NATIONAL BUREAU OF STANDARDS REPORT

9990

Progress Report

on

STRESS CORROSION BEHAVIOR
OF HIGH STRENGTH CORROSION RESISTANT MATERIALS

To

Materials Division
Naval Air Systems Command
Department of the Navy

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D. C. 20234.
[2] Located at Boulder, Colorado 80302.
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STRESS CORROSION BEHAVIOR OF HIGH STRENGTH CORROSION RESISTANT MATERIALS

By

W. F. Gerhold
Engineering Metallurgy Section

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Progress Report
on
Stress Corrosion Behavior
of High Strength Corrosion Resistant Materials

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Results to date in the investigation of the stress-corrosion behavior of high strength corrosion-resistant materials (authorized under RRMA 2007) are included herein.

The materials that are being studied in this investigation include the following:

Alloy Steels

Ph 14-4 Mo, "C"-rings
Ph 14-8 Mo, sheet
17-4 PH, sheet
17-4 PH, forging
PH 15-7 Mo, sheet
AM 350, sheet
AM 355, sheet
AM 355, wire
AM 357, sheet
17-7 PH, sheet
17-7 PH, wire
Thermenol, sheet
A 286, sheet
HNM, sheet
17 Cr-5 Ni, foil

Titanium Alloys

6 AV-4V
C105 VA
A110 AT
C115 VA
B120 VCA

The tests are being conducted in the marine atmosphere at the 80' and 800' lots at Kure Beach, N. C. Table 1 and Table 2 contain the results obtained from tests conducted at the 80' lot and the 800' lot, respectively.

These tests are continuing.

Results of Exposure

Table 1. Stress Corrosion in Marine Atmosphere at 80' Lot, Kure Beach, N. C.

Material and Treatment	Exposure Stress, % of Y. S.	Exposure Stress, ksi	No. of Specimens Exposed/Failed	Days to Failure (f)	Average Days to Failure (f)
PH 14-4 Mo, "C" rings					
Tempered at 900° F	75	142.1	3/0	747(3)NF	747NF
"	90	170.5	3/2	451(2),747NF	451,747(1)NF
"	100	189.5	3/3	184,187,378	250
Tempered at 1000° F	75	130.4	3/0	747(3)NF	747NF
"	90	156.5	3/0	747(3)NF	747NF
"	100	173.9	3/0	747(3)NF	747NF
Tempered at 1100° F	75	123.5	3/0	747(3)NF	747NF
"	90	148.2	3/0	747(3)NF	747NF
"	100	164.7	3/0	747(3)NF	747NF
PH 14-8 Mo alloy, sheet					
CRH 1050	50	121.2	5/0		(a)
"	75	181.8	5/0		(a)
"	90	218.2	5/0		(a)
"	100	231.1	5/0		(a)
SRH 1050	50	106.8	5/0		(a)
"	75	160.2	5/0		(a)
"	90	192.2	5/5	364,672(2),1861(2)	1086
"	100	211.4	5/4, 1 lost	174,355,364,672	391
17-4 PH alloy, sheet					
H 925	50	90.1	5/0		(b)
"	75	135.2	5/0		(b)
"	90	162.2	5/0		(b)
"	100	180.2	5/0		(b)

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of Y. S.	Exposure Stress, ksi	No. of Specimens Exposed/Failed	Days to Failure (f)	Average Days to Failure (f)
17-4 PH alloy, forging					
TH 925	50	82.7	3/0		(b)
"	75	124.4	3/0		(b)
"	90	148.9	3/0		(b)
"	100	165.4	3/0		(b)
TH 1025	50	76.3	3/0		(b)
"	75	114.4	3/0		(b)
"	90	137.3	3/0		(b)
"	100	152.5	3/0		(b)
TH 1150	50	56.3	3/0		(b)
"	75	84.4	3/0		(b)
"	90	101.3	3/0		(b)
"	100	112.5	3/0		(b)
PH 15-7 Mo alloy, sheet					
RH 950	50	106.0	5/5	19,20,58,66,118	56
"	75	159.0	5/5	4,5(2),15,16	9
"	90	190.8	5/5	4,13,15(3)	12
"	100	212.0	5/5	4(5)	4
RH 1050	50	103.0	5/1	2311	(b)
"	75	154.5	5/5	19,24,44,61,96	49
"	90	185.4	5/5	22,24(2),57,58	37
"	100	206.0	5/5	16,19,24(2),28	22
RH 1075	50	99.5	5/0		(b)
"	75	149.3	5/5	28,101,139,380,450	220
"	90	179.1	5/5	16,19(2),30.54	28
"	100	199.0	5/5	24,60,99,101,116	80

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of Y. S.	Exposure Stress, ksi	No. of Specimens Exposed/Failed	Days to Failure (f)	Average Days to Failure (f)
RH 1100	50	95.0	5.0		(b)
"	75	142.5	5/2	2010,2311	(b)
"	90	171.0	5/3	20,21,450	(b)
"	100	190.0	5/4	20,58,92,188	(b)
TH 1050	50	99.5	5/0		(b)
"	75	149.3	5/5	57,101,119,869,2255	680
"	90	179.1	5/5	56,57,150,157(2)	115
"	100	199.0	5/5	20,56,119,139,157	98
CH 900	50	124.5	5/0		(b)
"	75	186.8	5/2	1280,2311	(b)
"	90	224.1	5/3	128,365,2611	(b)
"	100	249.0	5/1	365	(b)
AM 350 alloy, sheet					
DA	50	72.6	5/0		(b)
"	75	108.9	5/0		(b)
"	90	130.7	5/1	2311	(b)
"	100	145.2	5/0		(b)
SCT	50	79.3	5/5	35,68,95(2),364	131
"	75	119.0	5/5	17(3),20,22	19
"	90	142.7	5/5	16(4),18	16
"	100	158.6	5/5	16(5)	16
CR	50	115.8	5/3, 1 lost	143(3)	(b)
"	75	173.6	5/5	25,38,41,57(2)	44
"	90	208.4	5/5	18(3),28(2)	22
"	100	231.5	5/5	18(2),25(2),41	25

Table I. (cont.)

Material and Treatment	Exposure Stress, % of Y. S.	Exposure Stress, ksi	No. of Specimens Exposed/Failed	Days to Failure (f)	Average Days to Failure (f)
AM 355 alloy, sheet					
DA	50	79.6	3/0		
"	75	119.4	3/2	1532,2611	(b)
"	90	143.3	3/3	149,410,480	346
"	100	159.2	3/3	874,1092,1532	1166
SCT	50	82.4	3/3	15(3)	15
"	75	123.6	3/3	3(3)	3
"	90	148.3	3/3	3(3)	3
"	100	164.8	3/3	3(3)	3
AM 355 alloy, wire					
0.090"d.	50	186.3	2/2	613,742	678
"	75	280.0	3/3	224,249(2)	241
"	90	338.6	2/2	145,364	255
AM 357 alloy, sheet					
50% CRT-800° F	50	140.9	5/5	4(5)	4
"	75	211.4	5/5	3(3),4(2)	3
"	90	253.6	5/5	3(5)	3
"	100	258.4	5/5	4(5)	4
17-7 PH alloy, sheet					
RH 950	50	107.0	5/5	16(2),23(2),69	29
"	75	160.5	5/5	3(4),15	5
"	90	192.6	5/5	2,3(4)	3
"	100	214.0	5/5	2(3),3(2)	2
RH 1050	50	89.0	5/0		(b)
"	75	133.5	5/2	886,2701	(b)
"	90	160.2	5/4	539(2),1110,2582	(b)
"	100	178.0	5/4	130,886,1092,1224	(b)

Table I. (cont.)

Material and Treatment	Exposure Stress, % of Y. S.	Exposure Stress, ksi	No. of Specimens Exposed/Failed	Days to Failure (f)	Average Days to Failure (f)
RH 1075	50	85.0	5/0		(b)
"	75	127.5	5/0		(b)
"	90	153.0	5/0		(b)
"	100	170.0	5/0		(b)
RH 1100	50	76.0	5/0		(b)
"	75	114.0	5/0		(b)
"	90	136.8	5/0		(b)
"	100	152.0	5/0		(b)
TH 1050	50	87.5	5/0		(b)
"	75	131.3	5/3	1587,1952,2359	(b)
"	90	157.5	5/2	2307,2319	(b)
"	100	175.0	5/2	118,2701	(b)
CH 900	50	133.0	5/0		(b)
"	75	199.5	5/5	16,138,390,820,2170	707
"	90	239.4	5/5	28,31,56,58,820	199
"	100	266.0	5/5	3,13,18,22,35	18
17-7 PH alloy, wire-CH-C					
0.020" d.	50	160.0	3/3	97,339(2)	258
"	75	237.5	2/2	34,86	60
"	90	285.0	3/3	1,93,109	68
0.039" d.	50	165.9	3/0	1339(3)NF	1339NF
"	75	248.8	3/0		(b)
"	90	298.5	3/3	344,346,364	351
0.055" d.	50	156.3	3/0		(c)
"	75	236.3	3/0		(c)
"	90	288.3	3/3	1hr.,55,461	172
0.120" d.	50	154.4	3/3	43,110,136	96
"	75	227.2	3/2	33,45	(c)
"	90	271.4	2/2	69,109	89

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of Y. S.	Exposure Stress, ksi	No. of Specimens Exposed/Failed	Days to Failure (f)	Average Days to Failure (f)
Thermenol alloy, sheet					
Transverse	50	75.8	5/5	65,88,92,364(2)	195
"	75	113.7	5/4	143,187,364(2)	(b)
"	90	136.4	5/5	15,38,45,55(2)	42
"	100	151.6	5/4, 1 lost	36(3),364	118
Longitudinal	50	61.9	4/2	469.897	(b)
"	75	92.9	4/1	390	(b)
"	90	111.4	4/4	115,379,445,1195	533
"	100	123.8	4/2	349,1972	(b)
A 286 alloy, sheet					
Solution treated and aged	50	53.7	5/0		(b)
"	75	80.6	5/0		(b)
"	90	96.7	5/0		(b)
"	100	107.4	5/0		(b)
HNM alloy, sheet					
TH 1350	50	36.4	5/0		(b)
"	75	54.6	5/0		(b)
"	90	65.5	5/0		(b)
"	100	72.8	5/0		(b)
17 Cr-5 Ni alloy, foil					
CR	50	141.8	3/3	13,16,19	16
"	75	210.0	3/3	3,10(2)	8
"	90	254.4	3/3	3(2),6	4
CR and aged	50	154.3	3/3	13,22(e),25(e)	--
"	75	235.5	3/3	12,13,13	13
"	90	279.3	3/3	16,12,12	13

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of Y. S.	Exposure Stress, ksi	No. of Specimens Exposed/Failed	Days to Failure (f)	Average Days to Failure (f)
Titanium alloy, sheet					
6 Al-4V, STA(d)	50	87.6	5/0		(b)
"	75	131.3	5/0		(b)
"	90	157.6	5/0		(b)
"	100	175.0	5/0		(b)
C 105 VA, STA(d)	50	87.2	5/0		(b)
"	75	130.8	5/0		(b)
"	90	157.0	5/0		(b)
"	100	174.4	5/0		(b)
A 110 AT, STA(d)	50	62.1	5/0		(b)
"	75	93.2	5/0		(b)
"	90	111.8	5/0		(b)
"	100	124.2	5/0		(b)
C 115 VA, STA(d)	50	86.3	5/0		(b)
"	75	129.5	5/0		(b)
"	90	115.3	5/0		(b)
"	100	172.6	5/0		(b)
B 120 VCA, STA(d)	50	88.6	5/0		(b)
"	75	132.8	5/0		(b)
"	90	159.4	5/0		(b)
"	100	177.1	5/0		(b)

(a) Exposure period for specimens still in test - 5.1 yrs.
(b) Exposure period for specimens still in test - 7.6 yrs.
(c) Exposure period for specimens still in test - 6.6 yrs.
(d) STA - solution treatment and aged.
(e) Broke at spot welds in bottom grip
(f) NF - denotes no failure, specimen removed from test after number of days shown.

Table 2. Stress Corrosion in Marine Atmosphere at 800' Lot, Kure Beach, N. C.

Material and Treatment	Exposure Stress, % of Y. S.	Exposure Stress, ksi	No. of Specimens Exposed/Failed	Days to Failure	Average Days to Failure
PH 14-8 Mo alloy, sheet					
CRH 1050	75	181.8	5/0		(b)
SRH	75	160.2	5/0		(b)
17-4 PH alloy, sheet					
H 925	75	135.2	5/0		(a)
17-4 PH alloy, forging					
TH 925	75	124.4	3/0		(a)
TH 1025	75	114.4	3/0		(a)
TH 1150	75	84.4	3/0		(a)
PH 15-7 Mo alloy, sheet					
RH 950	75	159.0	5/5	18,20,21(2),22	20
RH 1050	75	154.5	5/5	26(3),35,1635	350
RH 1075	75	149.3	5/3	40,61,172	(a)
RH 1100	75	142.5	5/0		(a)
TH 1050	75	149.3	5/4	35(2),38(2)	(a)
CH 900	75	186.8	5/0		(a)

Table 2. (cont.)

Material and Treatment	Exposure Stress, % of Y. S.	Exposure Stress, ksi	No. of Specimens Exposed/Failed	Days to Failure	Average Days to Failure
AM 350 alloy, sheet					
DA	75	108.9	5/0		(a)
SCT	75	119.0	5/5	26(2),38,47,381	104
CR	75	173.6	5/2	174(2)	(a)
AM 355 alloy, sheet					
DA	75	119.4	3/0		(a)
SCT	75	123.6	3/3	18(2),19	18
AM 357 alloy, sheet					
50% CRT-800° F	75	211.4	5/5	3(3),4(2)	3
17-7 PH alloy, sheet					
RH 950	75	160.5	5/5	18(2),21(2),22	20
RH 1050	75	133.5	5/0		(a)
RH 1075	75	127.5	5/0		(a)
RH 1100	75	114.0	5/0		(a)
TH 1050	75	131.3	5/0		(a)
CH 900	75	199.5	5/1	40	(a)

Table 2. (cont.)

Material and Treatment	Exposure Stress, % of Y. S.	Exposure Stress, ksi	No. of Specimens Exposed/Failed	Days to Failure	Average Days to Failure
Thermenol alloy, sheet					
Transverse	75	113.7	5/5	31,46,47,99,391	122
Longitudinal	75	92.9	4/3	251,333[c] 1359	(a)
A 286 alloy, sheet					
STA[d]	75	80.6	5/0		(a)
HNM alloy, sheet					
TH 1350	75	54.6	5/0		(a)
Titanium alloys, sheet					
6 Al-4V, STA[d]	75	131.3	5/0		(a)
C 105 VA, STA[d]	75	130.8	5/0		(a)
A 110 AT, STA[d]	75	93.2	5/0		(a)
C 115 VA, STA[d]	75	129.5	5/0		(a)
B 120 VCA, STA[d]	75	132.8	5/0		(a)

(a) Exposure period for specimens still in test - 7.6 yrs.
(b) Exposure period for specimens still in test - 5.1 yrs.
(c) Piece spalled at edge.
(d) Solution treated and aged.


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