9398

QUARTERLY STATUS REPORT FOR THE
QUARTER ENDING JULY 31, 1966 ON

NBS PROJECT 3120445

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

by

Hugh L. Logan

Gilbert M. Ugiansky
and
S. Wayne Stiefel

for

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

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

NATIONAL BUREAU OF STANDARDS REPORT

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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.

PROGRAM PLANNING CHART*

(Showing Dates Initiated and Duration)

Macroscopic study of materials to determine grain flow in 3 orientations initiated 12/15/65 - duration, 2 months.

Machine Tensile Specimens
1/1/66
2 weeks

Determine Tensile Properties for Notched and Un-notched Specimens
1/15/66
2 months

Machine Stress Corrosion Specimens
2/15/66
1 month

Set up Stress Corrosion Tests
3/15/66
6 months

Measure Elongation and Chemical Solution Potentials
3/15/66
6 months

Light Micrograph Study
12/15/65
2 months

Electron Micrograph Study of Replicas and Thinned Specimens
2/1/66
6 months

Electron Microprobe Study
6/1/66
6 months

Preferred Orientation Studies
3/15/66
6 months

Determine Grain Boundary Intercepts in 3 Orientations
6/15/66
2 months

The completion of various phases of the investigation may be affected by the move of the Metallurgy Division of the National Bureau of Standards from Washington, D.C. to the new Gaithersburg, Maryland facilities on or about October 4, 1966.

*All investigations of 2219 alloys have been delayed due to the supplier's recall of that material.

Anticipated Work

A. Continue stress-corrosion tests for 7075 plate material, using full thickness and specific depth short transverse specimens.

B. Continue electron-micrograph and microprobe studies.

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

D. Complete preferred orientation studies.

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 were also studied.

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

Macroscopic examinations of the 7075 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.

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 were completed.

Abstract

The 2219 plate material originally supplied was defective and has now been replaced. Tensile properties of this material in three orientations with respect to the direction of rolling have been determined and are reported. Specimens have been machined for stress-corrosion testing.

Specimens from the 7075-T651 plate having 1/4" gage lengths, centered at various depths below the surface of the plate, indicate a definite decrease in tensile properties of the plate in the first 1/2" below the surface. There is little further change in properties to the center of the plate.

Apparatus has been assembled and is being tested to maintain the temperature of the corrodent at 35 ± 0.1°C during stress-corrosion tests.

Electronmicrographic studies of replicas of the surface of the 7075-T651 material indicate the desirability of transmission studies.

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

plate material

The 2219-T37 and T87/originally supplied was recalled by the producer as being defective. Defects had been noted in this laboratory (see report dated April 30, 1966). Both the 2219-T37 and T87 plates were replaced by the producer. Tensile specimens have been machined from these plates with orientations in three directions with respect to the direction of rolling; namely, in the direction of rolling and in the long and short transverse directions. Inasmuch as the dimensions of the short transverse specimens were limited by the plate thickness, 2 1/2", the dimension of all specimens, whatever the orientation, were the same. They had a circular cross section, diameter .160 ± .005" with a 1/2" gage length. The tensile and yield strengths of these materials are given in Table 1.

Specimens of the 2219 alloy in the two heat treated conditions for stress-corrosion tests, and disks for preferred orientation studies, have also been machined from the replacement plates and will be tested as soon as possible.

Preferred orientation studies made on specimens at intervals of 1/8" from the surface to the center of the 7075-T651 material showed a marked change in the preferred orientation of the alloy in the first half inch below the surface of the plate. It was considered that the preferred orientation could have an effect on the susceptibility to cracking. To investigate this, specimens with 1/4" gage lengths were machined with the gage length centers 3/8, 5/8, etc., below the surface of the plate. The tensile strengths and estimated yield strengths are plotted in Figure 1. It is seen that there is a marked decrease in tensile strength of the material in the first 1/2" below the surface of the plate. The tensile strength of the material at a depth of 5/8" is actually less than the estimated yield strength 1/4" below the surface of the plate.

Specimens were also machined for stress-corrosion tests with very short gage lengths centered as indicated above at various depths below the plate surface and are awaiting tests.

It has been pointed out that a change in temperature from 7° to 25°C[1] may make an order of magnitude difference in the exposure period to failure of specimens in a stress-corrosion test. Because we may expect relatively small differences in susceptibility to cracking with the distance the center of the gage length of the specimen is below the surface of the plate, we have assembled and are presently testing a system designed to continuously circulate the corrodent we are using (0.3% NaCl + 3.0% $K_2Cr_2O_7$ + 3.0% CrO_3) maintained at a temperature of 35.0 ± 0.1°C around the specimen loaded in direct tension. Exposure periods to failure are automatically recorded to 0.1 minutes.

Replicas of an etched surface of the 7075-T6 alloy extrusion have been made and examined using the electron microscope.

Pitting shown in the grain to the left in the electronmicrograph, Figure 2, is believed to have resulted from the attack of a precipitate by the etchant.

Some pitting is also noted along the grain boundary. There was very little pitting in the grain to the right of the boundary. This is possibly due to a difference in orientation of the two grains. The electron-micrograph, Figure 3, shows another area in which pitting was severe. The large triangular pits in this grain suggest that its orientation is close to {111}.

In order to further investigate the precipitation in this alloy, attempts are in progress to obtain foil for transmission electron-micrographs.

Specimens at two orientations with respect to the direction of rolling of the 7075-T651 plate have been prepared for electron-probe analysis.

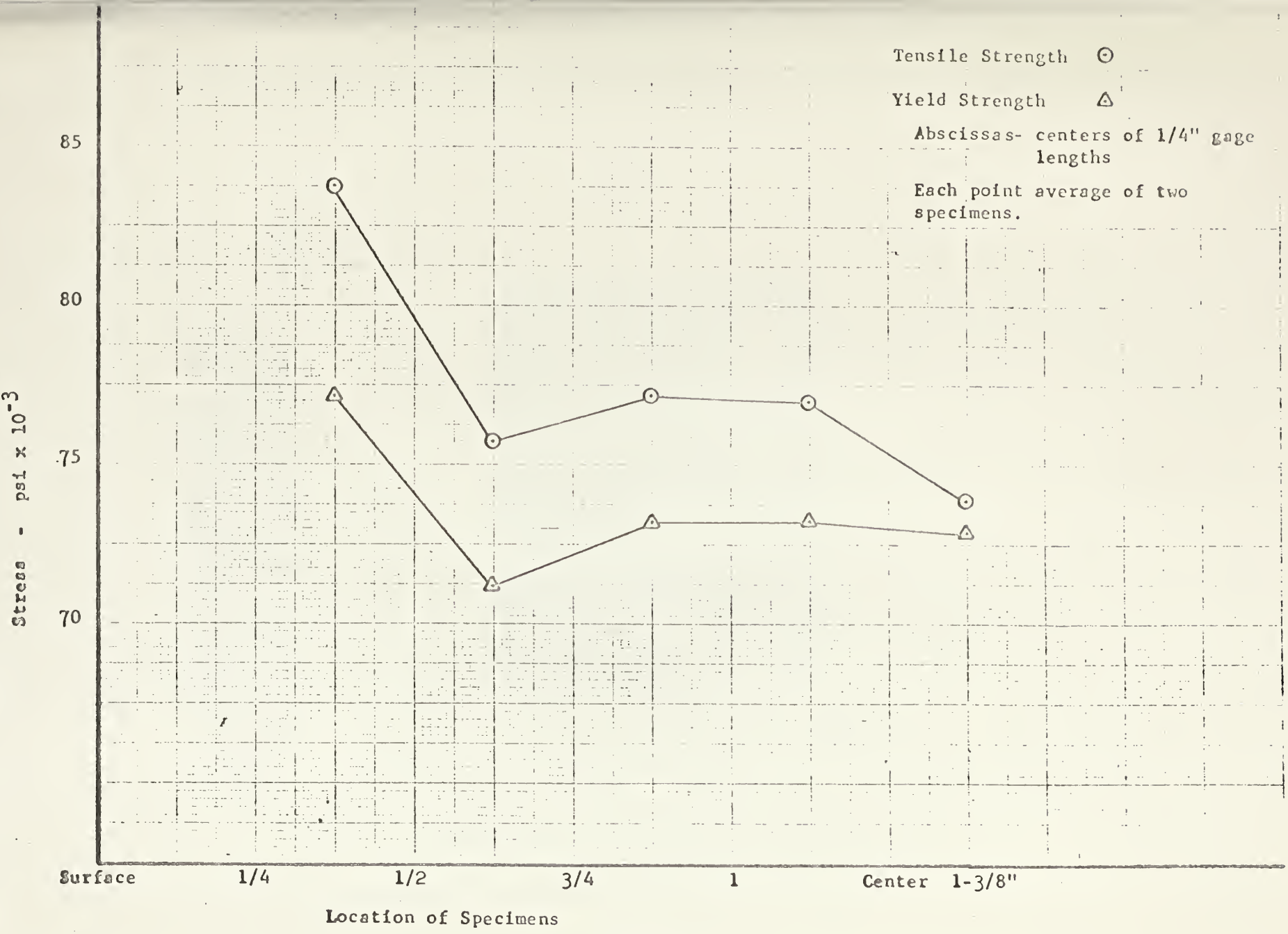
Tensile Strength ⊙
Yield Strength △
Abscissas- centers of 1/4" gage lengths
Each point average of two specimens.
85
80
75
70
Stress - psi x 10^{-3}
Surface
1/4
1/2
3/4
1
Center 1-3/8"
Location of Specimens

FIGURE 1

Figure 2. Electron-micrograph of surface of two grains of 7075-T6 material. Note pitting in grain on left and at the grain boundary. This is probably due to an attack by the etchant on a precipitate. x 6000

Figure 3. Electron-micrograph of surface of grain having approximately {111} orientation. x 6000

Table 1

Tensile Properties of 2219 Aluminum Alloy Plate[x]

Heat-treated	Yield Strength psi Orientation[xx]			Tensile Strength psi Orientation[xx]		
	ST	LT	L	ST	LT	L
T37	32,000	37,300	43,700	51,700	56,800	55,500
T87	54,500	54,800	57,300	66,000	69,400	69,900

x Specimen diameter 0.160", gage length 1/2"

xx ST - short transverse
LT - long transverse
L - longitudinal