# LABORATORY NOTEBOOK

# LABORATORY NOTEBOOK

NOTEBOOK NO. 744

CONTINUED FROM NOTEBOOK NO. 729 CONTINUED TO NOTEBOOK NO.

**ASSIGNED TO:**

NAME Xihua He, Div. 20

SIGNATURE He Xihua DATE 9/13/05

DATE ISSUED BY

PHONE EMAIL

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NOTES: Continuation of Notebook 729
Project #: 20.06002.01.322
Brian K. Deeby - BKD

CNWRA
CONTROLLED
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[LAB-168-4LO-v02-Feb-2004]

NOTEBOOK 744

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# Initial Scientific Notebook Entry for Corrosion of Dissimilar Metal Crevices as a Function of Solution, Torque, Area, and Dissimilar Metals

**Title:** Corrosion of Dissimilar Metal Crevices as a Function of Solution, Torque, Area, and Dissimilar Metals

**Tests Performed by**: Xihua He, Div. 20; Brian Derby, Div. 18

**Objectives:** Determine the corrosion potential, crevice corrosion repassivation potential, and crevice corrosion penetration depths of dissimilar metal crevices as a function of solution, torque, area, and dissimilar metals

**Proposed approach or procedure for achieving the objectives:** Tests are conducted in a glass test cell using a multiple crevice assembly consisting of a number of grooves and plateaus in accordance with ASTM G78. In this assembly, the serrated crevice former machined from base Alloy 22 or Titanium Grade-7 contacts with the crevice specimen to form an artificial crevice with 24 crevice sites. Then immerse the crevice assembly in solution to monitor the corrosion potential and perform cyclic polarization to obtain crevice corrosion repassivation potential (see reference 1 below). Penetration depths are obtained by galvanically coupling the crevice assembly to larger cathodes to initiate localized corrosion. The crevice specimens tested are mill-annealed base Alloy 22, welded + solution annealed Alloy 22, 316L stainless steel, zirconium. By varying the surface area of the crevice former, torque between dissimilar metal contact, and combination of dissimilar metal contacts, the corrosion of dissimilar metal crevices can be studied as a function of torque, area, and dissimilar metals.

**Equipment:** Electrochemical test cell with multiple crevice assembly, Solartron 1287 and 1480 multi-channel potentiostats, temperature controller, thermometer, pH mater, balance, torque screwdriver, caliper, microscope.
Calibration and due dates are provided in data sheet for each test.

**Materials:** Mill-annealed base Alloy 22, welded Alloy 22, 316L stainless steel, titanium Grade-7, zirconium. Material heats to be added prior to testing

**Specimen Specifications:** crevice specimens CNWRA drawing #20.06002.01.322.002 and crevice former CNWRA drawing #20.06002.01.322.006, #20.06002.01.322.008.A, #20.06002.01.322.011

**Measurement Parameters:** Temperature, open circuit potential, potential and current of specimen during polarization, penetration depth per ASTM standard G46.

**Required Level of Accuracy:** Temperature ±2°C, Potentials ±1 mV, Current ±1 microamp.

**Uncertainty and Sources of Error:** Open circuit potential changes with time. Current measurement error can occur for localized corrosion processes because the actively corroding area is not the same as the surface area of the test specimen.

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1. D.S. Dunn, Y.-M. Pan, K. Chiang, L. Yang, G.A. Cragnolino, X. He, "The localized corrosion resistance and mechanical properties of alloy 22 waste package outer containers", *Journal of Metals*, 57 (2005) 49-55.

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**TITLE** **PROJECT**

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** 316L HT#P80746 w/c-22 2277-3-3266 Crevice Washers & Hardware ~~X~~ 1/3 ratio x.H 9/22/05

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing** Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using C22 HT#2277-3-3266 Hardware Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** True Craft **Model# &Torque:** 75 In-lbs **SN:** 69400069l
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 21.66665 **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** ~~21.33507~~ 21.21195g x.H 9/2/05 **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 M NaCl
467.54g NaCl Lot #051510
+ DI water To 2000 mls

Test ID:
316SSBA2202b

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 7.66 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 8.36 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** E98-191
**Cal:** 6/22/05 **Due:** 12/22/05

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 4028031

**Gas:** Oc with Zero Air then 99.999% $N_2$ for E Repassivation
**Ecorr:** −366 mVSCE } in $N_2$ **Model:** Keithley 614 **SN:** 0704936
**Ept:** −78 mVSCE **Cal:** 5/27/05 **Due:** 5/26/06
**Potentiostat:** Solartron 1480 **SN:** 0024005J

**DATA FILE:** 316LBA220CAIR-B4, 316LBA220CN2-B4, Un1Ch4, 316LBA225M-B4, 316LBA22SU-B4, 316LBA SD-B4

**Number of Crevice Corrosion Sites:** 24 /24 (24 max.)

Crevice Corrosion on 24/24 feet of Crevice washers
C-22 Crevice Washers And Bolt/Nut No Corrosion
All Surfaces of Specimen And C-22 Hardware
Have Gold tint Staining

** Drawing # 20.06002.01.322.002

* Note CNWRA Drawing # See pg 1

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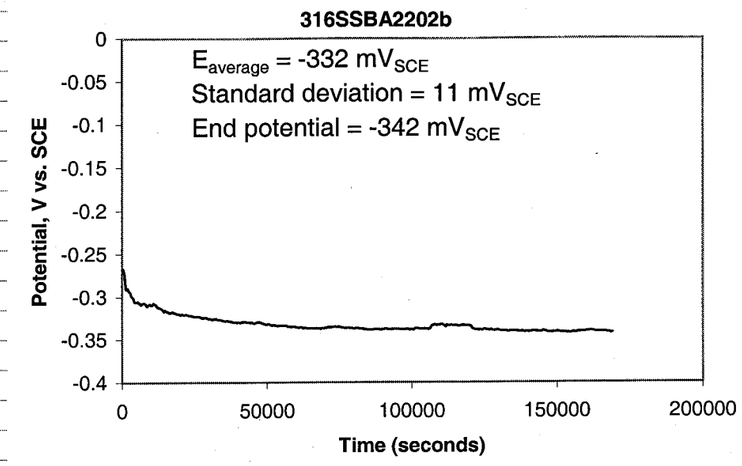


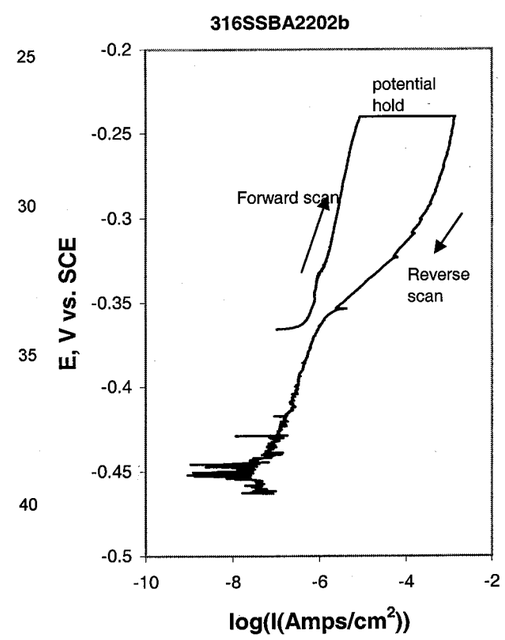


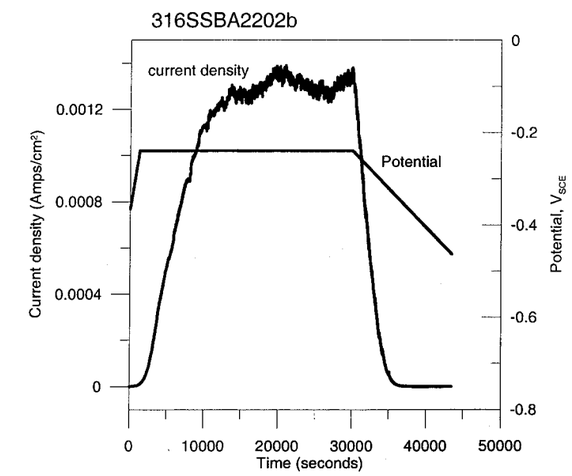


316 Stainless steel (Anode) with Base Alloy 22 (Cathode) crevice
Base Alloy 22 bolt and nut, no Teflon tape wrapped
Anode to cathode area ratio: ~~1/4~~ 1/3, Torque: 75 in-lbs
$N_2$ deaerated, 95 °C, 4 M NaCl solution x.H 9/22/05
Forward scan rate: 0.1 mV/s, Potential hold: -240 $mV_{SCE}$, for 8 hours;
Reverse scan rate: 0.0167 mV/s
Using entire assembly area as surface area for calculating current density
$i < 10^{-5}$ A/cm² at -339 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at -355 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at -363 $mV_{SCE}$
Using crevice specimen area as surface area for calculating current density
$i < 10^{-5}$ A/cm² at -355 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at -384 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at -408 $mV_{SCE}$

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 Base Alloy HT#2277-3-3266 w/Ti 7 HT#CN2775 Crevice Washers And

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing** Hardware * Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen ~~using C22 HT#2277-3-3266 Hardware Torque to~~ 50 in-oz.or 75 in lbs. 10/4/05 DLO

1/3 ratio X.H 9/22/05

**Torque Screwdriver:** Proto 6104 **Model# &Torque:** 50 In-Oz **SN:** 139072
**Cal:** 4/11/05 **Due:** 10/11/05

**Initial Weight:** 23.32869 g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.32518 g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:**

Test ID: BA22Ti702b

4.0 m NaCl
467.58g NaCl Lot #051510
+ DI water to 2000 mls

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 7.86 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 9.48 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065796

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** C96-816
**Cal:** 6/22/05 **Due:** 12/22/05

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 3329075

**Gas:** OC with Zero Air then 99.999% $N_2$ for E Repassivation

**Ecorr:** −76 $mV_{SCE}$ } in $N_2$ **Model:** Keithley 614 **SN:** 0704936
**Ept:** −32 $mV_{SCE}$ } **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN:** 0240053

**DATA FILE:** BA22Ti7-50-Un1Ch5, BA22Ti750N2, BA22Ti750SU-Un1Ch5, BA22Ti750SH-Un1Ch5, BA22Ti750SD-Un1Ch5

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion 0/24 feet of Crevice Washer Ti7 Crevice washers Nut/Bolt No Corrosion Gold tint staining on Specimen - Dull tint staining on Ti7 Hardware

** Drawing # 20.06002.01.322.002.

* Note: CNWRA Drawing # See pg #1

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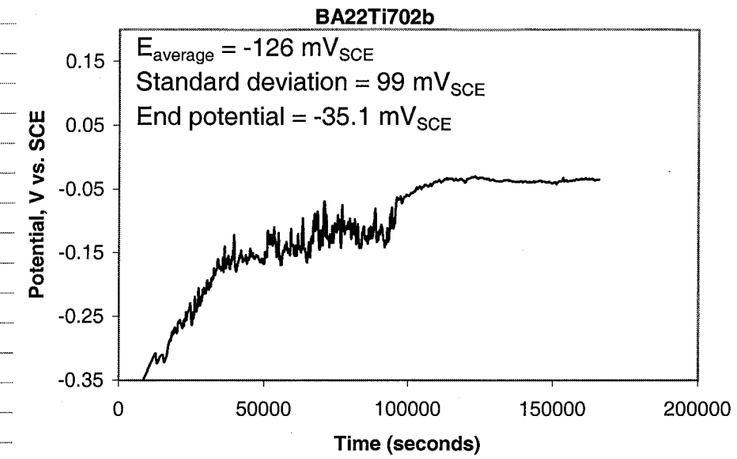


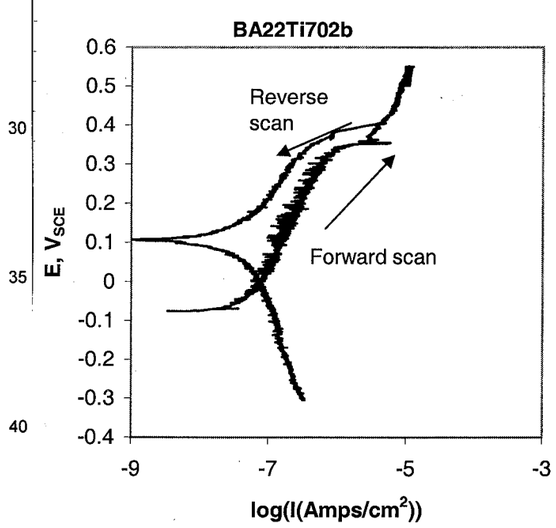


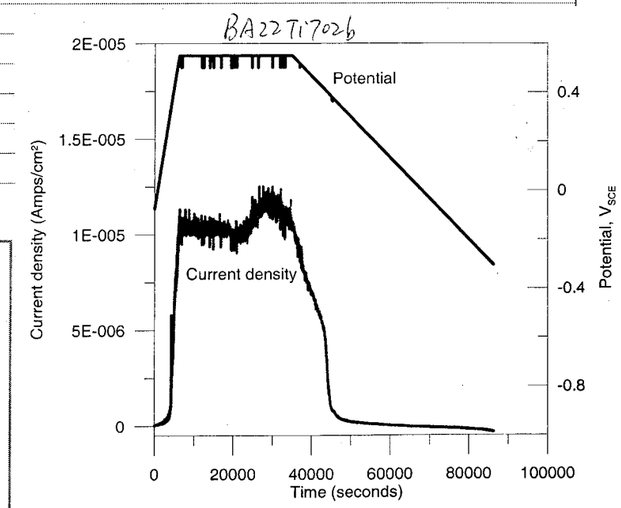


Base Alloy 22 (Anode) to Ti Gr7 crevice, Ti7 bolt and nut
Anode to cathode area ratio: ~~1/1~~ 1/3; Torque: 50 in-oz;
$N_2$ deaerated, 95 °C, 4 M NaCl solution X.H 9/22/05
Forward scan rate: 0.1 mV/s, Potential hold: 550 $mV_{SCE}$ for 8 hours
Reverse scan rate: 0.0167 mV/s
Using entire assembly area for current density calculation:
$i < 10^{-5}$ A/cm² at 539 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 395 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 384 $mV_{SCE}$
Using crevice specimen area for current density calculation:
$i < 10^{-5}$ A/cm² at 397 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 353 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 307 $mV_{SCE}$

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 Base Alloy HT#2277-3-3266 w/Ti 7 HT#CW2775 Crevice washers & Hardware

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing.** Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using ~~C22 HT#2277-3-3266 Hardware Torque to~~ 50 in-oz.or 75 in lbs. 10/4/05 DKJ

X.H 9/22/05

**Torque Screwdriver:** True Craft **Model# &Torque:** 75 In-lbs **SN:** 69400691
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 23.31297g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.30966g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 m NaCl
467.52g NaCl Lot# 051510
+ DI water to 2000 mls

Test ID: BA22Ti703b

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 7.12 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 7.23 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** H 98-179
**Cal:** 5/6/05 **Due:** 5/5/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 925105

**Gas:** ocp w/zero Air then 99.999% $N_2$ for E Repassivation

**Ecorr:** -201 $mV_{SCE}$ in $N_2$ **Model:** Keithley 614 **SN:** 0704936
**Ept:** 126 $mV_{SCE}$ **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN:** 00240053

**DATA FILE:** BA22Ti7-75air_UnlCh6, BA22Ti775N2, BA22Ti775SCL, BA22Ti775SH_UnlCh6, BA22Ti775SD_UnlCh6

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion 0/24 feet of Crevice washers
No Corrosion on Ti 7 Crevice washers or Nuts/Bolts
Gold tint staining on Specimen. Dull tint staining on Ti 7 Hardware

** Drawing # : 20.06002.01.322-002.

* Note: Specimen Repolished for further Testing CNWRA Drawing # see pg #1

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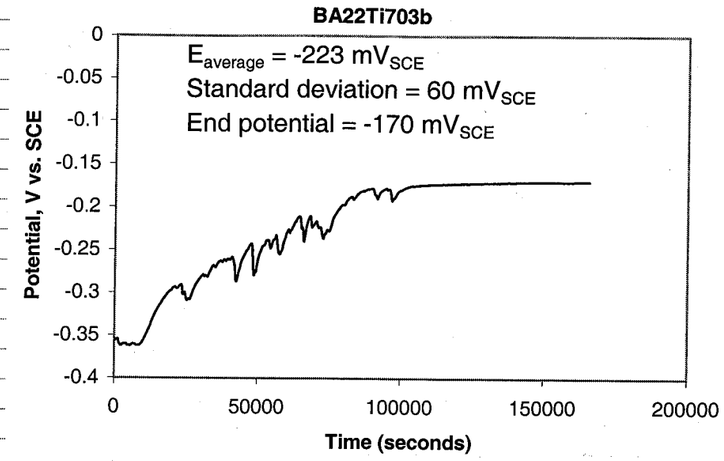


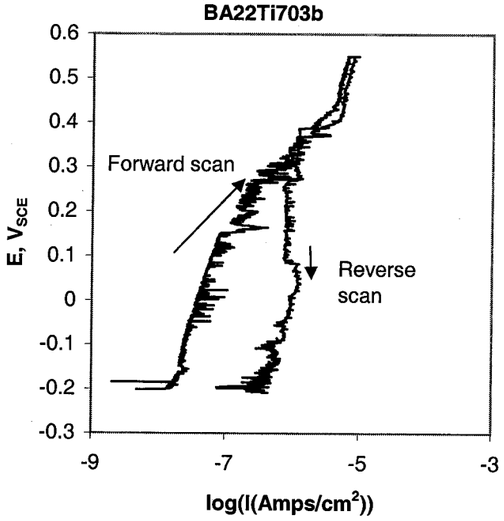


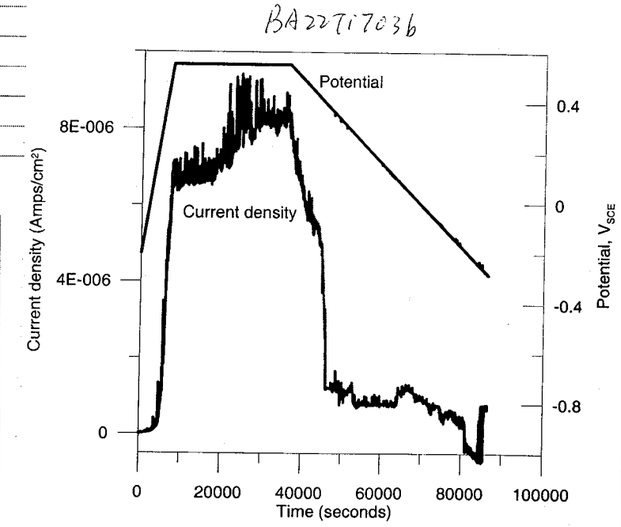


Base Alloy 22 (Anode) to Ti Gr7 crevice, Ti7 bolt and nut
Anode to cathode area ratio: ~~1/4~~ 1/3, Torque: 75 in-lbs;
$N_2$ deaerated, 95 °C, 4 M NaCl solution X.H 9/22/05
Forward scan rate: 0.1 mV/s, Potential hold: 550 $mV_{SCE}$ for 8 hours
Reverse scan rate: 0.0167 mV/s
Using entire assembly area for current density calculation:
$i < 10^{-5}$ A/cm² at 550 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 387 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 327 $mV_{SCE}$
Using crevice specimen area for current density calculation:
$i < 10^{-5}$ A/cm² at 387 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at -180 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at -185 $mV_{SCE}$

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 Base Alloy HT*2277-3-3266 w/ Ti7 HT#CN2775 Cathode Crevice Washers + Hardware 1/18

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing** Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using ~~C22 HT#2277-3-3266 Hardware Torque to~~ 10/4/05 DKS 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** Proto 6104 **Model# &Torque:** 70 In-oz **SN:** 139072
**Cal:** 4/11/05 **Due:** 10/11/05

**Initial Weight:** 23.32697g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.32504 g **Cal:** 5/11/05 **Due:** 11/11/06

**Solution:** 4.0 M NaCl
467.58g NaCl Lot # 051510
+ DI water To 2000 mls

Test ID: BA22Ti704b

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 7.75 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 7.44 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** H98-170
**Cal:** 4/27/05 **Due:** 4/27/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 3329075

**Gas:** OCP with zero Air then 99.995% $N_2$ for E Repassivation

**Ecorr:** −168 $mV_{SCE}$ } in $N_2$ **Model:** Keithley 614 **SN:** 0704936
**Ept:** +95 $mV_{SCE}$ **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN:** 0624005 3

**DATA FILE:** BA22Ti7-70air, BA22Ti7-70SD, BA22Ti7-70SH, BA22Ti7-70SH, BA22Ti7-70CN2-Un1Ch7

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion 0/24 feet of Crevice Washer
Ti7 Cathode with Crevice washers Nut/Bolt No Corrosion
Blue/gold tint staining on Specimen - Dull tint
Staining on Ti7 Hardware with Bolt And Nut

** Drawing # 20.06002.01.322.002.

*Note: CNWRA Drawing # See pg #1 - Specimen Repolished for further Testing

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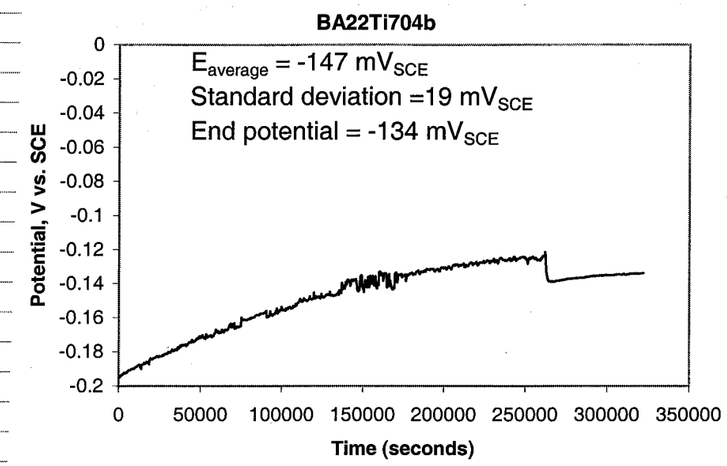


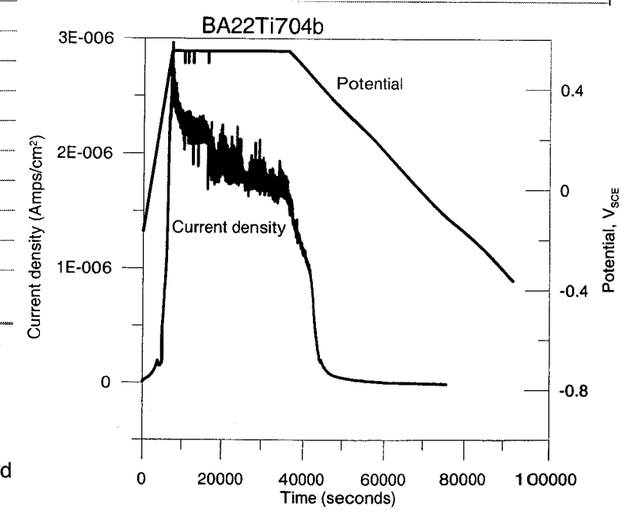


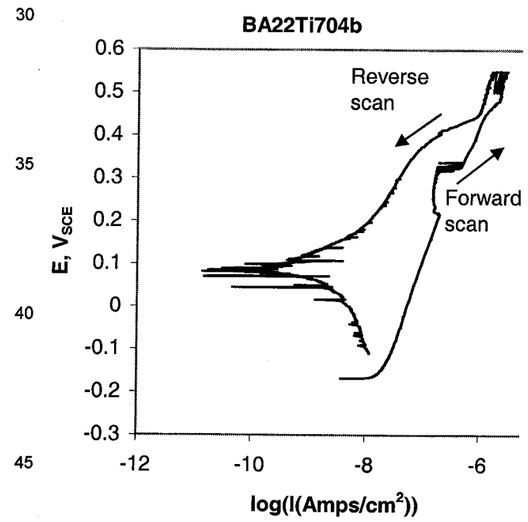


Base Alloy 22 (Anode) to Ti Gr7 crevice, Ti7 bolt and nut
Anode to cathode area ratio: ~1/18; Torque: 70 in-oz;
$N_2$ deaerated, 95 °C, 4 M NaCl solution
Forward scan rate: 0.1 mV/s, Potential hold: 550 $mV_{SCE}$ for 8 hours
Reverse scan rate: 0.0167 mV/s
Using entire assembly area for current density calculation:
$i < 10^{-5}$ A/cm² at 550 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 550 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 459 $mV_{SCE}$
Using crevice specimen area for current density calculation:
$i < 10^{-5}$ A/cm² at 433 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 379 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 334 $mV_{SCE}$

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 Base Alloy HT#2277-3-3266 w/Ti 7 HT# CN2775 Cathode Crevice Washer And Hardware 1/8

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing ** Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using ~~C22 HT#2277-3-3266 Hardware T Torque to~~ 10/4/05 JW 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** True Craft **Model# &Torque:** 75 In-lbs **Cal:** 7/22/05 **SN:** 694000691 **Due:** 7/21/06

**Initial Weight:** 23.50662g **Final Weight:** 23.50991g **Model:** Sartorius Genius **Cal:** 5/11/05 **SN:** 1280 9099 **Due:** 11/11/05

**Solution:** 4.0 m NaCl
467.54g NaCl Lot #051510
+ DI water to 2000mls

Test ID: BA22Ti701b

**Reagents measured with** **Model:** OHAUS **Cal:** 7/12/05 **SN:** 2883 **Due:** 1/12/06

**Initial pH:** 5.92 **Final pH:** 7.46 **Model:** Orion EA 940 **Cal:** 7/25/05 **pH Probe:** #13-620-296 **SN:** 2330 **Due:** 7/25/06 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **Cal:** 7/11/05 **SN:** 183303 **Due:** 1/11/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 0251439

Gas: OCP with Zero Air then 99.999% $N_2$ for E Repassivation

Ecorr: -244 mV$_{SCE}$ in $N_2$ **Model:** Keithley 614 **SN:** 0704936
Ept: 131 mV$_{SCE}$ **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN:** 00240053

**DATA FILE:** BA22Ti7-75air_UnlCh8, BA22Ti7_75N2_UnlCh8, BA22Ti7-75SU, BA22Ti7-75SH, BA22Ti7-75SD

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion 0/24 feet of Crevice Washer
Ti 7 Cathode with Crevice Washers Nut/Bolt No Corrosion
Gold tint staining on All Surfaces of Specimen
Ti 7 cathode Nut/Bolt Have Dull Staining on All Surfaces

** Drawing # 20.06002.01.322.002

* Note: CNWRA Drawing # See Pg #1

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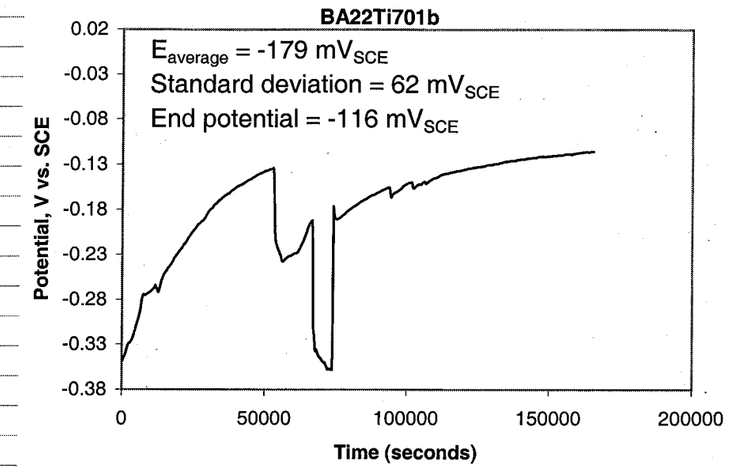


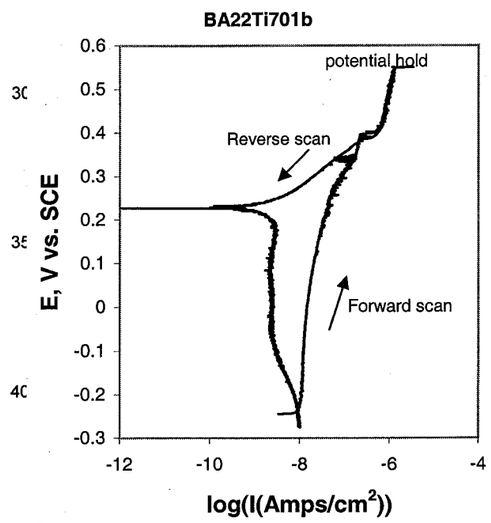


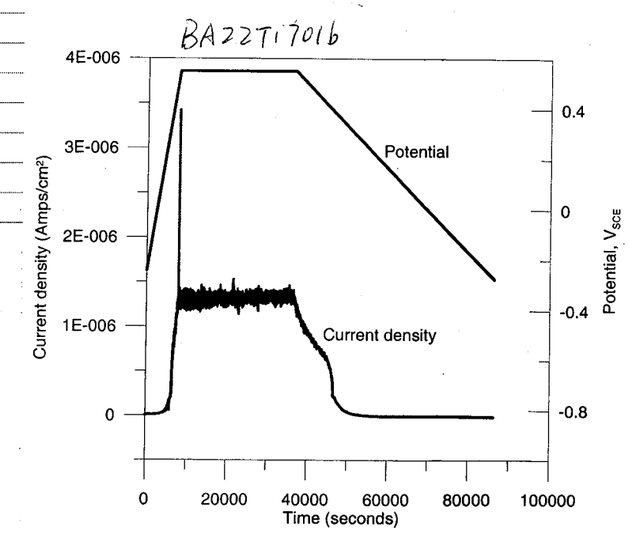


Base Alloy 22 (Anode) to Ti Gr7 crevice, Ti7 bolt and nut
Anode to cathode area ratio: ~~1/10~~ 1/8; Torque: 75 in-lbs;
$N_2$ deaerated, 95 °C, 4 M NaCl solution KH 9/22/05
Forward scan rate: 0.1 mV/s, Potential hold: 550 mV$_{SCE}$ for 5 hours
Reverse scan rate: 0.0167 mV/s
Using entire assembly area for current density calculation:
$i < 10^{-5}$ A/cm² at 550 mV$_{SCE}$; $i < 2*10^{-6}$ A/cm² at 550 mV$_{SCE}$;
$i < 10^{-6}$ A/cm² at 513 mV$_{SCE}$
Using crevice specimen area for current density calculation:
$i < 10^{-5}$ A/cm² at 397 mV$_{SCE}$; $i < 2*10^{-6}$ A/cm² at 356 mV$_{SCE}$;
$i < 10^{-6}$ A/cm² at 334 mV$_{SCE}$

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PROPRIETARY INFORMATION

**TITLE** **PROJECT**

Continued F

POTENTIAL SCAN AND HOLD

X.H 9/23/05

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 HT#2277-3-3292 WA813 w/ C-22 HT#2277-3-3266 1/3
Welded Solution Annealed See pg #58 HT#729 Crevice Washers And Hardware

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing** Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using C22 HT#2277-3-3266 Hardware Torgue to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** Proto 6104 **Model# &Torque:** 50 In-oz **SN:** 139072
**Cal:** 4/11/05 **Due:** 10/11/05

**Initial Weight:** 23.37495g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.37308g **Cal:** 5/11/05 **Due:** 11/11/06

**Solution:** 4 m NaCl
467.52g NaCl Lot#051510
+ DI To 2000 ml

Test ID:
WA22SABA2201C

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 8.49 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 7.45 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4063796

**Test Temperature:** 95°c **Measured with Hg Thermometer** **SN:** C96-377
**Cal:** 7/11/05 **Due:** 1/11/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 3300328

**Gas:** OCP with Zero Air then 99.999% $N_2$ for E Repassivation

**Ecorr:** −162 mV$_{SCE}$ **Model:** Keithley 614 **SN:** 0704936
**Ept:** 25 mV$_{SCE}$ **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron **SN:** 0023826J

**DATA FILE:** WA22SABA2211air-UnlCkl, WA22SABA2211bair-UnlCkl, WA22SABA2211N2, WA22SABA2211SD, WA22SABA2211SU, WA22SABA2211SH

**Number of Crevice Corrosion Sites:** 0 /24 (24 max.)

No Crevice Corrosion 0/24 feet of Crevice Washer
C-22 Crevice Washers Nut/Bolt show No sign of Corrosion
Gold tint staining on All Surfaces of Specimen
And C-22 Crevice washers And Hardware

** Drawing # 20.06002.01.322.002

* Specimen Repolished for further Testing - CNWRA Drawing # Scope!

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**TITLE** **PROJECT**

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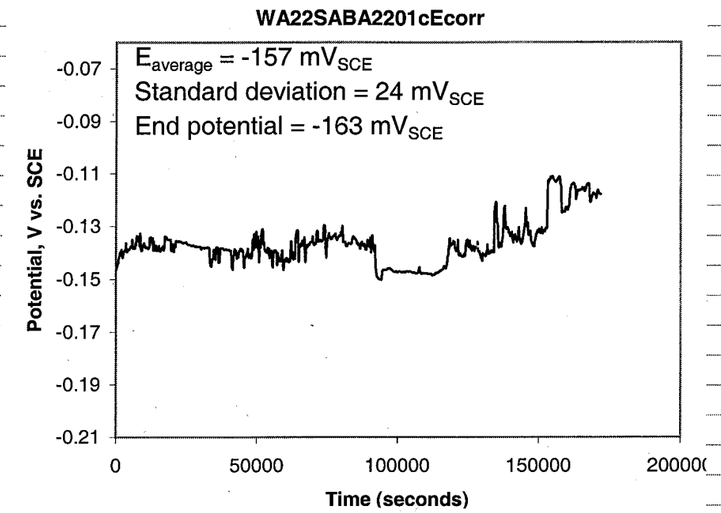


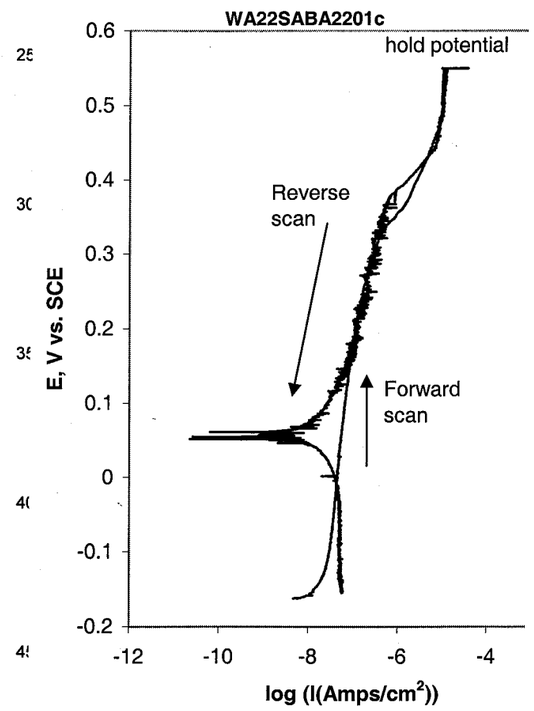


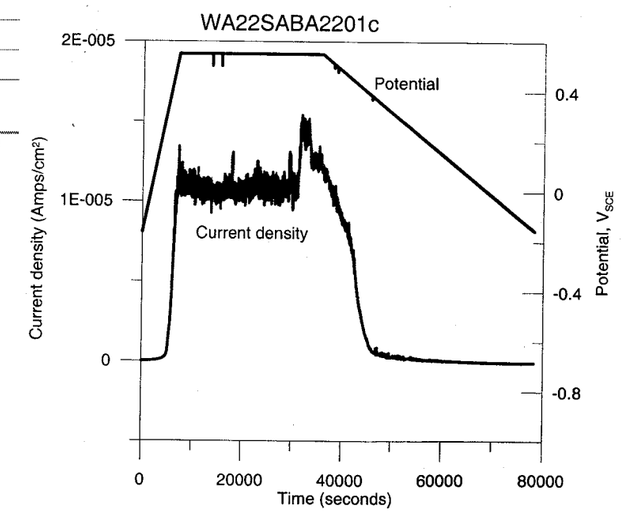


Welded + solution annealed Alloy 22 (Anode)
with Base Alloy 22 (Cathode) crevice
Base Alloy 22 bolt and nut 1/3 X.H 9/23/05
Anode to cathode area ratio: ~~1/1~~; Torque: 50 in-oz;
$N_2$ deaerated, 95 °C, 4 M NaCl solution
Forward scan rate: 0.1 mV/s; Potential hold: 550 mV$_{SCE}$ for 8 hours;
Reverse scan rate: 0.0167 mV/s
Using entire assembly area as surface area for current density,
$i < 10^{-5}$ A/cm² at 507 mV$_{SCE}$; $i < 2*10^{-6}$ A/cm² at 406 mV$_{SCE}$;
$i < 10^{-6}$ A/cm² at 390 mV$_{SCE}$
Using crevice specimen area as surface area for current density,
$i < 10^{-5}$ A/cm² at 411 mV$_{SCE}$; $i < 2*10^{-6}$ A/cm² at 360 mV$_{SCE}$;
$i < 10^{-6}$ A/cm² at 297 mV$_{SCE}$

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TITLE PROJECT

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POTENTIAL SCAN AND HOLD

x.rl 9/23/05

**Objective:** See page 1.

**Alloy / Heat No.:** C22 HT#2277-3-3292 wn813 W/C-22 HT#2277-3-3266 1/10 Welded Solution Annealed See pg #58 WB#729 Crevice Cathode w/ washers & Hardware

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing** Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using C22 HT#2277-3-3266 Hardware Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** Proto 6104 **Model# &Torque:** 50 In-Oz **SN:** 139072
**Cal:** 4/11/05 **Due:** 10/11/05

**Initial Weight:** 23.51561g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.50831g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4 M NaCl
467.52 g NaCl Lot #051510
+ DI Water To 2000 mls

Test ID:
WA22SABA2202C

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 7.34 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 7.42 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065176

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** 115858
**Cal:** 4/27/05 **Due:** 4/27/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 4028037

Gas: OCP with Zero Air then 99.999% $N_2$ for E Repassivation
Ecorr: −26 mV$_{SCE}$ **Model:** Keithley 614 **SN:** 0704936
Ept: 121 mV$_{SCE}$ **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN:** 00238265

**DATA FILE:** WA22SABA2215air-Unich2, WA22SABA2215bair-Unich2, WA22SABA2215N2, WA22SABA2215SU, WA22SABA2215SH, WA22SABA2215SD

**Number of Crevice Corrosion Sites:** 0 /24 (24 max.)

No Crevice Corrosion 0/24 feet of Crevice Washers
C-22 Crevice Cathode with Crevice Washers
Nut And Bolt have No Corrosion. Gold tint staining
on All Surfaces of Specimen light gold tint staining
on C-22 1/5 Cathode with Hardware

** Drawing # 20.06002.01.722.002

* Note: Specimen Repolished for further Testing - CNWRA Drawing # See pg 1

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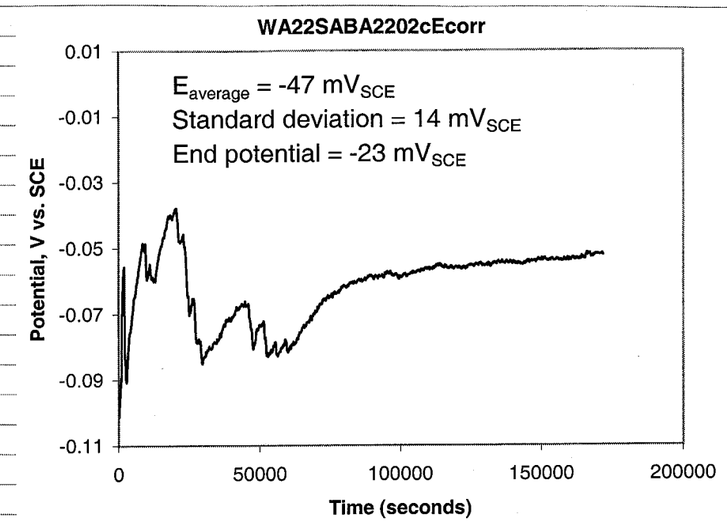


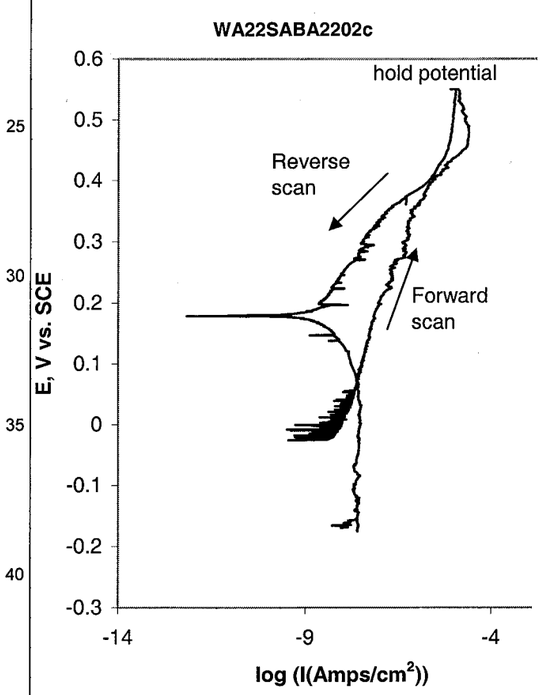


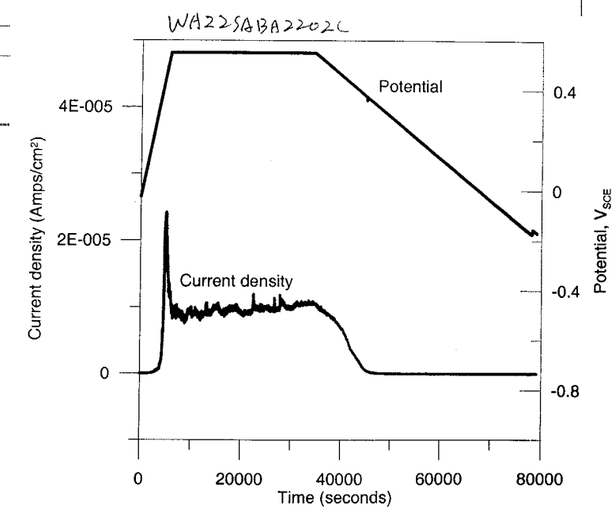


Welded + solution annealed Alloy 22 (Anode)
with Base Alloy 22 (Cathode) crevice
Base Alloy 22 bolt and nut 1/10 x.rl 9/23/05
Anode to cathode area ratio: ~1/5; Torque: 50 in-oz;
$N_2$ deaerated, 95 °C, 4 M NaCl solution
Forward scan rate: 0.1 mV/s; Potential hold: 550 mV$_{SCE}$ for 8 hours;
Reverse scan rate: 0.0167 mV/s
Using entire assembly area as surface area for current density,
$i < 10^{-5}$ A/cm² at 535 mV$_{SCE}$; $i < 2*10^{-6}$ A/cm² at 400 mV$_{SCE}$;
$i < 10^{-6}$ A/cm² at 385 mV$_{SCE}$
Using crevice specimen area as surface area for current density,
$i < 10^{-5}$ A/cm² at 385 mV$_{SCE}$; $i < 2*10^{-6}$ A/cm² at 354 mV$_{SCE}$;
$i < 10^{-6}$ A/cm² at 336 mV$_{SCE}$

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 HT#2277-3-3292 WN813 w/C-22 HT#2277-3-3266 X.H 9/27/05
welded Solution Annealed Sec Pg#58 NB#729 Crevice washers with Hardware

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing** 1/3 area ratio
Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using C22 HT#2277-3-3266 Hardware Torgue to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** True Craft **Model# &Torque:** 75 In.-lbs **SN:** 694000691
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 22.3791 g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 22.3758 g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 M NaCl
467.53 g NaCl lot #051510
+ DI To 2000 mls

Test ID: WA22SABA2204C

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/2/06

**Initial pH:** 5.16 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 5.84 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** 06-387
**Cal:** 7/11/05 **Due:** 1/11/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 0199568

Gas: OCP with zero Air then 99.999% $N_2$ for E Repassivation

Ecorr: -191 mV$_{SCE}$ in $N_2$ **Model:** Keithley 614 **SN:** 0704936
Ept: -25 mV$_{SCE}$ **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN:** 0024 00053

**DATA FILE:** WASA22BA22BOCATRb_Bicor_Un1Ch2, WASA22BA22OCUNZb_Bl_
WASA22BA22SUb_Bl_Un1Ch2, WASA22BA22SHb_Bl_Un1Ch2,

**Number of Crevice Corrosion Sites:** 0/24 (24 max.) WASA22BA22b_Bl_Un1Ch2

No Crevice Corrosion 0/24 fact of Crevice Washers
No Corrosion on C-22 Crevice Washers Nut/Bolt
gold tint staining on All Surfaces of Specimen
And Crevice Washers And Hardware

** Drawing # 20.06002.01.322.002.

*Note: CNWRA Drawing # See pg #1

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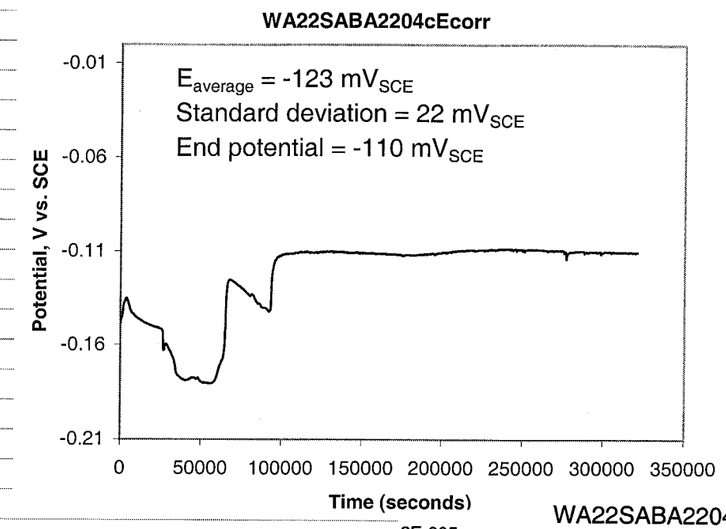


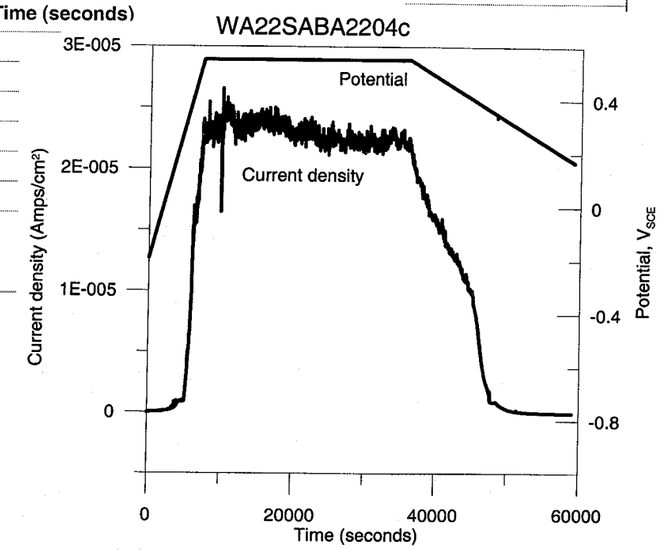


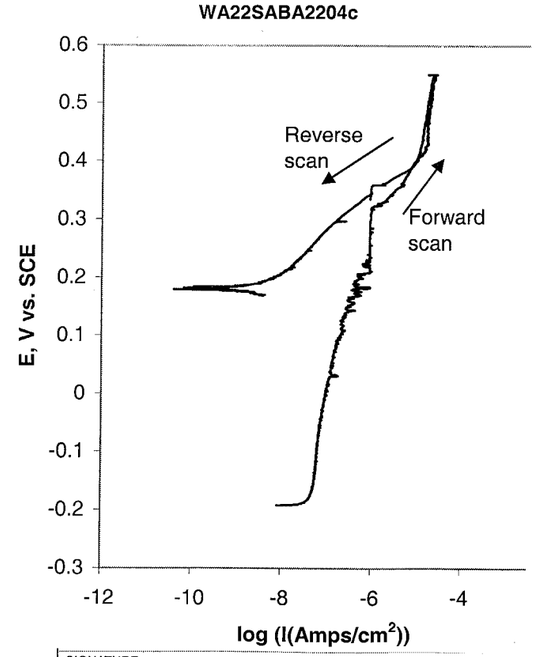


Welded + solution annealed Alloy 22 (Anode)
with Base Alloy 22 (Cathode) crevice
Base Alloy 22 bolt and nut
Anode to cathode area ratio: ~1/3; Torque: 75 in-lbs;
$N_2$ deaerated, 95 °C, 4 M NaCl solution
Forward scan rate: 0.1 mV/s; Potential hold: 550 mV$_{SCE}$ for 8 hours;
Reverse scan rate: 0.0167 mV/s
Using entire assembly area as surface area for current density,
$i < 10^{-5}$ A/cm² at 405 mV$_{SCE}$; $i < 2*10^{-6}$ A/cm² at 363 mV$_{SCE}$;
$i < 10^{-6}$ A/cm² at 358 mV$_{SCE}$
Using crevice specimen area as surface area for current density,
$i < 10^{-5}$ A/cm² at 367 mV$_{SCE}$; $i < 2*10^{-6}$ A/cm² at 327 mV$_{SCE}$;
$i < 10^{-6}$ A/cm² at 309 mV$_{SCE}$

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TITLE PROJECT

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** 316 L HT# P80746 w/C-22 2277-3-3266 Crevice washers And ** Hardware 1/3

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using C22 HT#2277-3-3266 Hardware Torgue to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** Proto 6104 **Model# &Torque:** 50 In-Oz **SN:** 139072
**Cal:** 4/11/05 **Due:** 10/11/05

**Initial Weight:** 21.67109g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 21.67076g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 0.5 m NaCl
58.44g NaCl 051510 Lot#
+ DI To 2000mls

Test ID:
316SSBA22HOLD

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 6.17 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 7.24 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196.

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** E98-191
**Cal:** 6/22/05 **Due:** 12/22/05

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 4028031

**Gas:** $N_2$ 99.999%

**Ecorr:** -440mV SCE **Model:** Keithley 614 **SN:** 0704936
**Ept:** -53mV SCE **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN:** 00240053

**DATA FILE:** 316LBA22SHErp-Un1Ch2, 316LBA22SHErp-Un1Ch2, 316LBA22Erp-Un1Ch2

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion on Specimen 316L - C-22 Crevice washers And Nut/Bolt No Corrosion - M/D Surface staining on Specimen - Also M/D staining on Crevice Hardware

** Drawing # 20.06002.01.322.002.

* Note: CNWRA Drawing # See pg 1

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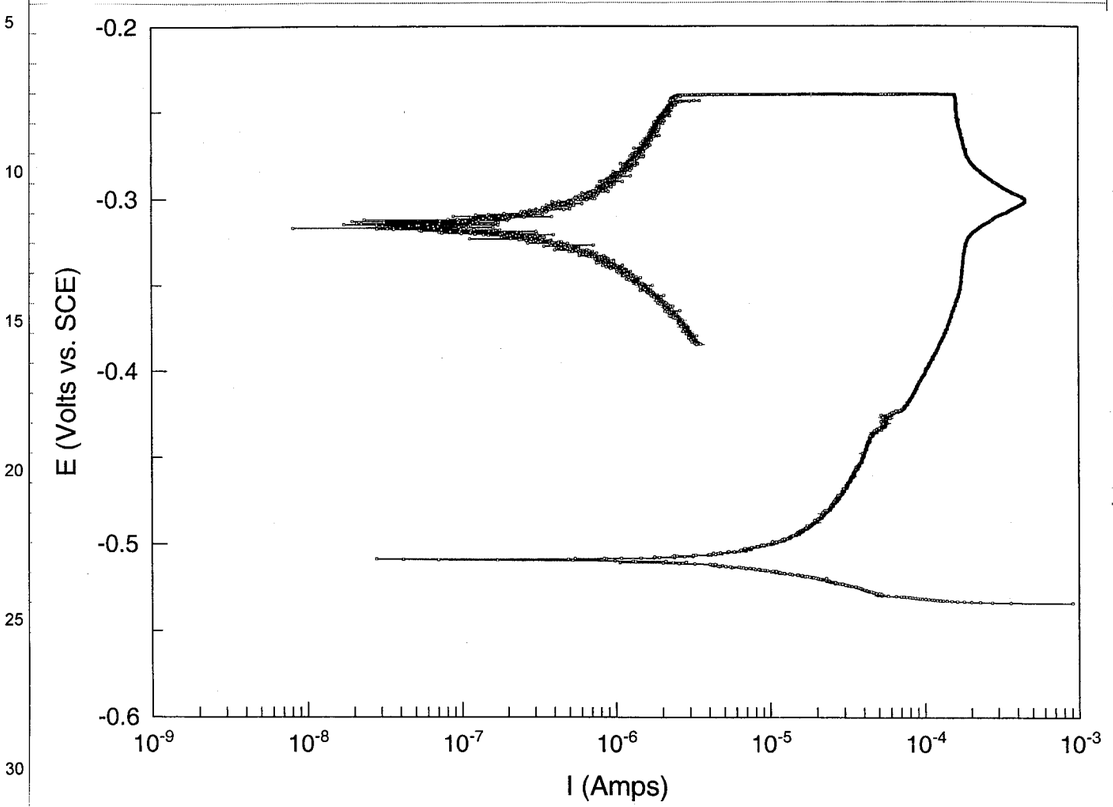


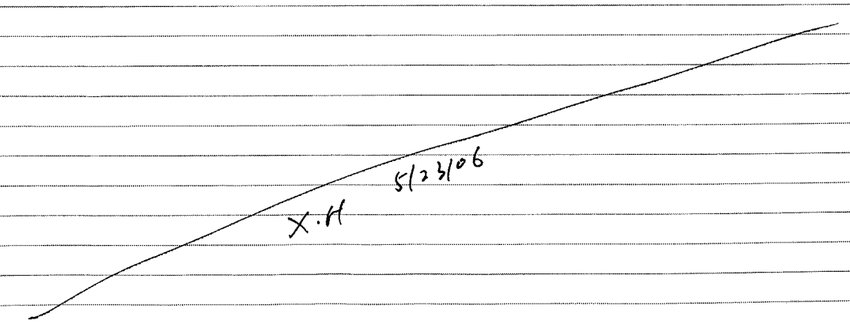


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TITLE PROJECT

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 HT# 2277-3-3292 WA 813 w/Ti 7 HT# CW2775 Crevice washers Solution Annealed Scepp #58 #229 Washer Aro Hardware 1/5

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing** #20.06002.01.322.002. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using hardware. Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** True Craft **Model# &Torque:** 75 In-lbs **SN:** 694000691
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 23.34445g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.34420g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 m NaCl
467.52g NaCl Lot#051510
+ DI water To 2000mls

Test ID:
WA22SATi701C

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 5.59 **Model:** Orion, EA 940 **SN:** 2330
**Final pH:** 5.43 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** E98-191
**Cal:** 6/22/05 **Due:** 12/22/05

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 4028031

**Gas:** ocp with Zero Air then 99.999% $N_2$ for E Repassivation

**Ecorr:** -105 mV/SCE **Model:** Keithley 614 **SN:** 0704936
**Ept:** -85.4 mV/SCE **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN:** 0240053

**DATA FILE:** WA22SATi701C/WA22SATi7airocp_Un1Ch2, WA22SATi7N2OC_Un1Ch2, WA22SATi7SH_Un1Ch2, WA22SATi7SD_Un1Ch2, WA22

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion on Specimen 0/24 feet of Crevice washer. No Corrosion on Ti 7 Crevice washers Aro Hardware. Very M/o Surface Staining on C-22 Specimen Aro Ti 7 Crevice washers Aro Hardware

* Note: Specimen Repolished for Further Testing. CNWRA Drawing # see pg 1

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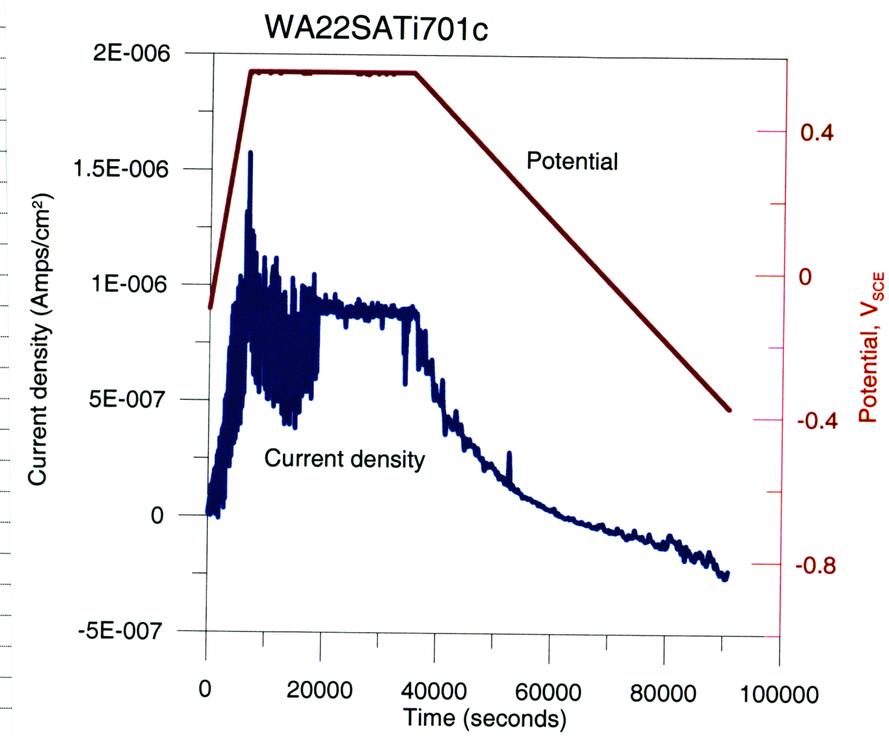


X.R 5/23/06

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 Base Alloy HT#2277-3-3266 w/C-22 2277-3-3266 Crevice Washers Ano Hardware 1/3

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing #20.06002.01.322.002. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using hardware. Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** True Craft **Model# &Torque:** 75 In-lbs **SN:** 694000691
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 23.35397g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.35286g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 m NaCl
467.52g NaCl Lot #051510
+ DI water To 2000 mls

Test ID: BA22BA2202C

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 5.82 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 5.78 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** C96-816
**Cal:** 6/22/05 **Due:** 12/22/05

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 3329075

**Gas:** OCP with Zero Air then 99.999% $N_2$ for E Repassivation

**Ecorr:** −151 $mV_{SCE}$ **Model:** Keithley 614 **SN:** 0704936
**Ept:** 271 $mV_{SCE}$ **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN:** 00240053

**DATA FILE:** BA22BA2202C/BA22BA2202CAZR-UnICh4, BA22BA2202CN2-UnICh4, BA22BA2205U, BA22BA2205H, BA22BA2205D-UnICh4

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion on Specimen 0/24 feet of Crevice washers. C-22 Crevice washers Ano Hardware No Sign of Corrosion. Gold tint Surface Staining on Specimen All Surfaces. Mild Gold tint Staining on C-22 Crevice washers Ano Hardware

* Note: Repolished Specimen for further Testing

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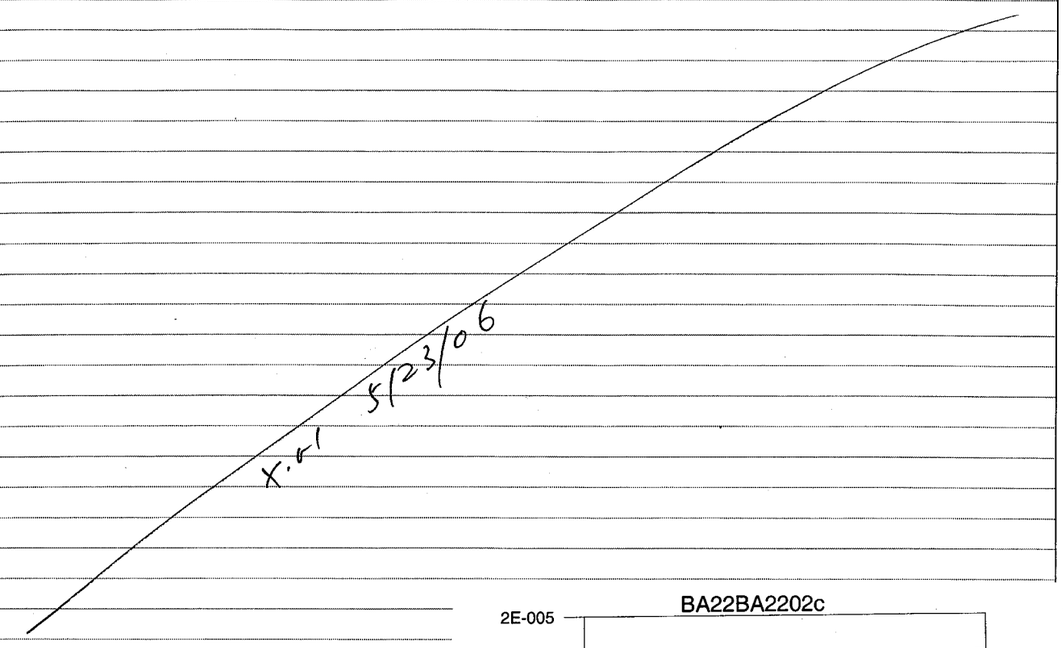


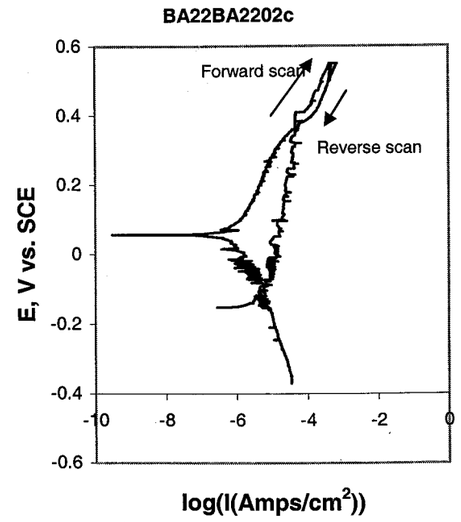


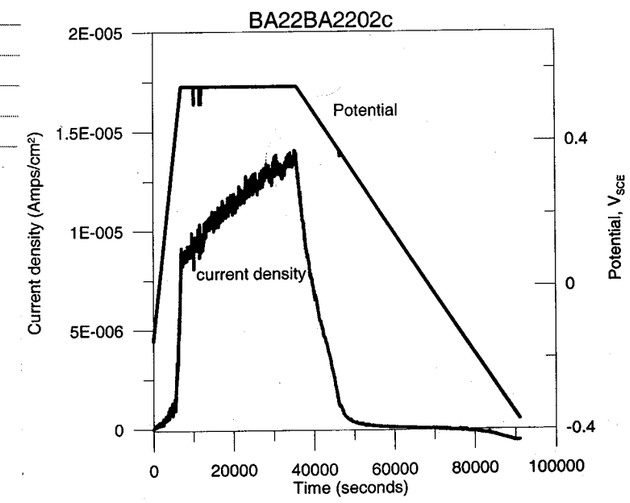


Base Alloy 22 (Anode) with Base Alloy 22 (Cathode) crevice
Base Alloy 22 bolt and nut, no Teflon tape wrapped
Anode to cathode area ratio: ~1/4 Torque: 75 in-lbs,
$N_2$ deaerated, 95 °C, 4 M NaCl solution X.H 10/5/05
Forward scan rate: 0.1 mV/s, Potential hold: 550 $mV_{SCE}$, for 8 hours;
Reverse scan rate: 0.0167 mV/s
Using crevice assembly area for calculating current density:
$i < 10^{-5}$ A/cm² at 520 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 389 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 366 $mV_{SCE}$
Using crevice specimen area for calculating current density:
$i < 10^{-5}$ A/cm² at 393 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 338 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 295 $mV_{SCE}$

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 Base Alloy HT#2277-3-3266 w/Ti7 HT#CN2775 Crevice Washers + Hardware 1/3

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing #20.06002.01.322.002. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using hardware. Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** True Craft **Model# &Torque:** 75 In-lbs **SN:** 694000691
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 23.20436g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.19979g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 m NaCl
467.52g NaCl Lot# 051510
+ DI water 2000mls

Test ID: BA22Ti703C

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 6.24 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 6.95 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** H98-179
**Cal:** 5/6/05 **Due:** 5/5/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 925105

**Gas:** DCP w/zero Air then 99.999% $N_2$ for E Repassivation
**Ecorr:** −257.8 $mV_{SCE}$ **Model:** Keithley 614 **SN:** 6704936
**Ept:** −383 $mV_{SCE}$ **Cal:** 5/27/05 **Due:** 5/26/06
**Potentiostat:** Solartron 1480 **SN:** 00240053

**DATA FILE:** BA22Ti7SUB6-Un1Ch6, BA22Ti7SHB6-Un1Ch6, BA22Ti7SDB6-Un1Ch6

**Number of Crevice Corrosion Sites:** 0 /24 (24 max.)

No Crevice Corrosion on Specimen 0/24 feet of Crevice Washer - Ti7 Crevice Washers and Hardware No Corrosion - Gold tint Surface staining on C-22 Specimen - Dull tint staining on Ti7 Hardware

* Specimen Repolished for further Testing

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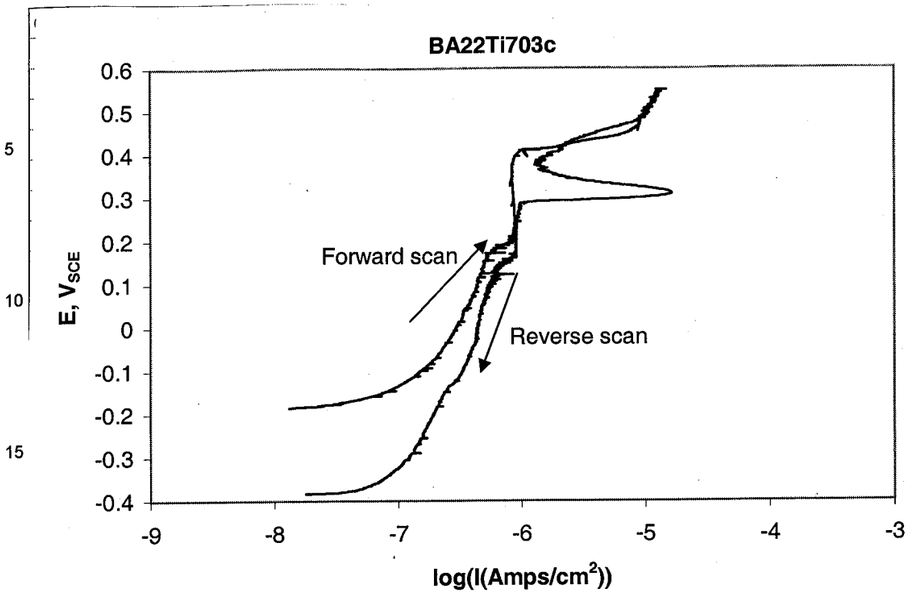


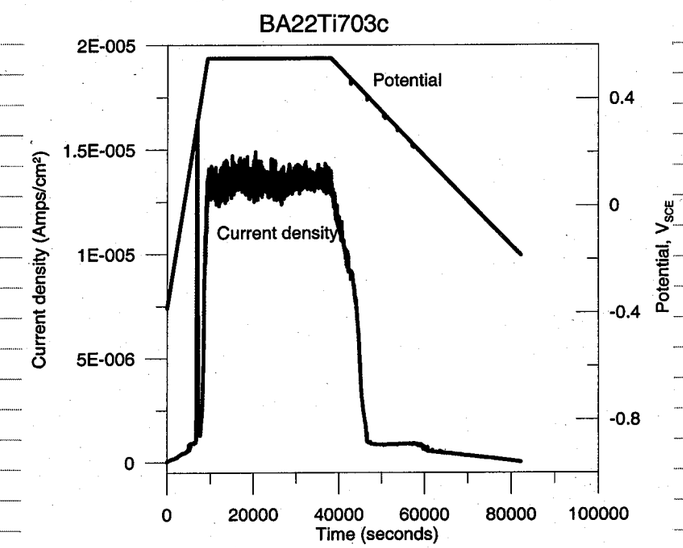


Base Alloy 22 (Anode) to Ti Gr7 crevice, Ti7 bolt and nut
Anode to cathode area ratio: ~1/3; Torque: 75 in-lbs;
$N_2$ deaerated, 95 °C, 4 M NaCl solution
Forward scan rate: 0.1 mV/s, Potential hold: 550 $mV_{SCE}$ for 8 hours
Reverse scan rate: 0.0167 mV/s
Using entire assembly area for current density calculation:
$i < 10^{-5}$ A/cm² at 495 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 418 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 410 $mV_{SCE}$
Using crevice specimen area for current density calculation:
$i < 10^{-5}$ A/cm² at 421 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 116 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at -50.6 $mV_{SCE}$

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 Base Alloy HT*2277-3-3266 w/Ti 7 HT*CW2775 Crevice washers & Hardware 1/3

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing #20.06002.01.322.002. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using hardware. Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** Proto **Model# &Torque:** 50 In-Oz. **SN:** 139072
**Cal:** 4/11/05 **Due:** 10/11/05

**Initial Weight:** 23.11883 g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.11648 g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 m NaCl
467.52g NaCl Lot #051510
+ DI water to 2000 mls

Test ID: BA22Ti702C

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 6.15 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 4.93 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°c **Measured with Hg Thermometer** **SN:** H98-170
**Cal:** 4/27/05 **Due:** 4/27/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 0251439

**Gas:** OCP w/zero Air then 99.999% $N_2$ E Repassivation

**Ecorr:** −265 $mV_{SCE}$ **Model:** Keithley 614 **SN:** 0704936
**Ept:** 303 $mV_{SCE}$ **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN:** 00240053

**DATA FILE:** BA22Ti702C — BA22Ti750CAIR-Un1Ch8, BA22Ti750CN2B8_Un1Ch8
BA22Ti750SUB8_Un1Ch8, BA22Ti750SH88-Un1Ch8, BA22Ti750DB8_Un1Ch8

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion 0/24 feet of Crevice washers
No Corrosion on Ti 7 Crevice Washers or Hardware
Very Mild Surface staining on C-22 Hardware
Slight Pull tint staining on Ti 7 Crevice washers And Hardware

* Note: Specimen Repolished for further Testing

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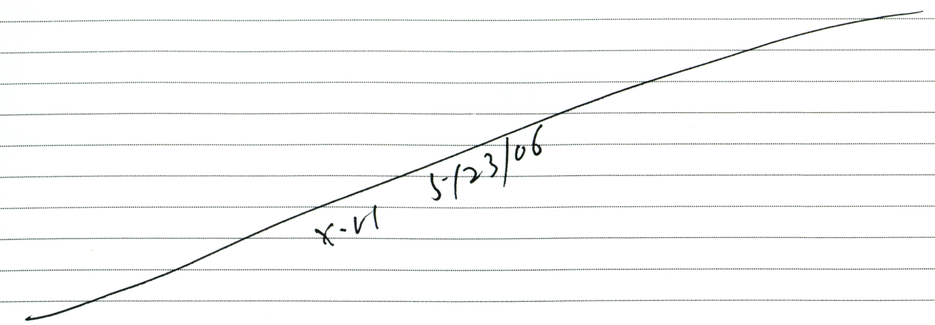


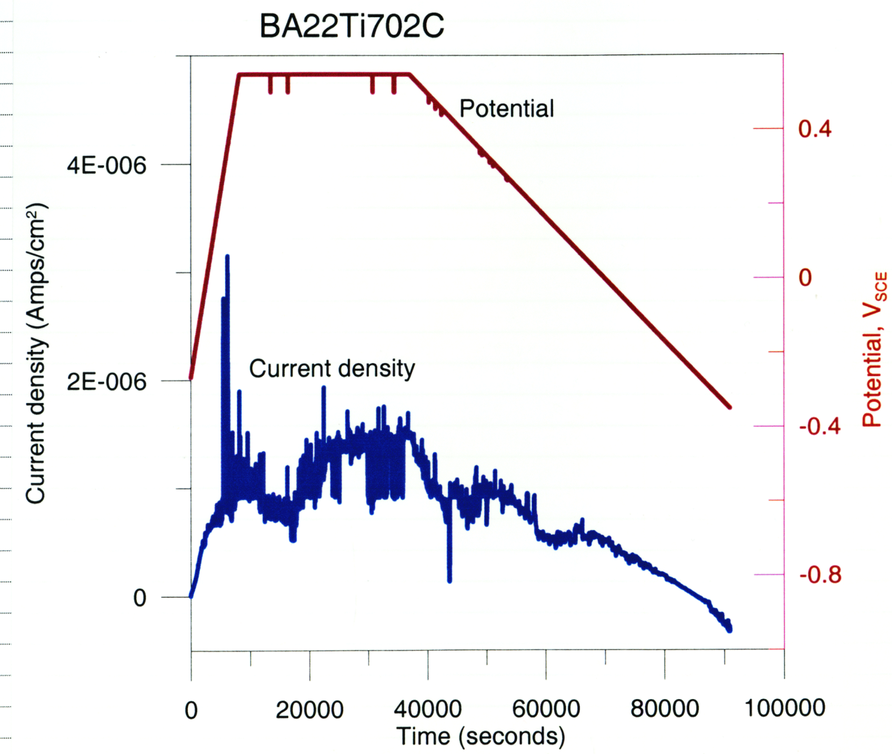


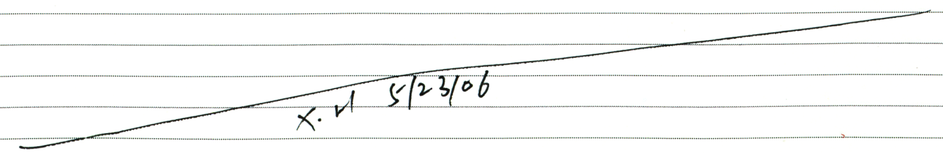


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## Test Matrix for Penetration Depth in Zero-air aerated 5 M NaCl solution at 95 °C

| Test number | Crevice assembly | | | | Coupling large plate | Torque |
|---|---|---|---|---|---|---|
| | Crevice specimen | Washer | Area ratio | Bolt and nut | | |
| 1 | Alloy 22 | Ti Gr.7 | 1/3 | Ti Gr.7 | Ti Gr.7 | 75 in-lbs |
| 2 | Alloy 22 | Teflon | _ | C276 | Ti Gr.7 | 100 in-oz |
| 3 | Alloy 22 | Ceramic washer wrapped with Teflon tape | _ | C276 | Ti Gr.7 | 75 in-lbs |
| 4 | WA22+SA | Alloy 22 | 1/3 | Alloy 22 | Alloy 22 | 75 in-lbs |
| 5 | WA22+SA | Teflon | - | C276 | Alloy 22 | 100 in-oz |
| 6 | WA22+SA | Ceramic washer wrapped with Teflon tape | - | C276 | Alloy 22 | 75 in-lbs |
| 7 | WA22+SA | Ti Gr.7 | 1/3 | Ti Gr.7 | Ti Gr.7 | 75 in-lbs |
| 8 | WA22+SA | Ceramic washer wrapped with Teflon tape | – | C276 | Ti Gr.7 | 75 in-lbs |
| 9 | 316L SS | Alloy 22 | 1/3 | Alloy 22 | Alloy 22 | 75 in-lbs |
| 10 | 316L SS | Ceramic washer wrapped with Teflon tape | - | C276 | Alloy 22 | 75 in-lbs |

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X.H 5/23/06

Procedures for removing oxides on titanium Grade-7 washers, bolts, and nuts per ASTM B600-91 Section 4.2.4:

1. Solution preparation:

300 mL D.I. water + 75 mL nitric acid (70%) Lot # 023958 + 10 mL hydrofluoric acid (50 %) Lot # 519070 + D.I. water to 500 mL total

2. Leave solution cool down to room temperature
3. Immerse titanium Grade-7 parts separately for 13 seconds
4. Rinse in hot D.I water (>70°C)
5. Further rinse in D.I. water

X.H 5/23/06

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Galvanic Corrosion Test

**Objective:** SEE PAGE #1

**SPECIMENS:** Specimens polished to 600 Grit finish then cleaned in acetone

C-22 Base Alloy HT# 2277-3-3266 with Ti 7 Crevice Washers And Hardware
1/3 HT# CN2775 - Ti 7 Plate HT# CN2775

**Torque Screwdriver:** True Craft 75 In-lbs **SN:** 694000691
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 23.16485 g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** ~~21.88303 g~~ 23.15530 g SKP 11/30/05 **Cal:** 5/11/05 **Due:** 11/11/05

**SOLUTION:** 5 m NaCl
584.42 g NaCl Lot # 051510
+ DI To 2000 mls

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 7.79 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 4.82 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**TEST TEMPERATURE:** 95°C **Thermometer:** Fisher **SN:** 51046103
**Cal:** 6/7/05 **Due:** 6/7/06
**Thermocouple SN:** 333 **Cal:** 7/26/05 **Due:** 1/26/06

**Reference Electrode:** Fisher SCE **# 13-620-52** **SN:** 3329075
**GAS:** Zero Air

~~Platinum Flag USED FOR OCP MEASUREMENT ONLY~~ X.H 11/5/06

Counter Electrode: Ti 7
**( CREVICE )** **( PLATE )**

**Ecorr:** -223 mv **Ecorr:** -489 mv **Model:** Keithley 614 **SN#:** 0704936
~~**Ept:** +245 mv **Ept:** +224 mv~~ **Cal:** 5/27/05 **Due:** 5/26/06
X.H 11/5/06 SKP 11/30/05

**Potentiostat:** Solartron 1480 **SN#:** 00240053 **Cal:** 8/23/05 **Due:** 2/23/~~05~~ 06

**TEST ID:** MA22Ti7Ti7a

**DATA FILES:** C22Ti7010-Unich1, C22Ti7010-Unich2, C22Ti7012-Unich1, C22Ti7012-Unich2, C22Ti7015, C22Ti7021, C22Ti7024, C22Ti7027, C22Ti7028, C22Ti7101, C22Ti7018, C22Ti7104, C22Ti7104b, C22Ti7107, C22Ti7110, C22Ti7113, C22Ti7116

**Specimen Examination:** C22Ti7119, C22Ti7122, C22Ti7123, C22Ti7126,
No Crevice Corrosion 9/24 feet of Ti 7 Crevice washers
No Sign of Corrosion on Ti 7 washers or Hardware
Mild Surface staining on Specimen dull tint staining on Ti 7 washers And Hardware - *Note Surface Etching under holder shows signs of Copper Buildup. TEFLON wrapped area which is above solution was corroded slightly.
* Note: Specimen Repolished for further Testing

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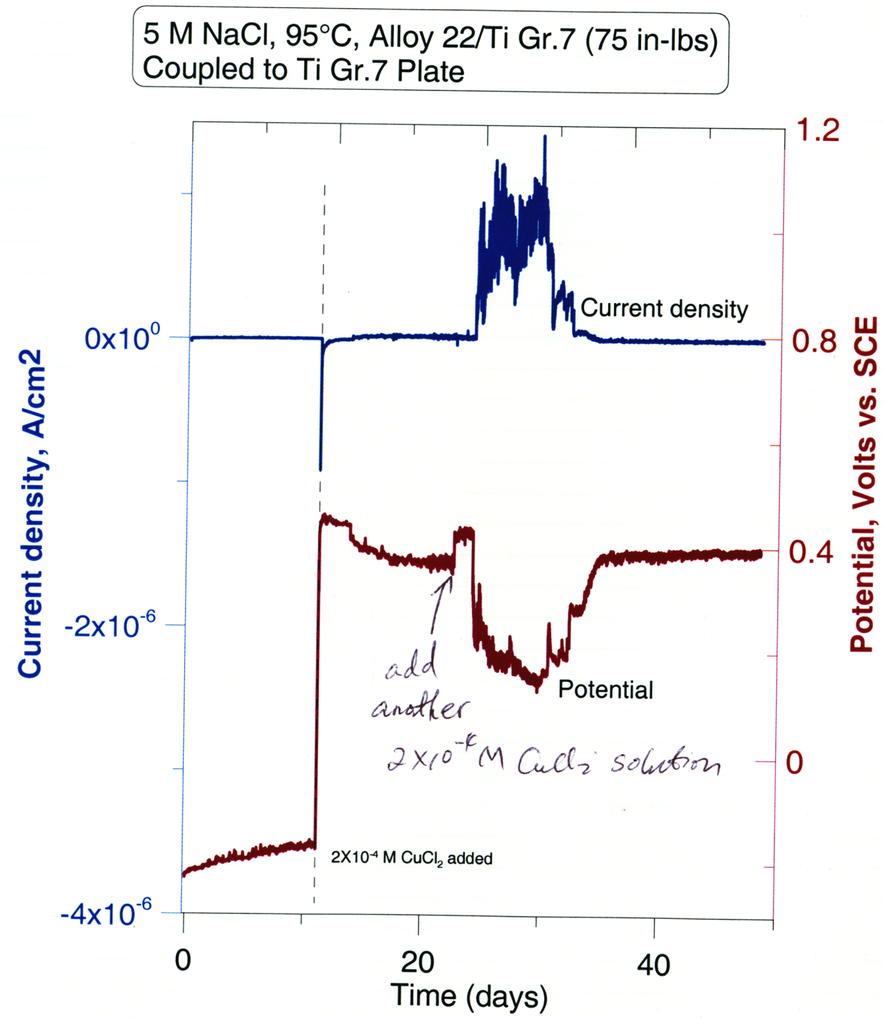
$CuCl_2 \cdot 2H_2O$ solution prepared on 10/17/05
20.097 g $CuCl_2 \cdot 2H_2O$ Lot # 897713 + DI water to 100 mls
pH = 2.47
pH measured with Orion EA940 SN# 2330
Cal: 7/25/05 Due: 7/25/06
Fisher probe 13-620-296 SN# 4065196
In 2L test solution, add 340 uL prepared $CuCl_2$ solution.

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Galvanic Corrosion Test

Objective: SEE PAGE #1

SPECIMENS: Specimens polished to 600 Grit finish then cleaned in acetone
C-22 Base Alloy HT#2277-3-3266 with Teflon Crevice Washers C-276 Hardware - Ti 7 Plate HT# CN2775

Torque Screwdriver: Proto 6104 100 In-Oz. SN: 139072
Cal: 4/11/05 Due: 10/11/05

Initial Weight: 23.03223g Model: Sartorius Genius SN: 12809099
Final Weight: 23.02304g Cal:5/11/05 Due:11/11/05

SOLUTION: 5 M NaCl
584.42g NaCl Lot #051510
+ DI ~~to~~ 2000mls

Reagents measured with Model: OHAUS SN: 2883
Cal:7/12/05 Due:1/12/06

Initial pH: 7.63 Model: Orion EA 940 SN:2330
Final pH: 5.79 Cal:7/25/05 Due:7/25/06
pH Probe: #13-620-296 SN: 4065196

TEST TEMPERATURE: 95°C Thermometer: Fisher SN: 51 046103
Cal: 6/7/05 Due: 6/7/06

Thermocouple SN: 333 Cal: 7/26/05 Due: 1/26/06

Reference Electrode: Fisher SCE # 13-620-52 SN: 4028031
GAS: Zero Air

~~Platinum Flag USED FOR OCP MEASUREMENT ONLY~~
Counter Electrode: Ti Gr7 Plate X.H 1/5/06
( CREVICE ) ( PLATE )
Ecorr: -208mv Ecorr: -463mv Model: Keithley 614 SN#:0704936
~~Ept: +21 mv~~ ~~Ept: +21 mv~~ Cal:5/27/05 Due:5/26/06
X.H 1/5/06 ~~5/26~~ 11/30/05
Potentiostat:Solartron 1480 SN#:00240053 Cal: 8/23/05 Due:2/23/~~05~~ 06

TEST ID: ~~MA22PTFE~~ MA22PTFETi7a
X.H 10/10/05

DATA FILES: C22PTFETi71010, 1012, 1015, 1018, 1021, 1024, 1027_Un1Ch3 Ch4
Number of crevice corrosion sites: 2/24 (24 Max.)

Specimen Examination:

Two teeth were corroded. No corrosion on other teeth.

Maximum penetration depth: 164 and 181 μm
Measured with Olympus metallurgical microscope PME3
Cal: 5/23/05 Due: 11/23/05

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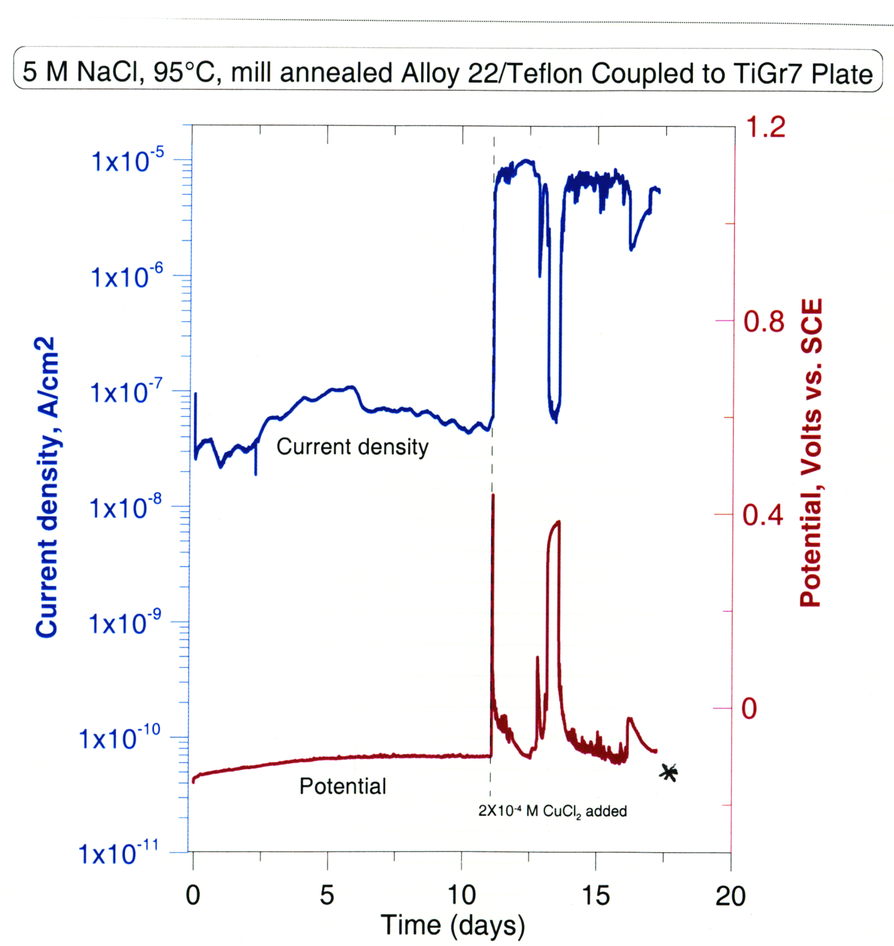
X.H 5/23/06




* Experiment was stopped by power outage.

* See page 31 for CuCl2 solution

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Galvanic Corrosion Test

Objective: SEE PAGE #1

SPECIMENS: Specimens polished to 600 Grit finish then cleaned in acetone

C-22 HT# 2277-3-3292 WN813 - welded Solution Annealed See NB#729 pg#58
C-22 HT# 2277-3-3266 Crevice Washers And Hardware 1/3 - C22 HT#2277-3-3266 Plate

Torque Screwdriver: True Craft 75 In-lbs SN: 6940006911
Cal: 7/22/05 Due: 7/21/06

Initial Weight: 23.2405 1g Model: Sartorius Genius SN: 12809099
Final Weight: 23.2400 2g Cal:5/11/05 Due:11/11/05

SOLUTION: 5 m NaCl
584.47g NaCl Lot#051510
+ DI To 2000 mls

Reagents measured with Model: OHAUS SN: 2883
Cal:7/12/05 Due:1/12/06

Initial pH: 7.87 Model: Orion EA 940 SN:2330
Final pH: 4.65 Cal:7/25/05 Due:7/25/06
pH Probe: #13-620-296 SN: 4065196

TEST TEMPERATURE: 95°c Thermometer: Fisher SN: 51046103
Cal: 6/7/05 Due: 6/7/06
Thermocouple SN: 333 Cal: 7/26/05 Due: 1/26/06

Reference Electrode: Fisher SCE # 13-620-52 SN: 925105
GAS: Zero Air

~~Platinum Flag USED FOR OCP MEASUREMENT ONLY~~
Counter Electrode: C22 Plate X.H 1/5/06
( CREVICE ) ( PLATE )
Ecorr: -154mv Ecorr: -176mv Model: Keithley 614 SN#:0704936
~~Ept: +274mv Ept: +274mv~~ Cal:5/27/05 Due:5/26/06
X.H 1/5/06 BWD 11/30/05

Potentiostat:Solartron 1480 SN#:00240053 Cal: 8/23/05 Due:2/23/~~05~~ 06

TEST ID: WA22SAMA22MA22A

DATA FILES: WSA22C221010-Unlch5, WSA22C221010_Unlch6, WSA22C221012, WSA22C221015, WSA22C221018, WSA22C221021, WSA22C221024, WSA22C221027, WSA22C221028, WSA22C221101, WSA22C221104, WSA22C221107, WSA22C221110, WSA22C221113, WSA22C221116, WSA22C221119, WSA22C221118, WSA22C221121, WSA22C221124

Specimen Examination:
Number of corrosion sites: 0/24 (Max 24)
No Corrosion 0/24 feet of Crevice Washer - No Corrosion on C-22 Crevice washers on Hardware - Mib Surface Staining on All C-22 material Dull tint In Color-

* Note: will Repolish Specimen for further Testing

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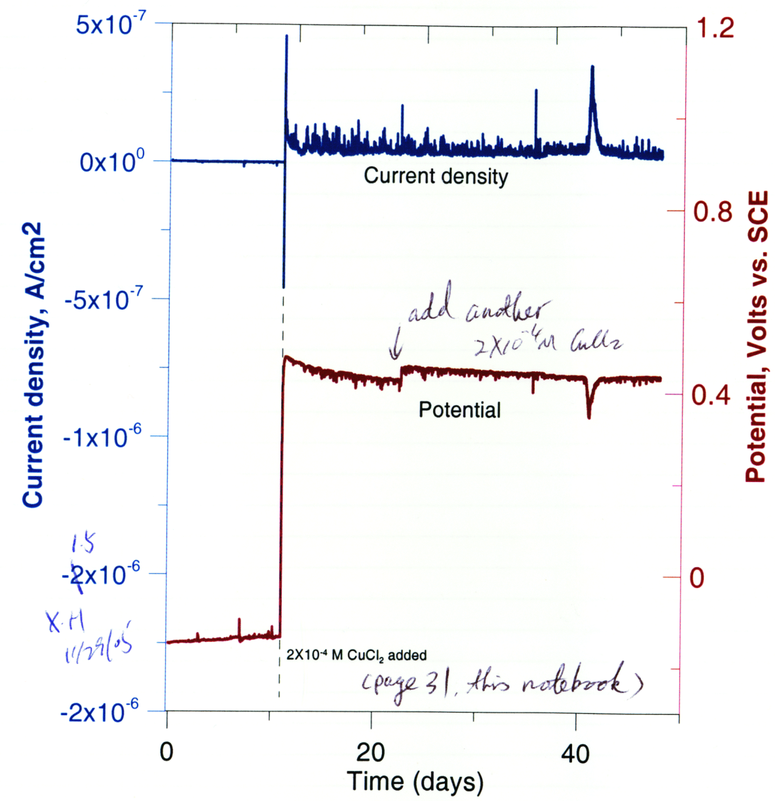
X.H 5/23/06

5 M NaCl, 95°C, Welded plus solution annealed Alloy 22/Alloy 22 crevice
75 in-lbs torque, Coupled to Alloy 22 Plate




X.H 5/23/06

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Galvanic Corrosion Test

Objective: SEE PAGE #1

SPECIMENS: Specimens polished to 600 Grit finish then cleaned in acetone
C-22 HT#2277-3-3292 WN813 - Welded Solution Annealed See pg #58 NB #729
Teflon Crevice Washers with C276 Hardware - C22 HT#2277-3-3266 Plate

Torque Screwdriver: Proto 6104 100 In-oz Cal: 4/11/05 SN: 139072 Due: 10/11/05

Initial Weight: 23.37854g Model: Sartorius Genius SN: 12809099
Final Weight: 23.37779g Cal:5/11/05 Due:11/11/05

SOLUTION: 5.0 M NaCl
584.41g NaCl Lot #051510
+ DI To 2000mls

Reagents measured with Model: OHAUS SN: 2883
Cal:7/12/05 Due:1/12/06

Initial pH: 7.84 Model: Orion EA 940 SN:2330
Final pH: 4.43 Cal:7/25/05 Due:7/25/06
pH Probe: #13-620-296 SN: 4065196

TEST TEMPERATURE: 95°C Thermometer: Fisher SN: 51046103
Cal: 6/7/05 Due: 6/7/06
Thermocouple SN: 333 Cal: 7/26/05 Due: 1/26/06

Reference Electrode: Fisher SCE # 13-620-52 SN: 251439
GAS: Zero Air

~~Platinum Flag USED FOR OCP MEASUREMENT ONLY~~
Counter Electrode: C22 Plate X.H 1/5/06
( CREVICE ) ( PLATE )
Ecorr: -184mv SCE Ecorr: -226mv SCE Model: Keithley 614 SN#:0704936
~~Ept: +231mv SCE~~ Ept: +231mv SCE Cal:5/27/05 Due:5/26/06
X.H 1/5/06 Due:11/26/05

Potentiostat:Solartron 1480 SN#:00240053 Cal: 8/23/05 Due:2/23/~~05~~ 06

TEST ID: WA22SAPTFEBA22A

DATA FILES: WSA22PTFEC221010, 1012, 1015, 1018, 1021, 1024, 1027, 1028, 1101, 1104, 1107, 1110, 1113, 1116, 1119, 1118, Ua(ch7), Ch8

Specimen Examination: No Corrosion 1/24 feet of Crevice washer. Mild Surface staining Around 5 feet of Crevice washer Gold tint. All other staining on Specimen Dull tint C-22 plate Specimen No Corrosion Just staining At Solution Vapor Interface

* Note will Repolish Specimen for Further Testing

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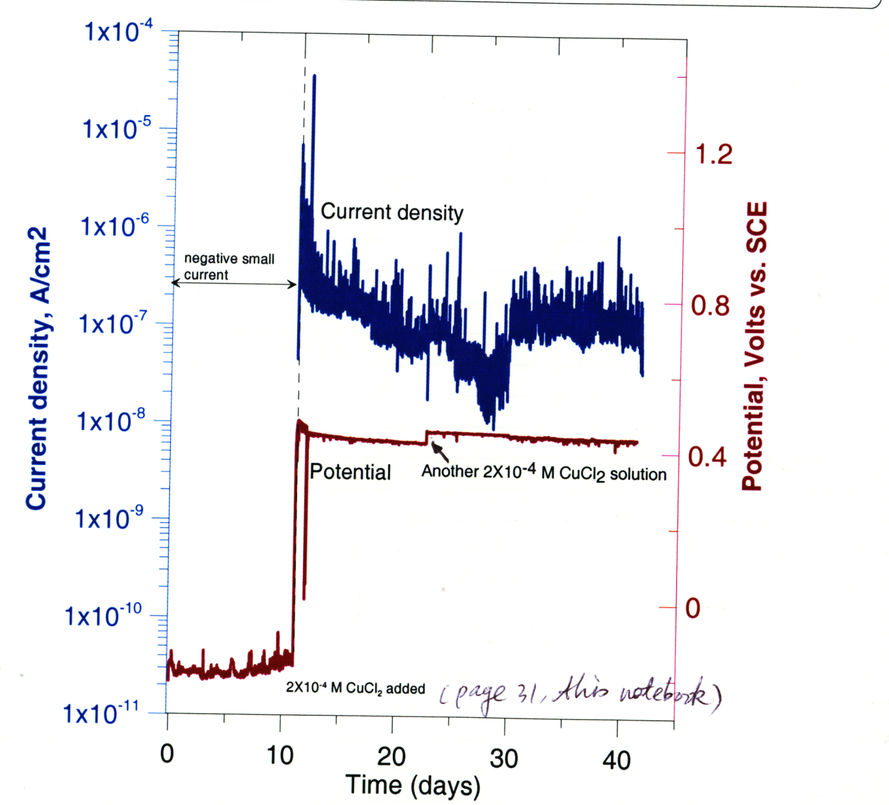
5/23/06




The current density is below $1 \times 10^{-6}$ A/cm². No indication of crevice corrosion initiation even with the addition of $CuCl_2$.

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 HT#2277-3-3266 Base Alloy. w/ Ti7 HT#CN2775 1/3 Crevice Washers And Hardware

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing #20.06002.01.322.002. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using hardware. Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** Snap-On **Model# &Torque:** 50 In-Oz **SN:** 1001200319
**Cal:** 5/4/05 **Due:** 11/4/05

**Initial Weight:** 23.81022g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.80980g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 m NaCl
467.56g NaCl Lot# 051510
+ DI water To 2000 mls

Test ID:
BA22Ti702d

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 5.72 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 7.44 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** H00.387
**Cal:** 7/11/05 **Due:** 1/11/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 0199568

**Gas:** Zero Air then 99.999% $N_2$ for E Repassivation

**Ecorr:** -6.9 mV$_{SCE}$ **Model:** Keithley 614 **SN:** 0704936
**Ept:** 98 mV$_{SCE}$ **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1287 **SN:** 0614 8500
Cal 5/25/05 Due: 11/25/05

**DATA FILE:** BA7170CA2R, BA22Ti750N2, BA22Ti750SU, BA22Ti750SH, BA22Ti750SD

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion on C-22 Base Alloy Specimen. Ti7 Crevice Washers And Hardware No Corrosion gold tint Staining on Specimen And Ti7 Crevice Washers And Bolt/Nut.

* Note: Specimen Repolished for further testing

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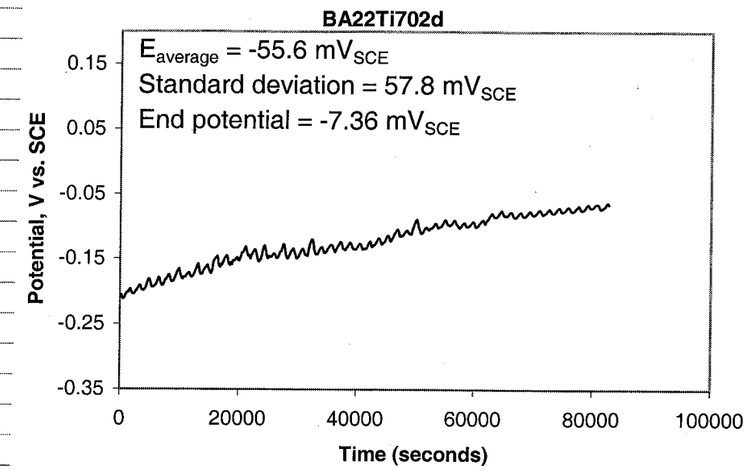


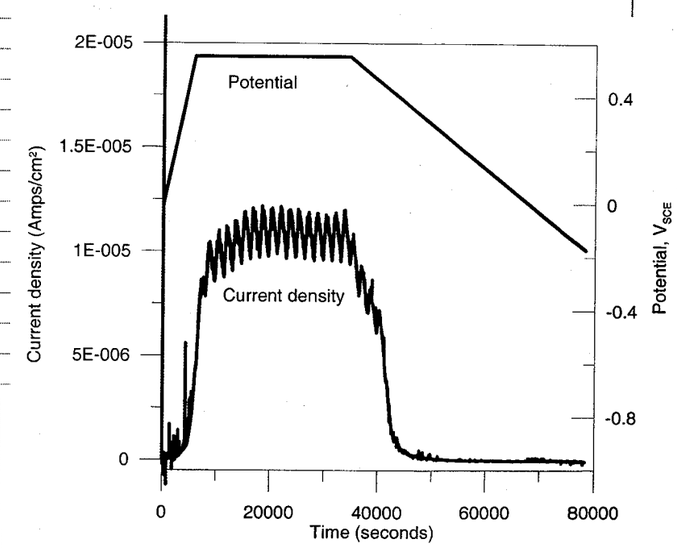


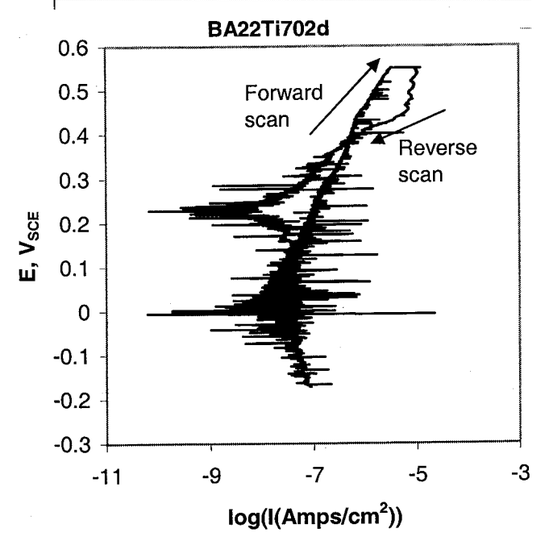


Base Alloy 22 (Anode) to Ti Gr7 crevice, Ti7 bolt and nut
Anode to cathode area ratio: ~1/3; Torque: 50 in-oz;
$N_2$ deaerated, 95 °C, 4 M NaCl solution
Forward scan rate: 0.1 mV/s, Potential hold: 550 mV$_{SCE}$ for 8 hours
Reverse scan rate: 0.0167 mV/s
Using entire assembly area for current density calculation:
$i < 10^{-5}$ A/cm² at 550 mV$_{SCE}$; $i < 2*10^{-6}$ A/cm² at 421 mV$_{SCE}$;
$i < 10^{-6}$ A/cm² at 411 mV$_{SCE}$
Using crevice specimen area for current density calculation:
$i < 10^{-5}$ A/cm² at 424 mV$_{SCE}$; $i < 2*10^{-6}$ A/cm² at 387 mV$_{SCE}$;
$i < 10^{-6}$ A/cm² at 359 mV$_{SCE}$

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## POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 HT# 2277-3-3292 WN813 w/ Ti 7 HT# CN2775 1/3 Crevice Washers
welded Solution Annealed See NB# 729 pg#58 Ano Hardware

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing #20.06002.01.322.002. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using hardware. Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** Teve - Craft **Model# &Torque:** 75 In-lbs **SN:** 694000691
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 23.47767 g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.47336g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 m NaCl
467.52g NaCl Lot# 051510
+ DI water to 2000 mls

Test ID: WA22SATi701d

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 5.68 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 7.56 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** C96-377
**Cal:** 7/11/05 **Due:** 1/11/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 3300328

**Gas:** Zero Air then 99.995% $N_2$ for E Repassivation

**Ecorr:** -184 $mV_{SCE}$ **Model:** Keithley 614 **SN:** 0555368
**Ept:** +79 $mV_{SCE}$ **Cal:** 9/14/05 **Due:** 3/14/06

**Potentiostat:** Solartron 1480 **SN:** 00238265
Cal: 6/1/05 Due: 12/1/05

**DATA FILE:** WA22SATi7H-Un1Ch7, WA22SATi7V2-Un1Ch7, WA22SATi7SU-Un1Ch7, WA22SATi7SH-Un1Ch7, WA22SATi7SD-Un1Ch7

**Number of Crevice Corrosion Sites:** 0 /24 (24 max.)

No Crevice Corrosion 0/24 feet of Crevice Washers on C-22
No Corrosion on Ti 7 Crevice washers or Hardware
Surface staining gold tint

* Note: Specimen Repolished for further Testing

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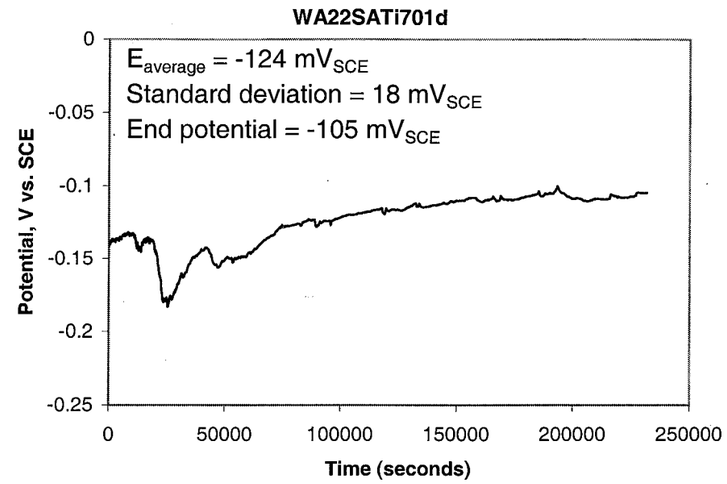


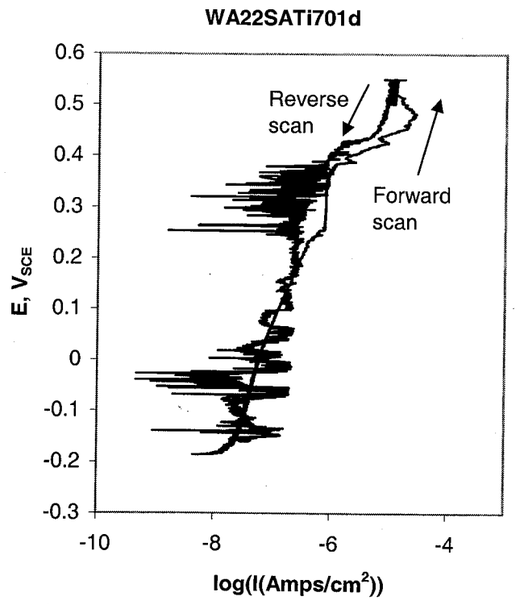


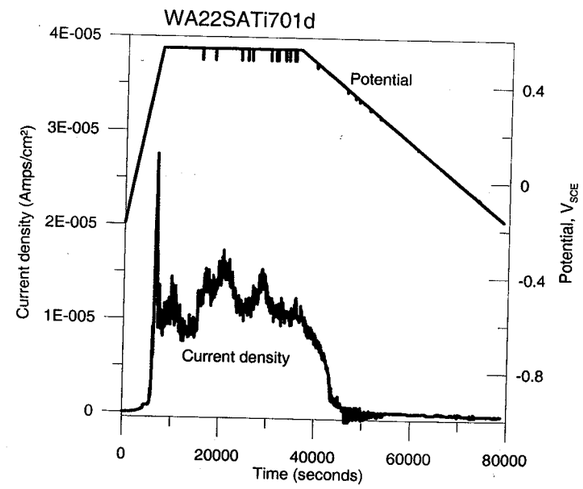


Welded+Solution Annealed Alloy 22 (Anode) to Ti Gr7 crevice, Ti7 bolt and nut
Anode to cathode area ratio: ~1/3; Torque: 75 in-lbs;
$N_2$ deaerated, 95 °C, 4 M NaCl solution
Forward scan rate: 0.1 mV/s, Potential hold: 550 $mV_{SCE}$ for 8 hours
Reverse scan rate: 0.0167 mV/s
Using entire assembly area for current density calculation:
$i < 10^{-5}$ A/cm² at 550 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 424 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 402 $mV_{SCE}$
Using crevice specimen area for current density calculation:
$i < 10^{-5}$ A/cm² at 430 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 382 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 381 $mV_{SCE}$

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No. :** C-22 HT# 2277-3-3242 WN813 w/Ti 7 HT #CN2775 1/18 Crevice Cathode
welded Solution Annealed See NB # 729 pg #58 Ano Hardware

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing #20.06002.01.322.002. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using hardware. Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** Teve-Craft **Model# &Torque:** 75 In-lbs **SN:** 69400069
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 23.54145g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.53714g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 m NaCl
467.53g NaCl Lot #051510
+ DI water to 2000 mls

Test ID: WA22SATi704C

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 5.43 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 7.54 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** **Measured with Hg Thermometer** **SN:** 115858
**Cal:** 4/27/05 **Due:** 4/27/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 4028037

**Gas:** Zero Air then 99.999% $N_2$ for E Repassivation

**Ecorr:** -153 $mV_{SCE}$ **Model:** Keithley 614 **SN:** 0555368
**Ept:** +34 $mV_{SCE}$ **Cal:** 9/14/05 **Due:** 3/14/06

**Potentiostat:** Solartron 1480 **SN:** 0238265
**DATA FILE:** WA22SATi7Lair-Un1Ch8, cal: 6/1/05 Due: 12/1/05
WA22SATi7LN2-Un1Ch8, WA22SATi7LSU-Un1Ch8, WA22SATi7LSH,
WA22SATi7LSD

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion 0/24 feet of Crevice washers on C-22
No Corrosion on Ti 7 Crevice on Hardware
gold tint staining on All Surfaces of C-22
dull tint staining on Surface of Ti 7 Ano Hardware

* Note: Specimen Repolished for further Testing

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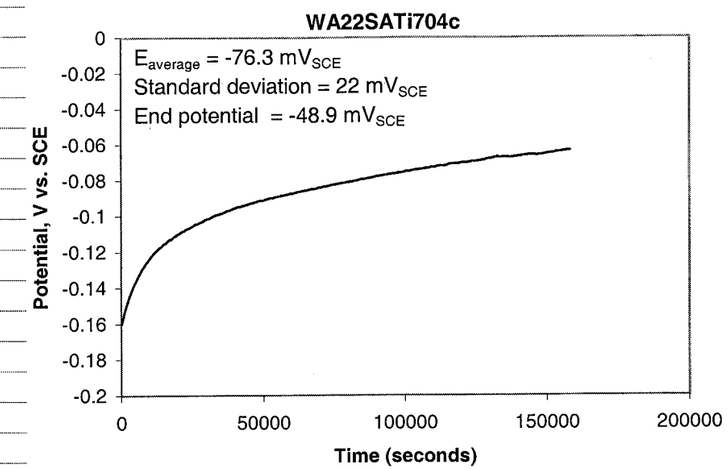


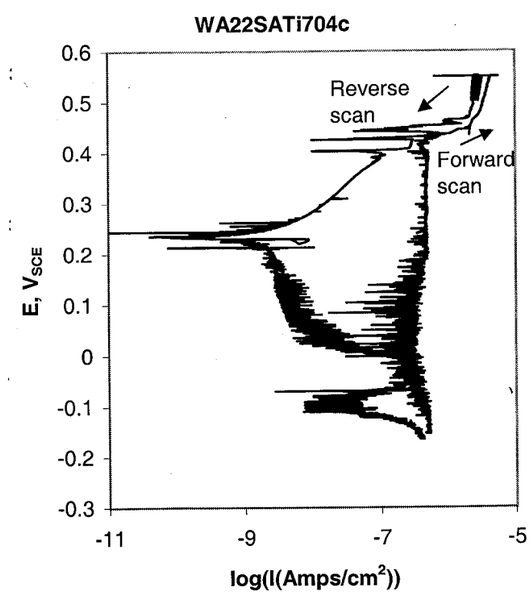


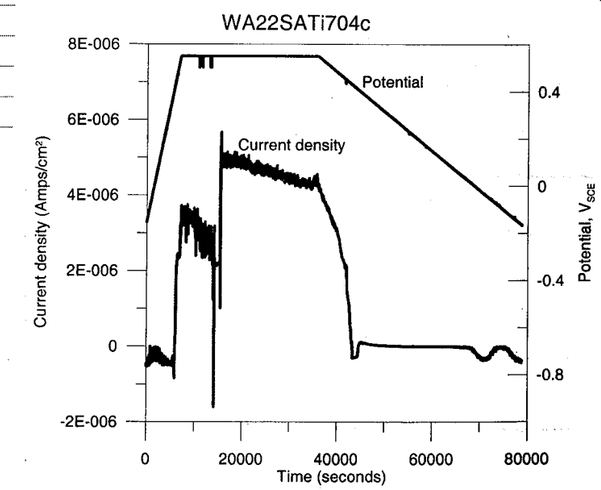


Welded+Solution Annealed Alloy 22 (Anode) to Ti Gr7 crevice, Ti7 bolt and nut
Anode to cathode area ratio: ~1/18; Torque: 75 in-lbs;
$N_2$ deaerated, 95 °C, 4 M NaCl solution
Forward scan rate: 0.1 mV/s, Potential hold: 550 $mV_{SCE}$ for 8 hours
Reverse scan rate: 0.0167 mV/s
Using entire assembly area for current density calculation:
$i < 10^{-5}$ A/cm² at 550 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 448 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 436 $mV_{SCE}$
Using crevice specimen area for current density calculation:
$i < 10^{-5}$ A/cm² at 433 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 429 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 427 $mV_{SCE}$

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## POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 MT#2277-3-3292 WN813 w/ C-22 MT#2277-3-3266 1/3 Crevice Washers And Hardware
Welded Solution Annealed See NB#729 Pg #58

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing #20.06002.01.322.002. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using hardware. Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** True-Craft **Model# &Torque:** 75 In. lbs **SN:** 694000691
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 23.46410g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.46158 **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 M NaCl
467.52g NaCl Lot#051510
+ DI to 2000mls

Test ID: WA22SABA2204d

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 5.55 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 5.02 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** M00-387
**Cal:** 7/11/05 **Due:** 1/11/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 0199568

**Gas:** Zero Air then 99.999% $N_2$ for E Repassivation
**Ecorr:** −153 mV/SCE **Model:** Keithley 614 **SN:** 0704936
**Ept:** 116 mV/SCE **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1287 **SN:** 06148500
Cal: 5/25/05 Due: 11/25/05

**DATA FILE:** WA22SAC22OCAIR, WA22SAC22OCN2, WA22SAC22SU, WA22SAC22SH, WA22SAC22SD

**Number of Crevice Corrosion Sites:** 0/24 (24 max.)

No Crevice Corrosion 0/24 feet of Crevice washer
No Corrosion on C-22 Crevice washers on Nut/Bolt

All Surfaces of Specimen And C-22 Hardware Have gold tint Surface Staining

* Note: Specimen Repolished for Further Testing

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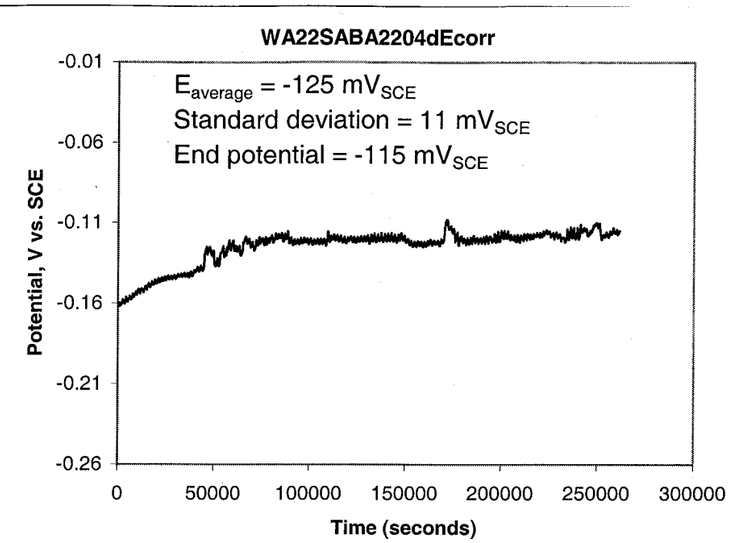


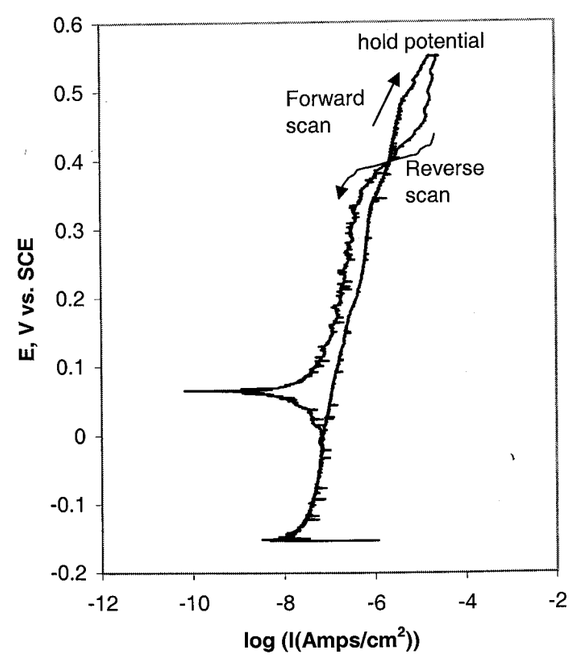


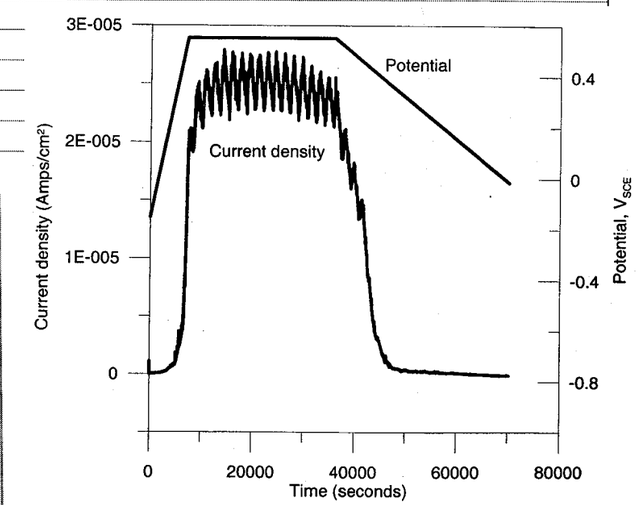


Welded + solution annealed Alloy 22 (Anode)
with Base Alloy 22 (Cathode) crevice
Base Alloy 22 bolt and nut
Anode to cathode area ratio: ~1/3; Torque: 75 in-lbs;
$N_2$ deaerated, 95 °C, 4 M NaCl solution
Forward scan rate: 0.1 mV/s; Potential hold: 550 $mV_{SCE}$ for 8 hours;
Reverse scan rate: 0.0167 mV/s
Using entire assembly area as surface area for current density,
$i < 10^{-5}$ A/cm² at 444 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 395 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 376 $mV_{SCE}$
Using crevice specimen area as surface area for current density,
$i < 10^{-5}$ A/cm² at 398 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 339 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 265 $mV_{SCE}$

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POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No.:** C-22 HT#2277-3-3296 WN813 W/C-22 HT#2277-3-3266
Welded - Solution Annealed See NB #729 Pg #58 Crevice Cathode with Hardware

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing #20.06002.01.322.002. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using hardware. Torque to 50 in-oz.or 75 in lbs. area ratio 1/10

**Torque Screwdriver:** SNAP - ON **Model# &Torque:** 50 in-oz. **SN:** 1001200319
**Cal:** 5/4/05 **Due:** 11/4/05

**Initial Weight:** 23.466709g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 23.46526g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 M NaCl
467.52g NaCl Lot #051510
+ DI To 2000 mls

Test ID: WA22SABA2202dEcorr

**Reagents measured with** XM 11/1/05 **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 6.57 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 5.49 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** 115858
**Cal:** 4/27/05 **Due:** 4/27/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 4028037

**Gas:** Zero Air then 99.999% $N_2$ for E Repassivation

**Ecorr:** -307.5 $mV_{SCE}$ **Model:** Keithley 614 **SN:** 0555368
**Ept:** 124 $mV_{SCE}$ **Cal:** 9/14/05 **Due:** 3/14/06

**Potentiostat:** Solartron 1480 **SN:** 00238265
Cal: 6/1/05 Due: 12/1/05

**DATA FILE:** WA22SAC2250_Un(Ch2, WA22SAC2250b, WA22SAC2250N2,
WA22SAC2250U_Un(Ch2, WA22SAC2250H, WA22SAC2250Hb, WA22SAC2250D

**Number of Crevice Corrosion Sites:** 0 /24 (24 max.)

No Corrosion 0/24 feet on C-22 Specimen -
No Sign of Corrosion on C-22 Crevice Cathode on C-22 Nut/Bolt
Both Specimen And Hardware Has gold tint surface staining

* Note: Specimen Repolished for further Testing

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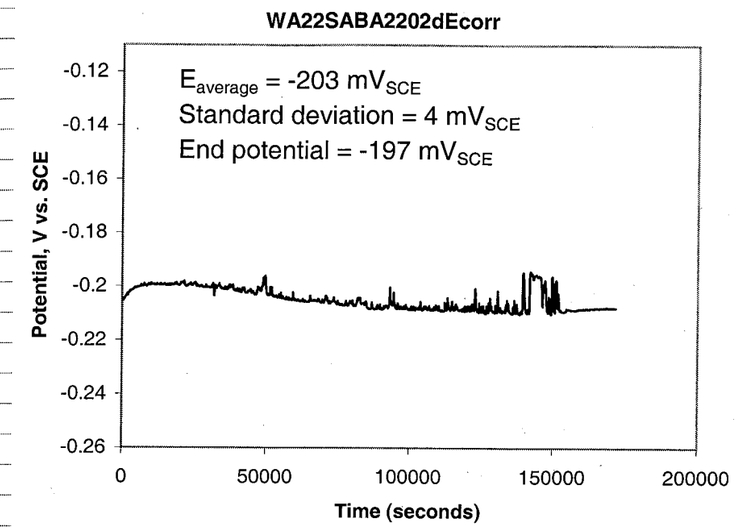


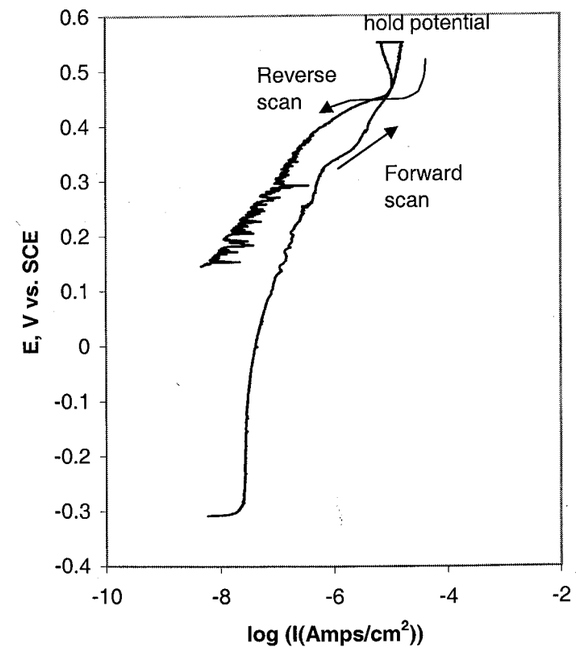


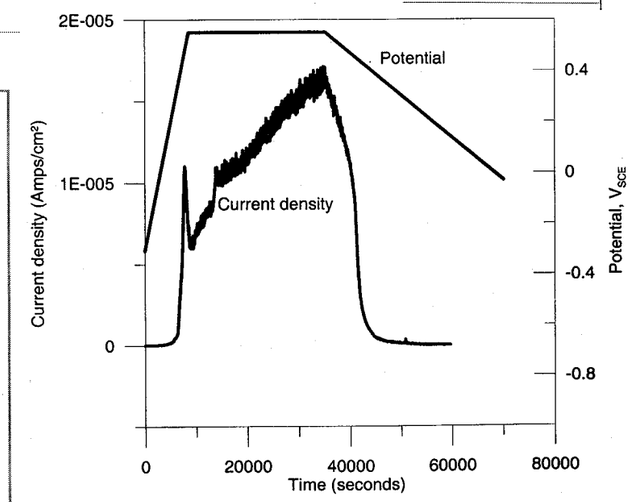


Welded + solution annealed Alloy 22 (Anode)
with Base Alloy 22 (Cathode) crevice
Base Alloy 22 bolt and nut
Anode to cathode area ratio: ~1/10; Torque: 50 in-oz;
$N_2$ deaerated, 95 °C, 4 M NaCl solution
Forward scan rate: 0.1 mV/s; Potential hold: 550 $mV_{SCE}$ for 8 hours;
Reverse scan rate: 0.0167 mV/s
Using entire assembly area as surface area for current density,
$i < 10^{-5}$ A/cm² at 462 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 430 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 413 $mV_{SCE}$
Using crevice specimen area as surface area for current density,
$i < 10^{-5}$ A/cm² at 410 $mV_{SCE}$; $i < 2*10^{-6}$ A/cm² at 341 $mV_{SCE}$;
$i < 10^{-6}$ A/cm² at 297 $mV_{SCE}$

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Galvanic Corrosion Test

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**Objective:** SEE PAGE #1

**SPECIMENS:** Specimens polished to 600 Grit finish then cleaned in acetone

C-22 Base Alloy HT# 2277-3-3266 w/C276 Nut/Bolt Ceramic Crevicewashers w/Teflon Tape

Ti 7 HT# CN2775 Plate

**Torque Screwdriver:** Tree Craft 75 In lbs **Cal:** 7/22/05 **SN:** 69400069 **Due:** 7/21/06

**Initial Weight:** 23.78939g **Model:** Sartorius Genius **SN:** 12809099

**Final Weight:** 23.76452g **Cal:** 5/11/05 **Due:** 11/11/05

**SOLUTION:** 5.0 m NaCl

584.42g NaCl Lot# 051510 + DI water to 2000mls

Test ID: MA22CerTi7a

**Reagents measured with** **Model:** OHAUS **SN:** 2883 **Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 5.70 **Model:** Orion EA 940 **SN:** 2330

**Final pH:** ~~4.03~~ 6.257 X.H 12/19/05 **Cal:** 7/25/05 **Due:** 7/25/06

**pH Probe:** #13-620-296 **SN:** 4065196

**TEST TEMPERATURE:** 95°C **Thermometer:** Fisher **SN:** M-00-387

**Cal:** 7/11/05 **Due:** 1/11/06

**Thermocouple SN:** Not Used **Cal:** **Due:**

**Reference Electrode:** Fisher SCE **# 13-620-52** **SN:** 4028031

**GAS: Zero Air**

~~Platinum Flag USED FOR OCP MEASUREMENT ONLY~~

Counter Electrode: Ti7 plate X.H 1/5/06

**( CREVICE )** **( PLATE )**

**Ecorr:** -154mv SCE **Ecorr:** +53mv SCE **Model:** Keithley 614 **SN#:** 0704936

~~**Ept:**~~ ~~**Ept:**~~ X.H 12/24/05 **Cal:** 5/27/05 **Due:** 5/26/06

**Potentiostat:** Solartron 1480 **SN#:** 00240053 **Cal:** 8/23/05 **Due:** ~~2/23/05~~ 2/23/06 BKD 11/30/05

~~**TEST ID:**~~ X.H 12/19/05

**DATA FILES:** C22CerTi71104, C22CerTi71107, C22CerTi71110, C22CerTi71113, C22CerTi71116, C22CerTi71119, C22CerTi71122, C22CerTi71125, C22CerTi71128, C22CerTi71201, C22CerTi71204, C22CerTi71207, C22CerTi71210, C22CerTi71213, C22CerTi71216

**Specimen Examination:** 24/24

Crevice Corrosion on 24/24 of Crevice washer feet. C-22 Specimen Has staining on All sides of Specimen. Ti7 plate Has Dull tint staining No Corrosion

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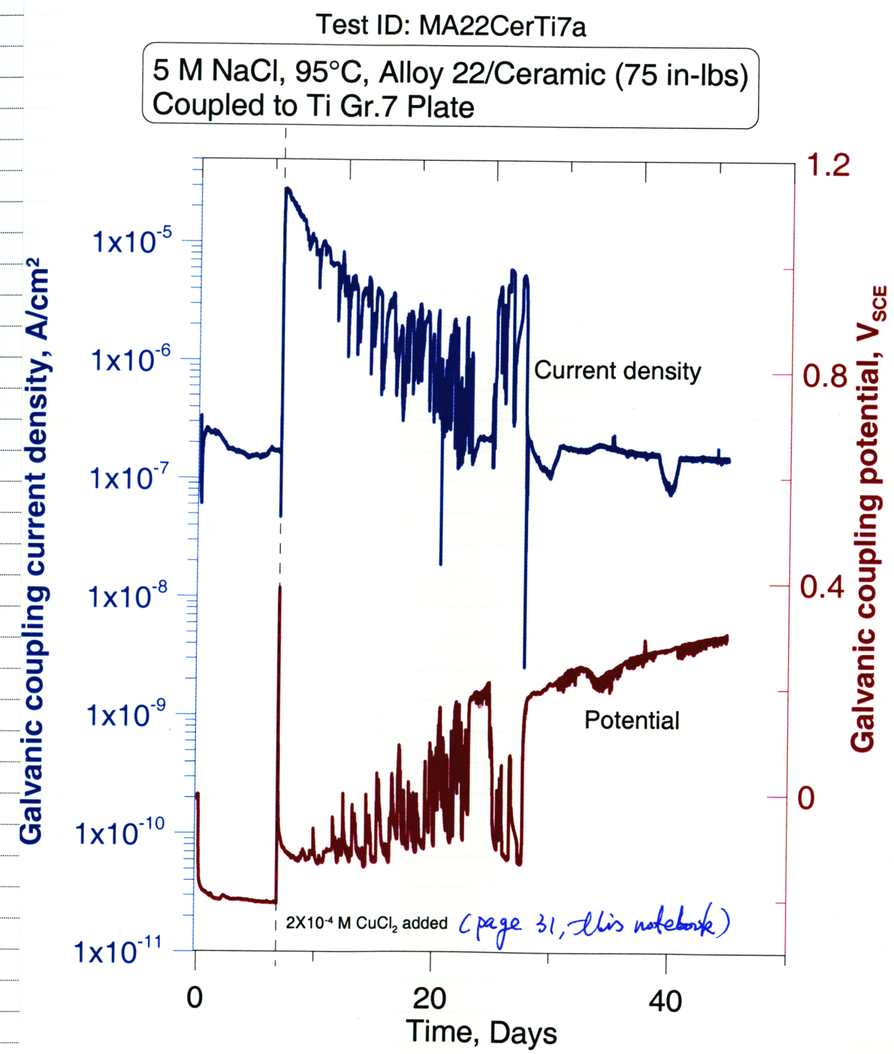
Number of Corrosion sites: 24/24 (24 max.)

Penetration depth: 74 μm, 80 μm, 112, 110, 60, 70, 85, 121, 135, 70, 64, 144, 70, 40, 43, 72, 51, 62, 61, 70, 50, 73, 43, 54 μm

Measured with Olympus Metallurgical Microscop MPE3, Cal: 12/13/05, Due: 6/13/06

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Galvanic Corrosion Test

**Objective:** SEE PAGE #1

**SPECIMENS:** Specimens polished to 600 Grit finish then cleaned in acetone

316 L HT# P80746 | C-22 Plate HT # 2277-3-3266 | C-22 Crevice washers HT # 2277-3-3266

**Torque Screwdriver:** True Craft 75 In-lbs **SN:** 694000691 **Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 21.37875g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 21.1126 5g **Cal:** 5/11/05 **Due:** 11/11/05

**SOLUTION:** 5.0 m NaCl
584.41g NaCl Lot # 051510
+ DI water To 2000mls

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 6.23 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 5.78 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**TEST TEMPERATURE:** 95°C **Thermometer:** Fisher **SN:** 51046103
**Cal:** 6/7/05 **Due:** 1/7/06
**Thermocouple SN:** 331 **Cal:** 11/7/05 **Due:** 5/6/06

**Reference Electrode:** Fisher SCE **# 13-620-52** **SN:** 0199568
**GAS:** Zero Air

~~Platinum Flag USED FOR OCP MEASUREMENT ONLY~~
Counter Electrode: C22 Plate X.rl ~~HHK~~ 1/5/06
**( CREVICE )** **( PLATE )** X.rl 1/5/06
**Ecorr:** -315mv **Ecorr:** -229mv **Model:** Keithley 614 **SN#:** 0704936
~~**Ept:**~~ ~~**Ept:**~~ **Cal:** 5/27/05 **Due:** 5/26/06
X.rl 12/20/05

**Potentiostat:** Solartron 1480 **SN#:** 00~~240053~~ 238265 **Cal:** 8/23/05 **Due:** 2/23/~~05~~ 06 HHK 11/21/05
X.rl 1/5/06

**TEST ID:** 316SSC22C22

**DATA FILES:** 316SSPR1104E, 316SSPR1104I, 316SSPR1107E, 316SSPR1107I, 316SSPR1110E, 316SSPR1110I, 316SSPR1113E, 316SSPR1113I, 316SSPR1116I, 316SSPR1116E, 316SSPR1119I, 316SSPR1119E, 316SSPR1122, 316SSPR1125, 316SSPR1128, 316SSPR1201, 316SSPR1204, 316SSPR1207, 316SSPR1209, 316SSPR1210, 1212

**Specimen Examination:** Crevice Corrosion on 22/24 feet of C-22 Crevice Washers 316 specimen Had Dull tint with Rust color staining on surface ~~Also~~ HHK 12/13/05 Also C-22 crevice Washers Had same staining But No Corrosion - C-22 Plate Had m/o surface staining No Corrosion

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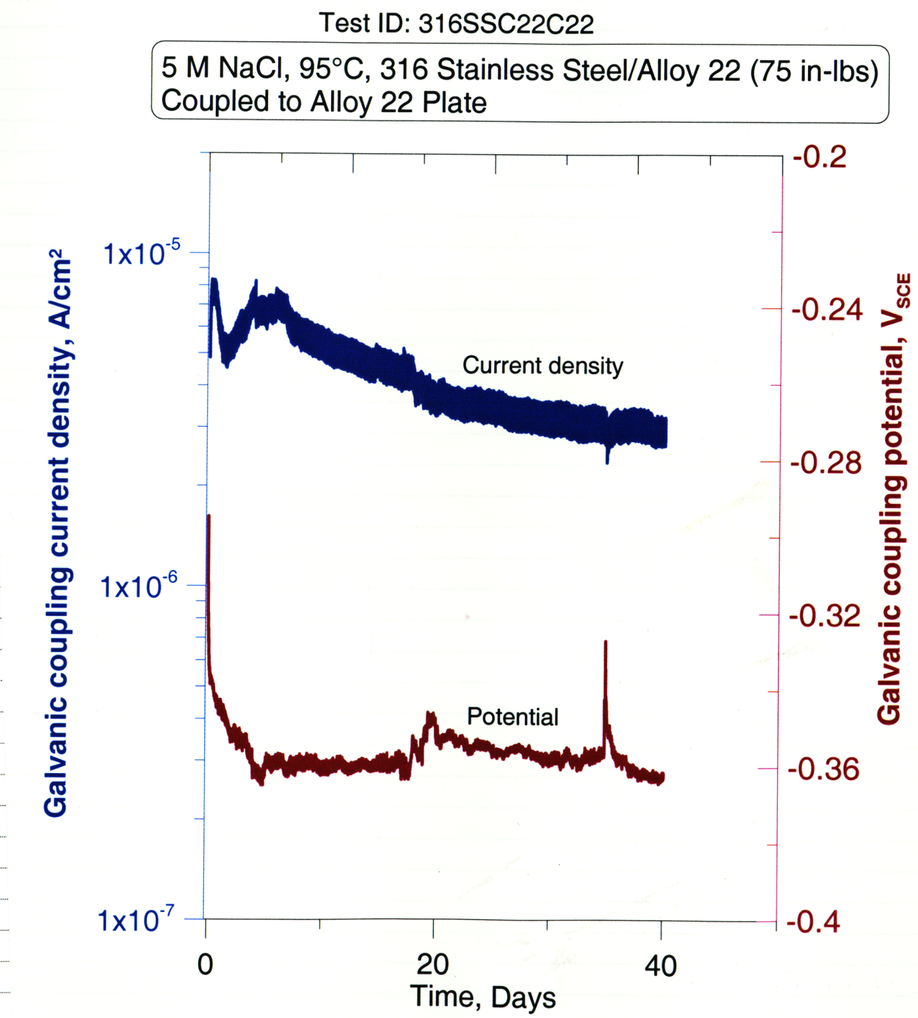
Total test time: 40.0 days
Number of corrosion sites: 22/24 (Max.) 24

Penetration depth: 76µm, 38, 20, 70, 22, 28, 40, 16, 44, 101, 47, 66, 18, 258, 68, 18, 44, 36, 15, 30, 31, 57µm
Measured with Olympus metallurgical microscope PME3
Cal: 12/13/05 Due: 6/13/06
Most corrosion is around the edge of the creviced area.

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## POTENTIAL SCAN AND HOLD

**Objective:** See page 1.

**Alloy / Heat No. :** C-22 HT# 2277-3-3266 Base Alloy w/ Ti 7 HT# CN2775 Crevice Washers 1/3 Nut/Bolt

**Specimen Preparation:** Specimen machined to dimensions specified in CNWRA Drawing #20.06002.01.322.002. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone then crevice forming washers attached to specimen using hardware. Torque to 50 in-oz.or 75 in lbs.

**Torque Screwdriver:** Tave Craft **Model# &Torque:** 75 In-lbs **SN:** 694000691
**Cal:** 7/22/05 **Due:** 7/21/06

**Initial Weight:** 23.55484 g **Model:** Sartorius Genius **SN:** 12809099
**Final Weight:** 22.70326 g **Cal:** 5/11/05 **Due:** 11/11/05

**Solution:** 4.0 m $MgCl_2 \cdot 6H_2O$
1626.58 g $MgCl_2 \cdot 6H_2O$ Lot # 044975
+ DI To 2000 mL

Test ID: BA22Ti703d

**Reagents measured with** **Model:** OHAUS **SN:** 2883
**Cal:** 7/12/05 **Due:** 1/12/06

**Initial pH:** 3.24 **Model:** Orion EA 940 **SN:** 2330
**Final pH:** 5.42 **Cal:** 7/25/05 **Due:** 7/25/06
**pH Probe:** #13-620-296 **SN:** 4065196

**Test Temperature:** 95°C **Measured with Hg Thermometer** **SN:** 115858
**Cal:** 4/27/05 **Due:** 4/27/06

**Counter Electrode:** Platinum Flag

**Reference Electrode:** Fisher 13-620-52 **SN:** 4028037

**Gas:** Zero Air then 99.995% $N_2$

**Ecorr:** -205 mV **Model:** Keithley 614 **SN:** 0555368
**Ept:** 406 mV **Cal:** 9/14/05 **Due:** 3/14/06

**Potentiostat:** Solartron 1287 **SN:** 00148560
Cal: 5/25/05 Due: 11/25/05

**DATA FILE:** C22Ti70CA2R, C22Ti70CMgCl2N2, C22Ti7MgCl2SLi, C22Ti7MgCl2SLb, C22Ti7MgCl2SH, C22Ti7MgCl2SLc, C22Ti7MgCl2SHb, C22Ti7MgCl2SLd, C22Ti7MgCl2SHC, C22Ti7MgCl2SLe,

**Number of Crevice Corrosion Sites:** 21/24 (24 max.)

Crevice Corrosion on 21/24 feet of Crevice washer Deep Corrosion Paths specimen All sides Have Surface staining - Some pitting on outer Surfaces Away from Crevice washers - Ti 7 Crevice washers Nut/bolt No Corrosion mild surface staining

More data files: C22Ti7MgCl2SHd, C22Ti7MgCl2SLf, C22Ti7MgCl2SHe, C22Ti7MgCl2SLg, C22Ti7MgCl2SHf, C22Ti7MgCl2SLh, C22Ti7MgCl2SHg, C22Ti7MgCl2SLi, C22Ti7MgCl2SHh

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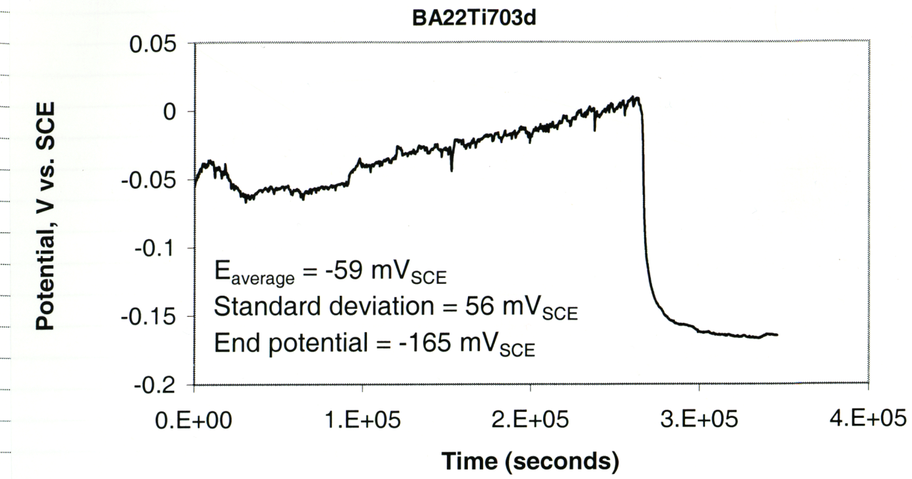


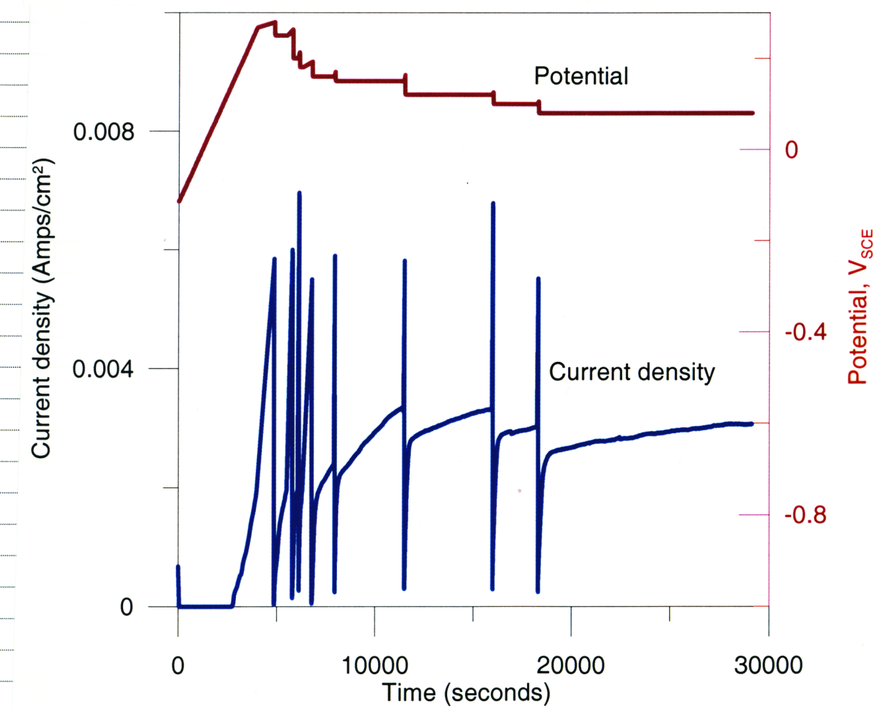


Base Alloy 22 (Anode) to Ti Gr7 crevice, Ti7 bolt and nut
Anode to cathode area ratio: ~1/3; Torque: 75 in-lbs;
$N_2$ deaerated, 95 °C, 4 M $MgCl_2$ solution
Forward scan rate: 0.1 mV/s, Potential hold: 80 $mV_{SCE}$ for 5 hours
Reverse scan rate: 0.0167 mV/s

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