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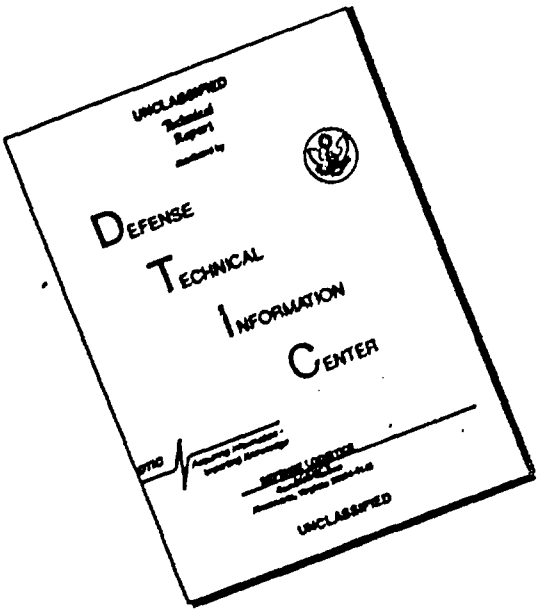

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REPORT NO: FGT-2343
DATE: 17 January

MATERIAL - UNCLAD 2020-T6 ALUMINUM ALLOY-
ELEVATED TEMPERATURE - CORROSION PROTECTIVE
SURFACE TREATMENTS FOR - DETERMINATION OF

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CONVAIR
A DIVISION OF GENERAL DYNAMICS CORPORATION
(FORT WORTH)

Department &
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TEST: F-7826
MODEL B-58

REPORT FGT-2343
DATE 9-10-59

TITLE

MATERIAL - UNCLAD 2020-T6 ALUMINUM ALLOY - ELEVATED TEMPERATURE - CORROSION PROTECTIVE SURFACE TREATMENTS FOR -DETERMINATION OF

SUBMITTED UNDER

Contract AF-33(600)-36200

The tests described in this report were conducted between May 1959 and August 1959.

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MATERIAL - UNCLAD 2020-T6 ALUMINUM ALLOY - ELEVATED TEMPERATURE - CORROSION PROTECTIVE SURFACE TREATMENTS FOR - DETERMINATION OF

PURPOSE

Unclad 2020-T6 aluminum alloy is being considered for B-58 application where parts may be subjected to elevated temperatures. Considerable weight savings may be realized in its use if the alloy meets all the required properties.

The purpose of this test was to evaluate the corrosion resistance of unclad 2020 aluminum alloy when protected by anodic coatings (MIL-A-8625A) or by chemical film treatment (MIL-C-5541) on exposure to elevated temperatures of 300°F and 350°F for 100 hours each.

SUMMARY

Unclad 2020-T6 aluminum alloy received Type I and II anodic coatings per MIL-A-8625A and Iridite 14-2 coatings per MIL-C-5541. Uncoated and coated panels from each process were subjected to the following: (1) no heat exposure, (2) 100 hours at 300°F, and (3) 100 hours at 350°F. The panels were then exposed to 20% salt spray, 120°F., 95% relative humidity, and 3 phase JP-4 salt water immersion environments. Tensile tests were conducted on coated and uncoated specimens which received the various heat soaks and salt spray exposure.

Test results revealed that 100 hours exposure to 300°F had little effect on the tensile properties of coated and uncoated 2020-T6 aluminum, whereas a similar exposure at 350°F decreased the yield and ultimate strengths by 13 to 22 percent.

Specimens representing all three coating processes passed the tensile requirements of MIL-A-8625A (Type I and II anodize) and MIL-C-5541 (Iridite 14-2) after salt spray exposure alone. However, elevated temperature exposure decreased the salt spray corrosion resistance of all specimens.

Type I, Type II and Iridite 14-2 coated 2020-T6 aluminum exhibited no visible signs of corrosion after 360 hours exposure to 120°F, 95% relative humidity or 48 hours exposure to 3 phase JP-4 salt water immersion.

MATERIAL - UNCLAD 2020-T6 ALUMINUM ALLOY - ELEVATED TEMPERATURE-CORROSION PROTECTIVE SURFACE TREATMENTS FOR - DETERMINATION OF

OBJECT:

To investigate the corrosion resistant properties of Type I and Type II anodize and Iridite 14-2 coatings on bare 2020-T6 aluminum alloy after 100 hours exposure to elevated temperatures of 300 and 350°F by determining the following:

I. Porosity By

(a) Salt Spray
(b) Humidity
(c) JP-4 3 phase immersion

II. Tensile Properties

TEST SPECIMENS, MATERIALS, AND EQUIPMENT:

I. Specimens

Item	Qty.	Size	Source
Bare 2020-T6 Aluminum Alloy	13	0.100"x10"x12"	Aluminum Co. of America, Alcoa, Tenn.

II. Materials

Item	Source
Type I (chromic acid) Anodize Solution	Prepared per MIL-A-8625A in Engr. Chem. Lab.
Type II (sulfuric acid) Anodize Solution	"
Iridite 14-2 Solution	Prepared per MIL-C-5541 in Eng. Chem. Lab.

III. Equipment

Item	Source
Salt Spray Cabinet	Ind. Filter and Pump Mfg. Co. Chicago, Ill.
Humidity Cabinet	American Instrument Co. Silver Springs, Md.

III. Equipment (Continued)

Item	Source
Tensile Machine	A. H. Emery Co. Stamford, Conn.
Blue "M" Electric Oven RT - 350°F	Blue "M" Electric Co. Blue Island, Ill.

PROCEDURE:

The test was conducted in four parts. Three 0.100" x 10" x 12" test panels of bare 2020-T6 aluminum alloy were coated by each of the three processes; Type I anodize, Type II anodize and Iridite 14-2. Four test panels of bare 2020-T6 were left uncoated and used for control specimens. The test panels were cut from the same sheet of material to prevent large variations in chemical and physical properties between samples. Type I and Type II anodize were applied per MIL-A-8625A. Coating weight was determined and found to be well over the minimum weight required in both cases. The Iridite 14-2 coating was applied per MIL-C-5541. Panels of each of the three coating processes and uncoated controls were subjected to: (1) no heat, (2) 300°F for 100 hours, and (3) 350°F for 100 hours. The specimens were then sheared to desired sizes for testing.

The following tests were performed:

(1) Salt Spray: One 5" x 6" panel from each coating process and heat soak was subjected to salt spray per FTMS 151, Method 811. Type I and Type II anodized panels were supported at a 6° inclination from the vertical for a total of 240 hours. Panels coated with Iridite 14-2 were supported at a 6° inclination for a total of 168 hours. All panels were examined every 24 hours until pitting developed and then the exposure was continued until total time had elapsed. Uncoated 5" x 6" panels were tested as controls.

(2) Humidity: One 5" x 6" panel from each coating process and heat soak was subjected to 120°F, 95% relative humidity for 360 hours per Procedure 3 of MIL-E-5272A. The panels were examined every 48 hours until pitting developed and then the exposure was continued until total time had elapsed. Uncoated 5" x 6" panels were tested as controls.

(3) Three Phase Immersion: One 5" x 6" panel from each coating process and heat soak was subjected to 48 hours three phase immersion (JP-4, JP-4 vapor, 3% NaCl solution at 140°F). The panels were then examined for pitting. Uncoated 5" x 6" panels were tested as controls.

(4) Tensile: Five coupons of each coating process and heat soak were prepared for tensile tests per FTJ 4751-38*. The tensile tests were conducted per FTMS 151, Method 211, on uncoated controls and coated specimens after exposures of zero, 168 hours, and 240 hours in salt spray.

RESULTS

The results of the various parts of the test are given in tabulated form as follows:

(1) Table I lists the number of pits/in^2 for each coating process and heat soak after various salt spray exposures.

(2) Table II(A) gives the number of pits/in^2 for each coating process and heat soak after 360 hours in the 120°F, 95% relative humidity cabinet.

(3) Table II(B) shows the effects of three phase immersion on each coating process and heat soak.

(4) Table III gives the results of tensile tests.

(5) Table IV shows the operating conditions of the salt spray chamber during specimen exposure.

DISCUSSION

Type I and Type II anodize coatings were applied per MIL-A-8625A. Iridite 14-2 chemical film was applied per MIL-C-5541. All three coatings were applied to bare 2020-T6 aluminum alloy.

Table I shows that 2020-T6 aluminum alloy, when coated by the two processes Type II anodize and Iridite 14-2, exhibit excellent corrosion resistant properties in salt spray environment when not subjected to elevated temperatures. However, the same type specimens when subjected to elevated temperatures show corrosion present after three to nine days salt spray exposure. The 2020-T6 aluminum alloy when coated with Type I anodize showed corrosion on panels both with and without heat soaks from three to seven days in the salt spray chamber.

Table II(A) shows that only the 2020-T6 aluminum control panels (with no protective coating) exhibited corrosion after 360 hours exposure in the humidity chamber. All coated panels passed the required humidity exposure time with no signs of corrosion.

*See Supplemental Sheet S-1.

Results of JP-4 three phase immersion test given in Table II(B) indicate no corrosion problem exists on coated panels or uncoated controls after 48 hour exposure.

The results listed in Table III show that the tensile properties of 2020-T6 aluminum alloy are slightly decreased by 300°F heat exposure whereas 350°F heat exposures decrease the yield strength by 16 to 22% in all cases (coated and uncoated) and the ultimate strength by 13 to 16%. Salt spray exposures alone seemed to have very little, if any, effect on the tensile properties of 2020-T6 aluminum alloy.

CONCLUSIONS:

The corrosion resistant properties of Type I and Type II anodize and Iridite 14-2 coatings on bare 2020-T6 aluminum alloy when exposed to elevated temperatures were investigated. The results of these investigations lead to the following conclusions:

I. Temperature Resistance

A. One hundred hours exposure to 300°F has little effect on the tensile properties of coated and uncoated 2020-T6 aluminum alloy.

B. One hundred hours exposure to 350°F decreases the yield and ultimate strengths of coated and uncoated 2020-T6 aluminum by 13 to 22 percent.

II. Corrosion Resistance

A. Salt Spray: Type I anodized 2020-T6 aluminum exhibits 5 pits per square inch of exposed surface after 240 hours salt spray exposure. Type II anodized and Iridite 14-2 coated 2020-T6 aluminum exhibit no visible corrosion after 240 and 168 hours salt spray exposure respectively. All coated specimens pass the tensile requirements of MIL-A-8625A (Type I and II anodize) and MIL-C-5541 (Iridite 14-2) after salt spray exposure.

Elevated temperature exposures decrease the salt spray corrosion resistance of coated and uncoated 2020-T6 aluminum. The tensile properties of coated specimens exposed to temperature and salt spray are approximately the same as those for uncoated specimens.

B. Humidity and 3 Phase Immersion: Type I, Type II, and Iridite 14-2 coated 2020-T6 aluminum show no visible signs of corrosion after 360 hours exposure to 120°F, 95% relative humidity or 48 hours exposure to 3 phase JP-4 salt water immersion.

TABLE I

RESULTS OF SALT SPRAY TESTS

Material and Treatment	100 Hr. Heat Exposure	Salt Spray Exposure	Specimen Number	Number of days exposed at first sign of corrosion.	Number of pits/in^2 after total exposure period.
Bare X-2020-T6 Material with no treatment.	No Heat Exposure	None	1-5	———	———
		168 Hr.	16-20	2 days	Pits too numerous to count.
		240 Hr.	21-25	2 days	Pits too numerous to count.
	300° F	None	26-30	———	———
		168 Hr.	41-45	2 days	Pits too numerous to count.
		240 Hr.	46-50	2 days	Pits too numerous to count.
	350° F	None	51-55	———	———
		168 Hr.	66-70	2 days	Pits too numerous to count.
		240 Hr.	71-75	2 days	Pits too numerous to count.
Bare X-2020-T6 Material with Type I Anodize. Applied per MIL-A-8625A	No Heat Exposure	None	76-80	———	———
		240 Hr.	91-95	7 days	5 pits/in^2
	300° F	None	96-100	———	———
		240 Hr.	111-115	4 days	8 pits/in^2
	350° F	None	116-120	———	———
		240 Hr.	131-135	3 days	11 pits/in^2
Bare X-2020-T6 Material with Type II Anodize. Applied per MIL-A-8625A	No Heat Exposure	None	136-140	———	———
		240 Hr.	151-155	no visible pits	No pits over entire surface.
	300° F	None	156-160	———	———
		240 Hr.	171-175	9 days	4 pits over entire surface. 13 pits/in^2
	350° F	None	176-180	———	———
		240 Hr.	191-195	9 days	4 pits over entire surface. 13 pits/in^2
Bare X-2020-T6 Material with Iridite No. 12. Applied per MIL-C-	No Heat Exposure	None	196-200	———	———
		168 Hr.	211-215	* no visible pits	No pits over entire surface.
	300° F	None	216-220	———	———
		168 Hr.	231-235	* 3 days	Pits too numerous to count.
	350° F	None	236-240	———	———
		168 Hr.	251-255	* no visible pits	No pits over entire surface.

UTILITY REPORT SHEET * This group of specimens was rerun and the results were reproducible.

TABLE II

RESULTS OF HUMIDITY AND JP-4 THREE PHASE IMMERSION-TESTS

(A.) 360 Hr. Humidity Test (120° F. 95%)

Material and Treatment	100 Hr. Heat Exposure	Specimen Number	Number of days exposed at first sign of corrosion.	Number of pits/in^2 after total exposure period.
Bare X-2020-T6 Material with no treatment.	No Heat	11-15	7 days	six
	300° F	36-40	6 days	Pits too numerous to count.
	350° F	61-65	4 days	"
Bare X-2020-T6 Material with Type I Anodize. Applied per Mil-A-8625A.	No Heat	86-90	No pits visible	No pits over entire surface.
	300° F	106-110	"	"
	350° F	126-130	"	"
Bare X-2020-T6 Material with Type II Anodize. Applied per Mil-A-8625A.	No Heat	146-150	"	"
	300° F	166-170	"	"
	350° F	186-190	"	"
Bare X-2020-T6 Material with Iridite 14-2. Applied per Mil-C-5541.	No Heat	206-210	"	"
	300° F	226-230	"	"
	350° F	246-250	"	"

(B.) JP-4 Three phase immersion test (48 hours exposure)

Material and Treatment	100 Hr. Heat Exposure	Specimen Number	Comments
Bare X-2020-T6 Material with no treatment.	No Heat	6-10	No pits over entire surface.
	300° F	31-35	"
	350° F	56-60	"
Bare X-2020-T6 Material with Type I Anodize. Applied per Mil-A-8625A.	No Heat	81-85	"
	300° F	101-105	"
	350° F	121-125	"
Bare X-2020-T6 Material with Type II Anodize. Applied per Mil-A-8625A.	No Heat	141-145	"
	300° F	161-165	"
	350° F	181-185	"
Bare X-2020-T6 Material with Iridite 14-2. Applied per Mil-C-5541.	No Heat	201-205	"
	300° F	221-225	"
	350°F	241-245	"

TABLE III

RESULTS OF TENSILE TESTS

Material and Treatment	100 Hr. Heat Exposure	Salt Spray Exposure	Specimen Number	Average Tensile Properties		
				Yield PSI	Ultimate PSI	* Percent Elongation
Bare X-2020-T6 Material with no treatment.	No Heat Exposure	None	1-5	75,075	79,800	8.4
		168 Hr.	15-20	75,680	80,280	4.4
		240 Hr.	21-25	76,640	82,040	6.2
	300° F	None	26-30	72,620	77,480	7.6
		168 Hr.	41-45	73,020	77,880	6.5
		240 Hr.	46-50	73,380	77,880	7.4
	350° F	None	51-55	58,700	66,950	7.2
		168 Hr.	66-70	56,360	66,560	7.3
		240 Hr.	71-75	56,880	66,080	8.2
Bare X-2020-T6 Material with Type I Anodize. Applied per Mil-A-8625A	No Heat Exposure	None	76-80	74,666	79,380	7.8
		240 Hr.	91-95	76,140	81,100	8.5
	300° F	None	96-100	72,800	77,360	7.6
		240 Hr.	111-115	71,000	77,500	7.7
	350°F	None	116-120	59,420	67,800	8.2
		240 Hr.	131-135	56,500	66,300	8.5
Bare X-2020-T6 Material with Type II Anodize. Applied per Mil-A-8625A	No Heat Exposure	None	136-140	73,420	78,760	7.7
		240 Hr.	151-155	73,600	80,000	7.8
	300° F	None	156-160	73,000	78,420	7.6
		240 Hr.	171-175	73,320	77,580	2.9
	350° F	None	176-180	61,760	68,520	7.8
		240 Hr.	191-195	61,720	68,680	4.5
Bare X-2020-T6 Material with Iridite 14-2. Applied per Mil-C-5541	No Heat Exposure	None	196-200	74,520	79,560	8.4
		168 Hr.	211-215	75,260	79,780	7.6
	300° F	None	216-220	72,980	77,740	7.5
		168 Hr.	231-235	73,460	78,020	7.3
	350° F	None	236-240	58,840	67,460	7.9
		168 Hr.	251-255	61,000	69,280	7.9

* Percent elongation in 2 inches.

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FORT WORTH

Test No. F-76 | TABLE IV
W. O. 575-11-506
Engineer J. L. Cozart
Prepared by

SALT SPRAY DATA AND RESULTS

Cabinet No. 1

REPORT NO. FGT-2843
MODEL B-58
DATE 9-10-59

	TEMPERATURE OF BOX °F	AIR GAUGE PRESSURE psi	TEMPERATURE OF HUMIDIFIER °F	SPECIFIC GRAVITY OF SALT SOLUTION	SPECIFIC GRAVITY OF FOG SOLUTION	Ml. FOG/HR. COLLECTED IN 10 CM FUNNEL	pH OF SALT SOLUTION	pH OF FOG SOLUTION
MAXIMUM	97°	12	110°	1.157	1.155	1.1	7.2	7.2
MINIMUM	92°	12	100	1.149	1.146	0.9	6.5	6.5

I. DESCRIPTION OF SPECIMENS AND/OR PARTS

Size: 5" x 6" x 0.100"

Alloy and Condition: 2020-T6 Aluminum

Coating, Finish, or Plate: Type I anodize - Type II anodize -Iridite 14-2

Edges Sealed With: Paraffin

Pre-Exposure Cleaning: M.E.K. Wipe - Vapor Degrease

II. No. of Specimens: 15

III. Reason for Test or Use of Part: Requested in test.

IV. Exposure Time: 168 hrs. - 240 hrs.

Date and Time in Chamber: 6-26-59 6-26-59

Date and Time out of Chamber 7-3-59 7-6-59

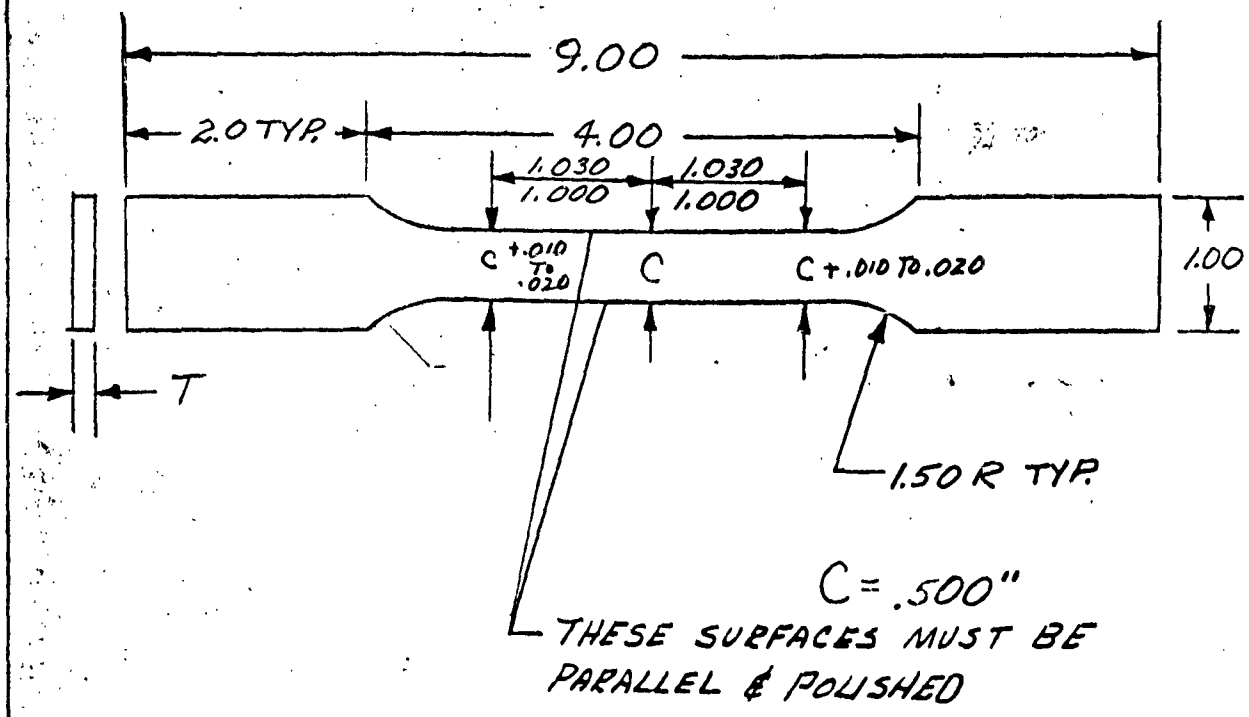
V. Method of Specimen Support: Supported 60° from the vertical in non-corrosive plexiglass rack.

VI. Results and Remarks: See Report.

INTERRUPTIONS

DATE	TIME OPE	TIME CLOSED	REASONS

Salt spray box opened about 15 minutes daily to inspect specimens and to maintain chamber.



TENSILE COUPON

FTJ 4751-38
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