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Aerojet-General CORPORATION

AZUSA, CALIFORNIA

INFORMAL REPORT OF PROGRESS

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TO: Commanding General
Frankford Arsenal
Philadelphia 37, Pennsylvania

Attn: ORDBA, Dr. H. Gisser

SUBJECT: Investigation of Stress-Corrosion Cracking of High-Strength Alloys

CONTRACT: DA-04-495-ORD-3069

PERIOD COVERED: 1 May through 31 May 1961

This is the eighth in a series of informal progress reports submitted in partial fulfillment of the contract.

AEROJET-GENERAL CORPORATION

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NOTE: The information contained herein is regarded as preliminary and subject to further checking, verification, and analysis.

I. OBJECTIVES

The objectives of this program are:

A. To study the susceptibility to stress-corrosion cracking of rocket-motor case materials: e.g., Vascojet 1000, Type 300M, and Ladish D6AC steels, AM355 and PH 15-7 Mo stainless steels, and B120VCA titanium

B. To study the environmental parameters, including the atmosphere outside and inside the rocket case, that affect the rate and extent of stress corrosion

C. To determine the effect of material parameters - composition, strength level, welding, micro-structure, surface conditions, etc. - on the stress-corrosion process

D. To devise and evaluate techniques for preventing the stress-corrosion cracking of rocket-motor case materials.

II. WORK PROGRESS

A. INTRODUCTION

In view of the fact that stainless steel (AISI Type 304 alloy) specimen holders are being employed to conduct the stress-corrosion testing of this program, and that the alloys being tested differ in composition from the holders, some concern has been expressed regarding the presence of galvanic couples (two dissimilar metals connected in an electrolyte) and the influence of galvanic corrosion upon the stress corrosion. The extent to which galvanic corrosion occurs and the distribution of galvanic currents on the stressed specimens (when coupling is made with the specimen holders) is not known at this time. However, experiments are being conducted to measure the potential of the various alloys when coupled with the specimen holders in the testing environments, the specimens being held in both stressed and unstressed states. It is not believed at this time that the effects of the galvanic couples materially affect the stress-corrosion behavior of the alloys being tested.

B. BENT-BEAM TESTS

The environmental stress-corrosion testing of bent-beam samples is approximately 60% complete. Table 1 summarizes all of the test data accumulated to date. Testing in 9 of the 11 environments was completed for 4 of the 6 alloys being evaluated (Vascojet 1000 and Ladish D6AC alloy steels, AM355 stainless steel, and B120VCA titanium alloy), and is in progress for a fifth alloy (Type 300M alloy steel). The final steps in specimen preparation for the sixth alloy (PH 15-7 Mo stainless steel) are nearing completion, and the specimens will be ready for testing shortly. Evaluations have been conducted in the particular environments of air, tap water, distilled water, sodium chloride solution (3% by wt), sodium dichromate solution (0.25% by wt), Marquench salt solution (1% by wt), aqueous soluble oil solution (4% by vol), trichloroethylene, and cosmoline. The two remaining environments in which evaluations will be made are soluble oil and high humidity; high-humidity testing of the Ladish D6AC alloy steel has been initiated.

In order to define the conditions of the air in which the stress-corrosion evaluations are being conducted, temperature and relative-humidity readings were recorded every four hours, at the same times that the inspections of the specimens under test were made. This analysis of the air revealed, over a period of time, that the average temperature was 73°F, ranging from a low of 62°F to a high of 88°F. Relative humidity averaged 52%, ranging from a low of 24% to a high of 74%. No attempt was made to analyze the air for any other variables.

C. U-BEND TESTS

It will be noted from Table 1 that very few failures have occurred with the bent-beam type specimens. This is due in part to the short duration of the testing period, and in part to the constant stress level (75% of the yield strength) at which the specimens were tested. These drawbacks can be overcome by employing U-bend test specimens, which means only bending flat specimens over a mandrel of a given diameter until U-shapes with two parallel sides are obtained. The specimens are then held in this configuration during environmental testing. This method of testing is much more severe than the bent-beam type of specimens now employed. Stress levels, ranging from nearly zero to the yield strength of the alloy, are obtained. Thus, the duration of the testing period will be appreciably shortened, and the qualitative evaluation of the stress-corrosion studies of the various alloys will be accelerated with the U-bend type specimens.

U-bend test specimens are being prepared for conducting environmental stress-corrosion tests. These tests will serve to provide additional data to supplement the data now being accumulated with the bent-beam stress-corrosion tests.

III. FUTURE WORK

The following testing will be completed by the end of the first year of the program:

A. The stress-corrosion tests of Vascojet 1000, Ladish D6AC, AM355, and B120VCA titanium in the soluble oil and high-humidity environments.

B. The stress-corrosion tests of the 300M in all of the environments.

C. The specimen fabrication and stress-corrosion tests of the PH 15-7 Mo in all of the environments.

D. U-bend tests on specimens that show the greatest resistance to the bent-beam testing. This will allow for more severe testing where deemed appropriate.

TABLE 1

BENT-BEAM STRESS-CORROSION TEST DATA*

Alloy	Environment**	No. of Specimens Tested	No. of Specimens Failed	Average Time To Failure (Days)	Total Testing Time (Days)
Vascojet 1000	1	12	0	--	28
	2	12	0	--	21
	3	12	0	--	21
	4	12	0	--	21
	5	12	0	--	21
	6	12	0	--	21
	7	12	6	10.9	21
	8	12	6	5.6	21
	9	12	6	6.1	21
Ladish D6AC	1	12	0	--	28
	2	12	0	--	21
	3	12	0	--	21
	4	12	0	--	21
	5	12	0	--	21
	6	12	0	--	21

*Specimens stressed at 75% of yield strength

**Environments identified as follows:

1. Air
2. Marquench salt solution, 1 wt%
3. Sodium Dichromate solution, 0.25 wt%
4. Trichloroethylene
5. Cosmoline
6. Soluble oil solution, 4 vol%
7. Tap water
8. Distilled water
9. Sodium chloride solution, 3 wt%
10. High humidity

TABLE 1 (cont.)

Alloy	Environment	No. of Specimens Tested	No. of Specimens Failed	Average Time To Failure (Days)	Total Testing Time (Days)
Ladish D6AC	7	12	0	--	21
	8	12	0	--	21
	9	12	0	--	21
	10	12	1	5.6	7
B120VCA Titanium	1	18	0	--	28
	2	18	0	--	21
	3	18	0	--	21
	4	18	2	2.2	21
	5	18	0	--	21
	6	18	0	--	21
	7	18	0	--	21
	8	18	0	--	21
	9	18	2	0.02	21
AM355	1	6	0	--	28
	2	6	0	--	21
	3	6	0	--	21
	4	6	0	--	21
	5	6	0	--	21
	6	6	0	--	21
	7	6	0	--	21
	8	6	0	--	21
	9	6	0	--	21
300M	1	9	0	--	15
	2	9	0	--	15
	3	9	0	--	15

TABLE 1 (cont.)

Alloy	Environment	No. of Specimens Tested	No. of Specimens Failed	Average Time To Failure (Days)	Total Testing Time (Days)
300M	4	9	0	--	15
	5	9	0	--	15
	6	9	0	--	15
	7	9	0	--	15
	8	9	0	--	15
	9	9	0	--	15