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NBSIR 78-1587 (NASC)

Stress Corrosion Behavior of 7049-T76510, -T73510 and -T73511 Aluminum Alloy Extrusions

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U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, *Secretary*
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Reference: (a) Naval Air Systems Command, Department of the Navy request by AIR 52031G.

Introduction

Previous studies performed by NBS on the stress corrosion behavior of a 7049-T73 aluminum alloy die forging concluded that the alloy had good resistance to stress corrosion cracking except at areas immediately adjacent to the parting line.* Transverse C-ring test specimens machined from the forging at areas adjacent to the parting line and with the maximum stress (75% of the yield strength of the alloy) applied at these areas were found to have failed in a marine atmosphere after exposure for 798 days. C-ring specimens machined from similar areas of the forging had not failed after 62 days intermittent immersion (once in every 45 minutes) in an artificial laboratory environment (3.5% sodium chloride solution). Flat transverse tensile specimens machined from areas remote from the parting line of the forging had not failed after exposure for 62 days in the laboratory environment or 798 days in the marine atmosphere.

Reference (a) requested that NBS conduct tests to determine the stress corrosion behavior of 7049-T76510, -T73510 and -T73511 aluminum alloy extrusions in a marine environment.

Material

Three extruded 7049 aluminum alloy sections, each having a different temper (T76510, T73510 and T73511) were submitted to NBS. Specimens in the form of flat tensile bars were machined from the two extrusions with the -T76510 and -T73510 tempers and round tensile bars were machined from the 7049 -T73511 aluminum alloy extrusion. The flat specimens were approximately 6 in. (15.2 cm) long x 1.0 in. (2.54 cm) wide x 0.125 in. (3.2 mm) thick with a 2 in. long (5.1 cm) uniform reduced section. The round specimens having a temper of -T73511 were approximately 2 in. (5.1 cm) long with a reduced section of 0.125 in. (3.2 mm) diameter. All specimens were machined from the extrusions so that their principal axes were in the transverse direction with respect to the direction of extrusion of the alloy (long transverse direction for the flat specimens and short transverse direction for the round specimens).

*NBSIR #74-559, Stress Corrosion Behavior of Die Forged 7049-T73 Aluminum Alloy, E. Escalante and W. F. Gerhold, August 1974.

Metallography

The microstructures of the three different heat treated 7049 aluminum alloy materials display similar grain size and structure. There is some evidence of recrystallization having occurred. There also appears to be some intermetallic precipitation at the grain boundaries. Photomicrographs of the materials are shown in figures 1, 2 and 3.

Mechanical Properties

Tests were performed by NBS to determine the transverse mechanical properties of the three extrusions. The results of these tests are shown in Table I.

Stress Corrosion Tests

Stressed and unstressed specimens were exposed in the marine atmosphere at Kure Beach, NC [80 ft.(24 m) lot]. A system of weights and levers was used to obtain the desired stress on the flat test specimens having the T76510 and T73510 tempers. A constant strain fixture was utilized to apply the desired stress on the round specimens. For the stressed specimens, the applied stress was equivalent to approximately 50 and 75% of the yield strength of the alloys as determined by NBS [67.1 Ksi (463 MPa) for the -T76510 temper, 70.2 Ksi (484 MPa) for the T73510 temper, and 61.5 Ksi (424 MPa) for the -T73511 temper].

Results

Test results show that none of the flat 7049-T76510 nor 7049-T73510 specimens had failed after exposures of 798 days in the marine environment. However, one of the -T73510 tempered specimens which had been exposed for 798 days in the marine atmosphere, while stressed at 75% of its yield strength, developed a crack at the bolt hole where the load was applied to the specimen. The specimen fractured at this crack during the test to determine the tensile properties after exposure to the environment. Attempts were made to determine the cause of the crack at its origin. Metallographio examination and microhardness tests were employed but were inconclusive due to the extent of corrosion.

Two of the three round 7049-T73511 aluminum alloy tensile specimens which had been exposed at 75% of their yield strength for 797 days had failed in threaded areas during exposure. Another 7049 T73511 specimen which had also been exposed for 797 days at 50% of its yield strength failed in the threaded area during the test to determine its tensile strength after exposure. These failures were attributed to crevice corrosion. None of the round 7049 -T73511 test samples had failed at the reduced section after exposure in the marine atmosphere for 797 days.

In order to obtain some indication of the effect of corrosion attack on these extrusions, a comparison was made of the tensile strength of

unexposed specimens vs. that of stressed and unstressed specimens exposed to the marine environment. The values obtained were then averaged for each condition and stress level and calculated as the percent loss in tensile strength due to exposure in the environment. These test results given in Table II indicate a small average loss in tensile strength 4.5 to 5.3% for the -T76510 temper, 3.3 to 5.0% for the -T73510 temper and 0.5 to 3.4% for the -T73511 tempered alloy.

Conclusions

The results obtained from stress corrosion tests on 7049-T76510, 7049-T73510 and 7049-T73511 aluminum alloy extrusions indicate that the alloy is resistant to stress corrosion cracking in a marine atmosphere environment. There were no failures attributed to stress corrosion on any of the specimens after exposure periods up to 798 days. However, cracks or failures did develop in crevice areas where the specimens were secured to the stressing fixture. The alloy also exhibited a considerable amount of shallow surface pitting accompanied by heavy gray corrosion products. This surface pitting and corrosion resulted in an average loss in strength of 5% or less.

TABLE I

Transverse Mechanical Properties of 7049 Extruded Aluminum Alloy

Alloy and Treatment	Tensile Strength (1) Ksi (2)	Yield Strength (1) (0.2% offset) Ksi (2)	Percent Elongation in 2 in. (5.08 cm)(1)
7049-T76510	74.9	67.1	10
7049-T73510	78.0	70.2	10
7049-T73511	73.6	61.5	

(1) average of three specimens

(2) 1 Ksi = 6.8948 MPa

Table II. Average Loss in Tensile Strength of Transverse Specimens From 7049 Aluminum Alloy Extrusions

Alloy and Treatment	Exposure Stress: Percent of Yield Strength	Exposure Stress: Ksi (1)	Days Exposed (2)	Percent loss in Tensile Strength: Individual Specimen	Percent loss in Tensile Strength: Average (3)	Standard Deviation
7049-T76510 (long transverse)	0	0	798 NF	4.1		
	0	0	798 NF	4.0		
	0	0	798 NF	5.3	4.5	± 0.4
	50	33.7	798 NF	6.0		
	50	33.3	798 NF	5.1		
	50	33.6	798 NF	5.1	5.4	± 0.2
	75	49.9	798 NF	6.0		
	75	50.2	798 NF	4.8		
	75	49.9	798 NF	5.2	5.3	± 0.2
7049-T73510 (long transverse)	0	0	798 NF	4.7		
	0	0	798 NF	5.0		
	0	0	798 NF	4.7	4.8	<± 0.1
	50	35.5	798 NF	3.7		
	50	35.5	798 NF	4.5		
	50	35.5	798 NF	1.7	3.3	± 1.4
	75	52.2	798 NF	4.9		
	75	52.7	798 NF	7.6		
	75	52.2	798 NF	5.0	5.8 (5)	± 1.6
7049-T73511 (short transverse)	0	0	798 NF	+ 0.5		
	0	0	798 NF	2.2		
	0	0	798 NF	+ 0.5	0.4	± 1.6
	50	30.8	798 NF	0.1		
	50	30.8	798 NF	(4)		
	50	30.8	798 NF	2.1	1.1 (5)	± 1.0
	75	46.1	798 NF	3.4		
	75	46.1	798 NF	(4)		
	75	46.1	798 NF	(4)	—	—

(1) 1 Ksi = 6.8948 MPa.
(2) NF denotes no failure after exposure for number of days shown.
(3) Average for 3 specimens unless noted otherwise.
(4) Specimen failed at thread area during test to determine tensile properties after exposure in the marine atmosphere.
(5) Average for 2 specimens.

Figure 1. Microstructure of 7049-T76510 aluminum extrusion (long transverse direction). Etched, Keller's etch, X 50.

Figure 2. Microstructure of 7049-T73510 aluminum extrusion (long transverse direction). Etched, Keller's etch, X 50.

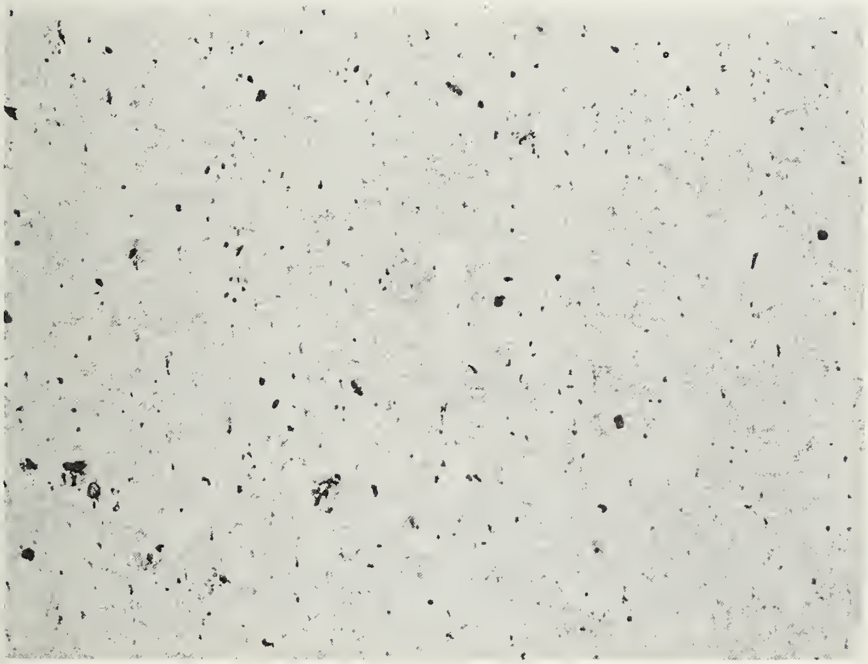

Figure 3. Microstructure of 7049-T73511 aluminum extrusion (short-transverse direction). Etched, Keller's etch, X 50.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Transverse tensile specimens of extruded 7049 aluminum alloy with tempers of -T76510, -T73510 and -T73511 were stressed at zero, fifty and seventy-five percent of the alloy's yield strength and exposed in a marine environment. After 798 days, there were no failures due to stress corrosion. The extruded 7049 material studied appears to be resistant to stress corrosion cracking in this environment.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Alloy; aluminum; extrusion; heat treatment; marine; mechanical properties; stress corrosion

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