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~~Aerjet~~-General CORPORATION

AZUSA, CALIFORNIA

I N F O R M A L R E P O R T O F P R O G R E S S

Copy No. 12

25 June 1962

TO: Commanding General
 Frankford Arsenal
 Philadelphia 37, Pennsylvania

 Attention: ORDEA, H. Rosenthal

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

CONTRACT: DA-04-495-ORD-3069

PERIOD
COVERED: 1 May through 31 May 1962

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

AERJET-GENERAL CORPORATION

R. F. Kimpel
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Structural Materials Division

NOTE: Information contained herein is regarded as preliminary
 and is 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, 300M, and Ladish D6AC steels, AM355 and PH15-7Mo 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, microstructure, 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. UNWELDED SPECIMEN TESTS

Both bent-beam and U-beam specimens were employed in evaluating the susceptibility to environmental stress-corrosion cracking of unwelded samples of the candidate alloys. A comprehensive summary of the bent-beam specimen test results is given in Table 1, and of the U-bend specimen test results in Table 2. The bent-beam specimens were stressed to 75% of the yield strength, and the U-bend specimens were bent over 12T- and 24T-diameter mandrels. The specimens were then exposed to environments representative of those that would exist during some phase of the manufacturing, testing, and long-term storage of solid-rocket-motor chambers. These tests were completed, and the data accumulated is quite indicative

of which alloys are susceptible to stress-corrosion cracking in the environments tested and of which environments induce stress-corrosion cracking of the alloys tested.

B. WELDED SPECIMEN TESTS

Welded bent-beam specimens of Ladish D6AC, 300M, and Vascojet 1000 steels, and of Bl20VCA titanium alloy were prepared; environmental testing is expected to begin shortly.

C. COATED SPECIMEN TESTS

Three protective coatings are currently being evaluated, two of epoxy-type and one a urethane-type coating. A summary of the environmental test data accumulated to date is given in Table 3. Specimens are currently being prepared with two other coatings, one a vinyl-type, and the other a zinc-filled coating. Environmental testing of these specimens will begin as soon as received from the coating vendors.

III. FUTURE WORK

A. Continuation of the environmental stress-corrosion testing of coated bent-beam specimens.

B. Environmental stress-corrosion testing of welded bent-beam specimens.

TABLE 1
BENT-BEAM STRESS-CORROSION TEST

Alloy	Yield Strength 0.2% Offset psi x 10 ⁻³	Air		Distilled Water		Tap Water		0.25% Na ₂ Cr ₂ O ₇ Solution		1% Marquench Salt Solution		3% NaCl So	
		No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)
Ladish D6AC	197.5	3	NF-28**	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	222.5	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	222.5	-	-	-	-	-	-	-	-	-	-	-	
	222.5	-	-	-	-	-	-	-	-	-	-	-	
	235.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	235.0	3	NF-298	1	NF-298	6	NF-298	3	NF-104	3	NF-104	3	
	235.0	-	-	1	103.8	-	-	-	-	-	-	-	
	235.0	-	-	1	125.0	-	-	-	-	-	-	-	
	235.0	-	-	1	138.7	-	-	-	-	-	-	-	
	235.0	-	-	1	148.7	-	-	-	-	-	-	-	
	235.0	-	-	1	165.7	-	-	-	-	-	-	-	
	252.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	252.0	3	NF-298	1	NF-298	1	151.0	3	NF-104	3	NF-104	3	
	252.0	-	-	1	84.0	1	151.7	-	-	-	-	-	
	252.0	-	-	1	95.8	1	151.7	-	-	-	-	-	
	252.0	-	-	1	112.0	1	155.1	-	-	-	-	-	
	252.0	-	-	1	113.0	1	185.7	-	-	-	-	-	
	252.0	-	-	1	118.7	1	186.7	-	-	-	-	-	
300M	196.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	196.0	-	-	-	-	-	-	-	-	-	-	-	
	196.0	-	-	-	-	-	-	-	-	-	-	-	
	213.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	213.0	-	-	-	-	-	-	-	-	-	-	-	
	213.0	-	-	-	-	-	-	-	-	-	-	-	
	233.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	233.0	-	-	1	84.0	1	151.7	-	-	-	-	-	
	233.0	-	-	1	139.0	1	151.7	-	-	-	-	-	
	233.0	-	-	1	171.9	1	186.7	-	-	-	-	-	
Vascojet 1000	194.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	212.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	237.5	3	NF-28	1	7.6	1	13.7	3	NF-21	3	NF-21	1	
	237.5	-	-	1	7.8	1	14.7	-	-	-	-	1	
	237.5	-	-	1	7.9	1	15.7	-	-	-	-	1	
	240.0	3	NF-28	1	1.8	1	2.7	3	NF-21	3	NF-21	1	
	240.0	-	-	1	3.2	1	8.8	-	-	-	-	1	
	240.0	-	-	1	4.3	1	9.7	-	-	-	-	1	
AM355	(T)199.0***	3	NF-49	3	NF-49	3	NF-49	3	NF-49	3	NF-49	3	
	(L)250.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(L)250.0	-	-	3	NF-298	3	NF-298	-	-	-	-	-	
	(L)278.5	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(L)278.5	-	-	3	NF-298	3	NF-298	-	-	-	-	-	
PH 15-7 Mo	199.5	3	NF-269	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	
	225.0	3	NF-269	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	
	237.0	3	NF-269	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	
B120VCA Titanium	(L)137.5	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(T)139.5	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	
	(T)139.5	-	-	-	-	-	-	-	-	-	-	1	
	(T)139.5	-	-	-	-	-	-	-	-	-	-	1	
	(T)145.5	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(T)145.5	-	-	-	-	-	-	-	-	-	-	-	
	(L)149.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(L)158.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(T)166.0	3	NF-28	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	
	(T)166.0	-	-	3	NF-298	3	NF-298	-	-	-	-	-	

* Stressed to 75% of the 0.2% offset yield strength.

** NF-28 = no failure in 28 days.

*** T = transverse, L = longitudinal.

TABLE 1

BENT-BEAM STRESS-CORROSION TEST DATA*

Environment													
1% Marquench Salt Solution		3% NaCl Solution		Trichloroethylene		Cosmoline		4% Soluble Oil Solution		High Humidity		Solid Propellant	
No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-181	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	NF-181	-	-
-	-	-	-	-	-	-	-	-	-	1	57.0	-	-
-	-	-	-	-	-	-	-	-	-	1	61.7	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	23.0	6	NF-134
3	NF-104	3	NF-104	3	NF-104	3	NF-104	3	NF-104	1	23.2	-	-
-	-	-	-	-	-	-	-	-	-	1	26.7	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	5.7	6	NF-134
3	NF-104	3	NF-104	3	NF-104	3	NF-104	3	NF-104	1	7.0	-	-
-	-	-	-	-	-	-	-	-	-	1	14.2	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	18.1	-	-
-	-	-	-	-	-	-	-	-	-	1	25.7	-	-
-	-	-	-	-	-	-	-	-	-	1	32.9	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	3.9	-	-
-	-	-	-	-	-	-	-	-	-	1	6.9	-	-
-	-	-	-	-	-	-	-	-	-	1	19.8	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	2.7	6	NF-134
-	-	-	-	-	-	-	-	-	-	1	3.9	-	-
-	-	-	-	-	-	-	-	-	-	1	4.8	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	-	-	-
3	NF-21	1	6.9	3	NF-21	3	NF-21	3	NF-21	-	-	-	-
-	-	1	10.0	-	-	-	-	-	-	-	-	-	-
-	-	1	10.1	-	-	-	-	-	-	-	-	-	-
3	NF-21	1	1.2	3	NF-21	3	NF-21	3	NF-21	-	-	4	NF-134
-	-	1	1.7	-	-	-	-	-	-	-	-	1	99.0
-	-	1	6.7	-	-	-	-	-	-	-	-	1	118.0
3	NF-49	3	NF-49	3	NF-49	3	NF-49	3	NF-49	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-81	6	NF-141
-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-112	-	-
3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-112	-	-
3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-109	3	NF-112	6	NF-141
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	2	NF-111	-	-
3	NF-21	1	NF-21	2	NF-21	3	NF-21	3	NF-21	2	NF-111	-	-
-	-	1	0.0+	1	3.4	-	-	-	-	-	-	-	-
-	-	1	0.03	-	-	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	2	NF-21	3	NF-21	3	NF-21	3	NF-111	-	-
-	-	-	-	1	0.9	-	-	-	-	-	-	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-111	-	-
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-111	6	NF-141
3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-111	6	NF-141
-	-	-	-	-	-	-	-	-	-	-	-	-	-

2

Table 1

TABLE 2
U-BEND STRESS-CORROSION TEST DATA

Alloy	Yield Strength 0.2% Offset $\text{psi} \times 10^{-3}$	Environment									
		Distilled Water		Tap Water		0.25% $\text{Na}_2\text{Cr}_2\text{O}_7$ Solution		1% Merguach Salt Solution		3% NaCl Solution	
		No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)
Ladish D6AC	197.5	1	NP-261*	2	NP-347	2	NP-347	2	NP-261	2	NP-347
	197.5	1	167.6	-	-	-	-	-	-	-	-
	222.5	1	137.3	2	NP-261	2	NP-347	2	NP-261	2	NP-347
	222.5	1	141.7	-	-	-	-	-	-	-	-
	235.0	1	20.2	1	33.3	1	NP-347	2	NP-347	1	62.4
	235.0	1	32.9	1	189.6	-	-	-	116.5	-	-
300M	252.0	1	18.4	1	28.9	2	NP-347	1	18.5	1	NP-347
	252.0	1	22.4	1	39.9	-	-	1	259.1	-	-
	196.0	1	111.7	2	NP-261	2	NP-347	2	NP-347	2	NP-347
	196.0	1	193.5	-	-	-	-	-	149.4	-	-
	213.0	1	18.4	2	NP-261	2	NP-347	2	NP-347	1	11.3
	213.0	1	34.9	-	-	-	-	-	40.9	-	-
Vascojet 1000	233.0	1	14.4	1	22.4	2	NP-347	1	182.7	1	11.3
	233.0	1	34.9	1	29.1	-	-	1	217.5	1	26.5
	194.0	1	140.7	1	140.7	2	NP-347	2	NP-347	1	NP-282
	194.0	1	181.5	1	163.4	-	-	-	49.9	-	-
	212.0	1	14.7	1	60.4	2	NP-347	2	NP-347	1	13.7
	212.0	1	141.7	1	69.4	-	-	-	53.3	-	-
-	240.0	1	4.4	1	7.4	2	NP-347	1	273.0	1	4.3
	240.0	1	11.4	1	19.5	-	-	1	276.0	1	6.8

* NP-261 = no failure in 261 days.

Table 2