NATIONAL BUREAU OF STANDARDS REPORT

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QUARTERLY STATUS REPORT FOR THE
QUARTER ENDING APRIL 30, 1966 ON

NBS PROJECT 3120445

INVESTIGATION OF THE DIRECTIONAL EFFECTS IN THE STRESS CORROSION OF ALUMINUM ALLOYS

by

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and
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for

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama

Contract H-2151A
Control 1-6-54-01046-01 (1F)

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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This report was prepared by the Corrosion Section, National Bureau of Standards under Contract No. H-2151A "Investigation of the Directional Effects in the Stress Corrosion of Aluminum Alloys" for the George C. Marshall Space Flight Center of the National Aeronautics and Space Administration. The work was administered under the technical direction of the Propulsion and Vehicle Engineering Laboratory, Materials Division of the George C. Marshall Space Flight Center with D. B. Franklin acting as project manager.

Anticipated Work

A. Continue stress-corrosion tests for 7075 plate material.

B. Continue electronmicrograph and microprobe studies.

C. Determine grain size in 3 orientations in 7075 plate material.

D. Complete preferred orientation studies.

Abstract

Macroscopic examinations of the 7075 and 2219 plate materials have been completed and hardness surveys were made through the thickness of these materials.

Both notched and un-notched tensile specimens were machined in three orientations from the plate materials. Soon after tensile tests were begun on the 2219 material, it was found to be faulty and was subsequently recalled by the manufacturer. Studies are in progress to determine the defect in that material.

Tensile properties were determined for the un-notched 7075 materials and the stress-corrosion tests were begun. Total immersion in a solution containing 0.3% NaCl + 3.0% $K_2Cr_2O_7$ + 3.0% CrO_3 was found to be superior to anodic polarization in 3 1/2% NaCl as a stress-corrosion environment.

Preferred orientation studies of 7075-T651 are nearly completed and studies of the 7075-T73 are in progress.

Work Accomplished to Start of Current Reporting Period

The grain flow of a 7075-T6 extrusion was studied to determine areas from which specimens could be machined and tensile properties were determined for both notched and un-notched specimens machined with their axes in the short transverse direction. The effect of notch radius on the tensile properties was also studied.

The microstructure of the 7075-T6 aluminum alloy extrusion was studied for different orientations at different distances from the die surface.

Investigation of the Directional Effects on the Stress Corrosion of Aluminum Alloys

Macroscopic examinations of the 7075 and 2219 plate materials have been made through the thickness of the plate on two planes with respect to the

direction of rolling, namely, normal to and in the direction of rolling.

Hardness surveys at 1/4 inch intervals were made through the thickness of the plate on all of these materials. In every case the material in the center of the plate was softer than that near the surfaces. The values are given in Table 1.

Metallographic and preferred orientations studies are being made on these materials to confirm the indications of uniformity found in the hardness studies on plate 2219-T87 and possibly plate 7075-T73 and to account, if possible, for the decrease in hardness toward the center of the material in plates 2219-T37 and 7075-T651. Subsize round tensile specimens were machined from these plates (a) with their long axes normal to the plate surface (short transverse specimens), and (b) with their long axes normal to the rolling direction and in the rolling plane (long transverse specimens), and (c) with their long axes in the direction of rolling of the plate (longitudinal specimens.) The softer material found in the centers of some of these plates is in the reduced sections of the short transverse specimens. The long transverse and longitudinal specimens were machined from layers of material near the centers of the short axes in the plates so that the entire specimens would be machined from the softer material.

Table 1. Hardness of Plate Specimens
(Rockwell B Scale)

Alloy	Top	Interior	Bottom
2219 T87	79	77	78
2219 T37	68	63	69
7075 T73	82.5	80	83
7075 T651	92	88	92

Top and bottom values were taken 1/4 inch from the two surfaces of the plate. Interior value was the minimum value recorded and was usually, but not necessarily, that nearest the center of the plate.

During machining of short transverse specimens from the 2219-T87 plate, three were broken. We attributed this to poor machining technique. However, two notched tensile specimens from a nearby area broke in tensile test not at the notch, but in a region having 9/4 the area at the root of the notch and at a stress computed to be 6100 psi. The location of these fractures was at approximately the same depth below the surface of the plate as those in the specimens broken during machining as shown with a macroetched cross-section of the plate in Figure 1. Adjacent short transverse specimens, one of which was sectioned longitudinally for metallographic examination, were radiographed and showed some indication of voids or inclusions. Figure 2 is a photomicrograph of the longitudinally sectioned specimen in the unetched condition. The macroconstituents are to be determined with the aid of the electron microprobe.

The supplier of the 2219 alloy plate has stated that the material was unsatisfactory, has asked that it be returned and has stated that they are fabricating new material to replace that being recalled. As of the date of this report, the replacement material has not been received.

The tensile properties of the 7075-T651 and 7075-T73 aluminum alloy plate material were determined in the short transverse, long transverse and longitudinal directions (Table 2).

Table 2. Tensile Properties of 7075-T651 and 7075-T73 Plate Materials in the Three Directions

Specimen Designation	Yield Strength (psi)	Tensile Strength (psi)
T651 Short Transverse	64,300	76,500
T651 Longitudinal	69,500	81,700
T651 Long Transverse	75,600	86,400
T73 Short Transverse	56,300	66,700
T73 Longitudinal	59,400	71,300
T73 Long Transverse	61,600	72,600

Two test methods were tried to accelerate stress-corrosion. Anodic polarization using a 3 1/2% NaCl solution produced a great amount of overall corrosion with exfoliation. The second method consisted of total immersion of the specimen in Alcoa H solution (0.3% NaCl + 3.0% $K_2Cr_2O_7$ + 3.0% CrO_3 using distilled water, solution pH 0.9). The specimens were electropolished in a perchloric acid-ethanol solution to remove the worked surface metal.

All tests were made using 75% of the specimen's yield strength. Times to failure for the 7075-T651 alloy were 5 minutes for the short transverse, 5.5 hours for the long transverse and 10.6 hours for the longitudinal specimens. (Preliminary tests - only one specimen tested in each orientation.) Photomicrographs (Figures 3, 4 and 5) were taken of the short transverse specimens and show the typical stress-corrosion cracks observed. The fractured surfaces are being replicated for electron microscopy studies. Work is continuing to determine if the long transverse and longitudinal specimens failed by stress-corrosion.

Preferred orientation studies of the 7075-T651 are nearly completed and studies of the 7075-T73 are in progress. An attempt will be made to correlate the preferred orientation in these materials with the stress-corrosion susceptibilities of specimens from the various directions.

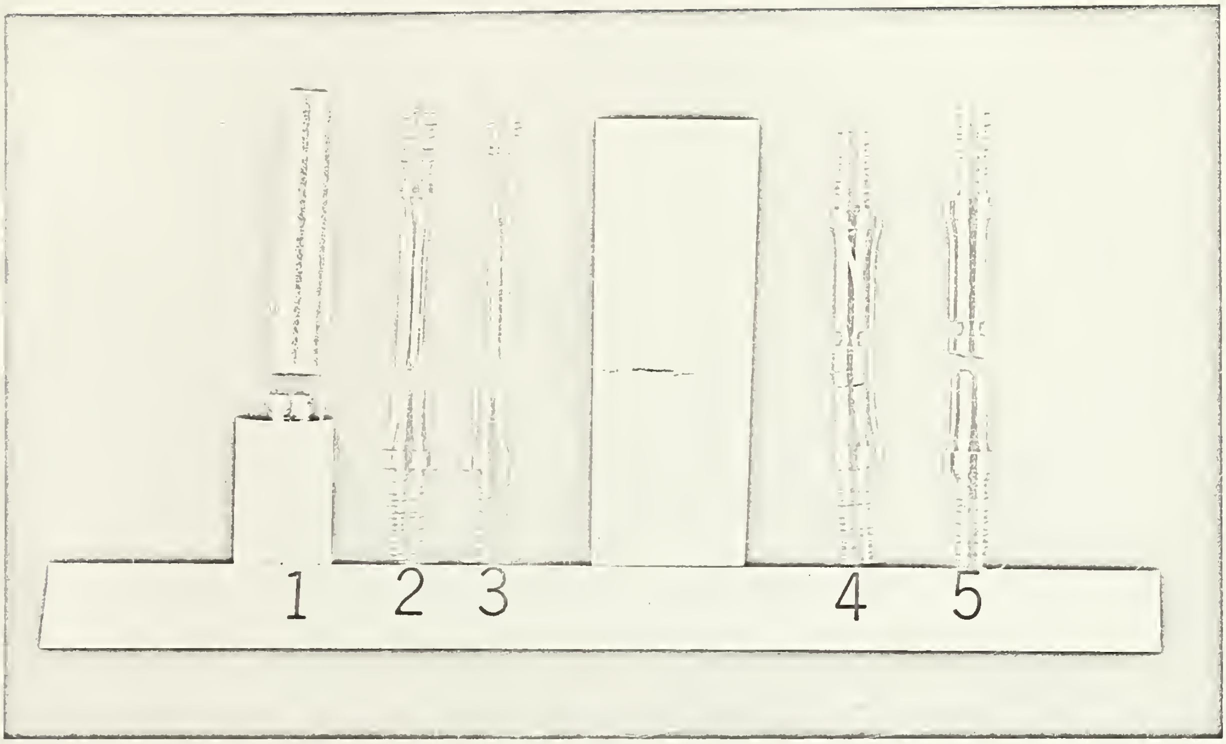

Figure 1

2219-T87 aluminum alloy short transverse specimens 1, 2, and 3 broke during machining. Specimens 4 and 5 broke in tensile test at a region 9/4 the area at the root of the notch. The cross-section of the plate was etched with Flick's reagent. X 1.

Figure 2

Photomicrograph of a 2219-T87 aluminum alloy short transverse tensile specimen prior to testing. Photomicrograph was taken at the same level as indicated by fractures in Figure 1. Unetched X 100

Figure 3

Photomicrograph of a 7075-T651 aluminum alloy short transverse specimen which failed at 75% of its yield strength after 5 minutes in Alcoa H solution. Note the intergranular stress-corrosion cracks which start at the pits. Keller's etch X 100

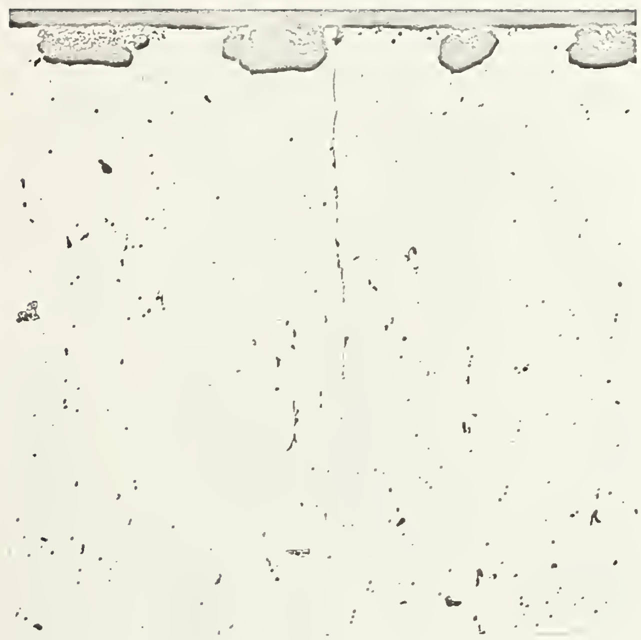

Figure 4

Photomicrograph of a 7075-T651 aluminum alloy short transverse specimen which failed at 75% of its yield strength after 5 minutes in Alcoa H solution. Unetched X 100

Figure 5

Photomicrograph of a 7075-T651 aluminum alloy short transverse specimen which failed at 75% of its yield strength after 5 minutes in Alcoa H solution. Note the intergranular stress-corrosion cracks which start at the pits. Compare with the unetched condition in Figure 4. Keller's etch X 100

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