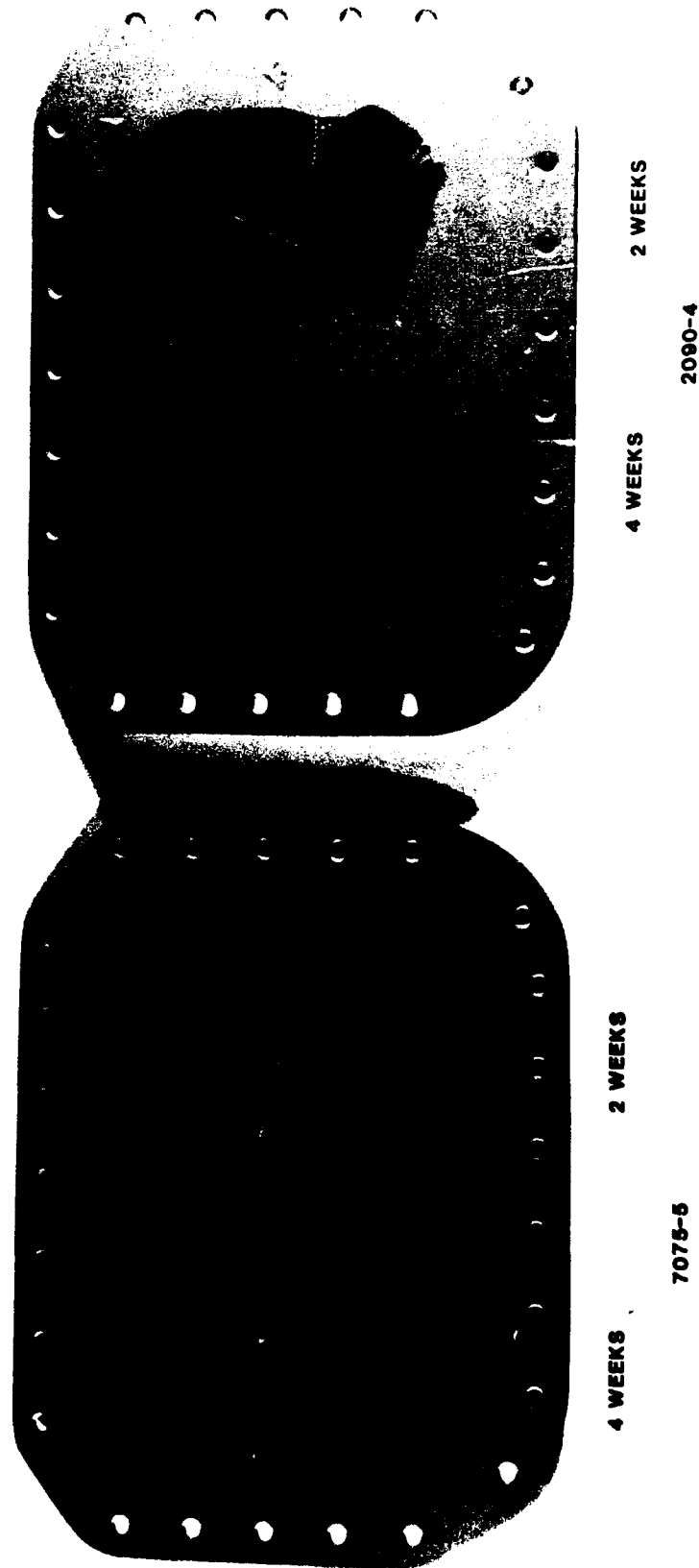


Figure 11. Access Covers Stripped After Cyclic Acidified Salt Spray/Dry Bottom Test.

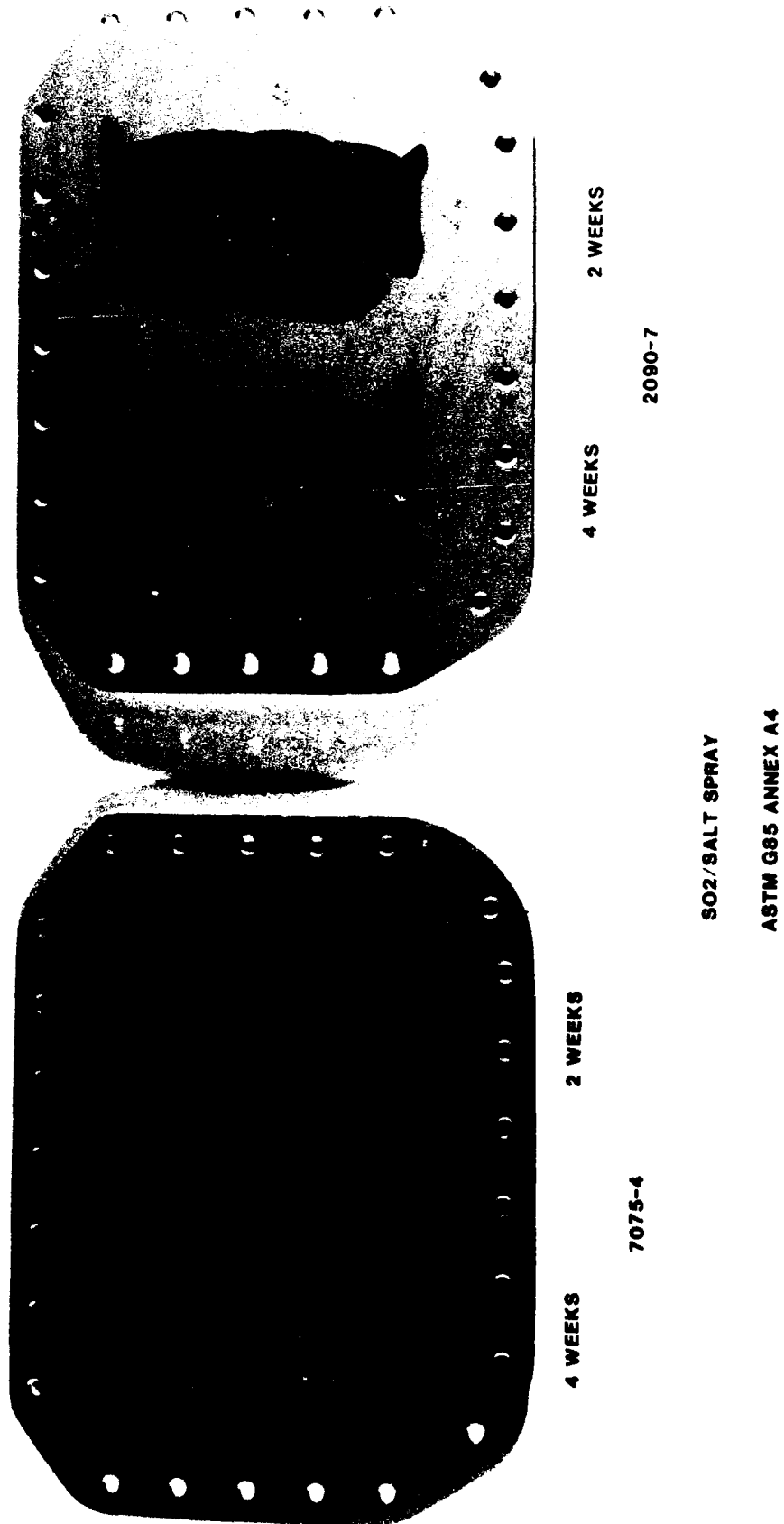


Figure 12. Access Covers Stripped After SO₂/Salt Spray Test.

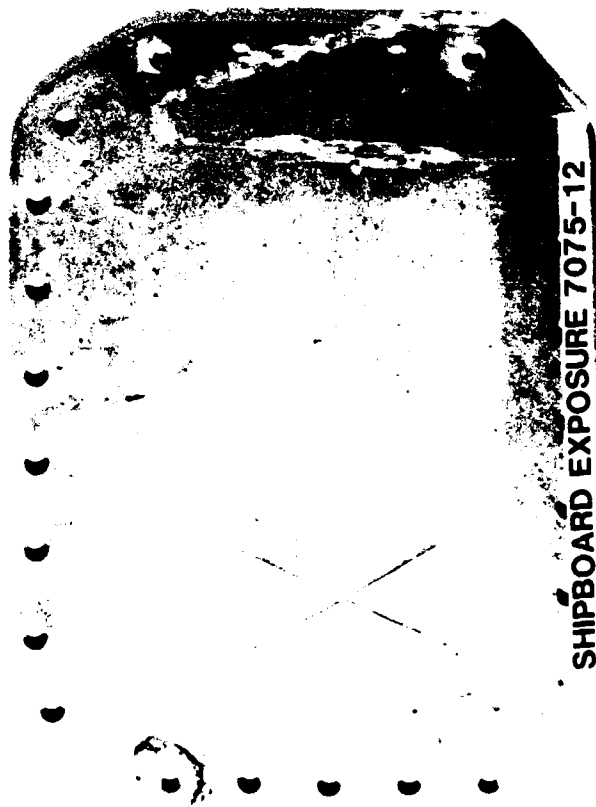


Figure 13. Access Covers After Shipboard Exposure.

DISTRIBUTION LIST (Continued)
Report No. NADC-91078-60

	No. of Copies
Sikorsky Aircraft	2
6900 Main Street	
Stratford, CT 06601-1381	
(1 for Chief Of Materials and Processes)	
(1 for T. Murphy, M/S S312A)	
 Martin Marietta Laboratories	 1
Martin Marietta Corp.	
1450 S. Rolling Road	
Baltimore, MD 21227-3898	
(1 for L. Christodoulou)	

DISTRIBUTION LIST (Continued)
Report No. NADC-91078-60

	No. of Copies
Center for Naval Analysis 4401 Fort Avenue P.O. Box 16268 Alexandria, VA 22302-0268	1
Naval Air Engineering Center Lakehurst, NJ 08733 (1 for K. Megerle, SESD Code 5314 KM) (1 for G. Fisher, SESD Code 5321)	2
National Center of Excellence in Metal- Working Technology Metalworking Technology, Inc. 1450 Scalp Ave. Johnstown, PA 15904 (1 for L. Otto)	1
Wright Laboratories Wright Patterson AFB, OH 45433-6533 (1 for C. Harmsworth, MLSE) (1 for J. Petrak, WL-ML' M)	2
Metals Information Analysis Center Purdue University Lafayette, IN	1
Vought Corp. P.O. Box 226144 Dallas, TX 75222 (1 for Chief of Materials and Processes) (1 for D. Petersen, Advanced Tech. Ctre.)	2
Grumman Aerospace Corp. Bethpage, NY 11714 (1 for Chief of Materials and Processes) (1 for P. Adler, Mail Stop A02-26) (1 for S. Demay, PL12, Dept. 441) (1 for J. Kennedy, Mail Stop A02-26) (1 for P. Shaw, Mail Stop A04-12) (1 for J. Greenspan, Mail Stop A04-12)	6
Lockheed Aeronautical Systems Company 86 South Cobb Drive Marietta, GA 30063-0199 (1 for D. Richardson, Dept 73-C2 (Zone 0199)) (1 for D. Chellman) (1 for Chief of Materials and Processes)	3

DISTRIBUTION LIST (Continued)
Report No. NADC-91078-60

	No. of Copies
McDonnell Aircraft Company McDonnell Douglas Corp. P.O. Box 5116 St. Louis, MO 63166 (1 for Chief of Materials and Processes) (1 for K.K. Sankaran, Mail Code 1021310) (1 for R. Newcomer, Mail Code 1021310)	3
Douglas Aircraft Company McDonnell Douglas Corp. 3855 Lakewood Blvd. Long Beach, CA 90846 (1 for Chief of Materials and Processes)	1
Northrop Corporation Aircraft Division 1 Northrop Ave. Hawthorne, CA 90250-3277 (1 for M. Rommel, 3872-62) (1 for Chief of Materials and Processes)	2
Rockwell International Corporation North American Aircraft Division P.O. Box 92098 Los Angeles, CA 90009 (1 for Chief of Materials and Processes)	1
Boeing Aerospace Co. Boeing Military Airplane Development P.O. Box 3999 Seattle, WA 98124 (1 for Chief of Materials and Processes)	1
Boeing Aircraft Company 3801 South Oliver Street Wichita, KS 67210 (1 for Chief of Materials and Processes)	1
General Dynamics, FT Worth Division P.O. Box 748 Fort Worth, TX 76101 (1 for Chief of Materials and Processes) (1 for Susan Kiehl, MZ 2853)	2

DISTRIBUTION LIST
Report No. NADC-91078-60

	No. of Copies
Naval Air Systems Command Jefferson Plaza One Washington, DC 20361-5300 (1 for S. Bettadapur (AIR-5304D)) (1 for M. Dubberly (AIR-5302)) (1 for J. Collins (AIR-5304)) (1 for H. Varmall (AIR-5304)) (1 for J. Thompson (AIR-5304C)) (1 for W. Koegel (AIR-5304D)) (1 for L. Slotter (AIR-536T))	7
NADEP Cherry Point Cherry Point, NC 28533-5030 (1 for B. Helms (Code 354)) (1 for Code 340)	2
NADEP Alameda Alameda, CA 94501 (1 for Code 340)	1
NADEP Pensacola Pensacola, FL 32508-5300 (1 for O. Hayes (Code 340)) (1 for N. Reeves ((Code 342))	2
NADEP Norfolk Norfolk, VA 23511 (1 for Code 340)	1
NADEP Jacksonville Jacksonville, FL 32212 (1 for Code 340)	1
NADEP North Island San Diego, CA 92135 (1 for Code 340)	1
Defense Technical Information Center Bldg. 5, Cameron Station Alexandria, VA 22314	2
Naval Air Development Center Warminster, PA 18974-5000 Attention: (20 for J. Kozol (Code 6063)) (2 for Technical Library (Code 8131))	22