

**NBSIR 73-103**

# **Stress Corrosion Behavior of High Strength Corrosion Resistant Materials**

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National Bureau of Standards  
Washington, D. C. 20234

February 7, 1973

Prepared for  
**Materials Division**  
**Naval Air Systems Command**  
**Department of the Navy**



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**U. S. DEPARTMENT OF COMMERCE, Frederick B. Dent, Secretary**  
**NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director**



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

E. Escalante and W. F. Gerhold  
Corrosion Section  
Metallurgy Division

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  
Custom 450  
Custom 455

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 at Kure Beach, North Carolina. Table 1 and Table 2 contain the results obtained from tests conducted at the 80' and the 800' lots, respectively.

These tests are continuing.



Results of Exposure

Table 1. Stress Corrosion in Marine Atmosphere at 80' Lot, Kure Beach, North Carolina

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)
<u>PH 14-4 Mo, "C" rings</u>					
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
<u>PH 14-8 Mo alloy, sheet</u>					
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	5/1	2536	(a)
"	90	192.2	5/5	364, 672 (2), 1861 (2)	1086
"	100	211.4	5/4	174, 355, 364, 672	391
			1	lost	





Table 1 (cont'd)

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)
<u>17-4 PH alloy, sheet</u>					
TH 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	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)
<u>PH 15-7 Mo alloy, sheet</u>					
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



Table 1 (cont'd)

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 15-7 Mo alloy, sheet (cont'd)					
RH 1050	50	103.0	5/3	2311, 2947, 4174	(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	5/2	2010, 2311	(b)
"	90	171.0	5/5	20, 21, 450, 3299, 2927	1343
"	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	5/5	1280, 2311, 3333 (2), 3452, 2742	2742
"	90	224.1	5/4	128, 365, 2611, 2947	(b)
"	100	249.0	5/3	365, 1904 (2)	(b)



Table 1 (cont'd)

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)
<u>AM 350 alloy, sheet</u>					
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	143(3)	(b)
"			1 lost		
"	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		
"	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



Table 1 (cont'd)

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)
<u>AM 355 alloy, wire</u>					
0.090" d	50	186.3	2/2	613,742	678
"	57	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	5/2	886,2701	(b)
"	90	160.2	5/5	539(2),1110,2582,4116	1777
"	100	178.0	5/5	130,886,1092,1224,4193	1505
RH 1075	50	85.0	5/0		(b)
"	75	127.5	5/0		(b)
"	90	153.0	5/1	4173	(b)
"	100	170.0	5/0		(b)





Table 1 (cont'd)

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)
<u>17-7 PH alloy, sheet</u>					
<u>(cont'd)</u>					
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	5/3	2307, 2319, 3828	(b)
"	100	175.0	5/2	118, 2701	(b)
CH 900	50	133.0	5/2	3003, 4116	(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
<u>17-7 PH alloy, wire-CH-C</u>					
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	3601 (3)NF	3601NF
"	90	298.5	3/3	344, 346, 364	351
0.055" d	50	156.3	3/0	3601 (3)NF	3601NF
"	75	236.3	3/2	1154, 2074, 3601NF	1614, 3601NF
"	90	288.3	3/3	1hr, 55, 461	172



Table 1 (cont'd)

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)
<u>17-7 PH alloy, wire-CH-C</u>					
(cont'd)					
0.120" d	50	154.4	3/3	43,110,136	96
"	75	227.2	3/3	33,45,1518	532
"	90	271.4	2/2	69,109	89
<u>Thermonol alloy, sheet</u>					
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	4/3	469,897,3336	(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)
<u>A 286 alloy, sheet</u>					
Solution treated & 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)
<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)



Table 1 (cont'd)

Material and Treatment	Exposure Stress % of Y. S.	Exposure Stress ksi	No. of Specimens Exposed/Failed	Days of Failure (f)	Average Days to Failure (f)
<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 & 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
<u>Custom 450</u>					
H 900	50	86.0	5/0		(c)
"	75	129.0	5/0		(c)
"	90	154.8	5/0		(c)
<u>Custom 455</u>					
H 1000	50	109.9	5/0		(c)
"	75	164.9	5/0		(c)
"	90	197.8	5/0		(c)
<u>Titanium alloy, sheet</u>					
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		(h)



Table 1 (cont'd)

Material and Treatment (cont'd)	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					
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 - 9.2 yrs.  
 (b) Exposure period for specimens still in test - 11.7 yrs.  
 (c) Exposure period for specimens still in test - 0.45 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.





Results of Exposure

Table 2. Stress Corrosion in Marine Atmosphere at 800' Lot, Kure Beach, North Carolina

Material and Treatment	Exposure Stress % of Y. S.	Exposure Stress ksi	No. of Specimens Exposed/Failed	Days to Failure	Average Days to Failure
<u>PH 14-8 Mo alloy, sheet</u>					
CRH 1050	75	181.8	5/0		(b)
SHR 1050	75	160.2	5/0		(b)
<u>17-4 PH alloy, sheet</u>					
TH 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	5/4	40, 61, 172, 2908	(a)
RH 1100	75	142.5	5/0		(a)



Table 2 (cont'd)

Material and Treatment	Exposure Stress % of Y. S.	Exposure Stress ksi	No. of Specimens Exposed/Failed	Days to Failure	Average Days to Failure
<u>17-7 PH alloy, sheet</u>					
<u>(cont'd)</u>					
RH 1100	75	114.0	5/0		(a)
TH 1050	75	131.3	5/1	40	(a)
CH 900	75	199.5	5/2	40,2554	(a)
<u>Thermonol alloy, sheet</u>					
Transverse	75	113.7	5/5	31,46,47,99,391	122
Longitudinal	75	92.9	4/3	251,333(d),1359	(a)
<u>A 286 alloy, sheet</u>					
STA(e)	75	80.6	5/0		(a)
<u>HNM alloy, sheet</u>					
TH 1350	75	54.6	5/0		(a)
<u>Custom 450</u>					
H 900	75	129.0	5/0		(c)
<u>Custom 455</u>					
H 1000	75	164.9	5/0		(c)



Table 2 (cont'd)

Material and Treatment	Exposure Stress % of Y. S.	Exposure Stress ksi	No. of Specimens Exposed/Failed	Days to Failure	Average Days to Failure
<u>Titanium alloys, sheet</u>					
6 Al-4V, STA (e)	75	131.3	5/0		(a)
C 105 VA, STA (e)	75	130.8	5/0		(a)
A 110 AT, STA (e)	75	93.2	5/0		(a)
C 115 VA, STA (e)	75	129.5	5/0		(a)
B 120 VCA, STA (e)	75	132.8	5/0		(a)

(a) Exposure period for specimens still in test - 11.7 yrs.

(b) Exposure period for specimens still in test - 9.2 yrs.

(c) Exposure period for specimens still in test - 0.45 yrs.

(d) Piece spalled at edge.

(e) Solution treated and aged.



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