C-22 Propagation Rate Measurement

Localized Corrosion

Alloy/Specimen: C22 with Heat # 2277-3-3266

Specimen Preparation: Specimen machined to dimensions 1.917"*0.250"specified in CNWRA Drawing #20.01402.5 71.019. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone and rinsed in DI water. PTFE crevice forming bolt pressed against specimen using torque screwdriver to 50 in-oz. XHL 11/3/05

Torque Screwdriver: Proto 6104 MFD USA **SN:** 139072 **Cal:** 4/11/05 **Due:** 10/11/05

Test ID: C22PR032

Initial weight: 12.48813 g

Final weight: 12.44450 g

Model: Sartorius Genius **SN:** 12809099 **Cal:** 11/10/04 **Due:** 05/10/05

Solution: 5 M NaCl + 2×10^{-3} M $CuCl_2$ (Page 83, this notebook)

584.4 g NaCl lot # 642966 + DI water to 2000 mLs

Reagents measured with

Model: OHAUS **SN:** 2883 **Cal:** 1/14/05 **Due:** 7/14/05

Initial pH: 7.12 **Model:** Orion EA 940 **SN:**2330 **Cal:** 7/21/04 **Due:** 7/21/05

Final pH: 5.23 **pH Probe:** #13-620-296 **SN:** ~~4079126P~~ 4065196P X.H 6/7/05

Test Temperature: 95°C Measured with thermocouple SN: 328 **Cal:** 2/7/2005 **Due:** 8/5/2005

Counter Electrode: Alloy 22 plate (Heat # 2277-1-3133) with surface area of 60 cm^2

Reference Electrode: Fisher 13-620-52 **SN:** 813148

Potentiostat: Multi-channel SI1480

SN: 00240551 **Cal:** 11/23/04 **Due:** 5/23/05

Cell set up: Two channels for each electrode, one channel to measure the coupling current, the other to measure the coupling potential

Data Files: C22PR0412Ia, C22PR0412Ea, C22PR0412Ib, C22PR0412Eb, C22PR0413I, C22PR0413E, C22PR0415I, C22PR0415E, C22PR0418I, C22PR0418E, C22PR0421I, C22PR0421E, C22PR0424E, C22PR0424I

Test dates: 4/12/2005 – 4/25/2005

Test time: ~13 days 1.096×10^6 seconds = 12.68 days charge = 147 coulombs

Creviced area: 109 mm^2

Estimated crevice corroded area: Not available. Corrosion is at the side, difficult to determine

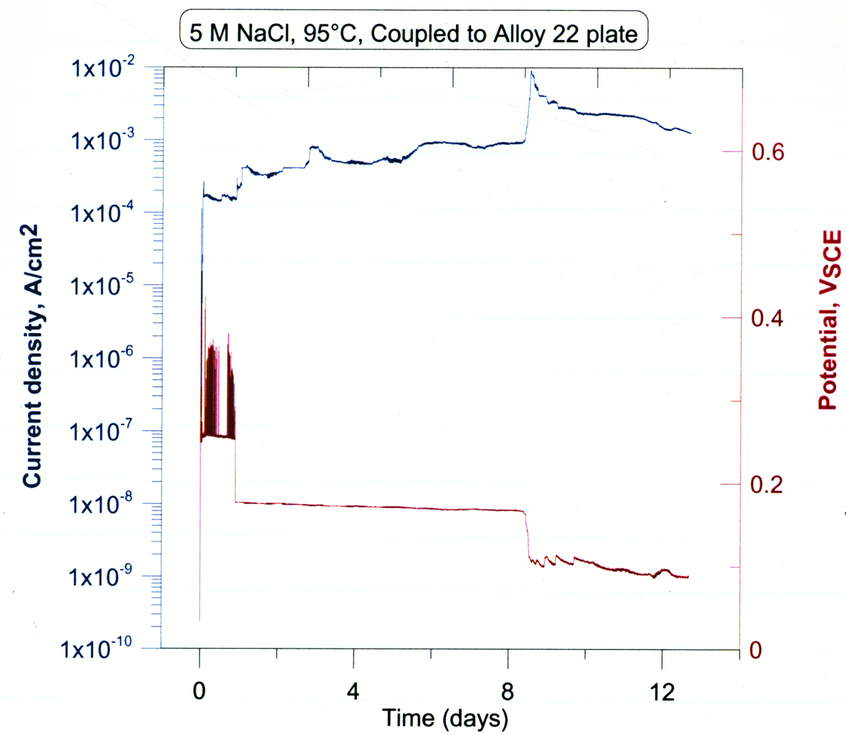
Maximum penetration depth:

Specimen examination:

All the corrosion starts around the crevice between the specimen and Teflon bottom lid.

Xihua He 4/25/2005

All the rest surface in solution is etched.



Xihua He 6/9/06

Xihua He 5/2/2005

Localized Corrosion
C-22 Propagation Rate Measurement

Alloy/Specimen: C22 with Heat # 2277-3-3266

Specimen Preparation: Specimen machined to dimensions 1.917"*0.250"specified in CNWRA Drawing #20.01402.571.019. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone and rinsed in DI water. PTFE crevice forming bolt pressed against specimen using torque screwdriver to 50 in-oz. X.H 11/3/05

Torque Screwdriver: Proto 6104 MFD USA **SN:** 139072 **Cal:** 4/11/05 **Due:** 10/11/05

Test ID: C22PR033

Initial weight: 12.46553 g **Model:** Sartorius Genius **SN:** 12809099

Final weight: 12.46125 g **Cal:** 11/10/04 **Due:** 05/10/05

Solution: 5 M NaCl + 2×10^{-4} M $CuCl_2$ (Page 83, this notebook)

584.4 g NaCl lot # 642966 + DI water to 2000 mLs

Reagents measured with **Model:** OHAUS **SN:** 2883 **Cal:** 1/14/05 **Due:** 7/14/05

Initial pH: 7.12 **Model:** Orion EA 940 **SN:**2330

Final pH: 6.21 **Cal:** 7/21/04 **Due:** 7/21/05

pH Probe: #13-620-296 **SN:** ~~4079126P~~ 40651961P X.H 6/7/05

Measured with Thermocouple SN: 333

Test Temperature: 95°C **Cal:** 2/7/05 **Due:** 8/5/05

Counter Electrode: Alloy 22 plate (Heat # 2277-1-3133) with surface area of 60 cm^2

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

Potentiostat: Multi-channel SI1480

SN: 00186634 **Cal:** 12/3/04 **Due:** 6/3/05

Cell set up: Two channels for each electrode, one channel to measure the coupling current, the other to measure the coupling potential

Data Files: C22PR0421Ia, C22PR0421Ea, C22PR0421Ib, C22PR0421Eb, C22PR0424I, C22PR0424E, C22PR0427I, C22PR0427E

Test dates: 4/21/05 ~ 4/28/05 Total charge: 15.37 coulombs

Test time: 5.98×10^5 seconds = 6.92 days

Creviced area: 10.9 mm^2

Estimated crevice corroded area: 10.5 mm^2

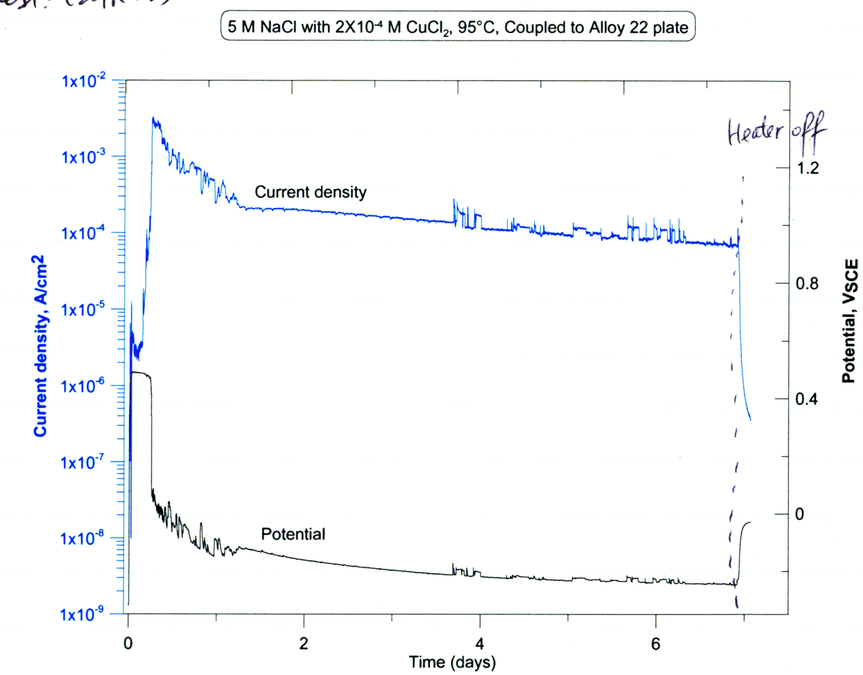
Maximum penetration depth: 107 μm

Specimen examination:

The entire creviced area is corroded. But the deeper penetration is around the edge of the creviced area.

Xihua He 4/29/05

Test: C22PR033



Xihua He 5/31/2005

Xihua He 6/9/06

Localized corrosion

C-22 Propagation Rate Measurement

Alloy/Specimen: C22 with Heat # 2277-3-3266

Specimen Preparation: Specimen machined to dimensions 1.917"*0.250"specified in CNWRA Drawing #20.0142. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone and rinsed in DI 571.019. water. PTFE crevice forming bolt pressed against specimen using torque screwdriver to 50 in-oz. X.H 11/3/05

Torque Screwdriver: Proto 6104 MFD USA **SN:** 139072
Cal: 4/11/05 **Due:** 10/11/05

Test ID: C22PR034

Initial weight: 12.50870 g **Model:** Sartorius Genius **SN:** 12809099

Final weight: 12.50491 g **Cal:** 11/10/04 **Due:** 05/10/05

Solution: 5 M NaCl + 2×10^{-3} M $CuCl_2$ (Page 83, this notebook)
584.4 g NaCl lot # 050089 + DI water to 2000 mLs

Reagents measured with **Model:** OHAUS **SN:** 2883
Cal: 1/14/05 **Due:** 7/14/05

Initial pH: 7.12 **Model:** Orion EA 940 **SN:**2330
Final pH: 5.54 **Cal:** 7/21/04 **Due:** 7/21/05
pH Probe: #13-620-296 **SN:** ~~4079126P~~ 4065196 P

Test Temperature: 95°C Measured with Thermocouple **Thermocouple** **SN:** 334
Cal: 4/6/05 **Due:** 10/6/05 X.H 6/7/05

Counter Electrode: Alloy 22 plate (Heat # 2277-1-3133) with surface area of 60 cm^2

Reference Electrode: Fisher 13-620-52 **SN:** 8131148

Potentiostat: Multi-channel SI1480
SN: 00186634 **Cal:** 12/3/04 **Due:** 6/3/05

Cell set up: Two channels for each electrode, one channel to measure the coupling current, the other to measure the coupling potential

Data Files:
C22PR0425Ia, C22PR0425Ea, C22PR0425Ib, C22PR0425Eb, C22PR0428I, C22PR0428E

Test dates: 4/25/2005 ~ 4/29/2005

Test time: 3.26×10^5 seconds = 3.77 days

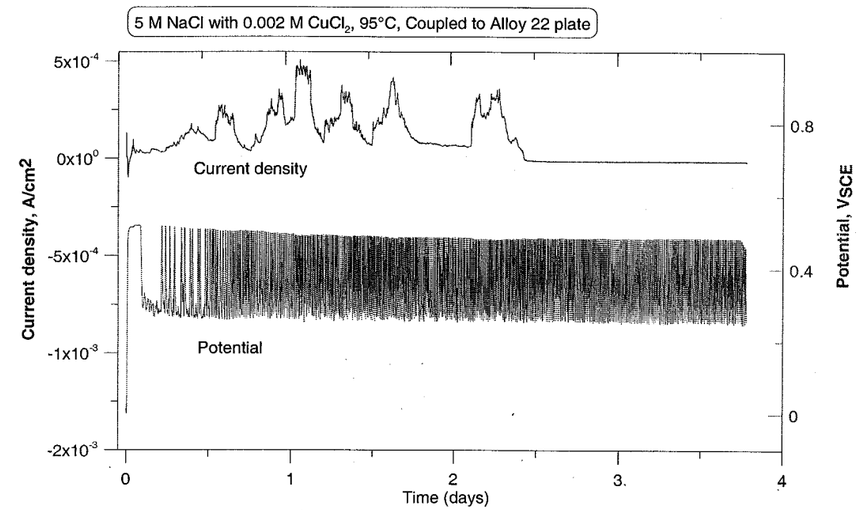
Creviced area: 10.3 mm^2

Estimated crevice corroded area: 10.3 mm^2

Maximum penetration depth: 115 μm Total charge: 3.34 coulombs

Specimen examination:
Creviced area is corroded. The surrounding area is etched forming color film. Corrosion is more uniformly distributed across the creviced area

Xihua He 4/29/05 X.H 4/29/05



Xihua He 5/2/05

Localized corrosion is repassivated at 2.04 days X.H 6/21/05

As indicated in CAR NO 2005-3, the cell temperature for tests between August 8, 2004 to May 11, 2005 were measured using calibrated thermocouple and temperature controller instead of calibrated thermocouple and calibrated thermocouple meter. On May 12, 2005, calibrated thermocouple meter was added to measure the temperature of all the on-going tests. It was found that the temperatures were off by about 2°C, which is in the required tolerance.

In addition, the fine focus knob of the metallurgical microscope used to measure localized corrosion penetration depth was verified to have 1 micrometer graduations using a calibrated caliper. The verification of the performance was recorded in scientific notebook 308, pages 184, 185, and 195.

Xihua He 6/7/2005

C-22 Localized Corrosion Propagation Rate Measurement

Alloy/Specimen: C22 with Heat # 2277-3-3266
Specimen Preparation: Specimen machined to dimensions 1.917"*0.250"specified in CNWRA Drawing# 20.9402.571.019. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone and rinsed in DI water. PTFE crevice forming bolt pressed against specimen using torque screwdriver to 50 in-oz. XH 1/3/05

Torque Screwdriver: PROTO 6104 MFD USA **SN:** 139072
Cal: 4/11/05 **Due:** 10/11/05

Test ID: C22PR035

Initial weight: 12.5455 6g **Model:** Sartorius Genius **SN:** 12809099
Final weight: 12.5401 9g **Cal:** 5/11/05 **Due:** 11/11/05

Solution: 5 M NaCl + $2X10^{-4}$ M $CuCl_2$ (Page 83, this notebook)
584.4 g NaCl lot # 642966 + DI water to 2000 mL

Reagents measured with **Model:** OHAUS **SN:** 2883
Cal: 1/14/05 **Due:** 7/14/05
Initial pH: 7.12 **Model:** Orion EA 940 **SN:**2330
Final pH: 5.26 **Cal:** 7/21/04 **Due:** 7/21/05
pH Probe: #13-620-296 **SN:** 4065196P

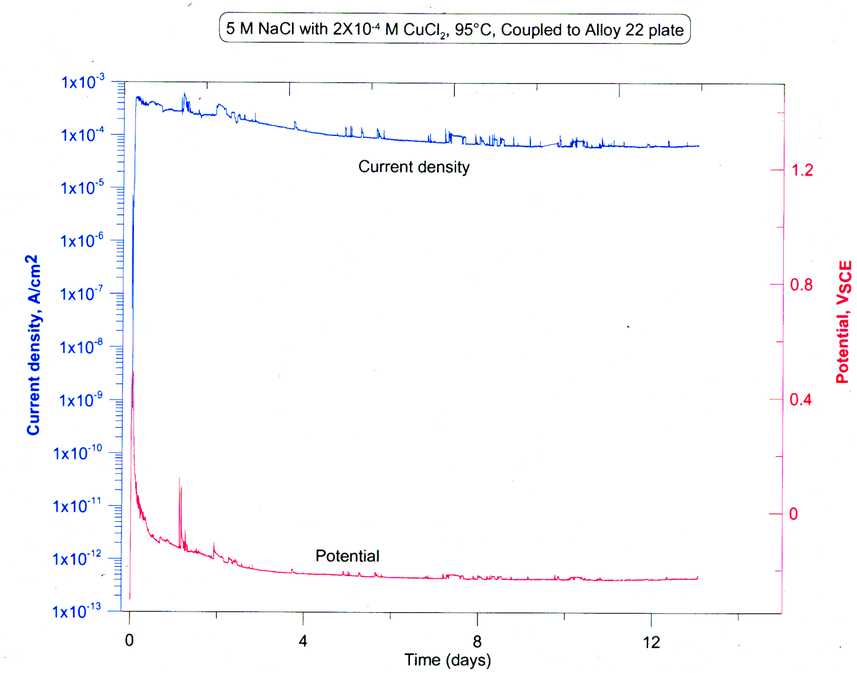
Test Temperature: 95°C **Thermocouple** **SN:** 333
Measured with thermocouple/thermocouple meter **Cal:** 2/7/05 **Due:** 8/5/05
Thermocouple meter **SN:** 3130900
Cal: 1/7/05 **Due:** 7/7/05

Counter Electrode: Alloy 22 plate (Heat # 2277-1-3133) with surface area of 60 cm^2
Reference Electrode: Fisher 13-620-52 **SN:** 0199568
Potentiostat: Multi-channel SI1480
SN: 00186634 **Cal:** 12/3/04 **Due:** 06/03/05
Cell set up: Two channels for curent and potential measurement, one channel to measure the coupling current, the other to measure the coupling potential
Data Files: C22PR0421Ia, C22PR0429Ea, C22PR0429Eb, C22PR0429Eb, C22PR0502I, C22PR0502E, C22PR0505E, C22PR0505I, C22PR0508I, C22PR0508E, C22PR0509I, C22PR0509E, C22PR0511E, C22PR0511I

Test dates: 4/29/05 – 5/12/05
Test time: $1.13X10^6$ seconds = 13.1 days Total charge = 15.93 coulombs

Creviced area: 10.9 mm^2
Estimated crevice corroded area: 8.72 mm^2
Maximum penetration depth: 156 μm

Specimen examination:
Corrosion is preferentially around the edge. Central region is not corroded.
Xihua He 5/12/05



Xihua He 6/9/06

Xihua He 5/13/05

C-22 Localized Corrosion Propagation Rate Measurement

Alloy/Specimen: C22 with Heat # 2277-3-3266
Specimen Preparation: Specimen machined to dimensions 1.917"*0.250"specified in CNWRA Drawing # 20-2402.571.009. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone and rinsed in DI water. PTFE crevice forming bolt pressed against specimen using torque screwdriver to 50 in-oz. X.H 11/3/05.

Torque Screwdriver: PROTO 6104 MFD USA **SN:** 139072
Cal: 4/11/05 **Due:** 10/11/05

Test ID: C22PR036

Initial weight: 12.58815 g **Model:** Sartorius Genius **SN:** 12809099
Final weight: 12.58154 g **Cal:** 5/11/05 **Due:** 11/11/05

Solution: 5 M NaCl + 2×10^{-4} M $CuCl_2$ (Page 83, this notebook)
584.4 g NaCl lot # 642966 + DI water to 2000 mL

Reagents measured with
Model: OHAUS **SN:** 2883
Cal: 1/14/05 **Due:** 7/14/05
Model: Orion EA 940 **SN:**2330
Cal: 7/21/04 **Due:** 7/21/05
pH Probe: #13-620-296 **SN:** 4065196P

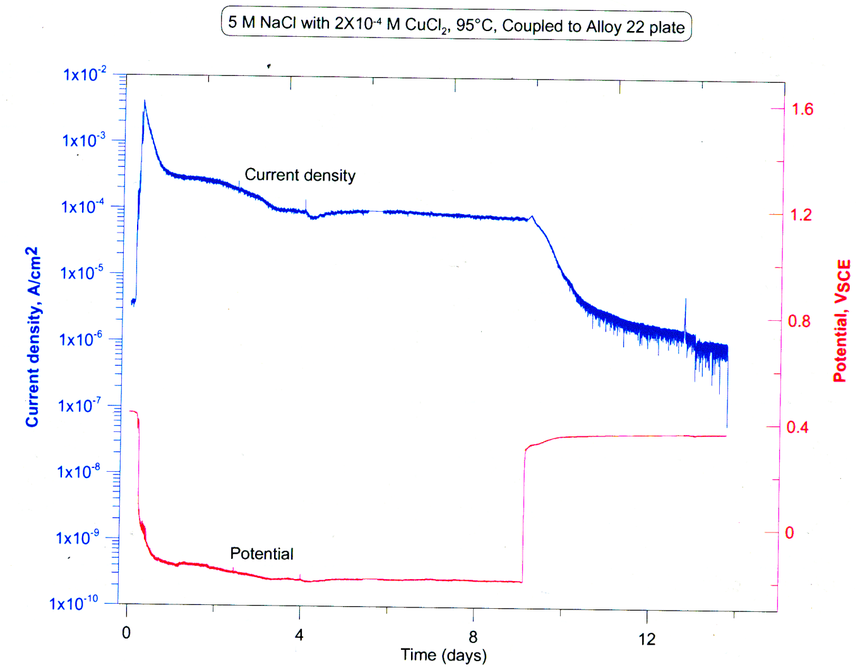
Initial pH: 7.12
Final pH: 5.42

Test Temperature: 95°C
Measured with thermocouple/thermocouple meter
Thermocouple **SN:** 33K
Cal: 4/6/05 **Due:** 10/6/05
Thermocouple meter **SN:** 3130900
Cal: 1/7/05 **Due:** 7/7/05

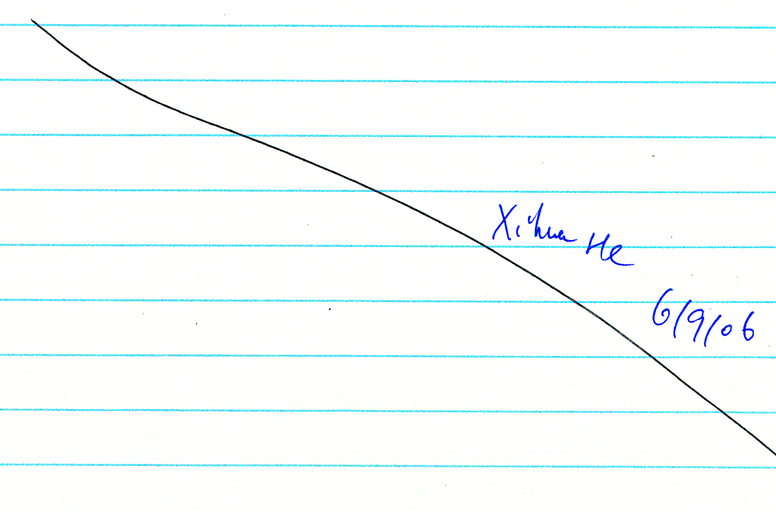
Counter Electrode: Alloy 22 plate (Heat # 2277-1-3133) with surface area of 60 cm^2
Reference Electrode: Fisher 13-620-52 **SN:** 8131148
Potentiostat: Multi-channel SI1480
SN: 00186634 **Cal:** 12/3/04 **Due:** 06/03/05
Cell set up: Two channels for curent and potential measurement, one channel to measure the coupling current, the other to measure the coupling potential
Data Files: C22PR0503bI, C22PR0503bE, C22PR0505I, C22PR0505E, C22PR0508E, C22PR0508I, C22PR0509E, C22PR0509I, C22PR0511I, C22PR0511E, C22PR0512E, C22PR0512I, C22PR0514I, C22PR0516bI, C22PR0516bE
Test dates: 5/3/05 ~ 5/17/05
Test time: 1.9×10^6 seconds = 13.8 days
Creviced area: 11.4 mm^2 Total charge = 17.80 coulombs
Estimated crevice corroded area: 9.8 mm^2
Maximum penetration depth: 200 μm

Specimen examination:
Deep penetration is around the edge. The central region is slightly corroded.

Xihua He 5/17/05



Xihua He 5/18/05



Xihua He 6/9/06

Localized Corrosion
C-22 Propagation Rate Measurement

Alloy/Specimen: C22 with Heat # 2277-3-3266

Specimen Preparation: Specimen machined to dimensions 1.917"*0.250"specified in CNWRA Drawing.* Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone and rinsed in DI water. PTFE crevice forming bolt pressed against specimen using torque screwdriver to 50 in-oz.

* Drawing # 20.01402.571.019 X.H 11/3/05

Torque Screwdriver: Snap-on USA **SN:** 1001200319
Cal: 5/4/05 **Due:** 11/4/05

Test ID: C22PR037

Initial weight: 10.51645 g **Model:** Sartorius Genius **SN:** 12809099
Final weight: **Cal:** 11/10/04 **Due:** 5/10/05

Solution: 5 M NaCl + $2X10^{-4}$ M $CuCl_2$ (Page 83, this notebook)
584.4 g NaCl lot # 050089 + DI water to 2000 mLs

Reagents measured with **Model:** OHAUS **SN:** 2883
Cal: 1/14/05 **Due:** 7/14/05
Initial pH: 7.12 **Model:** Orion EA 940 **SN:**2330
Final pH: 4.27 **Cal:** 7/21/04 **Due:** 7/21/05
pH Probe: #13-620-296 **SN:** ~~4079126P~~ 4065196 P X.H 6/7/05

Test Temperature: 95°C Measured with Thermocouple/Thermocouple meter
Thermocouple **SN:** 333
Cal: 2/7/05 **Due:** 8/5/05
Thermocouple meter **SN:** 3130900 **Cal:** 1/7/05
Due: 7/7/05

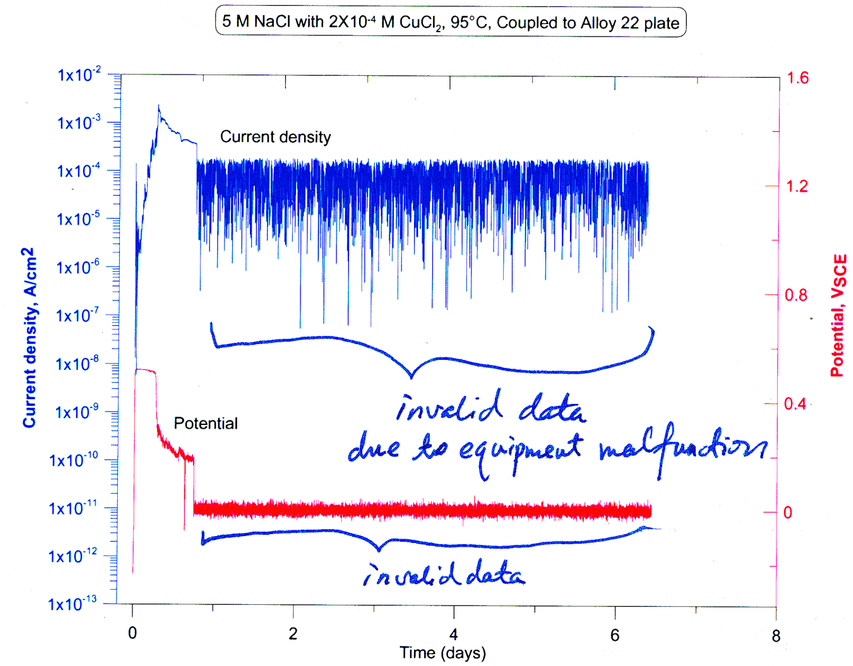
Counter Electrode: Alloy 22 plate (Heat # 2277-1-3133) with surface area of 60 cm^2
Reference Electrode: Fisher 13-620-52 **SN:** 0199568
Potentiostat: Multi-channel SI1480
SN: 00186634 **Cal:** 12/3/04 **Due:** 6/3/05
Cell set up: Two channels for each electrode, one channel to measure the coupling current, the other to measure the coupling potential
Data Files: C22PR0513Ia, C22PR0513Ea, C22PR0513Ib, C22PR0513Eb

Test dates: 5/13/05 ~ 5/16/05

Test time: Not available. Data is invalid.
Creviced area: 10.9 mm^2
Estimated crevice corroded area: 11.0 mm^2

Maximum penetration depth: 64 μm
Specimen examination:
Specimen is preferentially corroded around the edge and spreads inward and outward around the surrounding area.

Xihua He 5/18/05



* This set of data is invalid and will not be used due to equipment malfunction.
The experiment was set up on 5/13/05, Friday and left for the weekend. On Monday morning, 5/16/05, the computer and potentiostat lost communication. it ~~It~~ was noticed that X.H 5/16/05
The total length of time is wrong.
X.H 5/23/05

Xihua He 5/16/05

Xihua He 6/9/06

C-22 Localized Corrosion Propagation Rate Measurement

Alloy/Specimen: C22 with Heat # 2277-3-3266

Specimen Preparation: Specimen machined to dimensions 1.917"*0.250"specified in CNWRA Drawing #20.01402.571.04. Specimen surfaces polished to 600 Grit finish using SiC paper. Specimen cleaned in acetone and rinsed in DI water. PTFE crevice forming bolt pressed against specimen using torque screwdriver to 50 in-oz. XH 11/3/05

Torque Screwdriver: Snap-on USA **SN:** 1001200319
Cal: 5/4/05 **Due:** 11/4/05

Test ID: C22PR038

Initial weight: 10.23681 g **Model:** Sartorius Genius **SN:** 12809099

Final weight: 10.23061 g **Cal:** 5/11/05 **Due:** 11/11/05

Solution: 5 M NaCl + 2×10^{-4} M $CuCl_2$ (Page 97, this notebook)
584.4 g NaCl lot # 050089 + DI water to 2000 mL

Reagents measured with **Model:** OHAUS **SN:** 2883
Cal: 1/14/05 **Due:** 7/14/05

Initial pH: 7.12 **Model:** Orion EA 940 **SN:**2330
Final pH: 5.19 **Cal:** 7/21/04 **Due:** 7/21/05
pH Probe: #13-620-296 **SN:** ~~4079126P~~ 4065196P

Test Temperature: 95°C **Thermocouple** **SN:** 333 XH 6/7/05
Measured with thermocouple/thermocouple meter **Cal:** 2/7/05 **Due:** 8/5/05
Thermocouple meter **SN:** 3130900
Cal: 1/7/05 **Due:** 7/7/05

Counter Electrode: Alloy 22 plate (Heat # 2277-1-3133) with surface area of 60 cm^2

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

Potentiostat: Multi-channel SI1480
SN: 00186634 **Cal:** 12/3/04 **Due:** 6/3/05

Cell set up: Two channels for each electrode, one channel to measure the coupling current, the other to measure the coupling potential

Data Files: C22PR0519Ia, C22PR0519Ea, C22PR0519Ib, C22PR0519Eb, C22PR0522I, C22PR0522E, C22PR0525I, C22PR0525E, C22PR0528E, C22PR0528I

Test dates: 5/19/05 — 5/31/05

Test time: 1.027×10^6 seconds = 11.89 days **Charge:** 23.66 coulombs

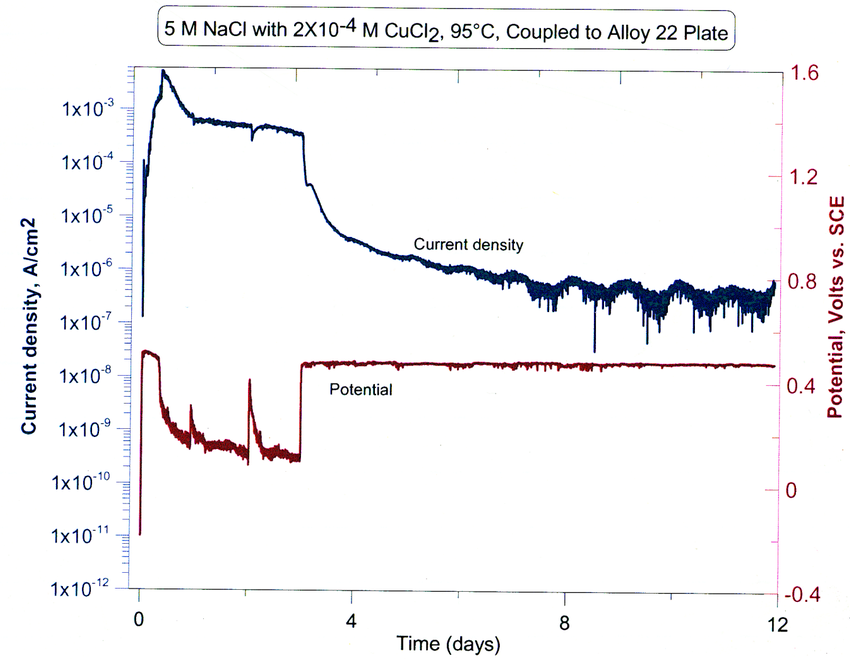
Creviced area: 10.9 mm^2

Estimated crevice corroded area: 10.9 mm^2

Maximum penetration depth: 220 μm **Measured with Olympus Metallurgical Microscope PME3**
Cal: 5/23/05 **Due:** 11/23/05

Specimen examination:
All the creviced ~~area~~ area is corroded. But deeper penetration is around the edge of the creviced area.
XH 5/31/05

Xihua He 5/31/05



Xihua He 5/31/05

Original $CuCl_2$ solution (prepared on 5/~~20~~19/2005)
XH 5/20/05

20.095 g $CuCl_2 \cdot 2H_2O$, Lot #897713
+ D.I water to 100 mls
pH = 2.30

Xihua He 5/20/05