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AEROJET-GENERAL CORPORATION

AZUSA, CALIFORNIA 91703 • ED 4-6211

VON KARMAN CENTER

27 March 1964

Subject: Informal Monthly Report on the Investigation of Stress Corrosion Cracking of High Strength Steels for the Month of February 1964. Report L0414-02-6

To: Commanding Officer
Frankford Arsenal
Philadelphia, Pennsylvania

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Reference: Contract DA-04-495-ORD-3069, Modification No. 4

This is the thirtieth in a series of informal progress reports submitted in partial fulfillment of the contract. It constitutes the sixth monthly report on the second 1-year continuation of the original 2-year program. It was written by R. B. Setterlund who was supervised by A. Rubin.

I. OBJECTIVES

A. To study the stress-corrosion characteristics of 18%-nickel maraging steel with respect to compositional variation.

B. To study the effect of environmental temperature on the rate of stress-corrosion cracking in three alloys: 18%-nickel maraging steel, a low-alloy martensitic steel, and a hot-worked die steel.

C. To study the electropotential changes occurring in 18%-nickel maraging steel during stress-corrosion exposure, and the effect of applied potential.

II. WORK PROGRESS

A. COMPOSITIONAL VARIATION

In order to study the effects of compositional variation, four heats of 18%-nickel maraging steel were obtained from three vendors. It was felt that these four heats, in conjunction with the heats previously tested, represent the compositional range of material under present commercial production.

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Particular attention is centered around the 250 ksi yield strength level, where the 18% nickel maraging steel appears to have the greatest interest. The chemical analysis of these materials are shown in Table 1, group b, and the mechanical properties in Table 2, group b.

These four heats along with conventional alloys (group c, Tables 1 and 2), are being tested in the three environments that caused the most rapid failures in the previous years work. These are: (1) aerated distilled water, (2) aerated 3% NaCl solution, and (3) 140°F water saturated air. Three replicate tests are being conducted for each test condition, using beam specimens stressed elastically to 75% of the yield strength, as well as plastically deformed U-bend specimens. As shown in Table 3 most all of these specimens have failed. The only maraging steel in the present series to resist cracking in the ambient distilled and salt water environments has been the 180 ksi yield material, tested at 75% of yield strength. However, even this alloy has tested in the plastically deformed condition. All maraging steel specimens have failed in the 140°F water saturated air environment. Complete data showing failure times will be presented in the next quarterly report.

B. ENVIRONMENTAL TEMPERATURE

In order to assess the effects of environmental temperature, bent-beam and U-bend specimens were tested in distilled water environments controlled to 120 and 160°F. All U-bend specimens in both environments have failed except for the low-alloy steel tempered at 1100°F. Environmental temperature was found to have a large effect on the failure time of maraging steel with the susceptibility doubling for every 18°F increase in temperature. These data will be shown in detail in the next quarterly report.

C. OTHER WORK

Center-notch specimens have been employed to date to determine (1) the critical crack growth energy (G_c), (2) the effect of stress on failure time, and (3) the effect of solution pH on failure time. Crack growth energies measurements are complete except two heat-treat conditions for the hot-worked die steel and are listed in Table 2. The stress-intensity factor, K, was found to have a large effect on failure time of maraging steels. Conversely, solution pH over the range 3 to 11 was found to have little effect on failure time of maraging steels at constant K values. These data will also be shown in the next quarterly report.

Coating evaluation tests on maraging steel are still under way. No failures have occurred since the last quarterly report.

It has been decided that U-bend specimens be utilized to measure the effects of applied potential on failure time of maraging steel. These tests will constitute the major effort during the final quarter of the contract period.

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TABLE 1

MILL-CERTIFIED CHEMICAL ANALYSIS OF PROGRAM MATERIALS

Supplier	Heat No.	C	Mn	P	S	Si	Ni	Co	Mo	Al	Cr	Zr	Ti	Ca	B	V
		Composition, %														
*(a) Maraging Steel from Previous Program																
Republic Steel	3960502	0.02	0.08	0.007	0.006	0.15	18.48	7.00	4.84	0.21	0.10	0.035	0.50	-	0.0036	-
Allegheny-Ludlum	443	0.029	0.002	0.004	0.008	0.009	18.51	8.48	4.92	0.089	-	-	0.52	-	-	-
Allegheny-Ludlum	W-24178	0.012	0.01	0.003	0.005	0.01	18.69	8.90	4.92	0.029	-	0.003	0.62	0.006	0.002	-
Allegheny-Ludlum	476	0.02	0.08	0.006	0.005	0.014	18.60	9.05	4.90	0.078	-	-	1.00	-	-	-
Allegheny-Ludlum	W-24254	0.009	0.09	0.002	0.005	0.06	20.41	-	-	0.29	-	0.002	1.40	0.004	0.003	-
(b) Maraging Steel for Present Program																
Republic Steel	3960523	0.029	0.06	0.005	0.006	0.05	17.79	8.50	3.48	0.13	-	-	0.23	-	-	-
Vanadium Alloys	07868	0.02	0.09	0.004	0.005	0.10	17.75	7.60	4.60	0.08	-	0.017	0.52	0.05	0.004	-
Latrobe Steel	C56858	0.03	0.03	0.004	0.008	0.05	18.34	8.00	4.75	0.11	-	0.03	0.49	-	0.004	-
Vanadium Alloys	07268	0.03	0.05	0.004	0.006	0.04	18.54	9.06	4.88	0.09	-	0.088	0.55	0.02	0.003	-
(c) Conventional High-Strength Steels																
Vanadium Alloys	07914	0.38	0.21	0.010	0.008	0.92	-	-	1.33	-	4.75	-	-	-	-	0.51
Allegheny-Ludlum	W-23217	0.495	0.62	0.009	0.003	0.20	0.57	-	0.94	-	1.00	-	-	-	-	0.05

*Some material from previous program will be used to obtain supplementary data.

TABLE 2

MECHANICAL PROPERTIES OF PROGRAM MATERIALS
(AEROJET DATA)

Code No.	Supplier	Heat No.	Heat Treatment Hours Hold	°F	0.2% Offset Yield Strength	Ultimate Tensile Strength	% Elongation	% Reduction in Area	Rc Hardness	Crack Growth Energy (G_c) in.-lb/in.^{2}
					(a) Maraging Steel From Previous Program*					
I-4	Republic Steel	3960502	3	900F	249.9	254.7	4.0	37.0	50.5	670.0
I-6	Allegheny-Ludlum	448**	3	↓	255.4	265.9	5.0	9.0	52.0	654.0
I-1	↓	W-24178***	3	↓	283.0	294.0	8.0	38.0	53.5	552.0
I-8	↓	476**	3	900F	323.3	330.0	2.5	27.0	56.0	402.0
H-1	Allegheny-Ludlum	W-24254	4	850F	291.3	302.2	3.0	17.0	54.0	58.3
					(b) Maraging Steel for Present Program					
K	Republic Steel	3960523	3	900F	181.5	190.7	5.0	43.0	42.0	638.0
L	Vanadium Alloys	07868	3	↓	248.2	248.2	4.0	-	49.0	692.0
M	Latrobe Steel	C56858	3	↓	269.7	275.7	5.0	34.0	51.5	640.0
N	Vanadium Alloys	07268	3	900F	279.1	288.1	4.0	18.0	52.0	560.0
					(c) Conventional High Strength Steels					
A-4	Vanadium Alloys	07914	4+4	1075F	219.2	257.7	7.0	44	49	-
A-3	↓	↓	↓	1025F	232.6	284.8	6.0	42	52.5	-
A-2	↓	↓	↓	975F	223.5	280.6	6.5	43	53	45.4
A-1	Vanadium Alloys	07914	4+4	940F	222.2	292.4	7.0	40	54	32.9
B-4	Allegheny-Ludlum	W-23217	2	1100F	203.1	218.5	11	46	44	563
B-3	↓	↓	2	900F	204.6	226.4	7.5	43.5	44	385
B-2	↓	↓	2	800F	214.5	241.2	7	38	45.5	325
B-1	Allegheny-Ludlum	W-23217	2	600F	237.4	281.3	6	25	51.5	182

*Some material from previous program will be used to obtain supplementary data.

**200 lb laboratory heats.

***Received 50% cold reduced, annealed 1 hr 1500°F.

TABLE 3

STATUS OF STRESS CORROSION TESTING

	Table 2 Code Numbers																
	H-1	I-4	I-6	I-7	I-8	K	L	M	N	A-1	A-2	A-3	A-4	B-1	B-2	B-3	B-4
Bent Beam Tests																	
Aerated Distilled Water	A	A	N	A	A	(N)	A	(P)	A	A	A	A	(N)	A	A	(P)	(N)
Aerated Salt Water	A	A	N	-	A	(N)	(N)	A	A	A	A	A	A	(P)	(N)	(N)	(N)
120F Distilled Water	-	A	-		A	(N)	A	A	A	A	A	A	A	A	A	(P)	(N)
140F Saturated Air	A	A	-	-	A	A	A	A	A	A	A	(P)	(N)	A	A	A	(N)
160F Distilled Water	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	(N)
U-Bend Tests																	
Aerated Distilled Water	A	A	-	-	-	(P)	A	A	(P)	A	A	A	A	A	A	A	(N)
Aerated Salt Water	A	-	-	-	-	(P)	A	A	(P)	A	A	A	A	A	(P)	(N)	(N)
120F Distilled Water	A	A	-	-	-	A	A	A	A	A	A	A	A	A	A	A	(N)
140F Saturated Air	-	A	-	-	-	A	A	A	A	A	A	A	A	A	A	A	(N)
160F Distilled Water	A	A	-	-	-	A	A	A	A	A	A	A	A	A	A	A	(N)

Code

A - All samples have failed.
P - Some have failed, some have not.
N - No failures to date.
( ) - Material presently in test.
- - No test planned.