

NATIONAL BUREAU OF STANDARDS REPORT

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Progress Report
on
STRESS CORROSION BEHAVIOR
OF HIGH STRENGTH CORROSION RESISTANT MATERIALS

by

W. F. Gerhold

To

Materials Division
Air Systems Command
Department of the Navy
Project Number RRMA 2007



U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Stress Corrosion Behavior of High Strength Corrosion Resistant Materials

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 Al-4V
- C105 VA
- A110 AT
- C115 VA
- B120 VCA

The tests are being conducted in the marine atmosphere at the 80' and 800' lots of the International Nickel Company's test site at Kure Beach, N. Car. 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 U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure (g)	Average Days to Failure (g)
			Exposed	Failed		
PH 14-4 Mo, "C" rings Tempered at 900° F " " " " Tempered at 1000° F " " " " Tempered at 1100° 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
	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
	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 " " " " " " SRH 1050 " " " " " "	50	121.2	5/0		
75		181.8	5/0			(a)
90		218.2	5/0			(a)
100		231.1	5/0			(a)
50		106.8	5/0			(a)
75		160.2	5/0			(a)
90		192.2	5/3		364, 672(2)	(a)
100		211.4	5/4, 1 lost		174, 355, 364, 672	391

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure (g)	Average Days to Failure (g)
			Exposed	Failed		
<u>17-4 PH alloy, sheet</u>						
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)
<u>17-4 PH alloy, forging</u>						
TH 925	50	82.7	5/0			(b)
"	75	124.4	5/0			(b)
"	90	148.9	5/0			(b)
"	100	165.4	5/0			(b)
TH 1025	50	76.3	5/0			(b)
"	75	114.4	5/0			(b)
"	90	137.3	5/0			(b)
"	100	152.5	5/0			(b)
TH 1150	50	56.3	5/0			(b)
"	75	84.4	5/0			(b)
"	90	101.3	5/0			(b)
"	100	112.5	5/0			(b)

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure (g)	Average Days to Failure (g)
			Exposed	Failed		
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	5/0			(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
RH 1100	50	95.0	5/0			(b)
"	75	142.5	5/0			(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	5/4		57, 101, 119, 869	(b)
"	90	179.1	5/5		56, 57, 150, 157(2)	115
"	100	199.0	5/5		20, 56, 119, 139, 157	98

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure (q)	Average Days to Failure (g)
			Exposed	Failed		
CH 900	50	124.5	5/0			(b)
"	75	186.8	5/1		1280	(b)
"	90	224.1	5/2		128,365	(b)
"	100	249.0	5/1		365	(b)
<u>AM 350 alloy, sheet</u>						
DA	50	72.6	5/0			(b)
"	75	108.9	5/0			(b)
"	90	130.7	5/0			(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
<u>AM 355 alloy, sheet</u>						
DA	50	79.6	3/0			(b)
"	75	119.4	3/1		1532	(b)
"	90	143.3	3/3		149,410,480	346
"	100	159.2	3/3		874,1092,1532	1166

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure (g)	Average Days to Failure (g)
			Exposed	Failed		
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
<u>AM 355 alloy, wire</u>						
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
<u>AM 357 alloy, sheet</u>						
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
<u>17-7 PH alloy, sheet</u>						
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	5/1		886	(b)
"	90	160.2	5/3		539(2),1110	(b)
"	100	178.0	5/4		130,886,1092,1224	(b)

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure (g)	Average Days to Failure (g)
			Exposed	Failed		
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	5/1		1587	(b)
"	90	157.5	5/0			(b)
"	100	175.0	5/1		118	(b)
CH 900	50	133.0	5/0			(b)
"	75	199.5	5/4		16, 138, 390, 820	(b)
"	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

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure (g)	Average Days to Failure (g)
			Exposed	Failed		
0.055" d.	50	156.3	3/0			(c)
"	75	236.3	3/0			(c)
"	90	288.3	3/3		1 hr., 55, 461	172
0.120" d.	50	154.4	3/3		43, 110, 136	96
"	75	227.2	3/2		33, 45	(d)
"	90	271.4	2/2		69, 109	89
<u>Thermonol alloy, sheet</u>						
Transverse	50	75.8	5/4		143, 187, 364 (2)	(b)
"	75	113.7	5/5		65, 88, 92, 364 (2)	195
"	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	4/1		349	(b)
<u>A 286 alloy, sheet</u>						
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)

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure (g)	Average Days to Failure (g)
			Exposed	Failed		
<u>HNM alloy, sheet</u>						
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)
<u>17 Cr-5 Ni alloy, foil</u>						
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(f), 25(f)	--
"	75	235.5	3/3		12	13
"	90	279.3	3/3			13
<u>Titanium Alloy, Sheet</u>						
6 Al-4V, STA(e)	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(e)	50	87.2	5/0			(b)
"	75	130.8	5/0			(b)
"	90	157.0	5/0			(b)
"	100	174.4	5/0			(b)

Table 1. (cont.)

Material and Treatment	Exposure Stress, % of U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure(g)	Average Days to Failure (g)
			Exposed	Failed		
A 110 AT, STA ^(e)	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 ^(e)	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 ^(e)	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 - 3.3 years
- (b) Exposure period for specimens still in test - 5 years
- (c) Exposure period for specimens still in test - 3.9 years
- (d) Exposure period for specimens still in test - 4 years
- (e) STA - solution treatment and aged
- (f) Broke at spot welds in bottom grip
- (g) (No failure). Specimens removed from test after number of days shown

Table 2. Results of Exposure

Stress Corrosion In Marine Atmosphere
At 800' Lot, Kure Beach, N. C.

Material and Treatment	Exposure Stress, % of U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure	Average Days to Failure
			Exposure	Failed		
<u>PH 14-8 Mo alloy, sheet</u>						
CRH 1050	75	181.8	3/0			(b)
SRH 1050	75	160.2	3/0			(b)
<u>17-4 PH alloy, sheet</u>						
H 925	75	135.2	5/0			(a)
<u>17-4 PH alloy, forging</u>						
TH 925	75	124.4	3/0			(a)
TH 1025	75	114.4	3/0			(a)
TH 1150	75	84.4	3/0			(a)
<u>PH 15-7 Mo alloy, sheet</u>						
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 U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure	Average Days to Failure
			Exposed	Failed		
<u>AM 350 alloy, sheet</u>						
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)
<u>AM 355 alloy, sheet</u>						
DA	75	119.4	3/0			(a)
SCT	75	123.6	3/0			(a)
<u>AM 357 alloy, sheet</u>						
50% CRT-800° F	75	211.4	5/5		3(3), 4(2)	3
<u>17-7 PH alloy, sheet</u>						
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)
<u>Thermol alloy, sheet</u>						
Transverse	75	113.7	5/5		31, 46, 47, 99, 391	122
Longitudinal	75	92.9	4/3		251, 333(c), 1359	(a)

Table 2. (cont.)

Material and Treatment	Exposure Stress, % of U. S.	Exposure Stress, ksi	No. of Specimens		Days to Failure	Average Days to Failure
			Exposed	Failed		
<u>A 286 alloy, sheet</u> STA ^(d)	75	80.6	5/0			(a)
<u>HNM alloy, sheet</u> TH 1350	75	54.6	5/0			(a)
<u>Titanium alloys, sheet</u> 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 - 5 yrs.
 (b) Exposure period for specimens still in test - 3.3 yrs.
 (c) Piece spalled at edge
 (d) Solution treated and aged

