AL-6XN®

LABORATORY CORROSION TESTS in Chloride Environments

Technology Department

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ROLLED ALLOYS
The world's heat, corrosion, titanium, and aerospace alloy specialists.

All of the laboratory data in this publication were developed by the Allegheny Ludlum Corporation Technical Center. Note that these are laboratory test results, valid only for the particular test conditions and heat of material involved. Variations in temperature, heat transfer conditions and seemingly minor impurities can significantly alter material behavior in corrosion. These data are offered as guidance for selecting those materials which will be further evaluated in the customer's specific environment.

The ASME code case 155-1, along with Figure NFN-12, are taken from the ASME Boiler and Pressure Vessel Code.

Note: Code case numbers, specification coverage and even allowable design stresses may change without notice. ASME information in this booklet is for initial guidance only. **DO CONSULT THE CURRENT ISSUE OF THE ASME BOILER AND PRESSURE VESSEL CODE.**

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I. The AL-6XN alloy

A. Introduction

AL-6XN® alloy, originally designed for seawater service, fits into the broad performance gap between common 316L stainless and the high nickel alloys such as C-276. The performance of AL-6XN alloy has led to wide acceptance for use as chemical process vessels, power plant scrubbers, seawater heat exchangers, pulp bleach plant filter washers, service water piping systems for nuclear power plants, reverse osmosis desalinization units, pharmaceutical process vessels and tubing, and food processing machinery. Availability of AL-6XN alloy is better than any other material in its class. Rolled Alloys carries an inventory of some one hundred-seventy different sizes and product forms, including pipe fittings. A like number of special pipe fittings are regularly produced to customer requirements.

The metallurgy and corrosion behavior of this alloy has been covered in depth by J. F. Grubb of Allegheny Ludlum Corporation in "AL-6XN® ALLOY", which is available from Rolled Alloys as Bulletin 1023. A 58 page fabrication manual, Rolled Alloys Bulletin 203, is also available. A compilation of all physical, mechanical and laboratory corrosion test data is in Rolled Alloys Bulletin 210.

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I. The AL-6XN alloy

B. Specifications

1. Chemistry

The specified chemistry range of AL-6XN alloy, in UNS N08367 is:

Ni	Cr	Mo	C	N	Mn	Si	P	S	Cu	Fe
23.50	20.00	6.00	0.030	0.18	2.00	1.00	0.040	0.030	0.75	remainder
25.50	22.00	7.00	max	0.25	max	max	max	max	max	

2. ASTM

Minimum Specified Mechanical Properties

	Ultimate Tensile,psi	0.2% Yield Strength, psi	Elongation %
Sheet, strip, welded pipe & tube under 3/16”	100,000	45,000	30
Plate, forgings, bar, rod welded pipe & tube 3/16” and heavier 95,000	45,000	30	

I. The AL-6XN alloy, continued

B. Specifications, continued

3. ASME

AL-6XN alloy is designated as UNS No. N08367 in the Unified Numbering System for alloys. In ASME Section IX AL-6XN alloy is P No. 45. The ASME Section VIII, Division 1 covers the use of AL-6XN alloy in welded construction through 800F. For external pressure design, use Fig NFN-12 of Section II, Part D. In ASME B31.1, AL-6XN is covered by Case 155-1, June 1993.

In ASME Section III, Division 1, Class 2 and 3, AL-6XN alloy is covered by Case N-438-3 through 800°F. For external pressure Figure 1 of this case is used.

2001 ASME Section VIII, Division 1 design stresses for AL-6XN are:

For Metal Temperature, °F, Not Exceeding	Maximum Allowable Stress Values, ksi								
	Welded pipe & tube under 3/16"		Sheet under 3/16"		Welded pipe & tube 3/16" & heavier		Plate, forgings, bar, rod		
100	24.3	24.3	28.6	28.6	23.1	23.1	27.1	27.1	
200	22.2	24.3	26.2	28.2	22.2	23.1	26.2	27.1	
300	20.2	23.0	23.8	27.0	20.2	21.8	23.8	25.7	400
18.7	22.0	21.9	25.8	18.7	20.9	21.9	24.6	500	
17.4	21.3	20.5	25.0	17.4	20.2	20.5	23.8	600	
16.5	20.8	19.4	24.5	16.5	19.8	19.4	23.3	650	
16.1	20.7	19.0	24.3	16.1	19.6	19.0	23.1	700	
15.8	20.5	18.6	24.1	15.8	19.5	18.6	22.9	750	
15.5	20.4	18.3	24.0	15.5	19.4	18.3	22.8	800	
15.3	20.2	18.0	23.8	15.3	19.2	18.0	22.6		
NOTES:	G14	G5, G14		--	G5	G14	G5, G14	--	G5

G5 Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66 2/3% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amounts of distortion can cause leakage or malfunction. G14 A factor of 0.85 has been applied in arriving at the maximum allowable stress values in tension for this material. Divide tabulated values by 0.85 for maximum allowable longitudinal tensile stress.

I. The AL-6XN alloy, continued

B. Specifications, continued

4. By Product Form

Alloy Form	Specifications	
Plate, sheet & strip	ASTM B 688 ASME SB-688	A 240 SA-240
Welded pipe	ASTM B 675 ASME SB-675	A 312 SA-312
Welded pipe, filler metal added	ASTM B 804 ASME	A 358 SA-358
Welded tube	ASTM B 676 ASME SB-676	A 249 SA-249
Rod, bar and wire	ASTM B 691 ASME SB-691	A 479 SA-479
Seamless pipe and tube	ASTM B 690 ASME SB-690	
Forged pipe flanges, fittings and valves	ASTM B 462 ASME SB-462	A 182 SA-182
Nickel alloy forgings	ASTM B 564 ASME SB-564	
Wrought nickel alloy weld fittings	ASTM B 366 ASME SB-366	
Billets and bars for reforging	ASTM B 472	
Castings (CN-3MN)	Code Case 2106-1 ASME Section VIII, Div. 1 Code Case N497 ASME Section III ASME SA-351	

I. The AL-6XN alloy, continued

B. Specifications, continued

6. Weld Fillers

a. Most Commonly Used

Alloy & Form	UNS	AWS/ASME
RA625 bare wire	N06625 N06625	AWS A5.14/ASME SFA-5.14 ERNiCrMo-3
RA112 covered electrodes	W86112	AWS A5.11/ASME SFA-5.11 ENiCrMo-3

Specified Chemistry Range

	C	Mn	Fe	P	S	Si	Cu	Ni	Al	Ti	Cr	Cb+	Mo	Other,
RA625	**0.10 max**	**0.50 max**	**5.0 max**	**0.02 max**	**0.015 max**	**0.50 max**	**0.50 max**	**58.0 min**	**0.40 max**	**0.40 max**	**20.0 23.0**	**3.15 4.15**	**8.0 10.0**	**0.50 max**
RA112	**0.10 max**	**1.0 max**	**7.0 max**	**0.03 max**	**0.02 max**	**0.75 max**	**0.50 max**	**55.0 min**	**-- --**	**-- --**	**20.0 23.0**	**3.15 4.15**	**8.0 10.0**	**0.50 max**

b. Higher Alloy Alternate

Alloy Form	UNS	AWS/ASME
Bare wire	N06686	AWS A5.14/ASME SFA-5.14 ERNiCrMo-14
Covered electrodes	W86686	AWS A5.11/ASME SFA-5.11 ENiCrMo-14

I. The AL-6XN alloy, continued

C. Physical Properties

Density 0.291 lb/inch^3 **8055 kg/m^3**
Melting Range 2410-2540°F **1321-1393°C**
Modulus of Elasticity

Temperature			
°F	**°C**	**psi**	**GPa**
75	24	28.3 x 10^6	195
200	93	27.4 x 10^6	189
400	204	26.1 x 10^6	180
600	316	24.8 x 10^6	171
800	427	23.4 x 10^6	161
1000	538	22.1 x 10^6	152

Specific Heat

°F	**Btu/lb•°F**	**°C**	**J/kg.K**
73	0.113	23	474
122	0.115	50	480
212	0.118	100	492
392	0.123	200	514
572	0.128	300	536
752	0.133	400	557
932	0.138	500	578
1112	0.146	600	610
1652	0.153	900	642
2012	0.158	1100	660
2192	0.160	1200	668

I. The AL-6XN alloy, continued

C. Physical Properties, continued

Thermal Diffusivity

°F	ft^2/hr	°C	$m^2/sec \times 10^{-6}$
73.4	0.119	23	3.05
122	0.122	50	3.14
212	0.128	100	3.31
392	0.141	200	3.64
572	0.153	300	3.95
752	0.164	400	4.23
932	0.173	500	4.46
1112	0.183	600	4.73
1652	0.205	900	5.30
2012	0.215	1100	5.54
2192	0.218	1200	5.63

Thermal Conductivity

°F	Btu • $ft/ft^2hr°F$	°C	W/m • K
73.4	6.724	23	11.64
122	7.010	50	12.13
212	7.574	100	13.11
392	8.702	200	15.06
572	9.847	300	17.04
752	10.96	400	18.97
932	12.01	500	20.79
1112	13.42	600	23.23
1652	15.82	900	27.39
2012	17.00	1100	29.43
2192	17.49	1200	30.27

Electrical Resistivity **75°F** **20°C**

535 Ohm • circ mil/ft 0.89 microhm • m

Magnetic Permeability at 200H

annealed 1/2 inch (12.7 mm) plate 1.0028 Oersted
65% cold-worked plate 1.0028 Oersted

I. The AL-6XN alloy, continued

C. Physical Properties, continued

Thermal Expansion

Temperature Range		Expansion Coefficient	
°F	**°C**	**inch/inch °F x 10^{-6}**	**m/m • K x 10^{-6}**
72 to 212	20 to 100	8.5	15.3
300	149	8.54	15.37
400	204	8.61	15.50
500	260	8.69	15.63
600	316	8.77	15.79
700	371	8.86	15.94
800	427	8.95	16.12
900	482	9.05	16.30
1000	538	9.16	16.49
1100	593	9.28	16.70
1200	649	9.40	16.9

II. Corrosion Data

A. Sodium Chloride (NaCl)

a. 5% Neutral Salt Spray Test
ASTM B 117
AL-6XN

Sample Condition	Time of Exposure Hours	% Surface Attack
Plain	48	0
	100	0
Plain	48	0
	100	0
Welded	48	0
	100	0
Welded	48	0
	100	0

Sample Size - 4” x 6”

Heat No. - 876733

Plain - ~0.047” Cold Rolled, Bright Annealed

Welded - Same + Autogenous Gas Tungsten Arc Welded (GTAW)

II. Corrosion Data

A. Sodium Chloride (NaCl)

b. Crevice Corrosion in 2% Sodium Chloride,
pH 2.0 71°C (160°F)
One 4-day period, One 30-day period

Weight Loss (g/cm^2)

Alloy	4 day Period	30X Observation	30 day Period	Crevice Depth	30X Observation
316L	0.00001	No Attack	0.00003	0.010”	Micro Pits, Crevice Attack
	0.00000	“	0.00006	0.023”	“
904L	0.00001	Crevice Attack	0.00002	<0.001”	Crevice Attack
	0.00000	No Attack	0.00002	0.004”	“
AL-6XN	0.00000	No Attack	0.00001	--	No Attack
	0.00001	“	0.00001	--	“
625	0.00002	No Attack	0.00003	--	No Attack
	0.00001	“	0.00005	--	“
alloy G	0.00000	No Attack	0.00001	--	No Attack
	0.00000	“	0.00001	--	“
Titanium Grade 12	0.00000	No Attack	0.00001	--	No Attack
	0.00000	“	0.00001	--	“

Materials used: 316L density 8.027 g/cm^3, heat 838128; 904L density 7.950 g/cm^3, heat 883079; AL-6XN density 8.055 g/cm^3, heat 876733; 625 density 8.442 g/cm^3, heat 96656A; Alloy G density 8.30 g/cm^3; Ti Gr 12 density 4.512 g/cm^3. Duplicate plain specimens ~0.036—0.073 x 1 x 2”

Metal thickness loss = weight loss divided by density

II. Corrosion Data

A. Sodium Chloride (NaCl)

c. 26% NaCl (Saturated), various stainless grades

Alloy	pH	24°C (75°F)	38°C (100°F)	52°C (125°F)	66°C (150°F)	79°C (175°F)	93°C (200°F)	107°C (225°F)
304	10	C	C	CP	CP	C	C	C
(S30400)	8	C	C	CP	C	C	C	CP
	6	CP	C	P	C	P	P	CP
	4	C	CP	C	C	P	C	C
	2	CP	C	C	C	C	C	CP
316	10	N	N	N	CP	C	C	C
(S31600)	8	C	P	CP	P	C	CP	C
	6	N	C	C	CP	C	C	C
	4	N	P	C	N	CP	C	C
	2	N	C	CP	C	C	CP	C
18Cr 2Mo	10	N	N	CP	CP	P	P	CP
(S44400)	8	N	C	C	C	P	C	CP
	6	C	C	CP	CP	P	CP	C
	4	C	C	CP	P	CP	C	CP
	2	N	C	CP	CP	CP	CP	CP
E-Brite	10	N	N	C	N	N	P	CP
(S44627)	8	N	C	CP	CP	CP	P	CP
	6	N	C	C	CP	CP	P	CP
	4	C	C	CP	CP	CP	C	CP
	2	N	N	CP	C	C	CP	CP

Tests run 72 hours with artificial crevices, per ASTM G 48, duplicate specimans.
Corrosion observed by microscopic examination at 30X magnification.
N = No corrosion
C = Crevice corrosion
P = Pitting Corrosion
pH adjusted with HCl.

II. Corrosion Data

A. Sodium Chloride (NaCl)

d. Corrosion of AL-6XN Alloy in Saturated NaCl Brine 26%, at Various Temperatures and pH's

pH	75°F	100°F	125°F	150°F	175°F	200°F
10	N	N	N	N	N	N
8	N	N	N	C	N	C
6	N	N	N	C	C	C
4	N	N	N	N	C	N
2	N	N	N	N	C	C

N = No Corrosion **C =** Crevice **P =** Pitting

Duplicate 0.047 x 1 x 2" welded samples were tested at each condition. Crevices were created using Teflon® spacers and rubber bands per ASTM G 48. AL-6XN alloy heat 876733.

e. Laboratory Crevice Corrosion Tests* of Alloys
12,100 PPM Chlorides (as NaCl), pH 2
30 Day Exposure, 71C (160F)

Alloy	Mo Content	Weight Loss g/cm^2	Comments
316L (S31603)	2.2	0.0000 (0.023 in.) depth	Micro pits and crevice attack 0.058 cm
904L (N08904)	4.5	0.0000	Crevice attack to 0.010 cm (0.004 in.) depth
AL-6XN (N08367)	6.2	0.0000	No Corrosion
G (N06007)	6.5	0.0000	No Corrosion
625 (N06625)	9.0	0.0000	No Corrosion

***** Testing per ASTM G 48 Practice B, average of duplicate tests.

II. Corrosion Data

A. Sodium Chloride (NaCl)

f. Laboratory Crevice Corrosion Tests of Alloys
15,000 PPM Chlorides (as NaCl)
100 Hours 65.5C (150F)

	Weight Loss, g/cm^2		
Alloy	**pH 1**	**pH 3**	**pH 5**
317L (S31703)	0.0037 [a]	0.0002 [b]	0.0000 [c]
317LX™ (S31725)	0.0049 [a]	0.0000 [c]	0.0000
AL-6XN (N08367)	0.0000	0.0000	0.0000
C-276 (N10276)	0.0000	0.0000	0.0000

Tests conducted per ASTM G 48 Practice B, weight loss average of two specimens.

Acidified with H_2SO_4

[a] General corrosion observed, crevice attack to depth of 0.008 cm (0.003 in.).
[b] Crevice attack to maximum depth of 0.046 cm (0.018 in.).
[c] Light crevice attack to maximum depth of 0.023 cm (0.009 in.).

g. Laboratory Crevice Corrosion Tests of AL-6XN (N08367) Alloy
24,000 PPM Chloride Water With pH and Temperature Varied

Temperature		Weight Loss, g/cm^2			
C	**(F)**	**pH 0.5**	**pH 1**	**pH 2**	pH 4
43	(110)	0.0000	0.0000	0.0000	0.0000
49	(120)	0.0000	0.0000	0.0000	0.0000
54	(130)	0.0000	0.0000	0.0000	0.0000
60	(140)	0.0000	0.0000	0.0000	0.0000
66	(150)	0.0186	0.0000	0.0000	0.0000
71	(160)	--	0.0234	0.0000	0.0000

30 day tests, crevices per ASTM G 48 Practice B
Average of two tests
pH adjusted with H_2SO_4

II. Corrosion Data

A. Sodium Chloride (NaCl)

h. Crevice Corrosion, AL-6XN Alloy
40,000 ppm Chloride Water
pH and Temperature Varied

Temperature	Weight Loss, g/cm^2 pH 0.5	pH 1.0	pH 2.0	pH 4.0
110ºF (43ºC)	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000
120ºF (49ºC)	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000
130ºF (54ºC)	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000
140ºF (60ºC)	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000
150ºF (66ºC)	0.0172	0.0000	0.0000	0.0000
	0.0199	0.0000	0.0000	0.0000
160ºF (71ºC)	----	0.0254	0.0000	0.0000
	----	0.0214	0.0000	0.0000

30 day tests, crevices per ASTM G 48 Practice B. Solution pH adjusted with H_2SO_4

II. Corrosion Data

A. Sodium Chloride (NaCl)

i. Crevice Corrosion, AL-6XN Alloy
50,000 ppm Chloride Water
pH and Temperature Varied

	Weight Loss, g/cm^{2*}			
Temperature	**pH 4****	**pH 2**	**pH 1**	**pH 0.5**
130ºF (54ºC)	.0000 NA***	.0000 NA	.0000 SL.CA [2/8E]	.0000 SL.CA [1/8E]
140ºF (60ºC)	.0000 NA	.0000 SL.CA [1/8E]	.0001 SL.CA [7/8E]	.0252 GC,CA [8/8E]
150ºF (66ºC)	.0000 NA	.0000 NA	.0001 CA[4/8E]	.0228 GC,CA [8/8E]
160ºF (71ºC)	.0000 SL.CA [1/8E, 2/4B]	.0003 SL.CA [3/8E, 1/4B]	.0066 GC, CA [5/8E, 3/4B]	.0460 GC, CA [6/8E]

***** 30-day tests, crevices per ASTM G 48 Procedure B

****** Acidified with H_2SO_4

******* **NA** - no visible attack
SL - slight
CA - crevice attack
E = edge, **B =** crevice block
GC - general active corrosion

II. Corrosion Data

B. Seawater

a. Synthetic Seawater (pH = 8.2) 168 hours at 65°C (149°F)

Sample	inch/month	avg in/m	avg mm/year	avg mils/year
Titanium	0.00000			
Grade 2	0.00000	0.00000	0.00000	0.00000
AL-6XN	0.00000			
Heat 856657	0.00000	0.00000	0.00000	0.00000
AL 29-4C	0.00000			
Heat 857603	0.00000	0.00000	0.00000	0.00000
70Cu-30Ni	0.00006			
(C71500)	0.00006	0.00006	0.0171	0.675
90Cu-10Ni	0.00017			
	0.00018	0.00018	0.0529	2.084

II. Corrosion Data

B. Seawater

b. Erosion corrosion resistance of alloys in seawater[3] flowing at 125-140 ft/sec (39-50 m/sec)

		Corrosion Rate*	
Alloy	**UNS No.**	**mm/yr**	**mils/yr**
304	(S30400)	0.025	1
316	(S31600)	0.025	1
AL-6X®	(N08366)	0.025	1
90-10 Cu-Ni	(C70690)	0.63	25
6061 Aluminum	(A96061)	1.6	65
Carbon Steel	(A96061)	3.8	150

***** 30 day exposures in natural seawater at 9-15ºC (48-59ºF)

AL-6X alloy has been found to resist erosion damage even when exposed for 30 days to an excessive seawater flow velocity of 129 ft/sec (39 m/sec) at 9ºC (48ºF). Under comparable conditions the corrosion rates for other materials are listed above. AL-6XN alloy, which is a general improvement over the AL-6X alloy, has been successfully used as tubing in power plants with water velocities in excess of 8 ft/sec (2.4 m/sec).

II. Corrosion Data

C. Mixed Chlorides

a. Crevice Corrosion of Stainless Steel and Nickel Alloy
10,000 PPM Chloride and 1,000 PPM thiosulfate
72 Hours at 66C (150ºF)

Alloy	Weight Loss, g/cm^2 [No. Crevice Sites Attacked] pH 1	pH 2	pH 4.5	ph 6.5
10,000 PPM Chloride (as NaCl)				
316L (S31603)	0.0000 [29]	0.0000 [13]	0.0000 [11]	0.0000 [10]
317LX™ (S31725)	0.0036**	0.0000 [10]	0.0000 [2]	0.0000 [4]
317LXN™ (S31726)	0.0040**	0.0000 [1]	0.0000 [1]	0.0000 [1]
AL-6XN (N08367)	0.0000 [19]	0.0000 [0]	0.0000 [0]	0.0000 [0]
C-276 (N10276)	0.0000 [0]	0.0000 [0]	0.0000 [0]	0.0000 [0]
10,000 PPM Chloride (as NaCl), 1,000 PPM Thiosulfate as $Na_2S_20_3$				
316L (S31603)	0.0142 [40]	0.0002 [40]	0.0002 [27]	0.003 [17]
317LX (S31725)	0.0070**	0.0000 [3]	0.0000 [1]	0.0000 [0]
317LXN (S31726)	0.0009 [39]	0.0000 [1]	0.0000 [0]	0.0000 [0]
AL-6XN (N08367)	0.0013 [40]	0.0000 [0]	0.0000 [0]	0.0000 [0]
C-276 (N10276)	0.0011 [40]	0.0000 [0]	0.0000 [0]	0.0000 [0]

Crevice generated using Delrin® serrated spacers tightened to 55-60 in-lbs.

Weight loss are average of duplicate specimens. Numbers in brackets are the maximum number of crevice contact sites (out of 40 total) evidencing corrosion.

Sulfuric acid used to adjust pH

** General corrosion observed

II. Corrosion Data

C. Mixed Chlorides

b. Pitting and Crevice Corrosion in Saturated NaCl Brine With 1% NaOCl Addition Corrosion Observed

Alloy	pH	24 ° C (75ºF)	38ºC (100ºF)	52ºC (125ºF)	66ºC (150ºF)	79ºC (175ºF)	93ºC (200ºF)
AL-6XN	10	C	C	C	C	C	C
	8	C	C	C	C	C	C
	6	C	C	C	CP	CP	CP
	4	C	C	C	CP	CP	CP
	2	N	C	C	CP	CP	CP

N = No Corrosion **C =** Crevice **P =** Pitting

Duplicate 0.047 x 1 x 2” welded samples were tested at each condition.

Crevices were created using Teflon® spacers and rubber bands per ASTM G 48.

II. Corrosion Data

C. Mixed Chlorides

c. 2% $KMnO_4$-2% NaCl, 24 Hours
Pitting Test Results (No Crevices)

Alloy	Weight Loss, g/cm^2			
	25ºC (77ºF)	**50ºC (122ºF)**	**75ºC (167ºF)**	**90ºC (194ºF)**
316L	.00001	.00003	.00699*****	--
(S31603)	.00002	.00004	.00012	--
E-Brite®	.00002	.00004	.00067*****	.00297*****
(S44627)	.00004	.00004	.00007	.00427*****
AL 29-4C®	.00001	.00004	.00004	.00003
(S44735)	.00001	.00004	.00003	.00003
AL-6XN	.00001	.00003	.00006	.00004
(N08367)	.00001	.00003	.00005	.00003

*****Pitting observed

II. Corrosion Data

C. Mixed Chlorides

d. Crevice Corrosion Tests of Alloys In Severe Laboratory Acid Chloride Solution[1] (Green Death)

	Weight Loss, g/cm^2		
Alloy	**24ºC (75ºF)**	**50ºC (122ºF)**	**70ºC (158ºF)**
316L (S31603)	0.0006	0.0343	0.0390
317L (S31703)	0.0007	0.0377	0.0500
317LX™ (S31725)	0.0000	0.0319	0.0462
317LXN™ (S31726)	0.0000	0.0129	0.0462
904L (N08904)	0.0000	0.0221	0.0419
AL-6XN (N08367)	0.0000	0.0000	0.0266
625 (N06625)	0.0000	0.0000	0.0149
C-276 (N10276)	0.0000	0.0001	0.0004

7 Vol. % H_2SO_4, 3 Vol. % HCl, 1 Wt. % $CuCl_2$, 1 Wt. % $FeCl_3$

Tests per ASTM G 48 Practice B, 72 hour duration.

II. Corrosion Data

C. Mixed Chlorides

e. Crevice Corrosion of Alloys in Severe Simulated Scrubber Environment Solution (Green Death)

Alloy	UNS No.	Weight Loss, g/cm$_2$		
		24ºC (75ºF)	**50ºC (122ºF)**	**70ºC (158ºF)**
317LXN™	S31726	0.0000	0.0072	0.0483
		0.0000	0.0065	0.0501
Ferralium® 255	S39255	0.0000	0.0000	0.0235
		0.0000	0.0000	0.0239
2507	S39275	0.0000	0.0000	0.0051
		0.0000	0.0000	0.0039
AL-6XN®	N08367	0.0000	0.0000	0.0030
		0.0000	0.0000	0.0008

Tests conducted according to the procedures outlined in ASTM G 48, Practice B, but the solution used was 7% H_2SO_4, 3% HCl, 1 w/o $CuCl_2$ and 1% w/o $FeCl_3$. Time of test was 72 hours.

II. Corrosion Data

C. Mixed Chlorides

f. Green Death, Pitting and Crevice Corrosion Pitting Test (No Artificial Crevices) - 24 Hrs.

Alloy	Temperature	Wt. Loss g/cm^2	Number of Pits	Comments
AL-6XN	75ºC	.0150	3	A very few pits
(N08367)	(167ºF)	.0142	1	
825	75ºC	.0251	>50	Many pits
(N08825)	(167ºF)	.0274	>50	
625	75ºC	.0002	0	No pitting evident
(N06625)	(167ºF)	.0052	0	
C-276	75ºC	.0004	0	No corrosion
(N10276)	(167ºF)	.0004	0	evident
AL-6XN	102ºC	.0062	>50	Pitting on surfaces
(N08367)	(216ºF)	.0047	>50	and edges
825	102ºC	.0536	>50	Pitting on surfaces
(N08825)	(216ºF)	.0510	>50	and edges
625	102ºC	.0384	>50	Pitting on all
(N06625)	(216ºF)	.0395	>50	surfaces
C-276	102ºC	.0015	0	No localized
(N10276)	(216ºF)	.0015	0	corrosion

Test solution 7% H_2SO_4 3% HCl 1% $CuCl_2$ 1% $FeCl_3$

II. Corrosion Data

C. Mixed Chlorides

f. Green Death, Pitting and Crevice Corrosion, continued

Crevice Corrosion Test (Teflon® block held in place with rubber bands) - 24 Hrs.

Alloy	Temperature	Wt. Loss g/cm^2	Number of pits	Comments
AL-6XN	75ºC	.0087	--	Edge and crevice block
(N08367)	(167ºF)	.0086	--	attack
825	75ºC	.0268	--	Edge and block attack
(N08825)	(167ºF)	.0287	--	
625	75ºC	.0089	--	Edge and block attack
(N06625)	(167ºF)	.0057	--	
C-276	75ºC	.0003	--	No local corrosion
(N10276)	(167ºF)	.0003	--	
AL-6XN	102ºC	.0069	--	Crevice attack under block
(N08367)	(216ºF)	.0070	--	and at edges
825	102ºC	.0451	--	General corrosion and
(N08825)	(216ºF)	.0580	--	pitting
625	102ºC	.0398	--	Pitting, perforation
(N06625)	(216ºF)	.0413	--	
C-276	102ºC	.0016	--	No localized corrosion
(N10276)	(216ºF)	.0016	--	

"Green Death" Solution
7 Vol. % H_2SO_4
3 Vol. % HCl
1 Wt. % $CuCl_2$
1 Wt. % $FeCl_3$

II. Corrosion Data

C. Mixed Chlorides

g. Weight Loss Measurement For Welded Austenitic Plate Samples In A Simulated Severe Scrubber Solution[2] (Green Death)

Base Metal	Filler	Weight Loss (mg/cm^2) 20ºC	30ºC	35ºC	40ºC	50ºC	70ºC
317LX™	317LX	0.351	1.115	3.449	12.341	26.8973	--
	Alloy G (ERNiCrMo-1)	0.196	1.247	0.989	7.834	22.051	--
	904L	0.132	0.931	2.472	9.063	17.616	--
	112 (ENiCrMo-3)	0.287	0.895	0.769	4.998	18.650	--
317LXN™	Alloy G (ERNiCrMo-1)	--	1.139	0.425	7.335	--	--
	904L	0.316	0.584	0.719	4.396	16.420	--
	112 (ENiCrMo-3)	--	--	--	--	32.703	--
904L	G (ERNiCrMo-1)	--	--	--	--	22.521	--
	625 (ERNiCrMo-3)	--	--	--	--	23.317	--
AL-6XN®	625 (ERNiCrMo-3)	0.016	0.013	--	--	2.198	23.991

Duplicate 2.5 cm x 5.1 cm 0.635 (1 x 2 x 0.250 inch) creviced specimens tested (per ASTM G 48) in 7 vol. % H_2SO_4, 3 vol. % HCl, 1 wt. % $CuCl_2$, 1 wt. % $FeCl_3$ for 72 hours.

II. Corrosion Data

C. Mixed Chlorides

h. Maximum Depth of Pitting in Welded Austenitic Plate . Samples exposed to a Severe Simulated Scrubber Solution[2] (green death)

		Exposure: Successive 72 hour periods at 20, 30, 35 and 40ºC				**Exposure: 72 hours at 50ºC**			
		Maximum Depth of Pitting (cm)		**Location**		**Maximum Depth of Pitting (cm)**		**Location**	
Base Metal	**Filler**	**Face**	**Root**	**Face**	**Root**	**Face**	**Root**	**Face**	**Root**
317LX™	317LX	0.178	0.178	W	W	0.211	0.142	W	W
	Alloy G (ERNiCrMo-1)	0.079	0.178	BM	FL	0.117	0.279	BM	W
	904L	0.005	0.203	W	W	0.089	0.165	BM	W
	112 (ENICrMo-3)	0.013	0.107	BM	BM	0.076	0.084	FL	BM
317LXN™	317LX	--	--	--	--	0.145	0.086	W	W
	Alloy G (ERNiCrMo-1)	0.038	0.114	BM	W	--	--	--	--
	904L	0.117	0.147	W	W	--	--	--	--
	112 (ENiCrMo-3)	--	--	--	--	0.097	0.089	W	W
904L	Alloy G (ERNiCrMo-1)	--	--	--	--	0.058	0.170	BM	W
	625 (ERNiCrMo-3)	--	--	--	--	0.097	0.089	W	W
AL-6XN®	625 (ERNiCrMo-3)	--	--	--	--	0.051	0.119	W	W

***** Location: BM = Base Metal, W = Weld, FL = Fusion Line

Duplicate 2.5 cm x 5.1 cm x 0.635 cm (1 x 2 x 0.250 inch) creviced specimens tested (per ASTM G 48) at the temperatures and for the time periods shown above.

II. Corrosion Data

C. Mixed Chlorides

i. Crevice Corrosion Tests in Brine

Brine Composition (% by weight):

20.7% NaCl, 4.6% $CaCl_2$, 1.2% $MgCl_2$, 0.1% $CaSO_4$

Conditions:

pH 6.8 (adjusted with HCl from as-mixed value of 7.6 test. 72 hours, atmospheric pressure

Type of Test:

Immersion with reflux, Teflon® crevice, duplicate 2" x 1" sheet samples, (except for the welded sample where a single plate specimen was tested)

Test Results:

Alloy		**Weight Loss, mg/cm^2 120ºF**		**170ºF**		**224ºF (Boiling)**	
316	(S31600)	0.05	C	0.06	C	0.01	C
E-Brite®	(S44627)	0.04	P	0.07	P	0**	N
AL-6X®	(N08366)	0.01	N	0	N	0.01	N
AL 29-4C®	(S44735)	0.01	N	0	N	0	N
AL 29-4-2®	(S44800)	0.01	N	0	N	0	N
Titanium	(R50400)	0.01	N	0	N	0	N
Alloy 400*	(N04400)	0.03	C	0.07	C	0.25	P

N = No localized attack **C =** Crevice attack observed **P =** Pitting observed
*** =** Welded plate sample **** =** Weight loss less than 0.01 mg/cm^2 are note 0

II. Corrosion Data

C. Mixed Chlorides

j. Crevice Corrosion of Various Materials in a Salt Solution

Material: AL-6X® alloy Ht. No. 02145, AL 29-4-2® Ht. No. 0983317S, AL 29-4C® Ht. 718284, 625 Ht. No. 96656A, 400 Ht. No. M7182B, Titanium, ~0.060" x 1" x 2" duplicate, plain specimens.

Solution: 21.6% NaCl, 0.77% $NaClO_3$, 0.43% Na_2SO_4 balance water pH 7± 0.5

Temperature: Boiling (222ºF, 106ºC)

Time: One 72 hour period

Material		**Weight Loss (g/cm^2)**		**Avg.**	**Remarks**
AL 29-4C®	(S44735)	0.0000	0.0000	0.0000	No attack
AL 29-4-2®	(S44800)	0.0000	0.0000	0.0000	No attack
AL 6X®	(N08366)	0.0000	0.0000	0.0000	One very light crevice spot*
625	(N06625)	0.0000	0.0000	0.0000	No attack
Alloy 400	(N04400)	0.0057	0.0082	0.0069	Crevice attack
Titanium	(R50400)	0.0000	0.0000	0.0000	Light crevice attack

Crevices created by 1/2" Teflon® spacers and rubber bands according to ASTM G 48.

*** Note:** AL-6X alloy lacks the nitrogen content of AL-6XN® alloy Expect similiar results with AL-6XN except it is doubtful that any signs of attack would be seen with AL-6XN.

II. Corrosion Data

C. Mixed Chlorides

k. Corrosion Test Results
Evaporator Technology Corporation Brine

Brine Composition: 10 - 12% Sodium Chloride, 1 - 2% Glycerine, 0.1 - 0.5% Glycidol
pH: 7.79
Temperatures: Boiling (220ºF), Reflux
Length of Test: 120 hours
Samples: 1" x 2" x approximately 0.060" thickness
Pitting Tests: Plain samples, no crevices
Crevice Corrosion Tests: Samples with drilled holes (3/8"diameter), fitted with inert (Rulon™) crevice device with 40 plateaus (20 per side).

Corrosion Observed:

NA - No attack of any kind
G - General Corrosion only, i.e. no pitting
C - Crevice corrosion observed under Rulon
Crevice former plateaus (number of plateaus attacked)
P - Pitting corrosion
LP - Very light pitting corrosion observable with stero microscope

Test Results:

	Pitting Test		**Crevice Corrosion Test**
Material	**IPM**	**(MPY)**	**Wt. Loss, mg/cm^2**
Carbon Steel	.00118	(14.2) G	--
	.00186	(22.4) G	--
316L	.00005	(0.60) P	.40 C (2/40)
(S31603)	--	--	.22 C (2/40)
904L	.00002	(0.29) P	.23 C (5/40)
(N08904)	--	--	.22 C (3/40)
AL-6XN®	.00001	(0.14) LP	.17 C (3/40)
(N08367)	--	--	.23 C (5/40)
Titanium	.00000	(0.00) NA	.00 NA (0/40)
(R50400)	--	--	.00 NA (0/40)
Alloy 400	.00040	(4.89) G	1.48 G (0/40)
(N04400)	--	--	1.81 G (0/40)
625	.00000	(0.06) NA	.05 NA (0/40)
(N06625)	--	--	.13 C (3/40)

II. Corrosion Data

D. $FeCl_3$ (Ferric Chloride)

a. Crevice Corrosion Test Results of AL-6XN In 10% $FeCl_3 \cdot 6H_20$ (ASTM G 48, Practice B)

Material: AL-6XN alloy
Heat No.: 876733
Condition: **Plain -** ~0.047" bright annealed strip
Welded - Same + Autogenous Gas Tungsten Arc Weld (GTAW)
Sample Size: 0.047 x 1.0 x 2.0"
Solution: 10% $FeCl_3 \cdot 6H_2O$
Temperature: Various
Time: One 72 Hour Period

Temperature		**Weight Loss - g/cm^2**			
ºF	**ºC**	**Plain**		**Welded**	
72	22.2	0.0000	0.0000	0.0000	0.0000
85	29.4	0.0000	0.0000	--	--
90	32.2	0.0000	0.0000	0.0000	0.0000
95	35.0	0.0000	0.0000	0.0003	0.0000
100	37.8	0.0000	0.0000	0.0013	0.0004
105	40.6	0.0000	0.0000	--	--
110	43.3	0.0000	0.0000	--	--
115	46.1	0.0000	0.0000	--	--
122	50.0	0.0167	0.0135	--	--

II. Corrosion Data

D. $FeCl_3$ (Ferric Chloride)

b. Crevice Corrosion Test Results of Alloys in 10% $FeCl_3 \cdot 6H_2O$ (ASTM G 48, Practice B, 72 hours)

		Weight Loss g/cm^2			
Alloy	**UNS No.**	**95ºF (35ºC)**	**105ºF (40ºC)**	**115ºF (46ºC)**	**120ºF (49ºC)**
317LXN™	S31726	0.0014	0.0045	0.0085	--
		0.0011	0.0044	0.0058	--
Ferralium® 255	S39255	0.0000	0.0000	0.0000	0.0031
		0.0000	0.0000	0.0000	0.0040
AL-6XN	N08367	0.0000	0.0000	0.0000	0.0002
		0.0000	0.0000	0.0000	0.0005
2507	S39275	0.0000	0.0000	0.0000	0.0000
		0.0000	0.0000	0.0000	0.0000

II. Corrosion Data

D. Ferric Chloride ($FeCl_3 \cdot 6H_2O$)

c. Temperature For Initiation of Crevice Corrosion Alloys in Ferric Chloride Solution

Alloy	UNS No.	Molybdenum Content	Critical Crevice Corrosion Temperature °C	°F	Pitting Resistance Equivalent, (PRE)N
E-Brite®	**S44627**	1	24	75	29
316L	**S31603**	2.1	-3	27	23
825	**N08825**	2.7	-3	27	30
2205	**S31803**	3.1	20	68	38
317L	**S31703**	3.2	2	35	29
AL 29-4C®	**S44735**	4	52	125	42
AL 29-4-2®	**S44800**	4	58	136	42
317LX™	**S31725**	4.4	18	63	33
317LXN™	**S31726**	4.4	20	68	34
904L	**N08904**	4.4	24	75	35
254 SMO®	**S31254**	6.1	43	110	46
AL-6X®	**N08366**	6.2	32	90	41
AL-6XN	**N08367**	6.2	43	110	48
G	**N06007**	6.5	30	86	43
625	**N06625**	9.0	45	113	51
C-276	**N10276**	15.4	55	130	66

10% $FeCl_3 \cdot 6H_2O$, per ASTM G 48 Practice B, (PRE) N = Cr + 3.3Mo + 30N

II. Corrosion Data

D. Ferric Chloride ($FeCl_3 \cdot 6H_2O$)

d. ASTM G 48 B Ferric Chloride Crevice Corrosion Test
72 hours at 50°C (122°F)

Alloy	Weight Loss g/cm^2	Crevice depth	Remarks
Gr. 2 Titanium (duplicate	0.0000	none	No crevice found at any depth. Etching is found on both sides under crevice results)
		block.	
AL-6XN 856657	0.0004	none	No crevice found at any depth. Etching Ht. is found on both sides under crevice Block.
AL-6XN 856657	0.0003	0.002”	Partial outline of crevice block found at Ht. depth of 0.002”
		0.001 to 0.007”	Attack in area under crevice block at depth of 0.001 to 0.007”
		0.002 to 0.008”	All edges have etching due to rubber band; depth varies from 0.002 to 0.008”
AL 29-4C Ht 857603	0.0000	none	No apparent attack
AL 29-4C Ht 857603	0.0000	none	No apparent attack
70Cu-30Ni R099	0.0851	?	General corrosion? Sample appears to Lot have experienced a great deal of general corrosion. The sample area surrounding where the crevice block was is extremely etched, appears to have pitted, and is discolored in appearance.

II. Corrosion Data

D. Ferric Chloride ($FeCl_3 \cdot 6H_2O$)

d. ASTM G 48 B Ferric Chloride Crevice Corrosion Test
72 hours at 50°C (122°F), continued

Alloy	Weight Loss g/cm^2	Crevice depth	Remarks
70Cu-30Ni R099	0.0834	?	General corrosion? Sample appears to have experienced a great deal of general corrosion. The sample area surrounding where the crevice block was is extremely etched, appears to have pitted, and is discolored in appearance. Lot
90Cu-10Ni R446	0.0867	?	General corrosion? Sample appears to have experienced a great deal of general corrosion. The sample area surrounding where the crevice block was is extremely etched, appears to have pitted, and is discolored in appearance. Lot
90Cu-10Ni R446	0.0769	?	General corrosion? Sample appears to have experienced a great deal of general corrosion. The sample area surrounding where the crevice block was is extremely etched, appears to have pitted, and is discolored in appearance. Lot

II. Corrosion Data

E. Sodium Hypochlorite Bleach (NaOCl)

Crevice corrosion per ASTM G 48 Practice B, multi-crevice assembly. Material tested AL-6XN alloy Heat 876733, 0.047 x 1 x 2" plain specimens.

NaOCl weight %	**Time, hours**	**Temp. F**	**(C)**	**Wt. Loss g/cm^2**	**Comments***	
0.02	96	160	(71)	.0000	N	
				.0000	N	
5.25	720	77	(25)	.0000	N	
				.0000	N	
5.25	720	104	(40)	.0000	N	Rb
				.0000	N	Rb
5.25	720	140	(60)	.0000	N	Rb
				.0000	C	Rb
5.25	96	160	(71)	.0001	C	Rb
				.0004	C	Rb

*** C =** crevice corrosion observed

N = no crevice corrosion observed

Rb = rubber bands replaced

II. Corrosion Data

F. Stress Corrosion Cracking, AL-6XN

a. 0.002—15.8% NaCl, 250—600°F (121—316°C)

Cl^-, Weight %	Test Temperature	Exposure Time, hours	Results
0.002	288°C (550°F)	1010	No cracking observed
0.002	316°C (600°F)	1021	No cracking observed
0.02	288°C (550°F)	510	Cracked specimens
0.02	260°C (500°F)	1008	No cracking observed
0.2	204°C (400°F)	1011	No cracking observed
0.2	232°C (450°F)	504	Cracked specimens
0.2	260°C (500°F)	504	Cracked specimens
15.8	121°C (250°F)	1011	No cracking observed
15.8	149°C (300°F)	1005	Cracked specimens
15.8	177°C (350°F)	480	Cracked specimens
15.8	204°C (400°F)	1088	Cracked specimens
15.8	260°C (500°F)	1008	Cracked specimens

II. Corrosion Data

F. Stress Corrosion Cracking

b. Stress Corrosion of AL-6XN Alloy in Boiling Solutions of 26% NaCl and 26% NaCl + 1% NaOCl at Various pH's

pH	Test Time (Hrs.)	26% NaCl	26% NaCl + 1% NaOCl
2	1000	NC	NC
4	1000	NC	NC
6	1000	NC	NC
8	1000	NC	NC
10	1000	NC	NC

NC = no cracking

Duplicate 0.047 x 1 x 4" welded one inch U-bend samples were tested at each condition. HCl used to adjust pH.

II. Corrosion Data

F. Stress Corrosion Cracking

c. Stress Corrosion Cracking Resistance of Fe-Cr-Ni-Mo Stainless Alloys[4]

Alloy UNS No. and Condition	Condition of U-Bend Samples for Listed Times of Exposure (Hours in Given Boiling Test Solutions (wt pct)			
	33 LiCl	**42 $MgCl_2$**	**26 NaCl**	**50 NaOH**
316	OK	Cracked	OK	OK
(S31600)	500	24-24	1000	1000
GTAW Shield:				
Pure Ar	OK	Cracked	OK	Not
	500	24-24	1000	Tested
AL-6X®	Cracked	Cracked	OK	OK
(N08366)	OK-200	96-120	200	200
GTAW Shield:				
Pure Ar	Cracked	Cracked	OK	OK
	OK-200	96-144	200	200
AL-6XN®	OK	Cracked	OK	OK
(N08367)	501	552-1128	1075	210
GTAW Shield:				
Pure Ar	OK	Cracked	OK	OK
	501	1339-2131	1075	210
Ar + 5.0% N_2	OK	Cracked	OK	OK
	573	652-652	1004	200

Duplicate U-bend samples, from 0.047” thick strip, were tested in the mill-produced condition unless noted otherwise. AL-6XN alloy heat 876733. Exposure times are given for each sample only when cracks were observed on one or both samples. Samples marked “OK” did not crack in the listed periods of time.

II. Corrosion Data

F. Stress Corrosion Cracking

d. Stress Corrosion Cracking Resistance
Austenitic Alloys in Boiling Chloride Solutions

Alloy		Performance, Boiling Solution 42% $MgCl_2$ 200 h	26% NaCl (pH 7) 1000 h
316L	(S31603)	F	F
317L	(S31703)	F	F
317LX™	(S31725)	F	P
317LXN™	(S31726)	F	**AL-6XN** (N08367)
P/F		P	
C-276	(N10276)	P	P

U = bent specimens immersed for indicated period of time
F = failure by SCC within time indicated
P = no failure within time indicated

II. Corrosion Data

F. Stress Corrosion Cracking

e. Performance of Stressed Stainless Steel Specimens Boiling Laboratory Chloride Environments[5]

Alloy		Performance of U-Bent Samples* 42% $MgCl_2$		26% NaCl	
Austenitic					
304L	(S30403)	F	(21)	F	(300-1000)
316L	(S31603)	F	(45)	NF	(1000)
317L	(S31703)	F	(72)	F	(1000)
317LX™	(S31725)	F	(120)	NF	(1000)
904L	(N08904)	NF	(200)	NF	(1000)
AL-6X®	(N08366)	F	(96-144)	NF	(1000)
AL-6XN™	(N08367)	F	(500-1300)	NF	(200)
		NF	(2130)	NF	(1075)
Ferritic					
439	(S43035)	NF	(1000)	NF	(1000)
E-Brite®	(S44627)	NF	(200)	NF	(1000)
AL 29-4C®	(S44735)	NF	(200)	NF	(1000)
AL 29-4®	(S44700)	NF	(200)	NF	(200)
AL 29-4-2®	(S44800)	F	(18)	NF	(1000)
Duplex					
2205	(S31803)	F	(19-106)	NF	(1000)

***F =** Failure by SCC within time (hours), shown in parentheses

NF = No failure. Tests terminated after time (hours), shown in parentheses. Where two numbers are given, results of two tests.

II. Corrosion Data

F. Stress Corrosion Cracking

f. Stress Corrosion of Types 304, 316, and AL-6XN in 40% Calcium Chloride

Alloy	Heat #	Time to initial crack (Hrs.)	Total test time (Hrs.)	Comments
304	841027	144	144	Crevice corrosion
		144	144	Crevice corrosion
316	722146	144	336	Crevice corrosion
		144	1000	No crevice attack
AL-6XN	834360	1000	1000	No crevice attack
		1000	1000	No crevice attack

Duplicate 1” x 4” one inch U-bend samples tested. Solution in weight percent. Temperature of test solution, boiling ~109ºC (~228ºF). Crevices generated by the Teflon® insulating gasket.

II. Corrosion Data

G. Dissimilar Metal Crevice Corrosion

a. Dissimilar Metal Crevice (DMC) Corrosion Tests in Ferric Chloride[6]
10% $FeCl_3 \bullet 6H_2O$ at 38ºC (100ºF)

Alloys in a DMC	Weight Loss (g/cm^2) for Given Time Period (hours) 24	48	96	192	384
316 (S31600)	0.0166	0.0208	0.0288	0.0281	0.0292
AL 29-4C® (S44735)	0.0005	0.0016	0.0025	0.0092	0.0083

Two contacting 1 x 2 inch (25 x 51mm) samples were placed between two grooved TFE-fluorocarbon washers, and the entire assembly held together by two rubber bands.

b. Dissimiliar Metal Crevice (DMC) Corrosion Tests in Ferric Chloride[6]
10% $FeCl_3 \bullet 6H_2O$ at 38 º C (100ºF)

Alloys in a DMC	Weight Loss (g/cm2) for Given Time Period (hours) 168	720	1140	2160
AL 29-4C (S44735)	0.0000	0.0000	0.0000	0.0000
AL-6X® (N08366)	0.0012	0.0004	0.0004	0.0002
AL 29-4C	0.0000	0.0000	0.0000	0.0000
AL-6XN (N08367)	0.0000	0.0000	0.0000	0.0000

Two contacting 1 x 2” samples assembled as above.

II. Corrosion Data

G. Dissimilar Metal Crevice Corrosion

c. Results for Dissimilar Metal Crevice (DMC) Exposures In Natural Seawater[6]

DMC	Alloys	Weight Loss (mg/cm^2) for Given Time Period (Days) 30	60	90	180	276	365
A	**AL 29-4C® (S44735)**	0.00	0.50	0.01	0.01	0.02	0.01
	316 (S31600)	0.18	0.23	0.41	1.84	1.32	0.33
	AL 29-4C (S44735)	0.00	0.00	0.75	0.01	0.00	0.01
B	**AL-6X® (N08366)**	0.02	0.01	0.01	0.01	0.61	0.03
	316 (S31600)	2.96	0.60	0.05	0.03	3.45	1.33
	AL-6X (N08366)	0.01	0.01	0.01	0.01	0.01	0.03
C	**AL-6XN (N08367)**	0.01	0.01	0.02	0.01	0.02	0.03
	316 (S31600)	2.26	0.67	1.01	0.17	1.54	5.76
	AL-6XN (N08367)	0.01	0.01	0.01	0.01	0.01	0.03
D	**AL 29-4C (S44735)**	0.00	0.00	0.01	0.01	0.00	0.01
	AL-6XN (N08367)	0.01	0.01	0.01	0.01	0.01	0.02
	AL 29-4C (S44735)	0.00	0.00	0.01	0.01	0.00	0.01

DMC assemblies consisted of three 4 x 6 inch (102 x 152mm) strip samples in the various combinations. The assemblies were held together by nylon nuts and bolts, tightened with an applied torque of 9.7 inch-lb (1.1N-m). Assemblies were exposed at the Battelle Marine Laboratory at Ponce Inlet, Florida. Filtered seawater flowed continuously over the samples.

mm/y x 39.37 = Mils per year

II. Corrosion Data

H. Hydrochloric (HCl)

a. AL-6XN, pH 0.5 to 1.5

Temperature °C	Temperature (°F)	Corrosion Rate, mm/year pH 0.5	pH 1.0	pH 1.5
65.5	(150)	0.9139	0.0010	0.0009
79.4	(175)	--	0.0009	--
93.3	(200)	--	0.0008	0.0008

mm/y x 39.37 = Mils per year

b. AL-6XN, 2 to 8 weight % HCl

Temperature °C	Temperature (°F)	Conc. Wt. % HCl	Corrosion Rate, mm/year 2	3	4	5	6	8
23	(73)		0.003	0.003	0.003	0.102	0.216	0.270
52	(126)		---	0.553	0.348	1.698	1.935	---

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