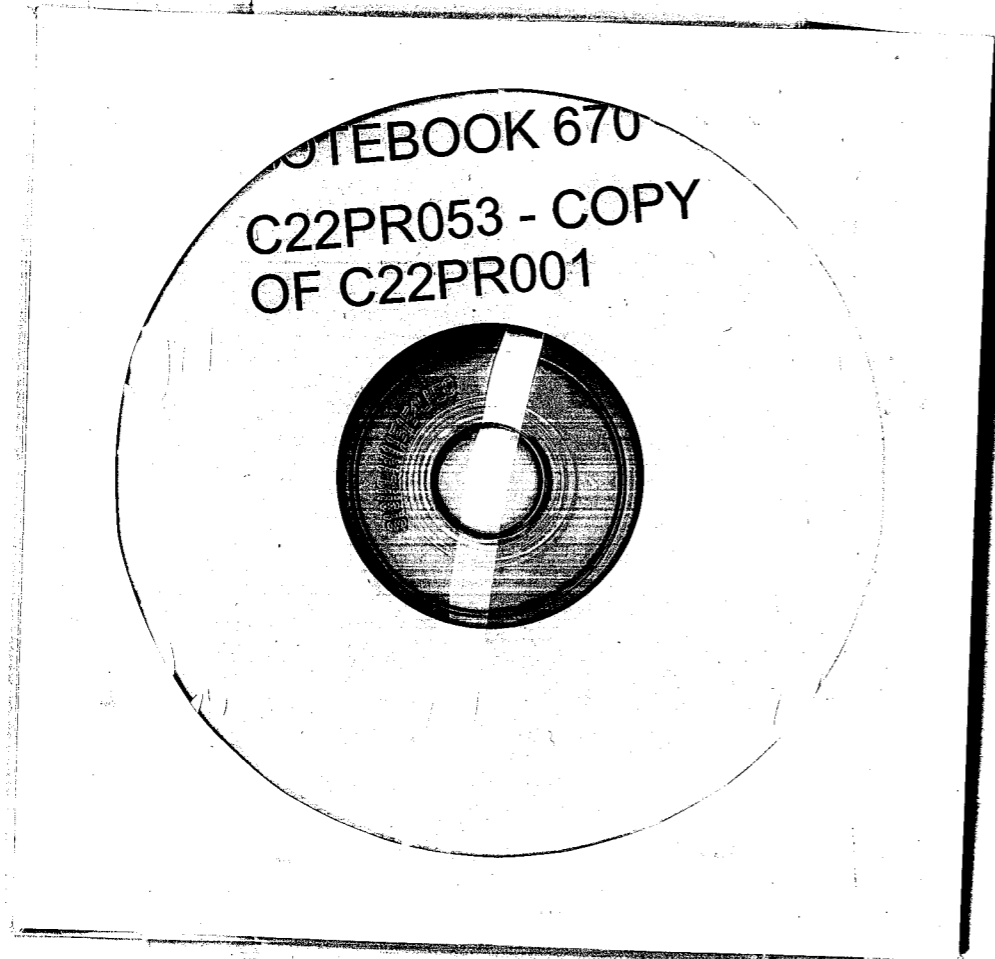


Propagation Rate # 670

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

CNWRA  
CONTROLLED  
COPY 670



Issued to Xihua He

Division: 20

Xihua He

X.H.

Brian K. Derby

BKD

Dustin Noll

DN

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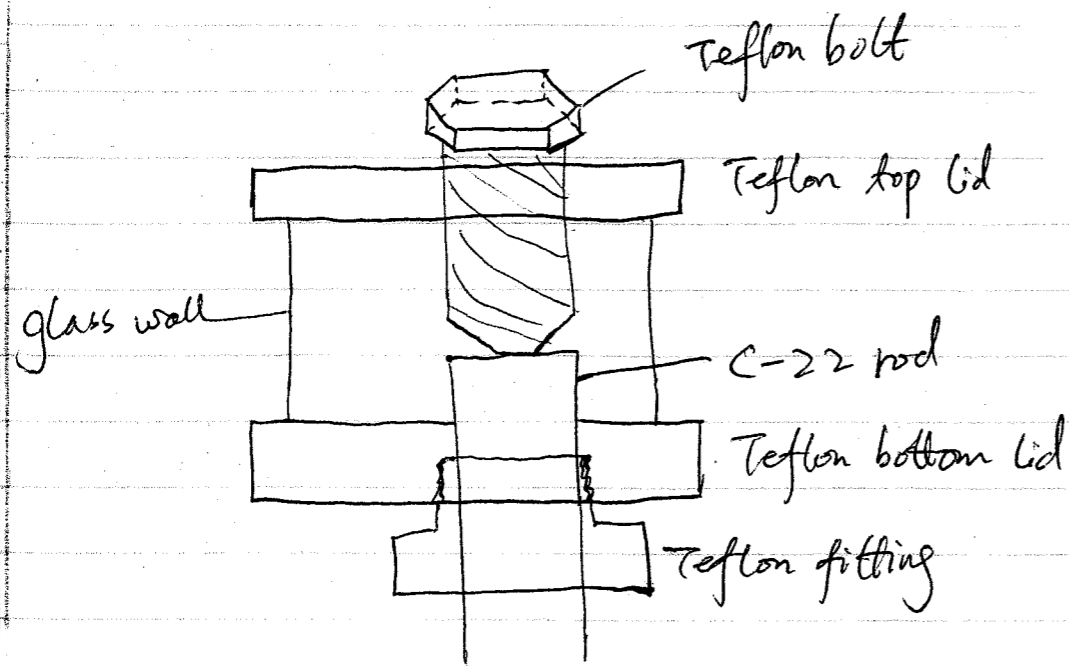
**Initial Scientific Notebook for Alloy 22 Propagation Rate Measurements****Title:** Alloy 22 Propagation Rate Measurements**Tests Performed by:** Xihua He, Div. 20; Brian Derby, Div. 18**Objectives:** Determine the propagation rate of alloy-22 as functions of time, temperature, and solution composition**Equipment:** Electrochemical test cell with single crevice, Solartron 1287 potentiostat, thermocouple and temperature controller, microscope**Materials:** Alloy 22. Material heats to be added prior to testing.**Specimen Specifications:** Cylindrical specimens 0.250"×1.915"**Measurement Parameters:** Temperature and time of exposure, Potential and Current of specimen during test, penetration depth per ASTM standard G46-94. Standard Guide for Examination and Evaluation of Pitting Corrosion (microscopical method 1 division = 1 μm)**Required Level of Accuracy:** Temperature ±2°C, Time of exposure ±1 minute, Potentials ±1 mV, Current ±0.01 microamp.**Uncertainty and Sources of Error:** Current density calculated as current divided by corroded specimen area. Actual current density of corroding areas is not determined. Current density measurement error can occur for localized processes because the actively corroding area is not the same as the creviced area of the test specimen

The initial entry was revised on 5/26/05 and posted on page 199.

The entry was revised based on CAR No: 2005-3.

Xihua He 7/15/2005

# Electrochemical Cell

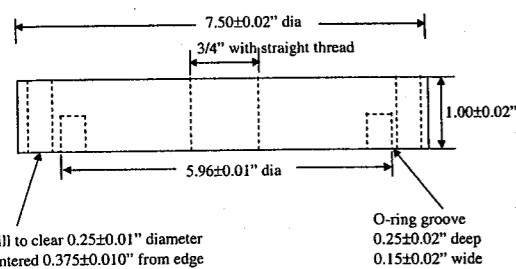
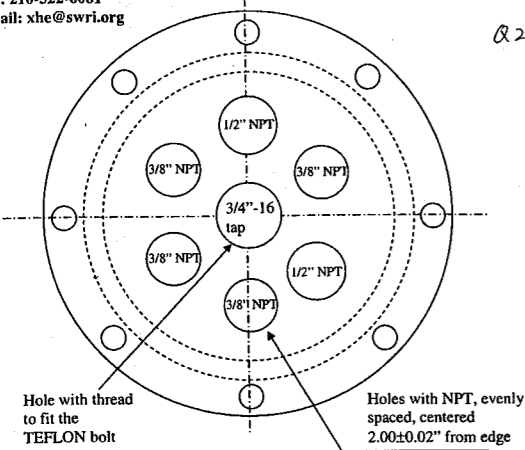


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### TEFLON top lid

SwRI drawing #  
06002.01.081.013

20.08.11



Initiated by: X. He Date 6/16/2004

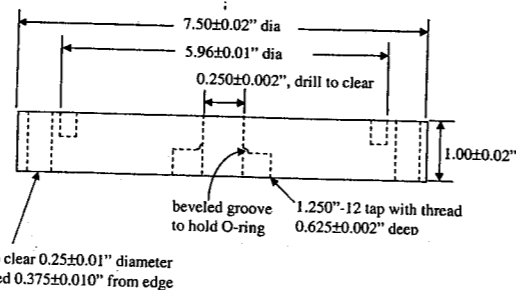
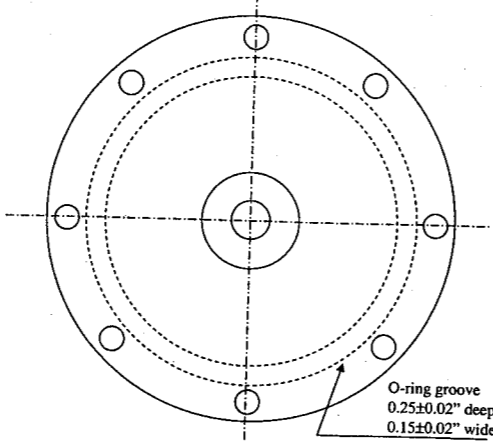
Reviewed by: V. Jain Date 6/17/04

QA approval: B. Brient Date 6/17/04

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### TEFLON bottom lid

SwRI drawing #  
06002.01.081.016



Initiated by: X. He Date 6/16/2004

Reviewed by: V. Jain Date 6/17/04

QA approval: B. Brient Date 6/17/04

Xihua He  
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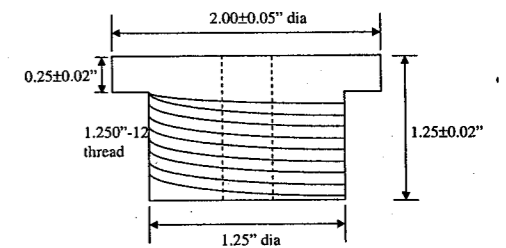
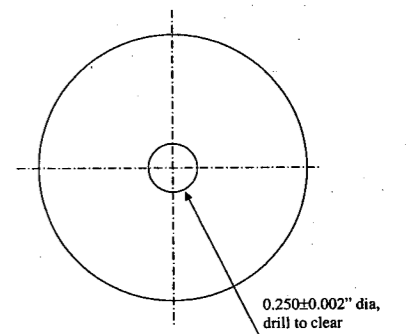
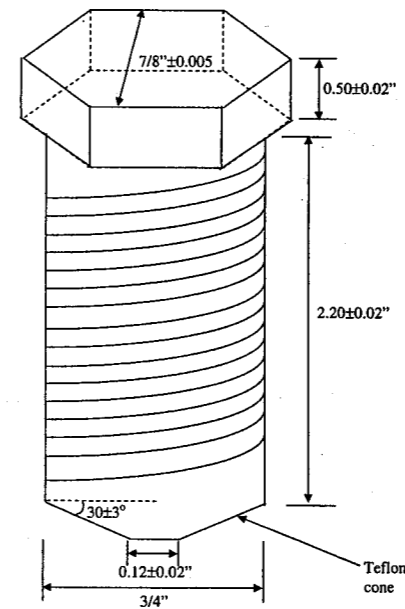
SwRI drawing #  
06002.01.081.014

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SwRI drawing #  
06002.01.081.017

### TEFLON Fitting for bottom lid

### Teflon bolt with 3/4"-16 thread to fit on top lid



Initiated by: X. He Date 6/16/2004

Reviewed by: V. Jain Date 6/17/04

QA approval: B. Brient Date 6/17/04

Initiated by: X. He Date 6/17/04

Reviewed by: V. Jain Date 6/17/05

QA approval: B. Brient Date 6/17/04

Equivalent weight of Alloy 22: 26.04 g/equivalent  
density ρ for Alloy 22: 8.69 g/cm<sup>3</sup>

X.H 5/23/05

Localized Corrosion  
C-22 Propagation Rate Measurement  
X.H 5/23/05

Alloy/Specimen: C22 with Heat # 2277-8-3175

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: Snap-on USA SN: 1001200319  
Cal: 03/03/04 Due: 9/03/04

Test ID: C22PROP001

Solution:

4M MgCl<sub>2</sub>

2033.1g MgCl<sub>2</sub> 6H<sub>2</sub>O LA # 041703 + DI H<sub>2</sub>O to 2.5L

Reagents measured with Model: OHAUS SN: 2883  
Cal: 2/04/04 Due: 8/04/04

Initial pH: 2.31 Model: Orion EA 940 SN: 2330  
Final pH: 3.69 Cal: 7/21/04 Due: 7/21/05  
pH Probe: #13-620-296 SN: 4079126P

Test Temperature: 110°C Measured with Thermocouple SN: 333  
Cal: 07/20/04 Due: 01/20/05

Counter Electrode: Platinum Flag  
Reference Electrode: Fisher 13-620-52 SN: 0199568  
Potentiostat: SI1287 Cal: 01/26/04 Due: 07/26/04

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22Prop-0803, C22Prop-0804, C22Prop-0805, C22Prop-0806,  
C22Prop-0807, C22Prop-0808, C22Prop-0809, C22Prop-0812,  
C22Prop-0815

Test dates: Aug. 3 ~ Aug. 17, 2004

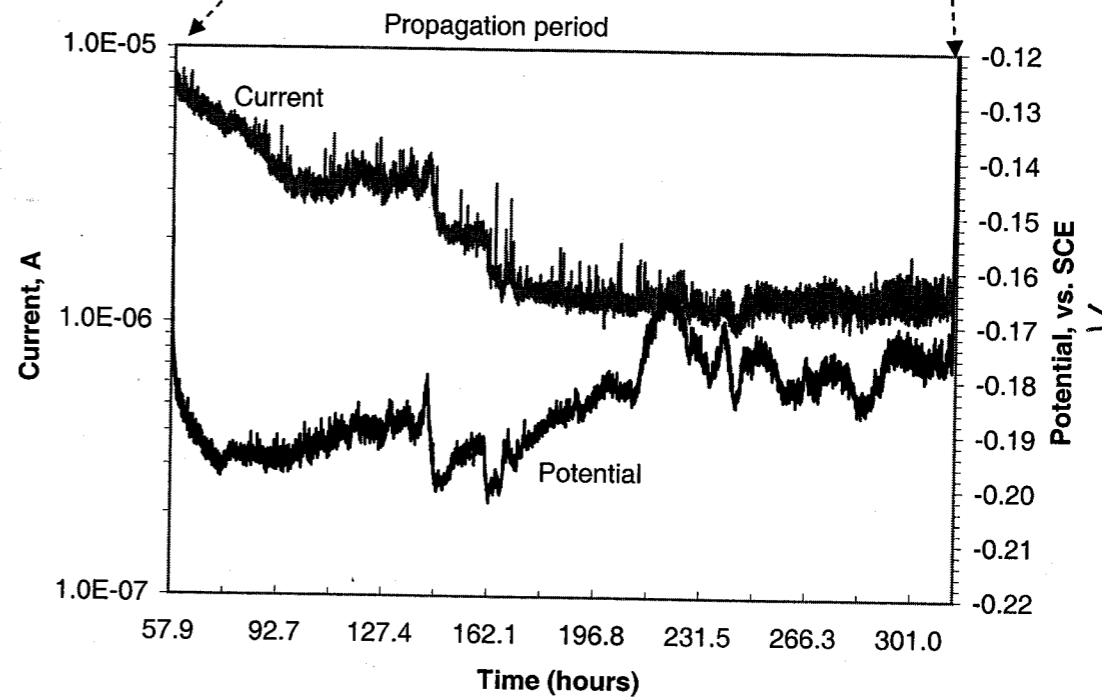
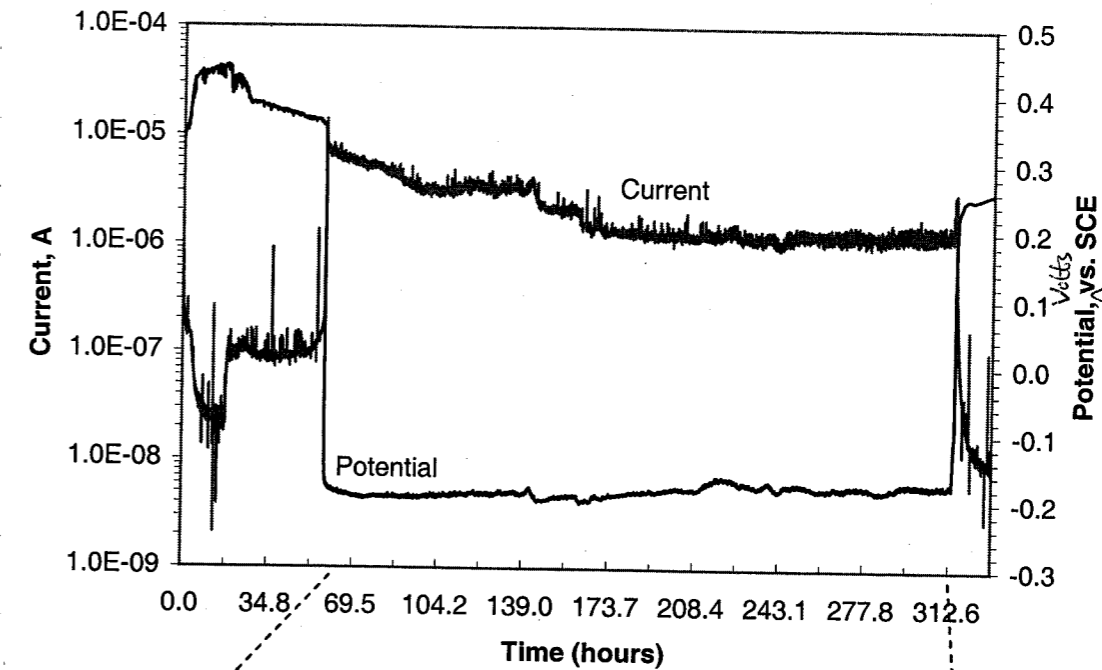
Propagation time: 70.7 days  $1.13 \times 10^6$  seconds = 313.7 hours = 13.1 days

Crevice area:  $\pi \times (\frac{3.65}{2})^2 = 10.6 \text{ mm}^2$   
Estimated crevice corroded area:  $5.9 \text{ mm}^2$

Maximum penetration depth: 130  $\mu\text{m}$

\* Specimen was cut 5-mm from the corroded front face for future use. X.H 4/26/2005

Xihua He 8/20/04



$$\text{Current density} = \frac{\text{Current (A)}}{0.106 \text{ cm}^2}$$

Xihua He 8/23/04

Localized Corrosion  
C-22 Propagation Rate Measurement  
X.H 5/23/05

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 11/7/05

Torque Screwdriver: Snap-on USA SN: 1001200319  
Cal: 03/03/04 Due: 09/03/04

Test ID: C22PR002

Solution: 4M MgCl<sub>2</sub> 2033.1g MgCl<sub>2</sub>·6H<sub>2</sub>O Lot # 041703 + D.I water to 2.5L X.H 5/2/05  
Same solution as test C22PR001 (Page 8)

Reagents measured with Model: OHAUS SN: 2883  
Cal: 7/15/04 Due: 1/15/05

Initial pH: 2.31 Model: Orion EA 940 SN: 2330  
Final pH: 3.34 Cal: 7/21/04 Due: 7/21/05  
pH Probe: #13-620-296 SN: 4079126P

Test Temperature: 110°C Measured with Thermocouple SN: 333  
Cal: 07/20/04 Due: 01/20/05

Counter Electrode: Platinum Flag  
Reference Electrode: Fisher 13-620-52 SN: 0199568  
Potentiostat: SI1287 Cal: 01/26/04 Due: 07/26/04

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22Prop-0818, C22Prop-0821, C22Prop-0824, C22Prop-0827, C22Prop-0827b

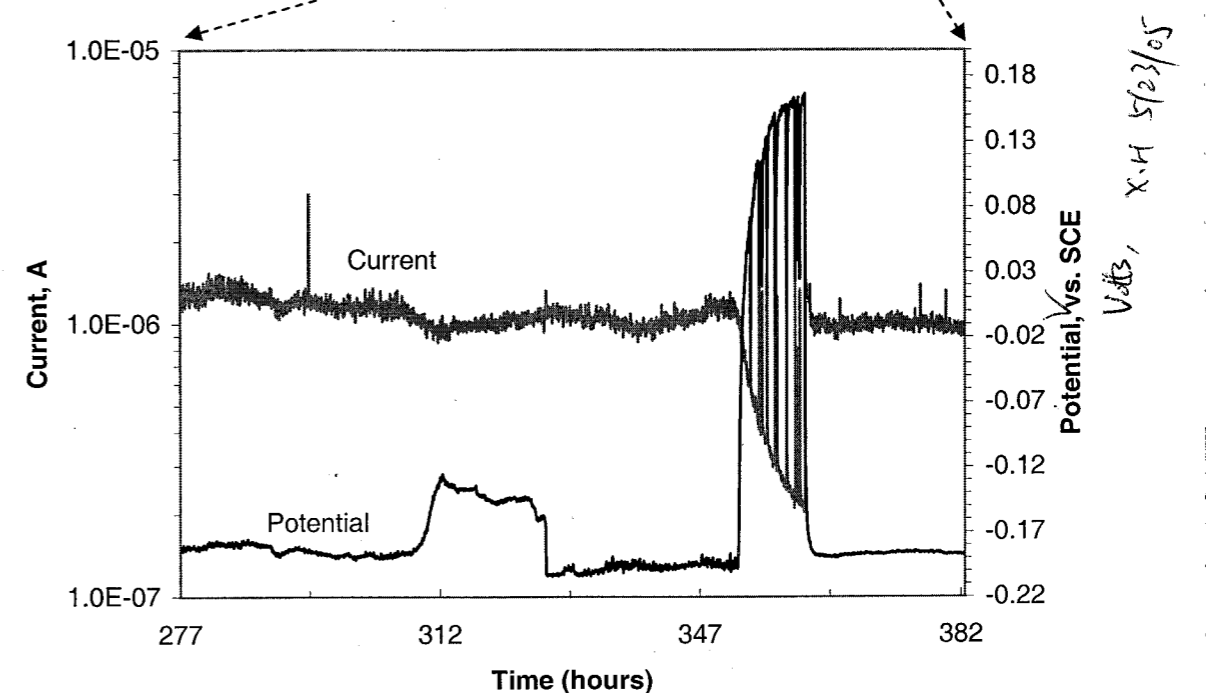
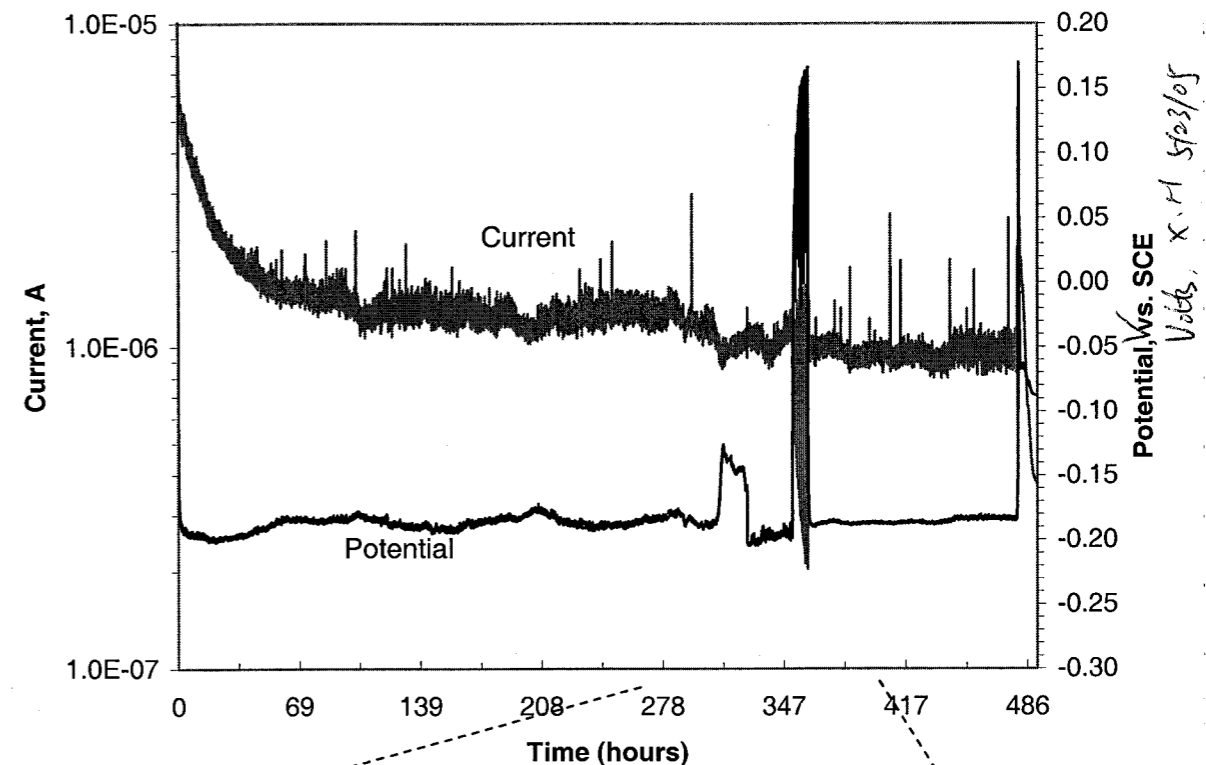
Test dates: Aug. 18 - Sept. 8, 2004 X.H 5/24/05

Test length: 480.1 hours or 1.728 x 10<sup>6</sup> seconds or 20.0 days X.H 5/23/05

Crevice area: 10.6 mm<sup>2</sup> ← (6.37 mm<sup>2</sup>)  
Estimated crevice corroded area: 128 μm X.H 5/23/05  
Maximum penetration depth: ←

Front face crevice area is corroded. There is one pit at the side which is below the solution level

Xihua He 8/20/2004



$$\text{Current density} = \frac{\text{Current (A)}}{0.106 \text{ (cm}^2\text{)}}$$

Xihua He 9/10/2004



Localized Corrosion  
C-22 Propagation Rate Measurement

X.H 5/23/05

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

Specimen Preparation: Specimen machined to dimensions 1.917" x 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:

Snap-on USA  
Cal: 09/03/04

SN: 1001200319  
Due: 03/03/05

Test ID C22PROD3

Solution:

4M MgCl<sub>2</sub> 2033.1g MgCl<sub>2</sub> · 6H<sub>2</sub>O Lot # 041703 + DI water to 2.5L. X.H 5/23/05

same solution as test C22PROD1 (page 8)

Reagents measured with

Model: OHAUS  
Cal: 7/15/04

SN: 2883  
Due: 1/15/05

Initial pH: 2-3/  
Final pH:

Model: Orion EA 940  
Cal: 7/21/04

SN: 2330  
Due: 7/21/05  
SN: 4079126P

(not available, solution was drained away)

Test Temperature: 116°C

Measured with Thermocouple  
Cal: 07/20/04

SN: 333  
Due: 01/20/05

Counter Electrode: Platinum Flag

Reference Electrode: Fisher 13-620-52

Potentiostat: SI1287

Cal: 09/08/04

SN: 0199568  
Due: 03/26/05

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22Prop-0910, C22Prop-0913, C22Prop-0916

Test dates: Sept. 10 ~ Sept. 16, 2004

Test length: 130.5 hours or 4.698 x 10<sup>5</sup> seconds or 5.44 days

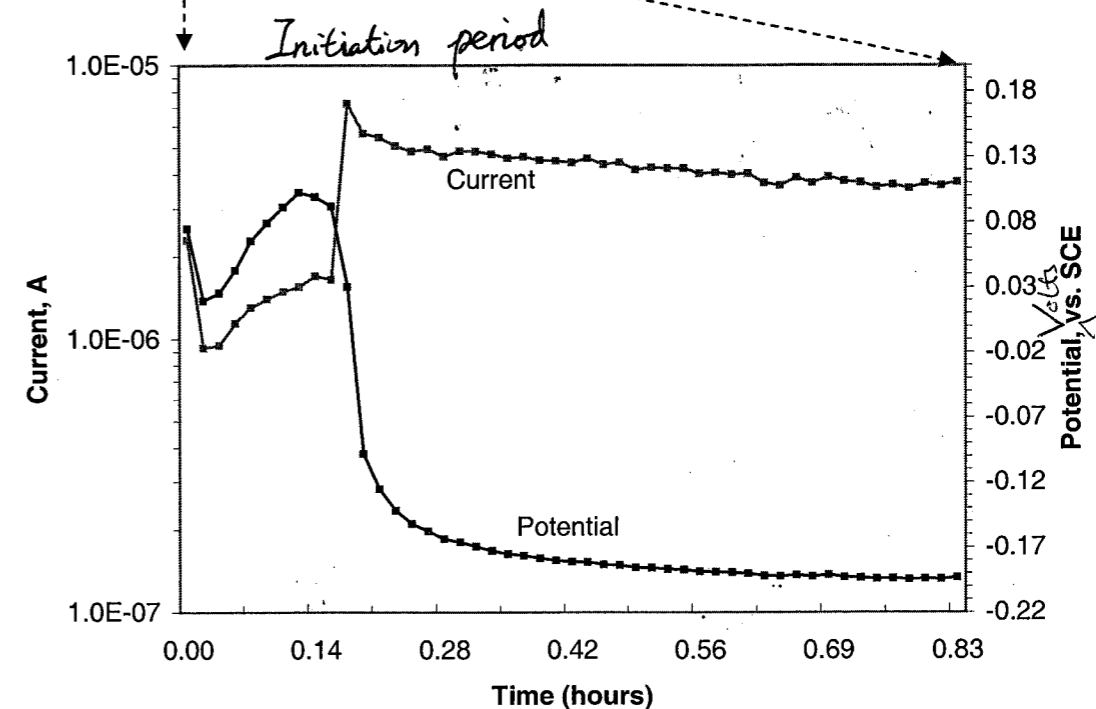
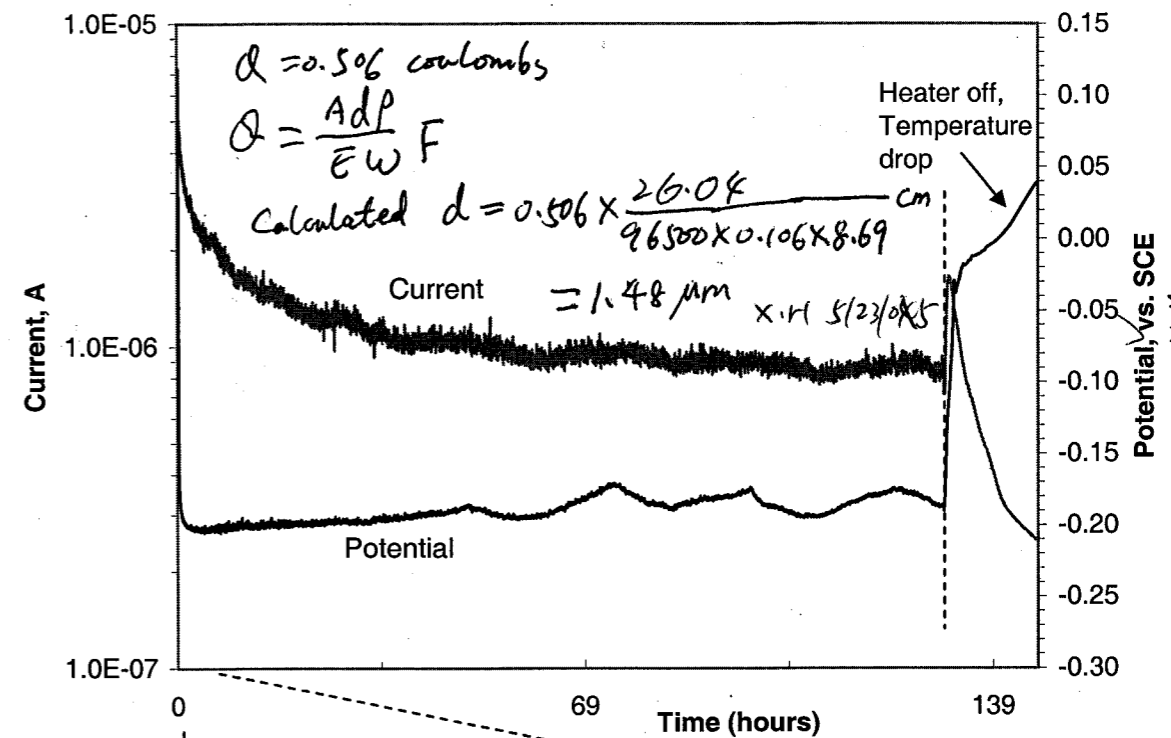
Crevice area: 10.6 mm<sup>2</sup>

Estimated crevice corroded area: 1.70 mm<sup>2</sup>

Maximum penetration depth: 116 μm

\* Specimen was cut 5-mm from the corroded front surface. The longer section without corrosion is used for later tests. X.H 4/26/2005

Xihua He 9/16/2004



Crevice corrosion is initiated in 675 seconds

$$\text{Current density} = \frac{\text{Current (A)}}{0.106 \text{ (cm}^2\text{)}}$$

Xihua He 9/16/2004

Localized Corrosion  
C-22 Propagation Rate Measurement

X.H. 5/23/05

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

Specimen Preparation: Specimen machined to dimensions 1.917" x 0.250" specified in CNWRA Drawing # 20-04402-5 7/01/04. 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. a precision compression stainless steel spring 0.80" (OD) x 0.026" (wire diameter) x 0.562" (length) purchased from McMaster-Carr. The spring is coated with microstop. X.H. 11/4/05

Torque Screwdriver: Snap-on USA SN: 1001200319 Cal: 09/03/04 Due: 03/03/05 X.H. 10/11/04

Test ID: C22PRO04

Solution:

4M MgCl<sub>2</sub> 2033.1g MgCl<sub>2</sub> · 6H<sub>2</sub>O Lot # 041703 + D.I water to 2.5 L. X.H. 5/23/05

Same solution as test C22PRO01 (Page 8)

Reagents measured with Model: OHAUS SN: 2883 Cal: 7/15/04 Due: 1/15/05

Initial pH: 2.31 Model: Orion EA 940 SN: 2330 Cal: 7/21/04 Due: 7/21/05  
Final pH: 4.1 pH Probe: #13-620-296 SN: 4079126P Cal: 5/14/04 Due: 11/14/04

Initial weight: Data was not taken X.H. 5/23/05  
Final weight: 12.29862 g model: Sartorius Genius SN: 12809099 Cal: 5/14/04 Due: 11/14/04

Test Temperature: 110°C Measured with Thermocouple SN: 333 Cal: 07/20/04 Due: 01/20/05

Counter Electrode: Platinum Flag  
Reference Electrode: Fisher 13-620-52 SN: 0199568  
Potentiostat: SI1287 Cal: 09/08/04 Due: 03/26/05

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22Prop-0923, C22Prop-0926, C22Prop-0929, C22Prop-1002, C22Prop-1005

Test dates: Sept. 23 - Oct. 7, 2004

Test length: 310.4 hours = 1.12 x 10<sup>6</sup> seconds = 12.9 days

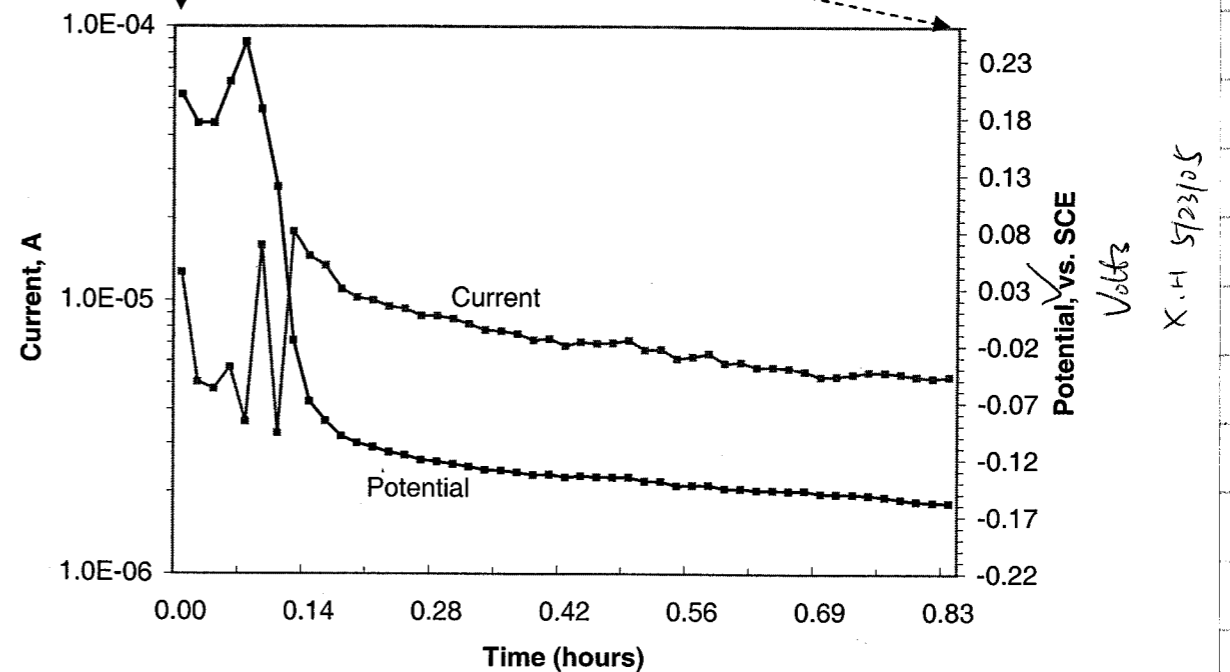
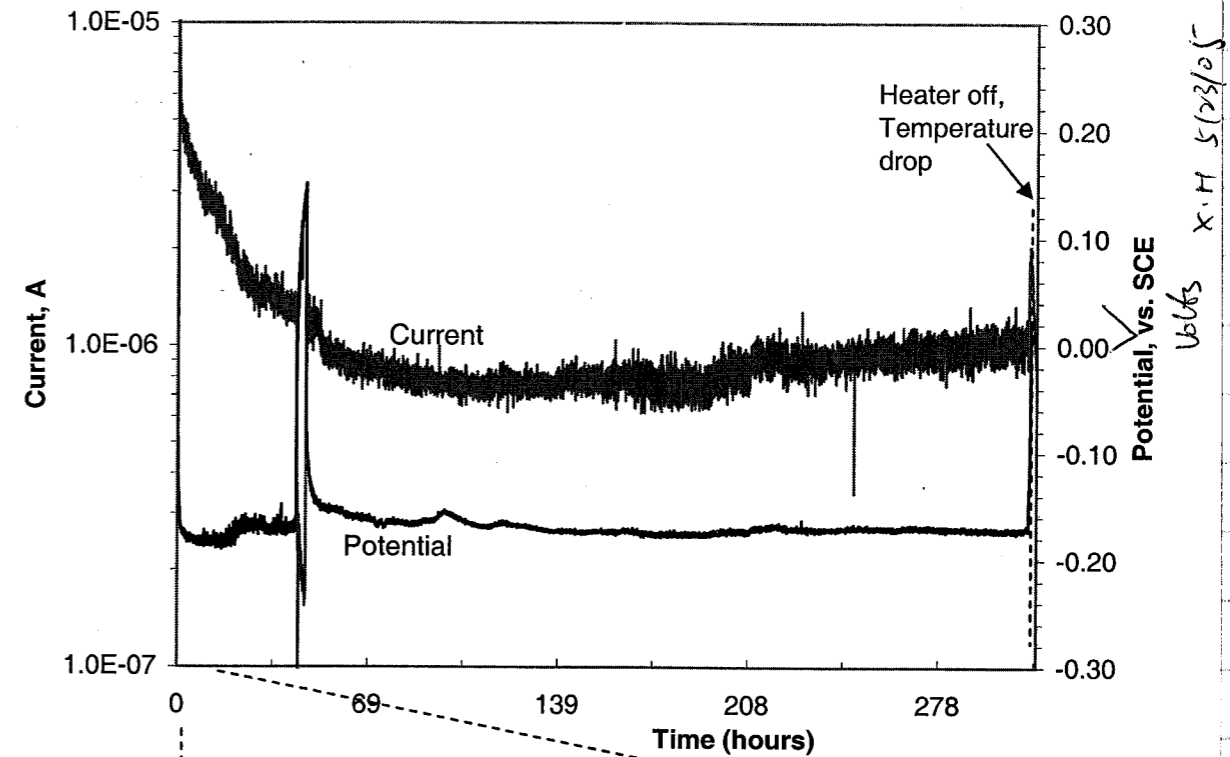
Crevice area:  $\pi \left( \frac{0.0955 \times 2.54}{2} \right)^2 = 4.62 \text{ mm}^2$

Estimated crevice corroded area: It is hard to decide. There are many pits.

Maximum penetration depth: 108 μm

Specimen examination: The creviced area is well defined. Many pits in the creviced area. Most are very shallow. Surface staining in occluded region.

Xibua He 10/11/04



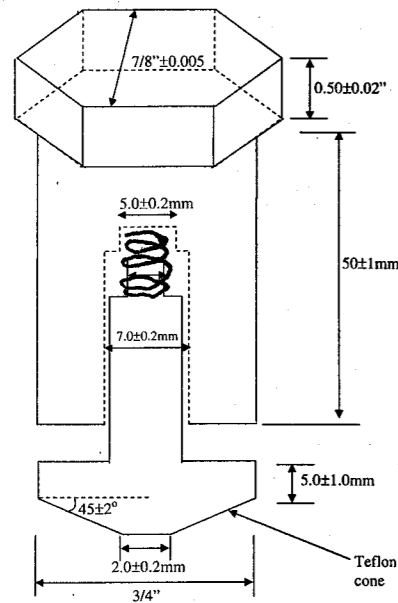
$$\text{Current density} = \frac{\text{Current (A)}}{0.0462 \text{ (cm}^2\text{)}}$$

Xibua He 10/18/04

Modified Teflon Bolt with spring inside

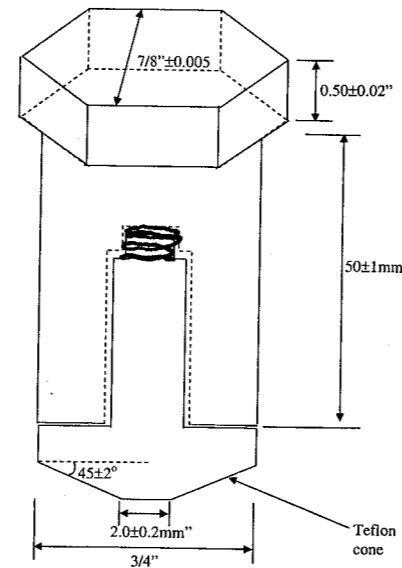
CNWA drawing #:

Teflon bolt with 3/4"-16 thread to fit on top lid while internal spring is not compressed



CNWA drawing #: 06002-01-081.019 top part

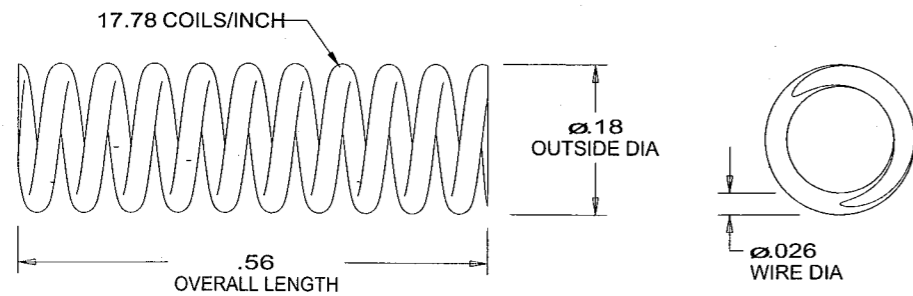
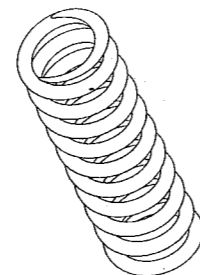
Teflon bolt with 3/4"-16 thread to fit on top lid while internal spring is compressed



06002-01-081.020

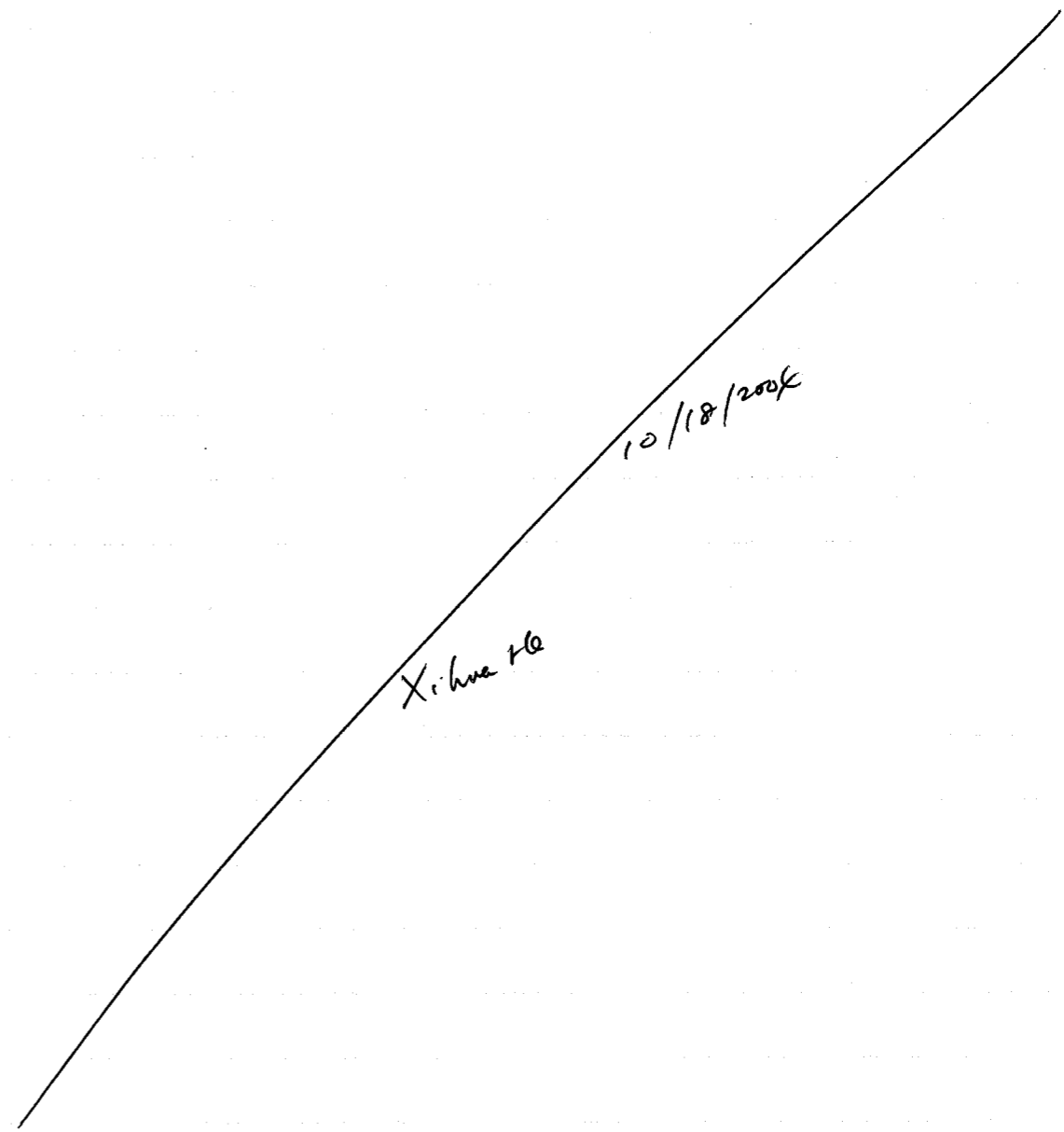
lower part

x-H 5/23/05



<b>McMASTER-CARR</b> SUPPLY COMPANY	PART NUMBER: 94350K3
	302 SS PRECISION COMPRESSION
DATE: May 2001	SPRING 9/16 OVERALL
SCALE: 9.000 : 1	LENGTH .18 OD .026 WIRE
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES	
http://www.mcmaster.com (c) 2001 McMaster-Carr Supply Company	

OUTSIDE DIAMETER TOLERANCE IS +.0037-.005" AND RATE TOLERANCE IS ±0.8%



Xihua He 10/18/04

C-22 Propagation Rate Measurement

Localized Corrosion

X.H. 5/23/05

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

Specimen Preparation: Specimen machined to dimensions 1.917" x 0.250" specified in CNWRA Drawing # 2001402 5/7/07. 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

Test ID: ~~C22PR005~~ C22PR005

Torque Screwdriver: X.H. 10/14/04 Snap-on USA SN: 1001200319 Cal: 09/03/04 Due: 03/03/05

Solution: 4 M MgCl2 2033.1 g MgCl2 · 6H2O Lot # 041703 + D.I water to 2.5 L Same solution as test C22PR001 (Page 8) X.H. 5/23/05

Initial weight: 12.40431 g Model: Sartorius Genius SN: 12809099 Cal: 05/14/04 Due: 11/14/04

Final weight: 12.40234 g Reagents measured with Model: OHAUS SN: 2883 Cal: 7/15/04 Due: 1/15/05

Initial pH: 2.310 Model: Orion EA 940 SN: 2330 Cal: 7/21/04 Due: 7/21/05

Final pH: 5.277 pH Probe: #13-620-296 SN: 4079126P

Test Temperature: 110°C Measured with Thermocouple SN: 333 Cal: 07/20/04 Due: 01/20/05

Counter Electrode: Platinum Flag Reference Electrode: Fisher 13-620-52 SN: 0199568 Potentiostat: SI1287 Cal: 10/06/04 Due: 04/06/05

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: ~~C22PR-0925, C22PR-0926, C22PR-0929, C22PR-1002, C22PR-1005~~ C22PR-1007, C22PR-1010 X.H. 10/11/04

Test dates: Oct. 7 ~ Oct. 12, 2004

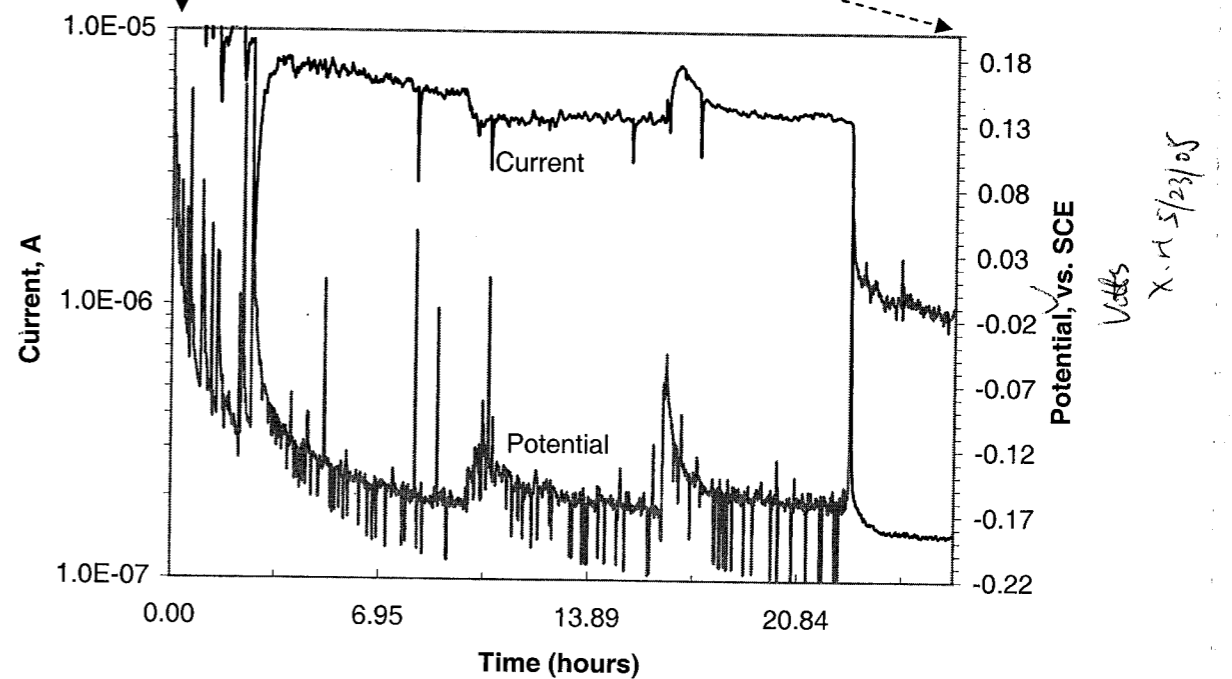
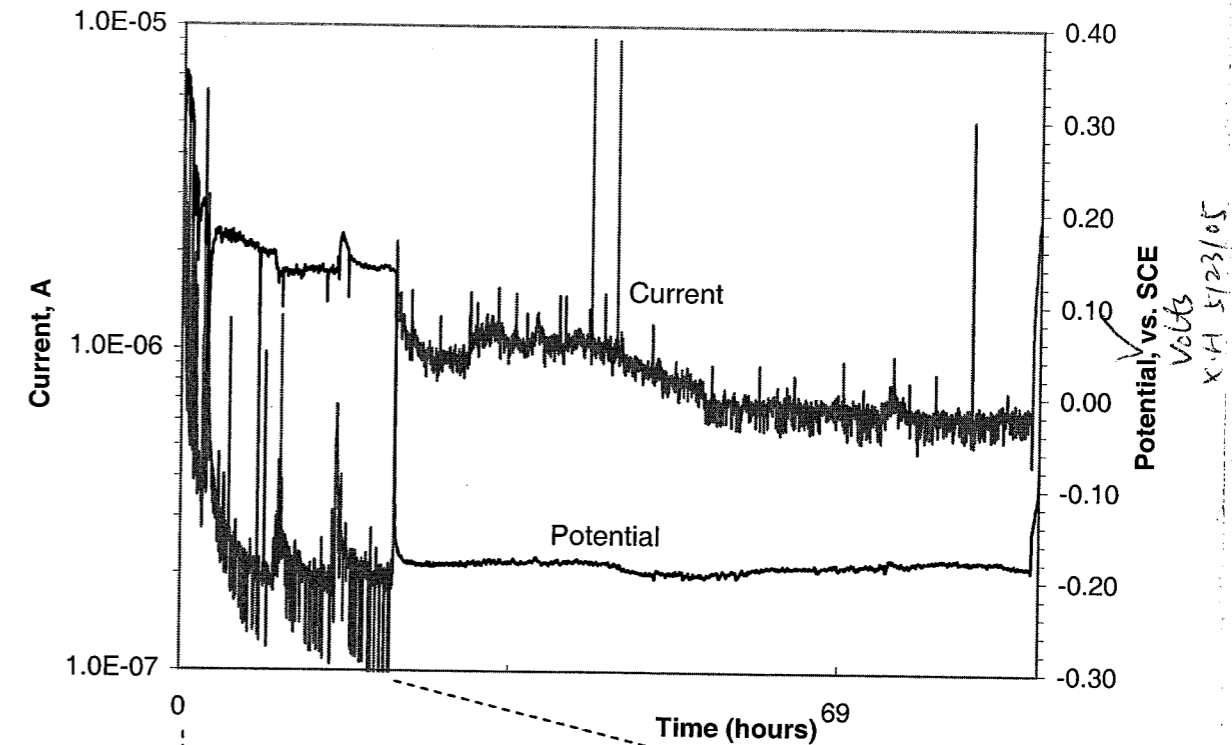
Test length: 89.7 hours = 3.23 x 10^5 seconds = 3.7 days

Crevice area: 10.6 mm^2 Estimated crevice corroded area: 0.748 mm^2 Maximum penetration depth: 46 μm

Specimen examination:

Corrosion is around the edge. There is mild surface staining.

X The specimen was cut 5-mm from the corroded front surface. The longer section without corrosion will be used for future tests. X.H. 4/26/05 Xihua He 10/11/2004



$$\text{Current density} = \frac{\text{Current (A)}}{0.106 \text{ (cm}^2\text{)}}$$

Xihua He 10/18/2004

C-22 Propagation Rate Measurement

Localized Corrosion X.H. 5/23/05

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

Specimen Preparation: Specimen machined to dimensions 1.917\*\*0.250" specified in CNWRA Drawing # 22.014.02. 5/21/05  
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

Test ID: C22PR006

Torque Screwdriver: Snap-on USA SN: 1001200319  
Cal: 09/03/04 Due: 03/03/05

Solution: 4M MgCl2 2033.1 g MgCl2.6H2O Lot # 041703 + D.I water to 2.5L  
Same solution as test C22PR001 (page 8) X.H. 5/23/05

Initial weight: 12.48822 g Model: Sartorius Genius SN: 12809099  
Final weight: 12.48796 g Cal: 05/14/04 Due: 11/14/04

Reagents measured with Model: OHAUS SN: 2883  
Cal: 7/15/04 Due: 1/15/05

Initial pH: 2.31 Model: Orion EA 940 SN: 2330  
Final pH: 4.95 Cal: 7/21/04 Due: 7/21/05  
pH Probe: #13-620-296 SN: 4079126P

Test Temperature: 110°C Measured with Thermocouple SN: 333  
Cal: 07/20/04 Due: 01/20/05

Counter Electrode: Platinum Flag  
Reference Electrode: Fisher 13-620-52 SN: 0199568  
Potentiostat: SI1287 Cal: 10/06/04 Due: 04/06/05

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22Prop-1014, C22Prop-1017, C22Prop-1020 X.H. 5/23/05

Test dates: Oct. 14 ~ Oct. 20, 2004

Test length:  $5.997 \times 10^5$  seconds = 166.6 hours = 6.94 days X.H. 5/23/05

Crevice area: 10.6 mm<sup>2</sup> X.H. 5/23/05

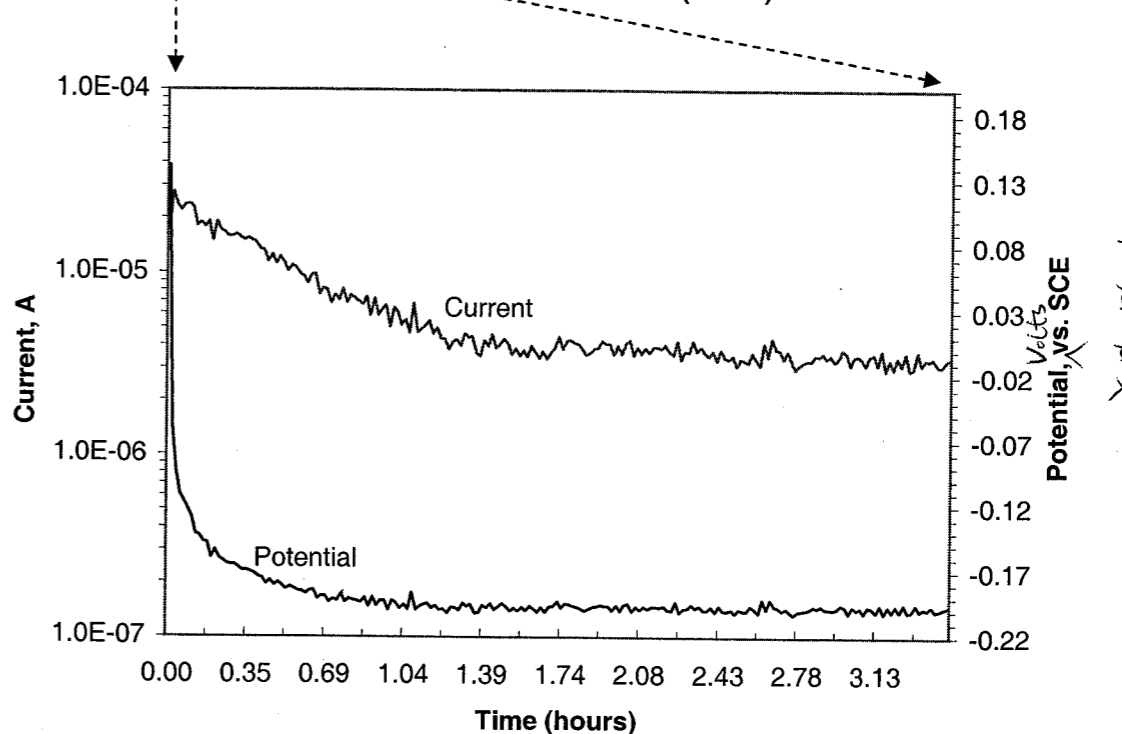
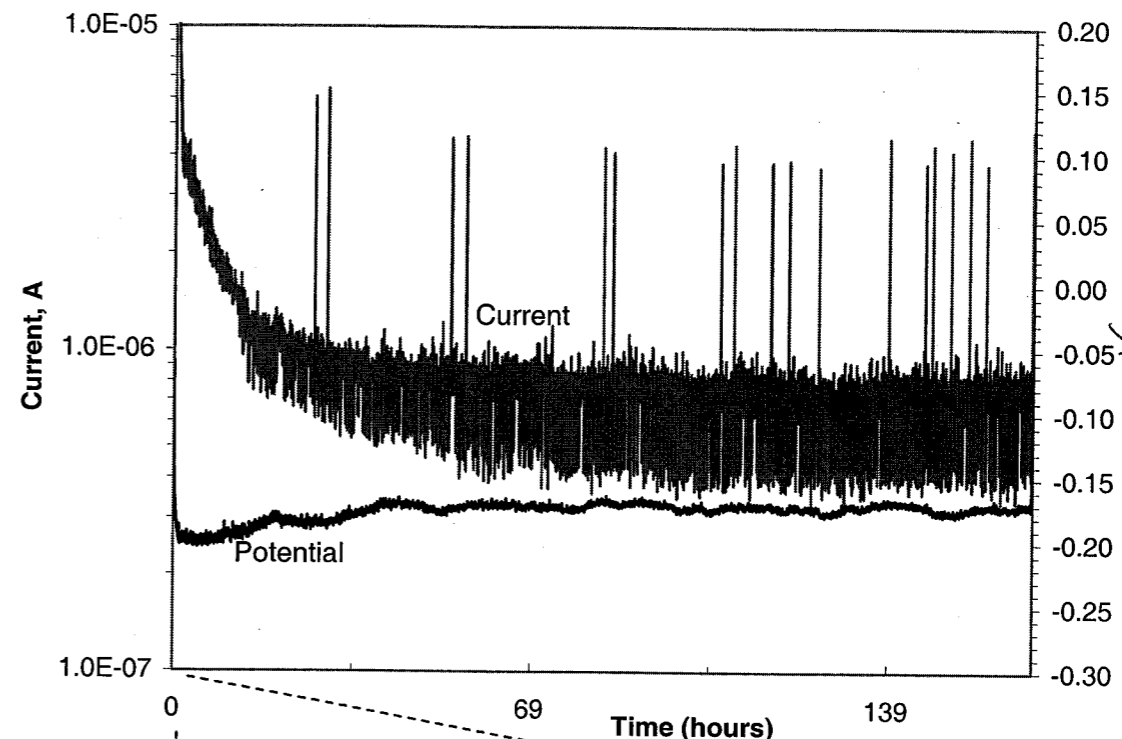
Estimated crevice corroded area: 3 mm<sup>2</sup> X.H. 5/23/05

Maximum penetration depth: 56 mm X.H. 5/23/05

Corrosion around part of the edge of the crevice area. No corrosion at

other area. X.H. 4/26/05  
\* The ~~spec~~ specimen was cut 5-mm from the corroded front surface. The longer section without corrosion will be used for future tests. X.H. 4/26/2005

Xihua He 12/14/04



\* The noise in current is due to random noise from the environment.  
Current density =  $\frac{\text{Current (A)}}{0.106 \text{ (cm}^2\text{)}}$   
Xihua He 10/22/2004

C-22 Propagation Rate Measurement  
Localized Corrosion X.H 5/23/05

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

Specimen Preparation: Specimen machined to dimensions 1.917" x 0.250" specified in CNWRA Drawing # 20-01602-571-019  
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 5/23/05

Test ID: C22PROP

Torque Screwdriver:

Snap-on USA  
Cal: 09/03/04

SN: 1001200319  
Due: 03/03/05

Solution: 4M MgCl<sub>2</sub> 2033.1g MgCl<sub>2</sub>·6H<sub>2</sub>O Lot # 041703 + D.I water to 2.5L  
Same solution as test C22PROP (page 8) X.H 5/23/05

Initial weight: 12.27206 g  
Final weight: 12.26925 g

Model: Sartorius Genius  
Cal: 05/14/04

SN: 12809099  
Due: 11/14/04

Reagents measured with

Model: OHAUS  
Cal: 7/15/04

SN: 2883  
Due: 1/15/05

Initial pH: 2.31  
Final pH: 5.25

Model: Orion EA 940  
Cal: 7/21/04  
pH Probe: #13-620-296

SN: 2330  
Due: 7/21/05  
SN: 4079126P

Test Temperature: 110°C

Measured with Thermocouple  
Cal: 07/20/04

SN: 333  
Due: 01/20/05

Counter Electrode: Platinum Flag

Reference Electrode: Fisher 13-620-52

SN: 0199568

Potentiostat: SI1287

Cal: 10/06/04

Due: 04/06/05

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22Prop-1025

Test dates: Oct. 25 ~ Oct 27, 2004

Test length:  $1.516 \times 10^5$  s = 42.11 hours = 1.75 days

Crevice area: 10.6 mm<sup>2</sup>

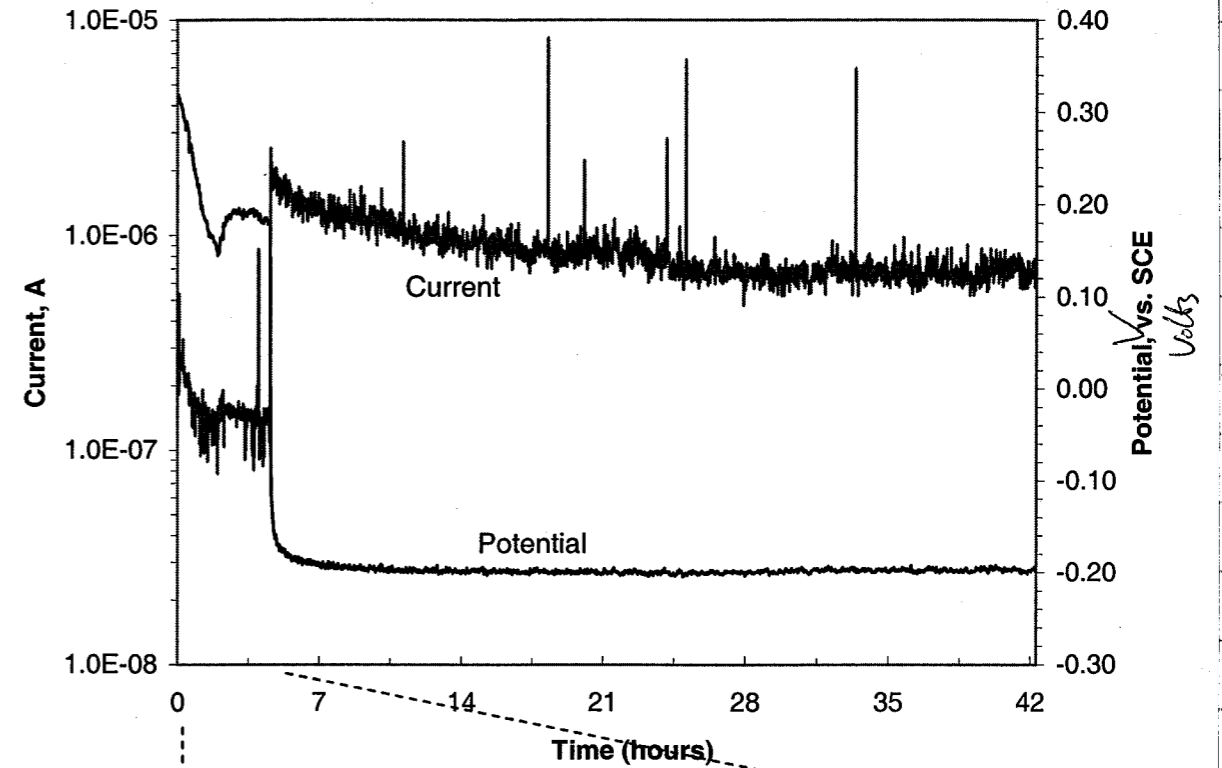
Estimated crevice corroded area:

Maximum penetration depth:

It is difficult to determine because the corrosion is at the side.

One spot at the side is corroded. No corrosion at the creviced region  
Specimen will be polished for future use.

Xihua He 10/27/04



X.H 5/23/05

X.H 5/23/05

Xihua He 11/1/04

*Localized Corrosion*  
C-22 Propagation Rate Measurement  
X.H. 5/23/05

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

Specimen Preparation: Specimen machined to dimensions 1.917" x 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 a precision compression stainless steel spring 0.180" (OD) X 0.026" (wire diameter) X 0.562" (length) purchased from McMaster-Carr. The spring is coated with microstop. (page 16) X.H. 11/3/05

Solution: 4 M MgCl<sub>2</sub>, same as test C22PR001, page 8

Test ID: ~~C22PR008~~ C22PR008 2033.1g MgCl<sub>2</sub>·6H<sub>2</sub>O lot # 041703 + D.I H<sub>2</sub>O to 2.5L X.H. 5/23/05

Initial weight: 12.35256g Model: Sartorius Genius SN: 12809099 Cal: 05/14/04 Due: 11/14/04 X.H. 5/23/05

Reagents measured with Model: OHAUS SN: 2883 Cal: 7/15/04 Due: 1/15/05

Initial pH: 2.31 Model: Orion EA 940 SN: 2330 Cal: 7/21/04 Due: 7/21/05  
Final pH: 5.04 pH Probe: #13-620-296 SN: 40791266

Test Temperature: 110°C Measured with Thermocouple SN: 333 Cal: 07/20/04 Due: 01/20/05

Counter Electrode: Platinum Flag SN: 0199568  
Reference Electrode: Fisher 13-620-52 Due: 04/06/05  
Potentiostat: SI1287 Cal: 10/06/04

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22Prop-1028, C22Prop-1031, C22Prop-1103

Test dates: Oct. 28 ~ Oct. Nov. 3, 2004 X.H. 11/4/2004

Test length:  $7.5 \times 10^5$  seconds = 208.3 hours = 8.68 days

Crevice area: 11.4 mm<sup>2</sup>  
Estimated crevice corroded area: 2.33 mm<sup>2</sup>

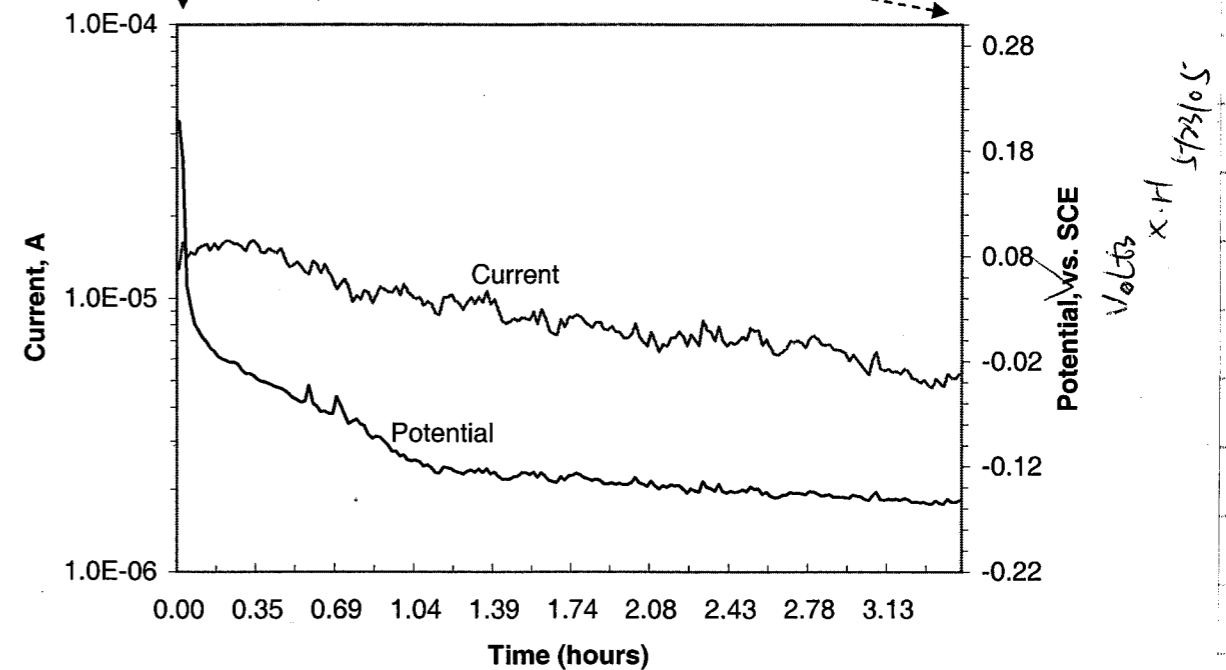
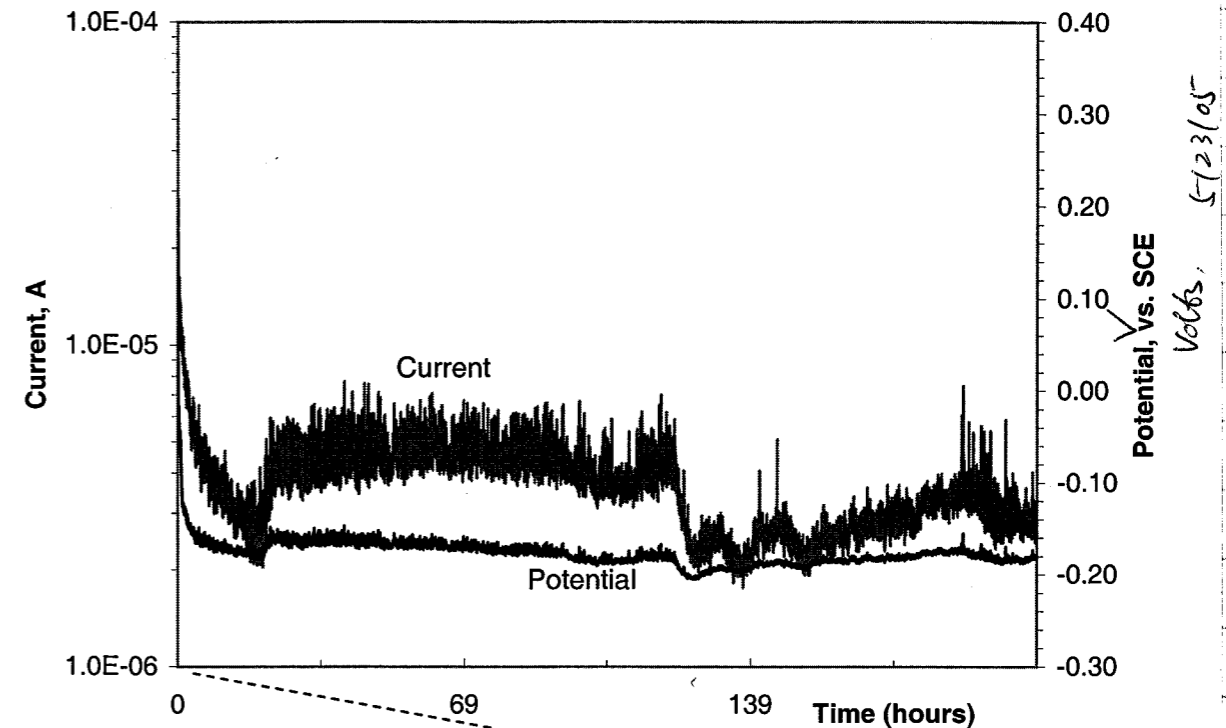
Maximum penetration depth: 146 μm

Specimen examination:

There is corrosion in the crevice area, but it is localized at the edge.

\* The specimen was cut 5-mm from the corroded front surface. The longer section without corrosion will be used for future use. X.H. 4/26/2005

Xihua He 11/4/2004



$$\text{Current density} = \frac{\text{Current (A)}}{0.114 \text{ cm}^2}$$

Xihua He 11/15/2004

*Localized corrosion*  
**C-22 Propagation Rate Measurement**  
*X.H 5/23/05*

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

**Specimen Preparation:** Specimen machined to dimensions 1.917" x 0.250" specified in CNWRA Drawing # 20402.571.019. 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 a precision compression stainless steel spring 0.180" (OD) X 0.026" (wire diameter) X 0.562" (length) purchased from McMaster-Carr. The spring is coated with microstop. *page (6)*

**Solution:** 4 M MgCl<sub>2</sub>, same as test C22PR001, page 8 *2033.1g MgCl<sub>2</sub>·6H<sub>2</sub>O Lot # 041703 + DI H<sub>2</sub>O to 25L*

**Test ID:** C22PR009  
**Initial weight:** 12.33748 g  
**Final weight:** 12.33709 g

**Model:** Sartorius Genius  
**Cal:** 05/14/04  
*11/10 X.H 11/18/04*

**SN:** 12809099  
**Due:** 11/14/04 *05/10/05*

**Reagents measured with**

**Model:** OHAUS  
**Cal:** 7/15/04

**SN:** 2883  
**Due:** 1/15/05

**Initial pH:** 2.31  
**Final pH:** 5.131

**Model:** Orion EA 940  
**Cal:** 7/21/04  
**pH Probe:** #13-620-296

**SN:** 2330  
**Due:** 7/21/05  
**SN:** 4079126P

**Test Temperature:** 110°C

**Measured with Thermocouple**  
**Cal:** 07/20/04

**SN:** 333  
**Due:** 01/20/05

**Counter Electrode:** Platinum Flag

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

**Potentiostat:** SI1287

**Cal:** 10/06/04

**SN:** 0199568  
**Due:** 04/06/05

**Cell set up:** WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

**Data Files:** C22PROP-1110, C22PROP-1113, C22PROP-1116

**Test dates:** Nov 10 ~ Nov 16, 2004

**Test length:**  $1.90 \times 10^2$  hours =  $6.82 \times 10^5$  seconds = 7.92 days

**Crevice area:** 4.38 mm<sup>2</sup>

**Estimated crevice corroded area:** 1.21 mm<sup>2</sup>

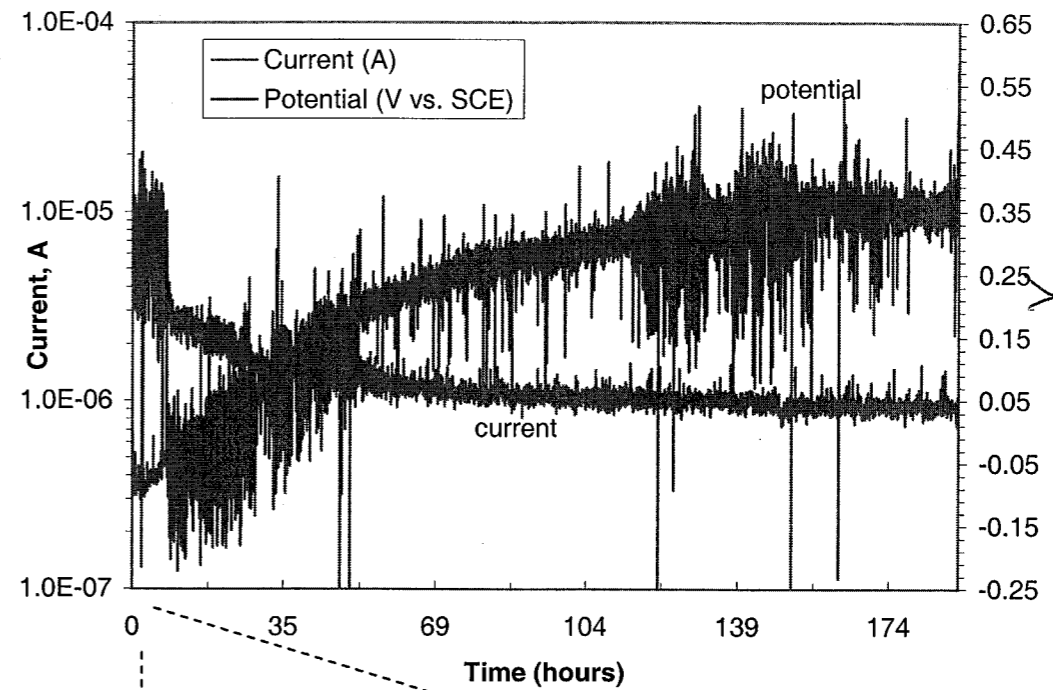
**Maximum penetration depth:** 70 μm

**Specimen examination:**

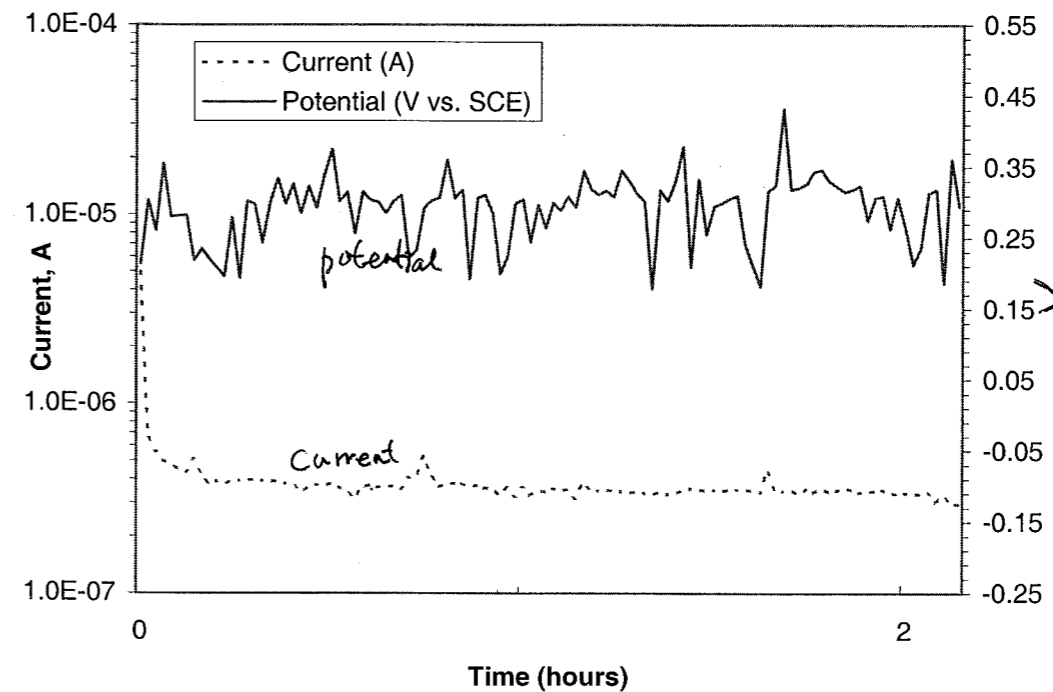
*Crevice corrosion and surface staining*

\* The specimen was cut 5-mm from the corroded front surface. The longer section without corrosion will be used for future use.  
*X.H 4/26/05*

*Xihua He 11/18/2004*



*\* Random noise in current and potential.*  
*Volts X.H 5/23/05*



*Volts X.H 5/23/05*

$$\text{Current density} = \frac{\text{Current (A)}}{0.0438 \text{ cm}^2}$$

*Xihua He 11/22/2004*



*Localized Corrosion*  
**C-22 Propagation Rate Measurement**  
*X-H 5/23/05*

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

**Specimen Preparation:** Specimen machined to dimensions 1.917" x 0.250" specified in CNWRA Drawing # 20 01402.57.09. 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 a precision compression stainless steel spring 0.180" (OD) X 0.026" (wire diameter) X 0.562" (length) purchased from McMaster-Carr. The spring is coated with microstop. (page 16)

*cell #2*  
**Solution:** 4 M MgCl<sub>2</sub>, same as test C22PR001, page 8 *2033.1 g MgCl<sub>2</sub>·6H<sub>2</sub>O Lot # 041703 + D.I water to 2.5L*  
**Test ID:** C22PR010 *X-H 5/23/05*

**Initial weight:** 12.26324 g **Model:** Sartorius Genius **SN:** 12809099  
**Final weight:** 12.26332 g **Cal:** 05/14/04 11/0/04 **Due:** 11/14/04 05/10/05  
*X-H 11/18/04* *X-H 11/18/04*

**Reagents measured with**  
**Model:** OHAUS **SN:** 2883  
**Cal:** 7/15/04 **Due:** 1/15/05

**Initial pH:** 2.31 **Model:** Orion EA 940 **SN:** 2330  
**Final pH:** 4.718 **Cal:** 7/21/04 **Due:** 7/21/05  
**pH Probe:** #13-620-296 **SN:** 4079126P

**Test Temperature:** 110°C **Measured with Thermocouple** **SN:** 335  
**Cal:** 07/20/04 **Due:** 01/20/05

**Counter Electrode:** Platinum Flag  
**Reference Electrode:** Fisher 13-620-52 **SN:** 9250078  
**Potentiostat:** SI1287 **Cal:** 09/09/04 **Due:** 03/09/05

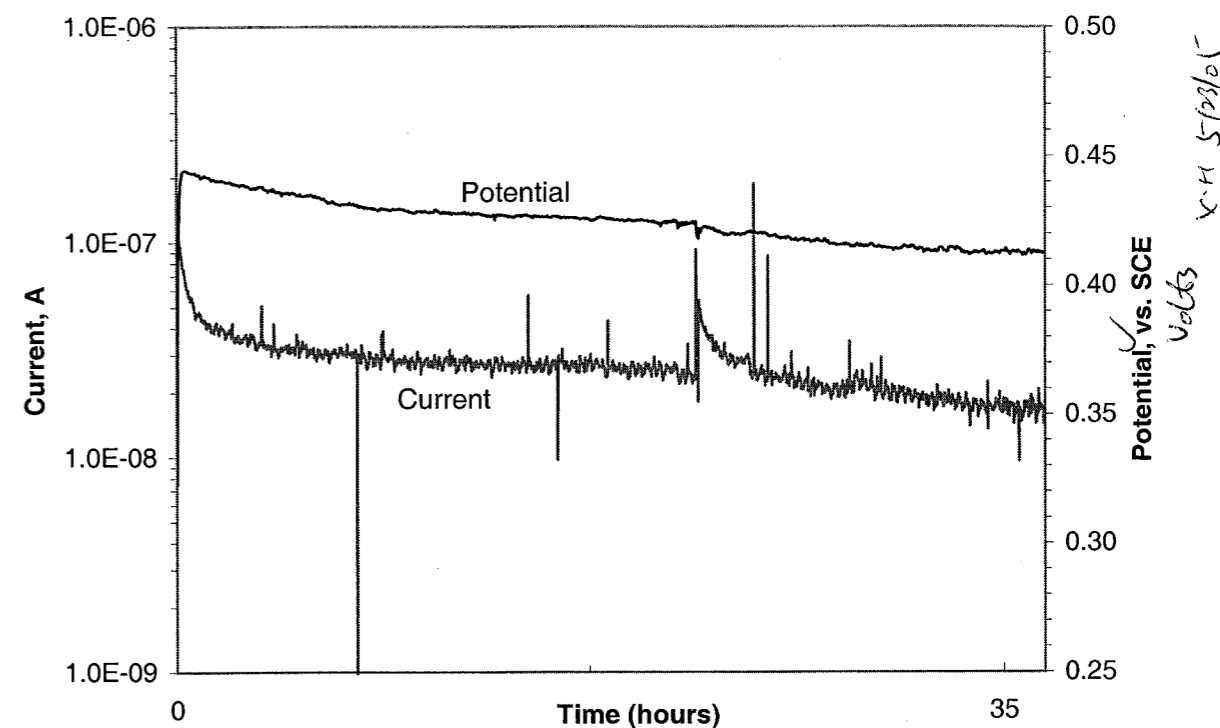
**Cell set up:** WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

**Data Files:** C22Prop-1116 #2  
**Test dates:** Nov. 16 ~ Nov. 18, 2004  
**Test length:** ~ 36 hours

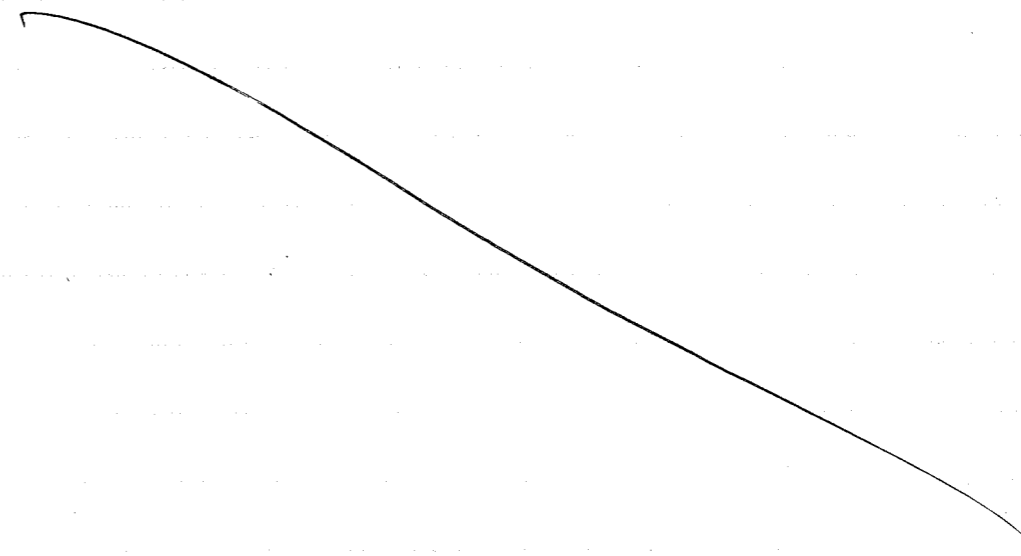
**Crevice area:** 4.38 mm<sup>2</sup>  
**Estimated crevice corroded area:** 0  
**Maximum penetration depth:** 0  
**Specimen examination:**

*No corrosion. Specimen will be polished for future use.*

*Xihua He 11/18/2004*



*\* Maybe the contact between Teflon bolt and C-22 specimen is too loose, no corrosion in crevice area.*  
*\* Current is low and potential is high. No initiation.*



*Xihua He 11/22/2004*

Localized Corrosion  
C-22 Propagation Rate Measurement  
X.H. 5/23/05

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

Specimen Preparation: Specimen machined to dimensions 1.917" x 0.250" specified in CNWRA Drawing # 20-01402-57101. 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 a precision compression stainless steel spring 0.180" (OD) X 0.026" (wire diameter) X 0.562" (length) purchased from McMaster-Carr. The spring is coated with microstop. (cell #1)

Solution: 4 M MgCl<sub>2</sub> same as test C22PR001, page 8 2033.1g MgCl<sub>2</sub> · 6H<sub>2</sub>O, Lot # 041703 + D.L.H.20 to 2.5L

Test ID: C22PR011

Initial weight: 12.55689g Model: Sartorius Genius SN: 12809099  
Final weight: 12.55194g Cal: 05/14/04 11/10/04 Due: 11/14/04 05/10/05  
 $\Delta W = 0.00495g$  X.H. 5/23/05  
Reagents measured with Model: OHAUS SN: 2883 Cal: 7/15/04 Due: 1/15/05

Initial pH: 2.31 Model: Orion EA 940 SN: 2330  
Final pH: 4.992 Cal: 7/21/04 Due: 7/21/05  
pH Probe: #13-620-296 SN: 4079126P

Test Temperature: 110°C Measured with Thermocouple SN: 333 Cal: 07/20/04 Due: 01/20/05

Counter Electrode: Platinum Flag  
Reference Electrode: Fisher 13-620-52 SN: 0199568  
Potentiostat: SI1287 Cal: 10/06/04 Due: 04/06/05

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22PR01-1118, C22PR01-1121

Test dates: Nov. 18 ~ Nov. 21, 2004

Test length:  $3.292 \times 10^5$  seconds = 91.44 hours = 3.81 days

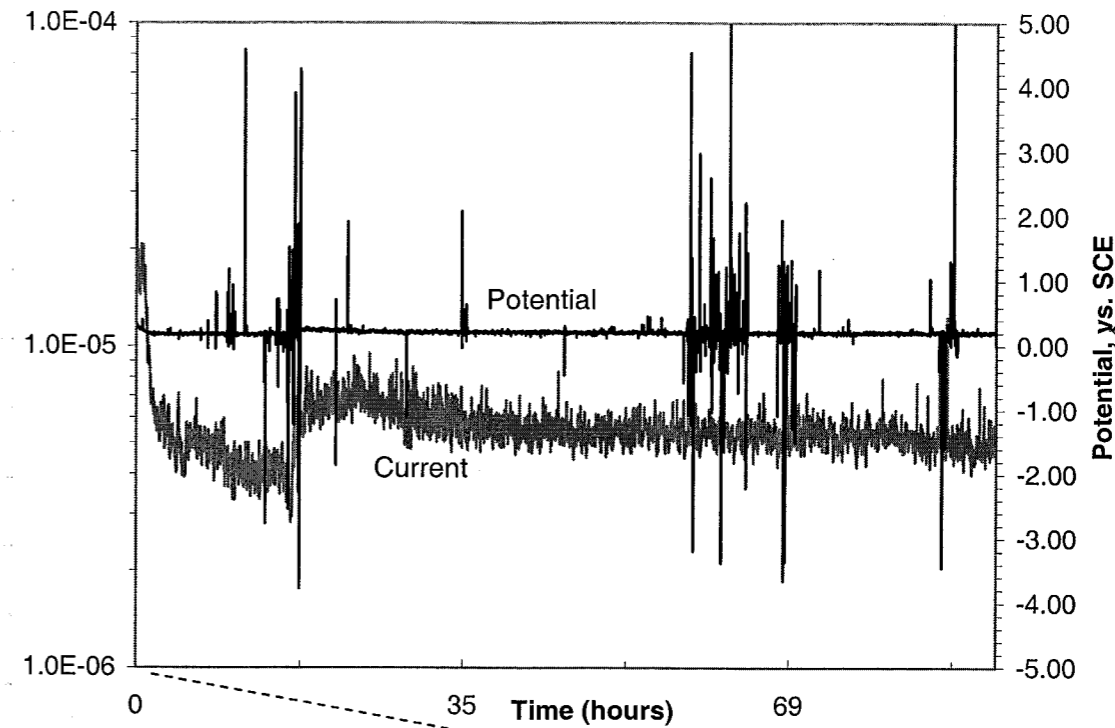
Crevice area: 10.6 mm<sup>2</sup>  
Estimated crevice corroded area: 3.08 mm<sup>2</sup>

Maximum penetration depth: 73 μm  
Specimen examination:

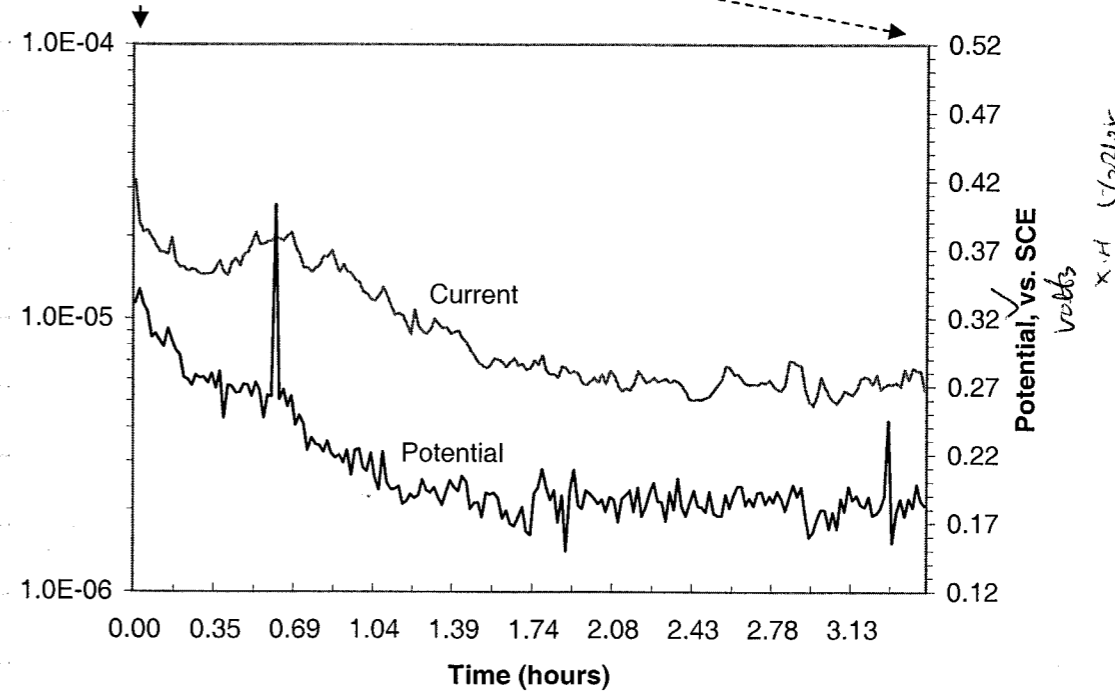
Corrosion around the edge

X.H. He 11/22/2004

\* The specimen was cut 5-mm from the corroded front surface. The longer section without corrosion will be used for future tests. X.H. 4/26/2005



Potential, vs. SCE Volts, X.H. 5/23/05  
 $Q = 1.77$  Coulombs  
Calculated charge from weight change:  
 $Q = \frac{0.00495}{26.04} \times 96485 = 18.34$  Coulombs



Potential, vs. SCE Volts, X.H. 5/23/05  
= 18.34 Coulombs

X.H. He 11/23/2004

C-22 Propagation Rate Measurement

Localized Corrosion X-H 5/23/05

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

Specimen Preparation: Specimen machined to dimensions 1.917" \* 0.250" specified in CNWRA Drawing # 20.01402.57.019. 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 screw driver to 50 in-oz. cell # 2

Test ID: C22PR012

Torque screwdriver: Snap-on USA

SN: 1001200319

Cal: 09/03/04

Due: 03/03/05

Solution: 4 M MgCl<sub>2</sub> same as test C22PR001, page 8

2033.1 g MgCl<sub>2</sub> 6H<sub>2</sub>O, Lot # 041703 + D.I water to 2.5 L X-H 5/23/05

Initial weight: 12.55064 g

Model: Sartorius Genius

SN: 12809099

Final weight: 12.53662 g

Cal: 05/14/04

Due: 11/14/04

Reagents measured with

Model: OHAUS

SN: 2883

Cal: 7/15/04

Due: 1/15/05

Initial pH: 2.31

Model: Orion EA 940

SN: 2330

Final pH: 5.16

Cal: 7/21/04

Due: 7/21/05

pH Probe: #13-620-296

SN: 4079126P

Test Temperature: 110°C

Measured with Thermocouple

SN: 3353

Counter Electrode: Platinum Flag

Cal: 07/20/04

Due: 01/20/05

Reference Electrode: Fisher 13-620-52

SN: 9250078

Potentiostat: SI1287

Cal: 09/09/04

Due: 03/09/05

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22PR01-1118#2, C22PR01-1121#2, C22PR01-1124#2, C22PR01-1127#2, C22PR01-1130#2

Test dates: Nov. 18 ~ Jan. 8 2005 C22PR01-1203#2, C22PR01-1206#2, C22PR01-1209#2, C22PR01-1212#2

Test length: C22PR01-1215#2, C22PR01-1218#2, C22PR01-1221#2, C22PR01-1224#2

Crevice area: 4.4 x 10<sup>6</sup> Seconds = 1222.2 days = 50.9 days X-H 5/23/05

Estimated crevice corroded area: 2.32 mm<sup>2</sup> C22PR01-1225#2, C22PR01-1228#2, C22PR01-1231#2, C22PR01-0103#2, C22PR01-0106#2 X-H 5/23/05

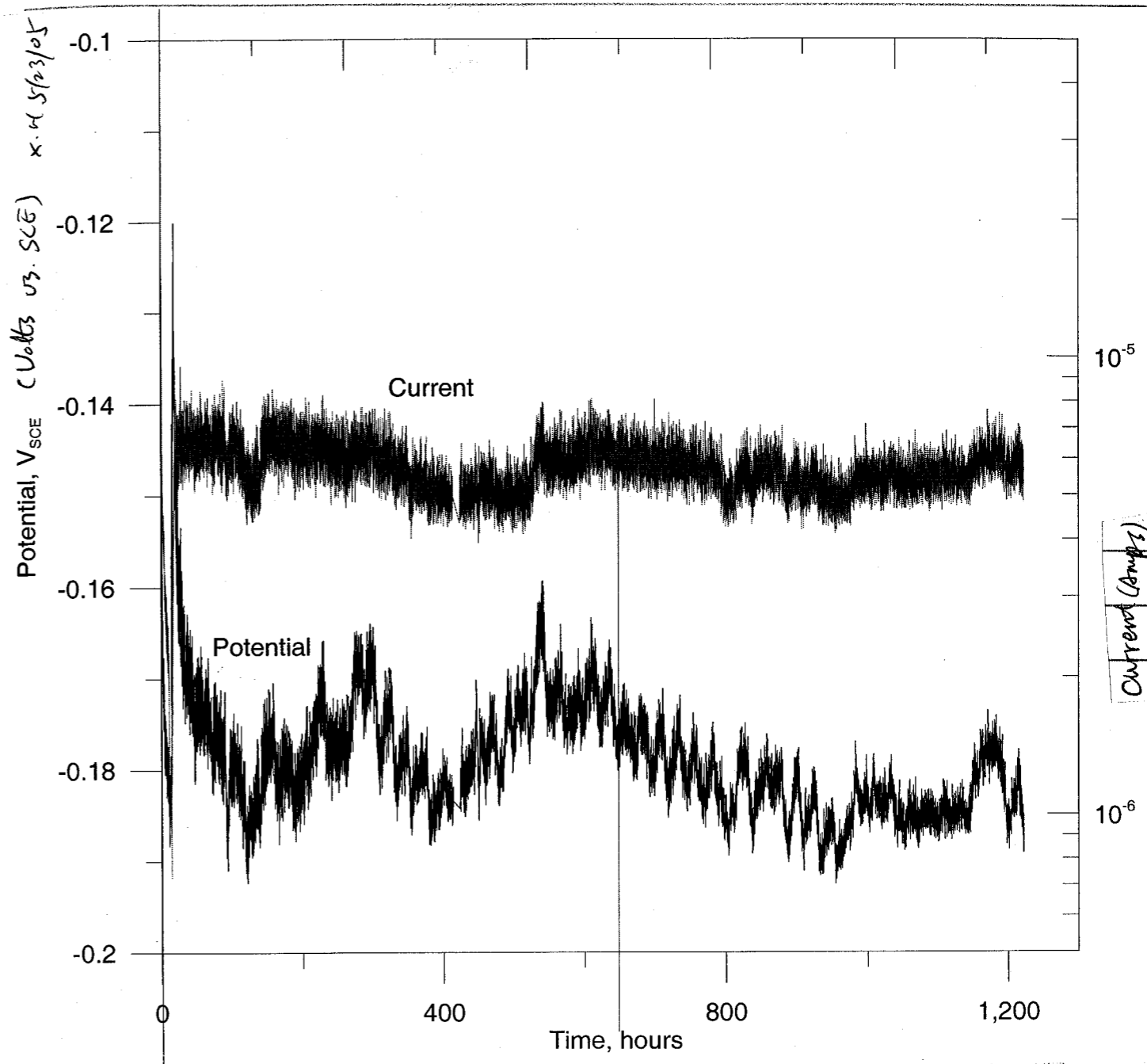
Maximum penetration depth: 487 μm X-H 5/23/05

Specimen examination:

A deep hole was created due to crevice corrosion

\* The specimen was cut 5-mm from the corroded front end. The longer section without corrosion will be used for future tests X-H 4/26/05

Xihua He 11/19/2004



Total charge Q = 25.071 Coulombs

charge calculated from weight change:

$$Q = \frac{0.01402}{26.02} \times 96485 = 51.9 \text{ Coulombs}$$

$$\text{Current density} = \frac{\text{Current (A)}}{0.0204 \text{ cm}^2}$$

Xihua He 1/10/2005

C-22 Propagation Rate Measurement

Localized Corrosion x.H 5/23/05

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

Specimen Preparation: Specimen machined to dimensions 1.917" \* 0.250" specified in CNWRA Drawing # 20-01402-57/019. 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 screw driver to 50 in-oz.

Test ID: C22PR013

Torque screwdriver: Snap-on USA

SN: 1001200319

Cal: 09/03/04

Due: 03/03/05

Solution: 4 M MgCl<sub>2</sub> same as test C22PR001, page 8

2033.1 g MgCl<sub>2</sub> · 6H<sub>2</sub>O, Lot # 041703 + D.I water to 2.5 L x.H 5/23/05

Initial weight: 12.60420g

Model: Sartorius Genius

SN: 12809099

Final weight: 12.57823g

Cal: 05/14/04 x.H 11/24/04  
11/10/04

Due: 11/14/04 x.H 11/24/04  
05/10/05

ΔW: 0.02597g  
Reagents measured with

Model: OHAUS

SN: 2883

Cal: 7/15/04

Due: 1/15/05

Initial pH: 2.31

Model: Orion EA 940

SN: 2330

Final pH: 4.44

Cal: 7/21/04

Due: 7/21/05

pH Probe: #13-620-296

SN: 4079126P

Test Temperature: 110°C

Measured with Thermocouple

SN: 3354 x.H 11/24/04

Cal: 07/20/04

Due: 01/20/05

Counter Electrode: Platinum Flag

SN: 0199568

Reference Electrode: Fisher 13-620-52

Potentiostat: SI1287

Cal: 10/06/04

Due: 04/06/05

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22Prop-1123, C22Prop-1124, C22Prop-1127, C22Prop-1130, C22Prop-1203, C22Prop-1209, C22Prop-1212, C22Prop-1215, C22Prop-1218, C22Prop-1221, C22Prop-1224, C22Prop-1227, C22Prop-1227b

Test dates: Nov 23 ~ Dec 28

Test length: 292384 seconds = 82.17 hours = 33.33 days

Crevice area: 10.6 mm<sup>2</sup>

Estimated crevice corroded area: 6.46 mm<sup>2</sup> x.H 5/23/05

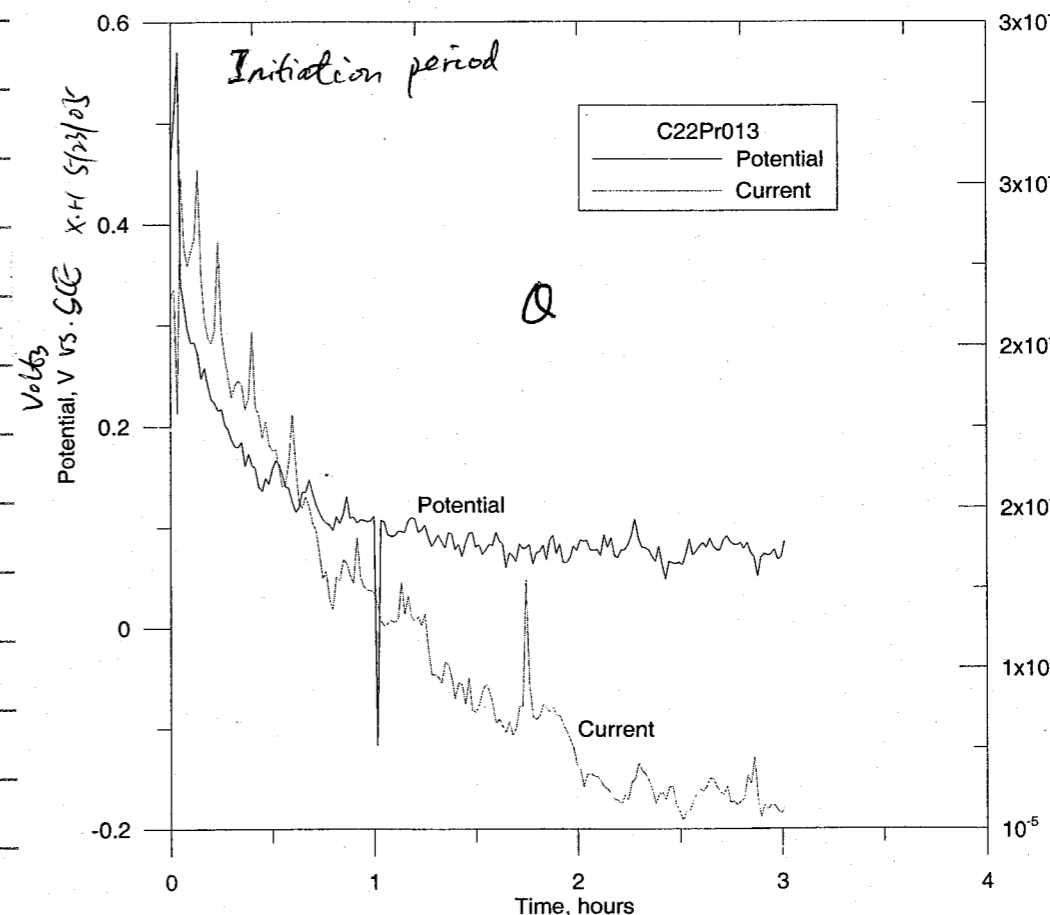
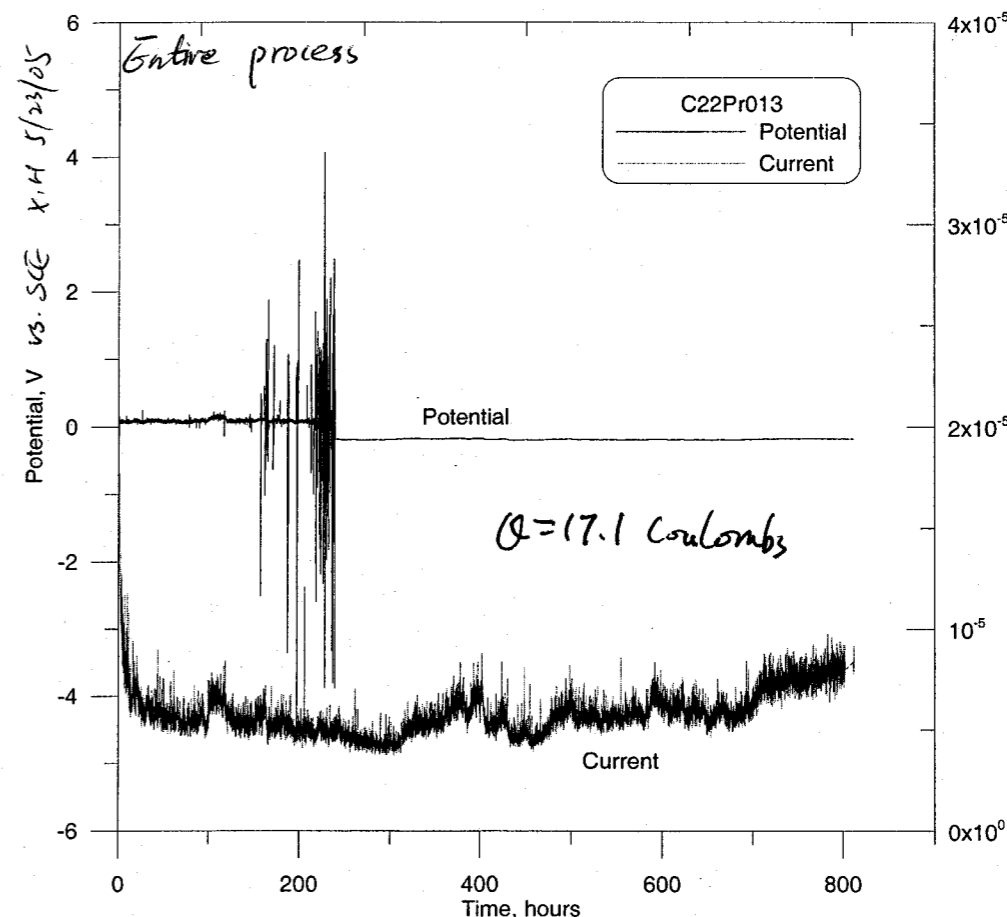
Maximum penetration depth: 361 μm x.H 5/23/05

Specimen examination:

Severe corrosion at one side of the creviced area. Surface staining around the corroded area.

Xihua He 11/24/04

\* Specimen was cut for 5-mm from the corroded front end. The longer section without corrosion will be used for future tests. x.H 4/26/05



Q = 17.1 Coulombs  
Charge calculated from ΔW:

$$Q = \frac{\Delta W}{\frac{eW}{F}}$$

$$= \frac{0.02597g}{26.04g} \times 96485$$

$$= 22.1 \text{ Coulombs}$$

Calculated d

$$d = \frac{Q \cdot eW}{A \cdot F}$$

$$= \frac{17.1 \times 26.04}{0.106 \times 96485}$$

$$= 5.01 \times 10^{-3} \text{ cm}$$

$$= 50.1 \mu\text{m}$$

Xihua He 12/29/04

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TECHNICAL OPERATING PROCEDURE

Proc. TOP-012

Revision 1

Page 9 of 9

SAMPLE CUSTODY ENTRY FORM

SAMPLE IDENTIFICATION (Mandatory)

Alloy 622 FILLER WIRE HEAT XX1977BG11

SAMPLE DESIGNATOR

DESCRIPTION OF SAMPLE (Mandatory)

ALLOY 622 FILLER WIRE HEAT XX1977BG11

0.045" DIA

REFERENCE TOP or SCIENTIFIC NOTEBOOK ENTRY

NOTEBOOK 503 P84

AMOUNT of SAMPLE 30 LBS SIZE 0.045" DIA

DATE of SAMPLE RECEIPT (Mandatory) 1/15/03

DATE of LOG ENTRY 2/19/03 by DARRELL DUNN

SAMPLE STORAGE LOCATION (Mandatory)

BLDG 57

Collection site:

Supplier: AMERICAN FILLER METALS

Other:

CNWRA FORM TOP-004

CNWRA Form TOP-2

Xihua He 10/29/2004

Localized Corrosion

C-22 Propagation Rate Measurement

Alloy/Specimen: Alloy 622, Heat # XX1977BG11 (page 36) G2000 R alloy with Heat # 2277-3-3200

Test ID: C22PR014 (1st test using probe)

Specimen Preparation: Four 1-mm wires was sealed in resin. 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 screw driver to 50 in-oz.

Solution: 4 M MgCl2, same as test C22PR001, page 8

2033.1 g MgCl2·6H2O, Lot # 041703 + D.I water to 2.5 L

Reagents measured with

Model: OHAUS

Cal: 7/15/04

SN: 2883

Due: 1/15/05

Initial pH: 2-34

Final pH: 5.57

Model: Orion EA 940

Cal: 7/21/04

SN: 2330

Due: 7/21/05

pH Probe: #13-620-296

SN: 4079126P

Torque screwdriver: Snap-on USA

SN: 1001200319

Cal: 07/03/04

Due: 03/03/05

Test Temperature: 110°C

Measured with Thermocouple

Cal: 07/20/04

SN: 330 Due: 01/20/05

Counter Electrode: Platinum Flag

Reference Electrode: Fisher 13-620-52

SN: 4028023p

Potentiostat: Solartron 1480

Cal: 12/03/04

Due: 06/03/05

Cell set up: Channel 1&2 to electrode with red wire, channel 3&4 to electrode with orange wire, channel 5&6 to electrode with blue wire, channel 7&8 to electrode with yellow wire

Data Files: Channels 7&8: C22PR1216Ec, C22PR1219E, C22PR1219Eb, C22PR1222E, C22PR1225I (yellow) C22PR1216Ic, C22PR1219I, C22PR1219Ib, C22PR1222I, C22PR1225I Channels 5&6: C22PR1216Ea, C22PR1216Eb, C22PR1219E, C22PR1219Eb, C22PR1222E (blue) Channels 3&4 (orange): C22PR1225E, C22PR1216Ia, C22PR1216Ib, C22PR1219I, C22PR1219Ib Channels 1&2 (red): C22PR1222I, C22PR1225I

Test dates: Dec. 17 ~ Dec. 30, 2004

Test length: 1.05 x 10^6 seconds = 291.7 hours = 12.1 days

Crevice area: Each wire A = pi(1/2)^2 = 0.785 mm^2

Maximum penetration depth:

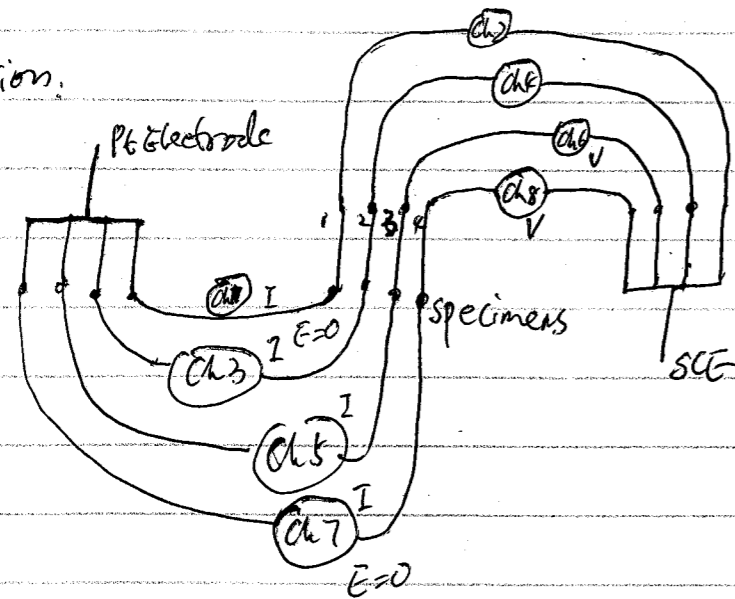
86 um, 72 um, 90 um

Specimen examination:

Three wires are corroded. One wire is only etched. Diagram showing yellow wire, blue wire, orange wire, and not corroded.

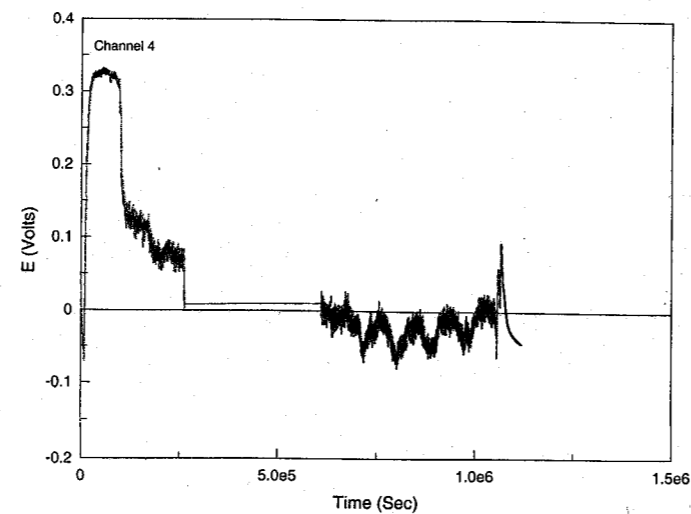
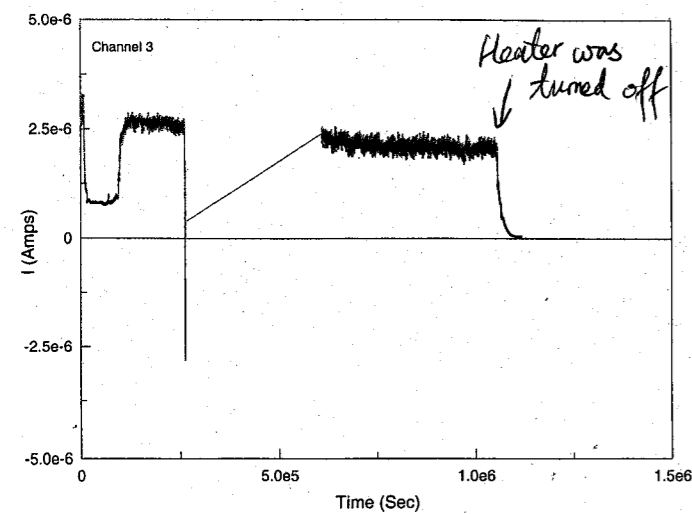
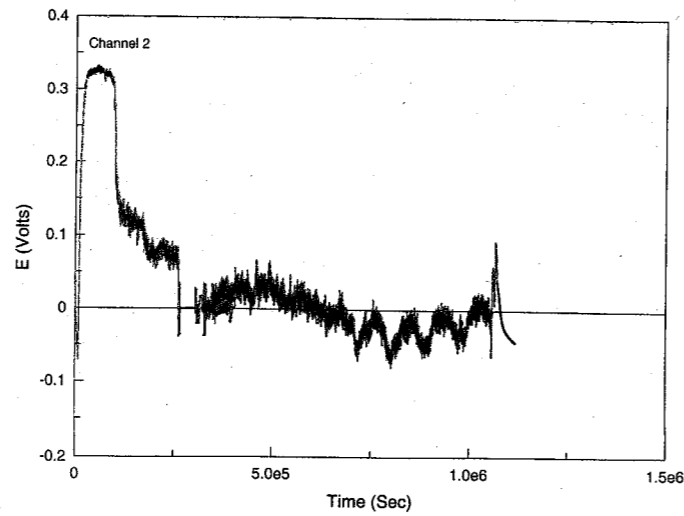
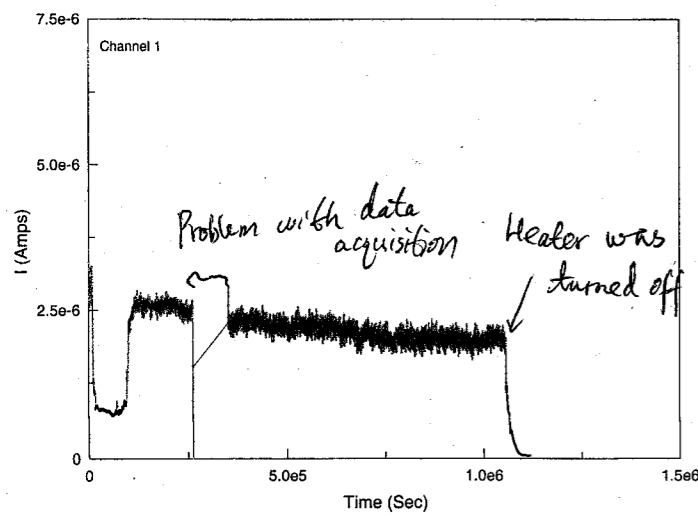
Xihua He 1/5/2005

Cell connection.

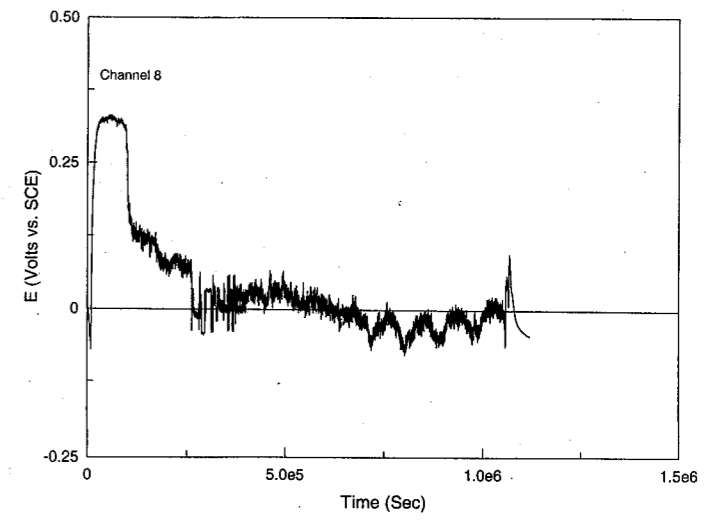
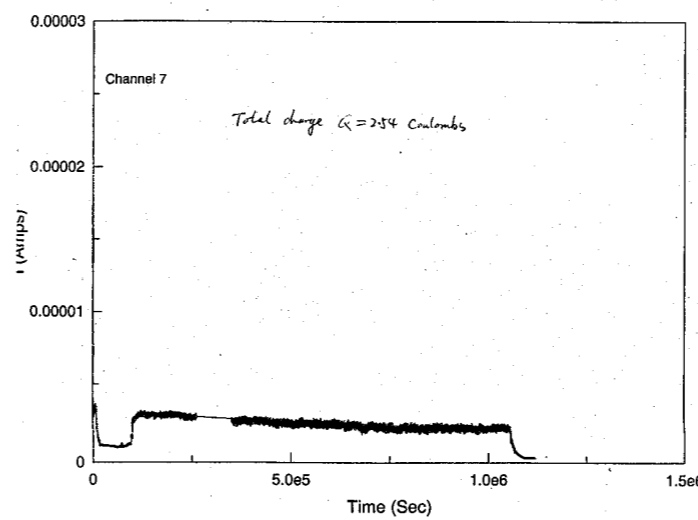
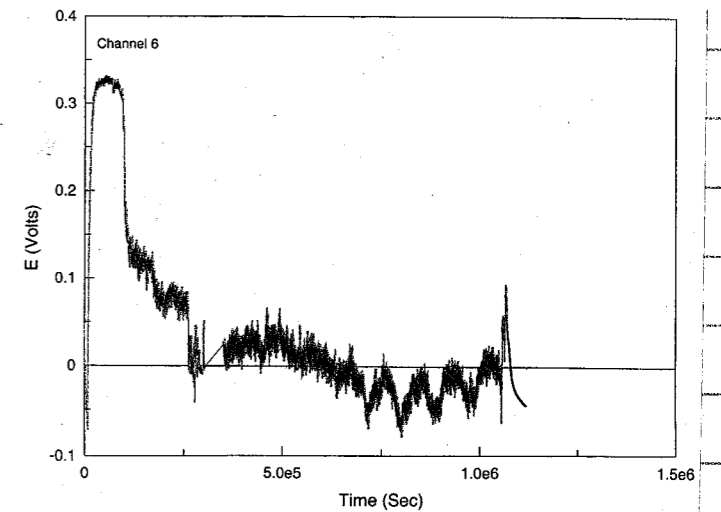
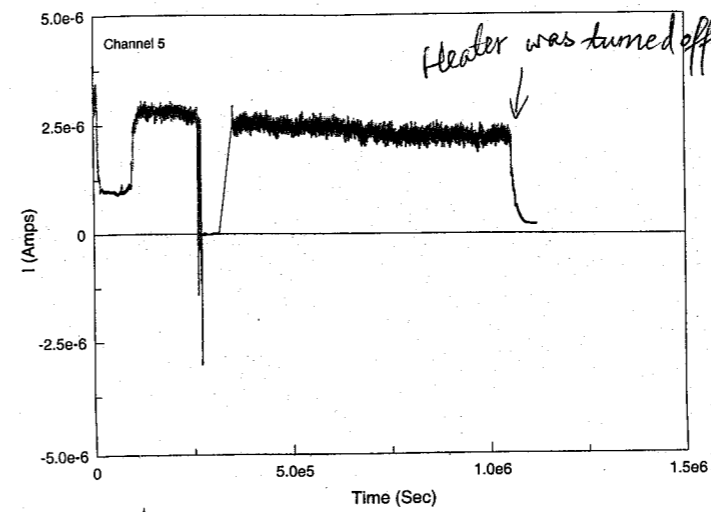


One SCE and one Pt cathode

Data from each channel.



X. Hua He 1/6/2005



Comments:

The measured current and potential from each channel are similar. Because of sharing one Pt electrode and one SCE reference electrode, channels crosstalk.

X. Hua He 1/6/2005

C-22 Propagation Rate Measurement  
Localized Corrosion 5/23/05

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

Specimen Preparation: Specimen machined to dimensions 1.917" x 0.250" specified in CNWRA Drawing # 20.01402.571. 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 a precision compression stainless steel spring 0.180" (OD) X 0.026" (wire diameter) X 0.562" (length) purchased from McMaster-Carr. The spring is coated with microstop.

cell #1

Solution: 4 M MgCl<sub>2</sub> same as test C22PR001, page 8

Test ID: C22PR015

Initial weight: 12.74239 g

Final weight: 12.73545 g

Model: Sartorius Genius

Cal: 11/10/04

SN: 12809099

Due: 05/10/05

Reagents measured with

Model: OHAUS

Cal: 7/15/04

SN: 2883

Due: 1/15/05

Initial pH: 2.31

Final pH: 4.67

Model: Orion EA 940

Cal: 7/21/04

SN: 2330

Due: 7/21/05

pH Probe: #13-620-296

SN: 4079126P

Test Temperature: 110°C → 100°C → 90°C Measured with Thermocouple

→ 85°C → 80°C → 75°C → 70°C → 60°C

→ 50°C → 40°C → 30°C → r.t.

SN: 333

Due: 01/20/05

Counter Electrode: Platinum Flag

Reference Electrode: Fisher 13-620-52

Potentiostat: SI1287

Cal: 10/06/04

SN: 0199568

Due: 04/06/05

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

Data Files: C22Prop-1229, C22Prop-1229b, C22Prop-01d, C22Prop-0104, C22Prop-0107, C22Prop-010, C22Prop-0111, C22Prop-0113, C22Prop-0115, C22Prop-0115b, C22Prop-0117, C22Prop-0119, C22Prop-0121, C22Prop-0123, C22Prop-0123a, C22Prop-0125, C22Prop-0127, C22Prop-0129, C22Prop-0131, C22Prop-0202, C22Prop-031b, C22Prop-0202b, C22Prop-0204, C22Prop-0206, C22Prop-0208

Test dates: 12/29/04 ~ 2/7/05

Test length: 3453822 seconds = 39.97 days

Crevice area: 10.6 mm<sup>2</sup>

Estimated crevice corroded area: 5.95 mm<sup>2</sup>

Maximum penetration depth: 320 μm

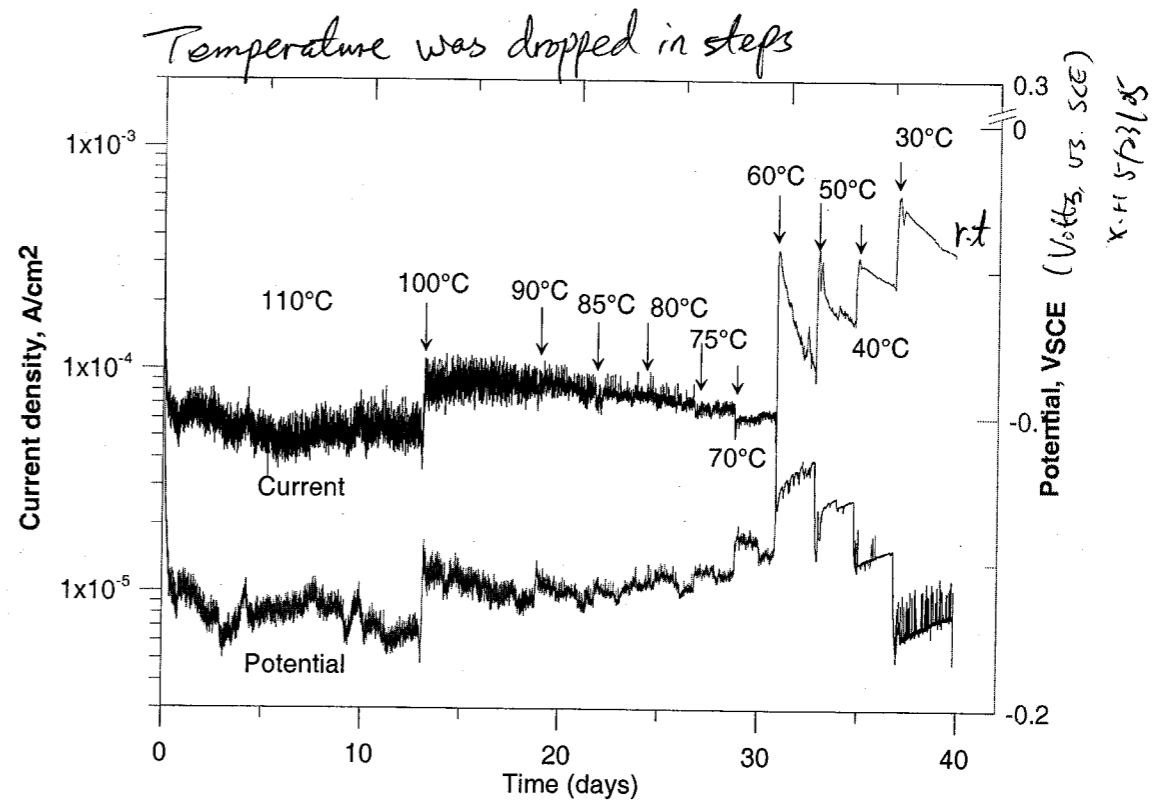
Specimen examination: Crevice area is corroded.

deep corrosion at one side of the specimen.

\* Specimen was cut ~ 5mm from the corroded front surface. The longer section without corrosion will be used for future tests.

X.H. 5/23/05

X.H. 4/26/05



$$\text{Current density} = \frac{\text{Current (A)}}{\text{Area (cm}^2\text{)}}$$

File C22Prop0111 at points 52. drop T to 100°C

C22Prop-0117 at 3562 points. drop T to 90°C

C22Prop-0121 at 3809 points, drop T to 85°C

C22Prop-0127a at 761 points, drop T to 80°C

C22Prop-0125, at 2228 points, drop T to 75°C

C22Prop-0127, at 3767 points, drop T to 70°C

C22Prop-0131, at 1371 points, drop T to 60°C

C22Prop-0131b, drop T to 50°C

C22Prop-0202b, at 1006 points, drop T to 40°C

C22Prop-0204, at 2539 points, drop T to 30°C

C22Prop-0208 at 2865 points, turn off header

X.H. 2/10/05

✓ x.H 5/23/05  
**C-22 Propagation Rate Measurement**  
*Localized Corrosion*

**Alloy/Specimen:** Hastelloy C-2000 alloy with Heat 2316-1-8122 Alloy 622, Heat # XK1977BG11 (page 36)  
**Specimen Preparation:** Four 1-mm wires was sealed in resin. Specimen surfaces polished to 600 Grit finish using SiC X.H. paper. Specimen cleaned in acetone and rinsed in DI water. PTFE crevice forming bolt pressed against specimen using 5/23/05 torque screwdriver to 50 in-oz.

**Torque Screwdriver:** Snap-on USA SN: 1001200319  
 Cal: 09/03/04 Due: 3/03/05

**Test ID:** C22PR016  
**Solution:** 4 M MgCl<sub>2</sub>, same as test C22PR001, page 8 (this notebook) 2033.1 g MgCl<sub>2</sub> · 6H<sub>2</sub>O, Lot # 041703  
 Reagents measured with Model: OHAUS SN: 2883 + D.I. has to 2.5L  
 Cal: 7/15/04 Due: 1/15/05 X.H 5/23/05  
 Model: Orion EA 940 SN: 2330  
 Cal: 7/21/04 Due: 7/21/05  
 pH Probe: #13-620-296 SN: 4079126P  
 Measured with Thermocouple SN: 330  
 Cal: 7/20/04 Due: 1/20/05

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

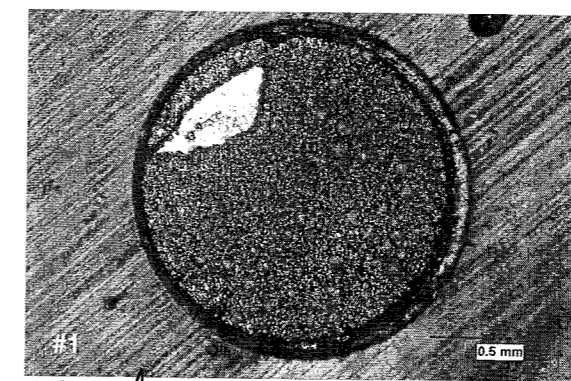
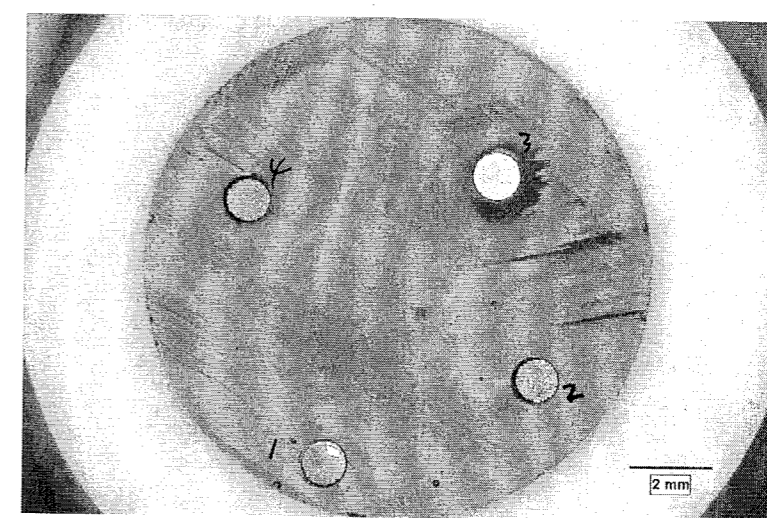
**Multi-channel Potentiostat:** SI1480 Cal: 12/03/04 Due: 06/03/05

Wire color coded in blue	Wire color coded in orange	Wire color coded in red
Channels 1&2	Channels 3&4	Channels 5&6
<b>Counter Electrode:</b> Pt foil with surface area of 261 mm <sup>2</sup> .	<b>Counter electrode:</b> Pt foil with surface area of 261 mm <sup>2</sup> .	<b>Counter Electrode:</b> Pt foil with surface area of 261 mm <sup>2</sup> .
<b>Reference Electrode:</b> Fisher 13-620-52	<b>Reference Electrode:</b> Fisher 13-620-52	<b>Reference Electrode:</b> Fisher 13-620-52
SN: 006619	SN: 3329075	SN: 4028023
Data Files: C22PR011Ea, C22PR011Eb, C22PR0114E, C22PR0117E, C22PR0114I, C22PR0117I, C22PR0114I, C22PR0117I	Data Files: C22PR011Ea, C22PR011Eb, C22PR0114E, C22PR0117E, C22PR0114I, C22PR0117I, C22PR0114I, C22PR0117I	Data Files: C22PR011Ea, C22PR011Eb, C22PR0114E, C22PR0117E, C22PR0114I, C22PR0117I, C22PR0114I, C22PR0117I
Test dates: 1/11 - 1/20, 2005	Test dates: 1/11 - 1/20, 2005	Test dates: 1/11 - 1/20, 2005
Test length	Test length	Test length
Crevice area: 0.785 mm <sup>2</sup>	Crevice area: 0.785 mm <sup>2</sup>	Crevice area: 0.785 mm <sup>2</sup>
Maximum penetration depth: 123 μm	Maximum penetration depth: 0	Maximum penetration depth: 169 μm
Specimen examination: Corroded wire recedes.	Specimen examination: Wire is not corroded. Minor surface staining	Specimen examination: Corroded wire recedes

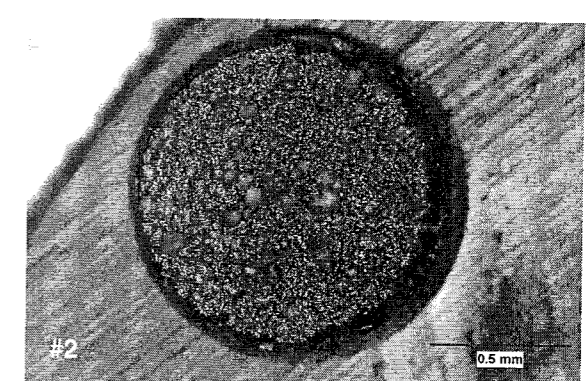
Wire color coded in yellow, Channels 7&8, Pt foil as counter electrode  
**Reference Electrode:** Fisher 13-620-52 SN: 0251439  
 Data files: C22PR011Ea, C22PR011Eb, C22PR0114E, C22PR0117E, C22PR0114I, C22PR0117I, C22PR0114I, C22PR0117I  
 Test dates: 1/11 - 1/20, 2005 Test length  
 Crevice area: 0.785 mm<sup>2</sup>  
 Maximum penetration depth: 168 μm  
 Specimen examination: Corroded wire recedes

Xihua He 1/24/2005

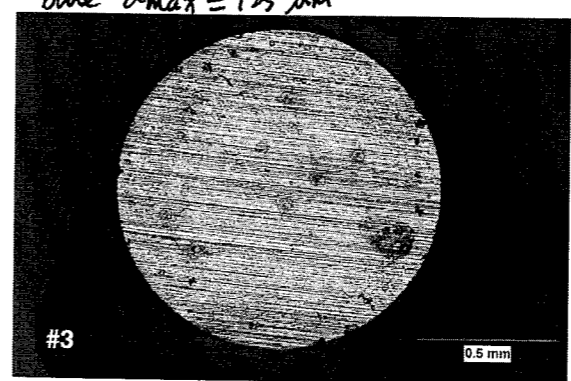
Working electrodes after test with three wires corroded



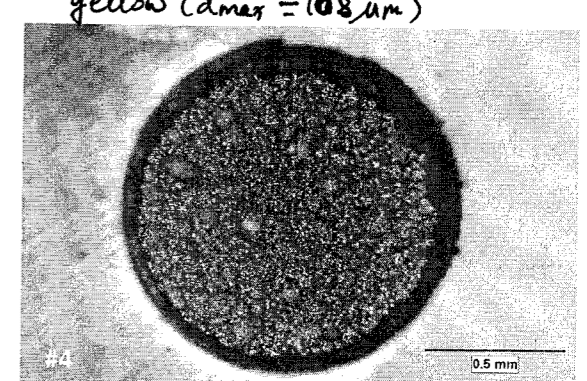
blue d<sub>max</sub> = 123 μm



yellow (d<sub>max</sub> = 168 μm)



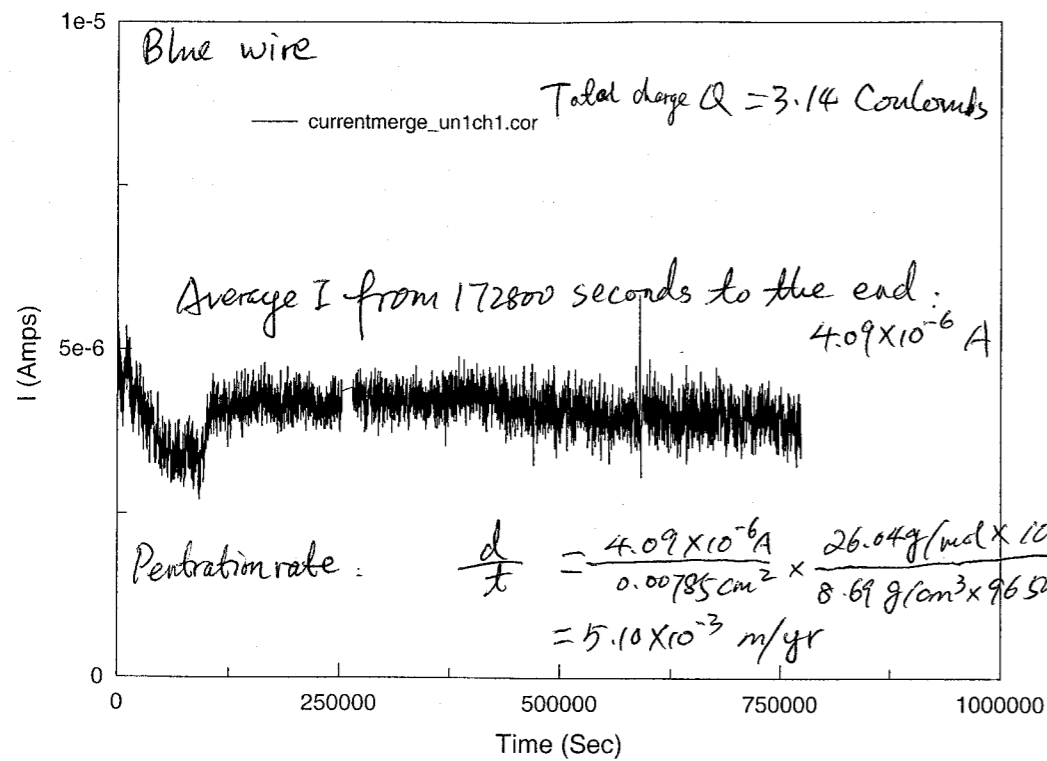
orange (not corroded)



red d<sub>max</sub> = 169 μm

Top part was cut and kept. Xihua He 1/24/05  
 The rest of the probe was polished and reused for test C22PR018 (page # 50).  
 X.H 5/23/05





Penetration rate:

$$\frac{d}{t} = i \frac{EW}{\rho F}$$

$i$  — Current density

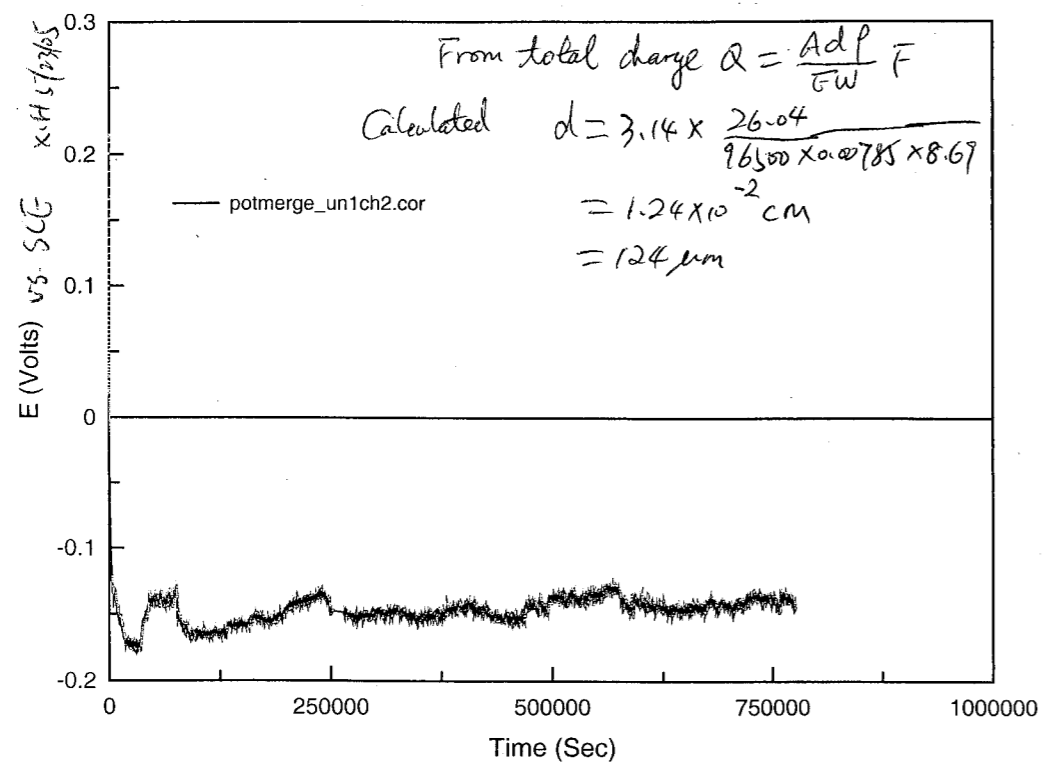
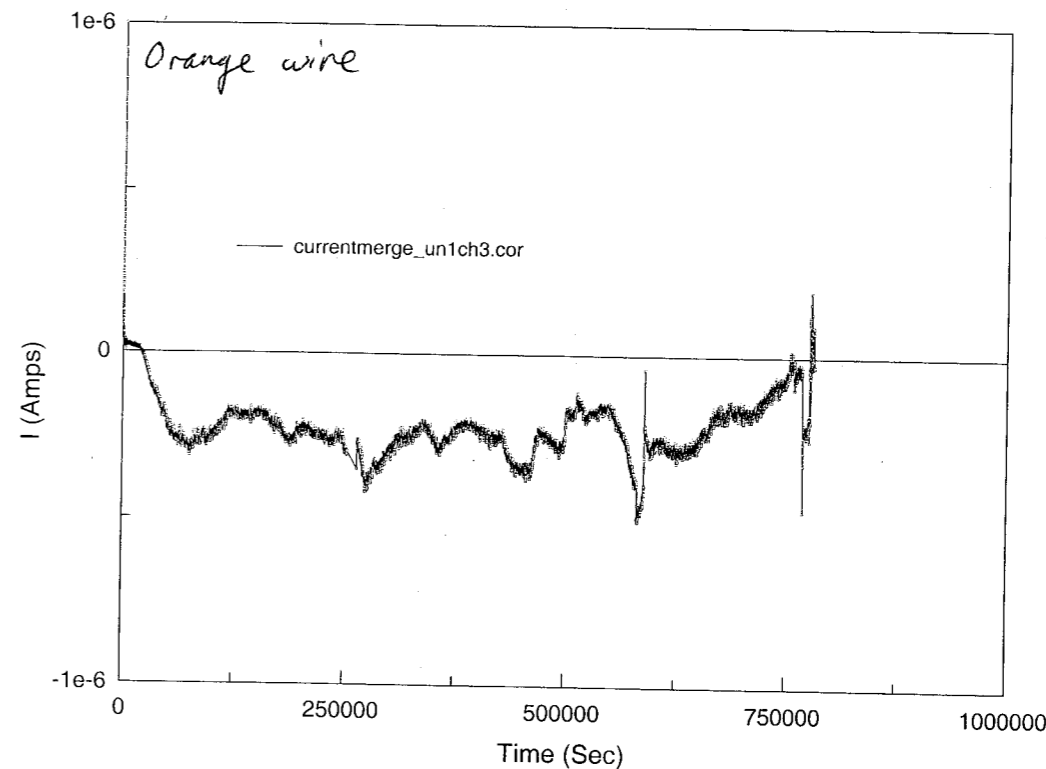
$EW = 26.04 \text{ g/mol}$

$\rho = 8.69 \text{ g/cm}^3$

$F$  — Faraday Constant

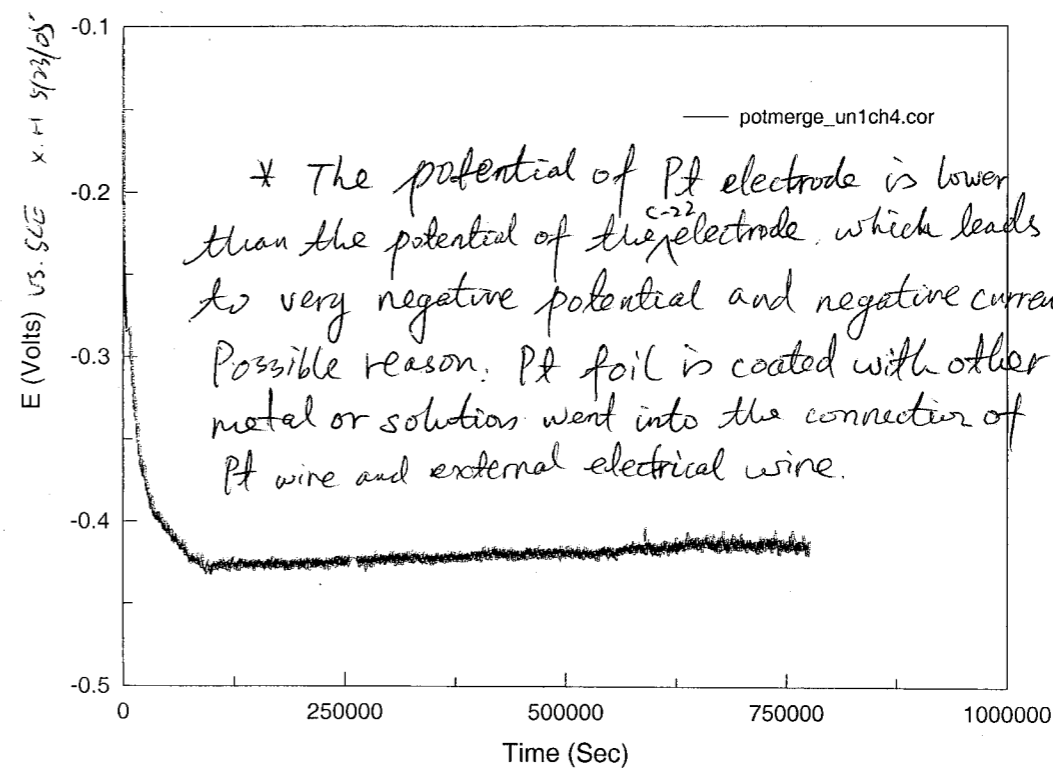
Penetration rate: 
$$\frac{d}{t} = \frac{4.09 \times 10^{-6} \text{ A}}{0.00785 \text{ cm}^2} \times \frac{26.04 \text{ g/mol} \times 10^{-2} \text{ m/cm} \times 365 \times 24 \times 3600}{8.69 \text{ g/cm}^3 \times 96500 \text{ A} \cdot \text{hr/mol}}$$

$= 5.10 \times 10^{-3} \text{ m/yr}$



$d$  — penetration depth

$A$  — surface area

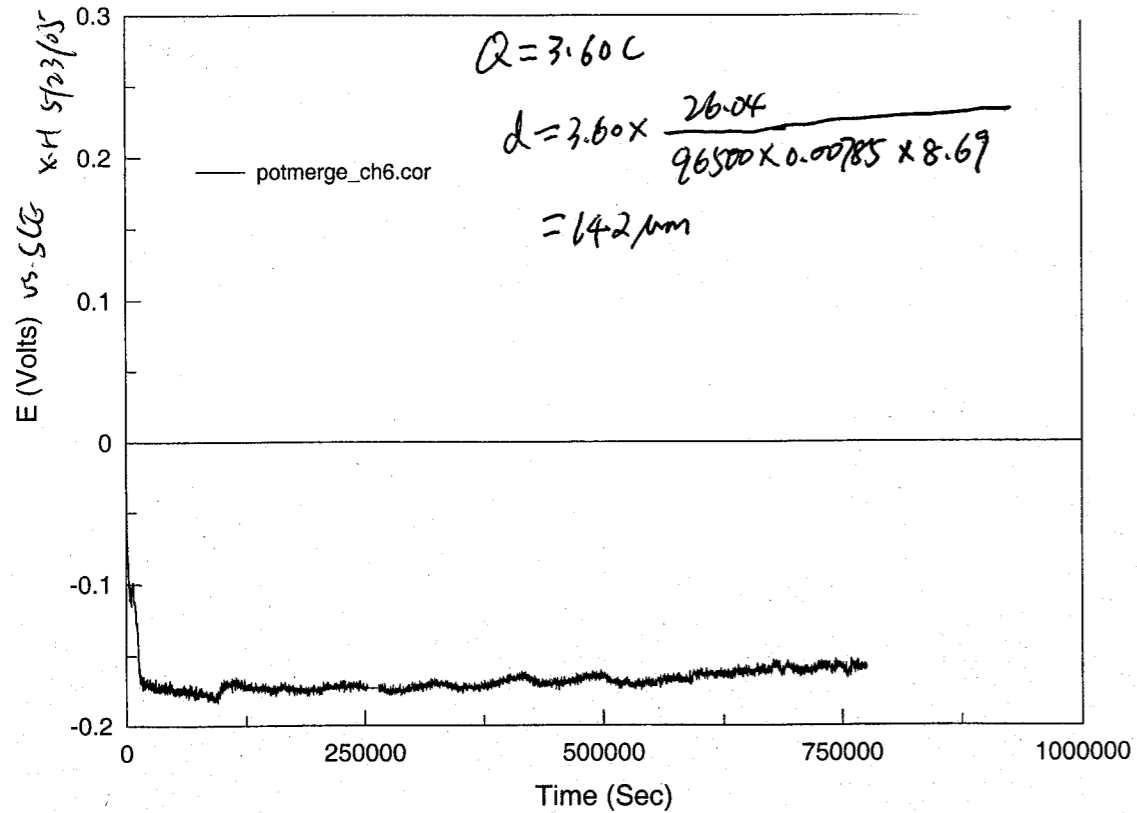
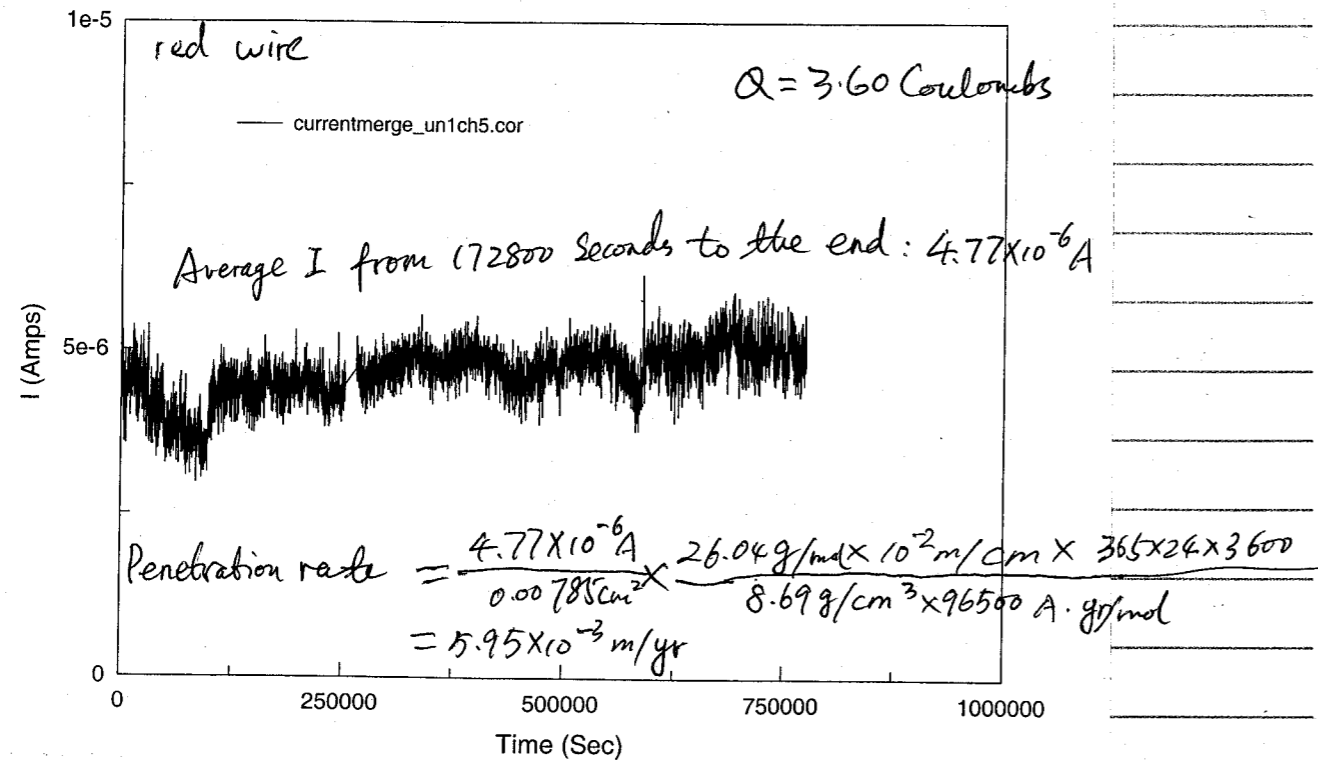


Current density  
 $= \frac{\text{Current (A)}}{0.00785 \text{ cm}^2}$

Xihua He 1/24/05

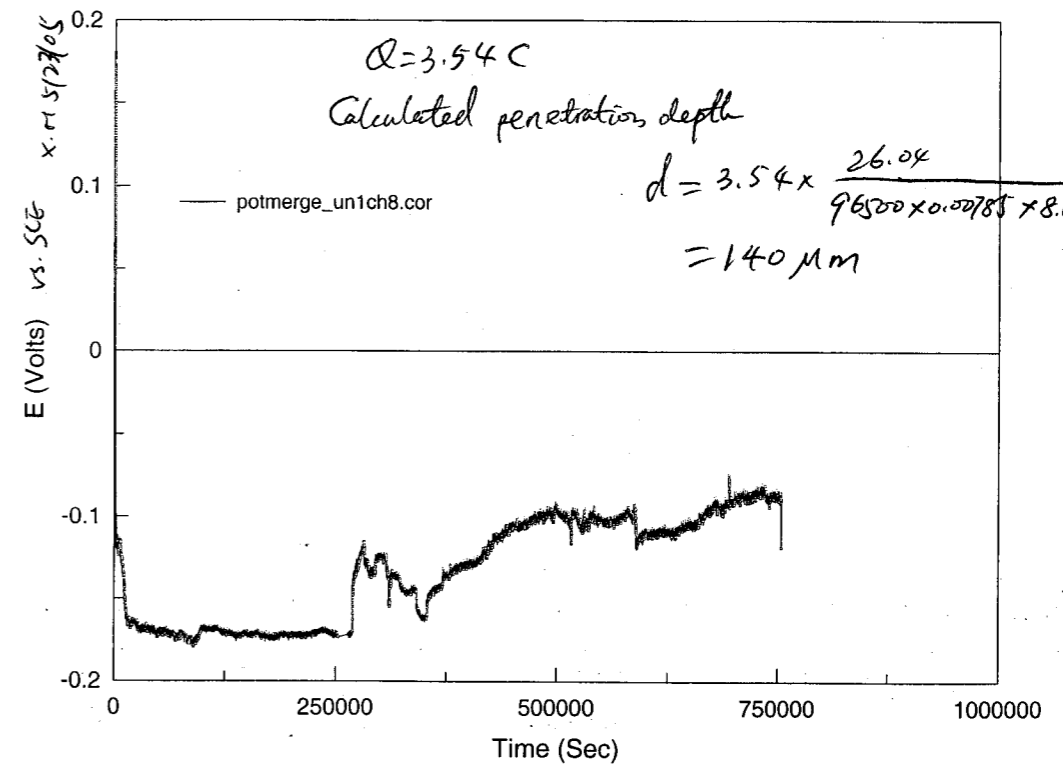
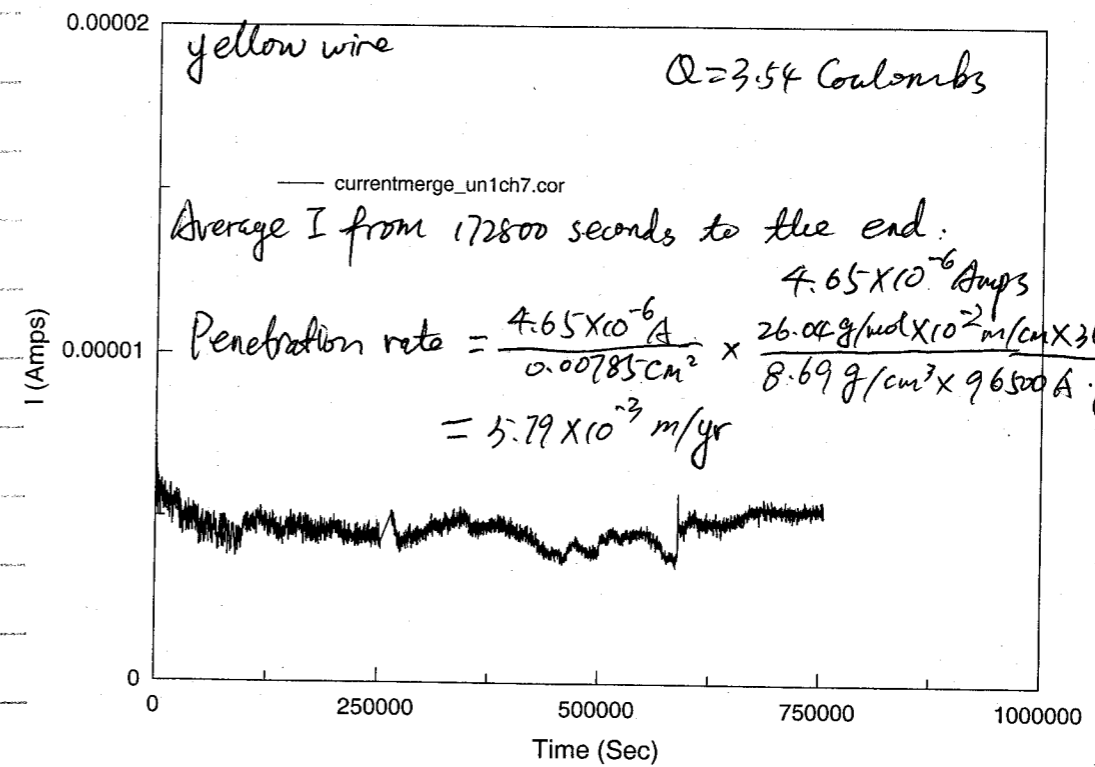
Penetration rate  $\frac{d}{t} = 9.8 \text{ } \mu\text{m/yr}$

Xihua He 1/24/05



Current density =  $\frac{\text{Current (A)}}{0.00785 \text{ (cm}^2\text{)}}$

Xihua He 1/24/05



Xihua He 1/24/05

**C-22 Propagation Rate Measurement**  
*Localized Corrosion*

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

X.H 5/23/05

**Specimen Preparation:** Specimen machined to dimensions 1.917" x 0.250" specified in CNWRA Drawing # 20.4402.57.019. 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 a precision compression stainless steel spring 0.180" (OD) X 0.026" (wire diameter) X 0.562" (length) purchased from McMaster-Carr. The spring is coated with microstop. (page 16)

Cell # 2

**Solution:** 4 M MgCl<sub>2</sub> same as test C22PR001, page 8

2033.1 g MgCl<sub>2</sub> 6H<sub>2</sub>O + D.I H<sub>2</sub>O to 2.5 L X.H 5/23/05

**Test ID:** C22PR017 Lot # 041703

**Initial weight:** 12.56495 g

**Final weight:** 12.56076 g

**Model:** Sartorius Genius

**SN:** 12809099

**Cal:** 11/10/04

**Due:** 05/10/05

**Reagents measured with**

**Model:** OHAUS

**SN:** 2883

**Cal:** 7/15/04

**Due:** 1/15/05

**Initial pH:** 2.31

**Model:** Orion EA 940

**SN:** 2330

**Final pH:** 5.08

**Cal:** 7/21/04

**Due:** 7/21/05

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

**SN:** 4079126P

**Test Temperature:** 110°C

**Measured with Thermocouple**

**SN:** 333

**Cal:** 07/20/04

**Due:** 01/20/05

**Counter Electrode:** Platinum Flag

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

**SN:** 00186634

**Potentiostat:** SI1287

**Cal:** 10/06/04

**Due:** 04/06/05

**Cell set up:** WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to Pt, CE unused

**Data Files:** C22Prop-0111#2a, C22Prop-0111#2b, C22Prop-0114#2, C22Prop-0117#2, C22Prop-0120#2

**Test dates:** 1/1/05 ~

C22Prop-0123#2, C22Prop-0126#2, C22Prop-0129#2,

**Test length:** 2.58 x 10<sup>6</sup> seconds =

C22Prop-0201#2, C22Prop-0204#2, C22Prop-0207#2, C22Prop-0210#2

**Crevice area:** 8.04 mm<sup>2</sup> 29.86 days

**Estimated crevice corroded area:**

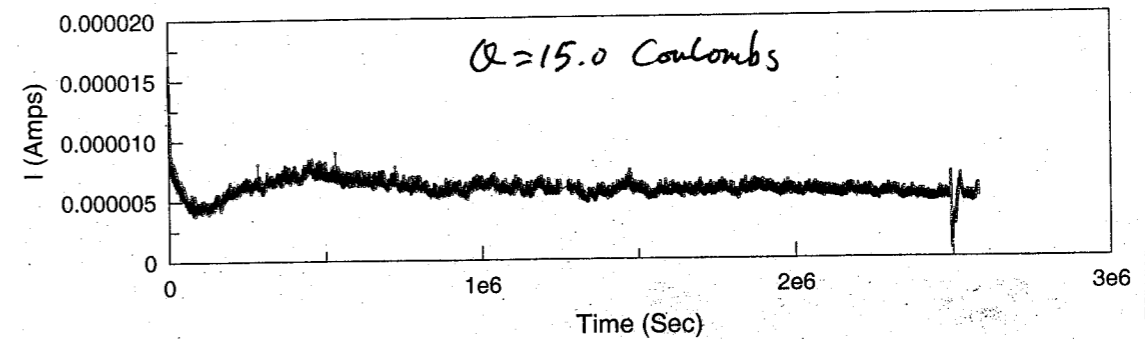
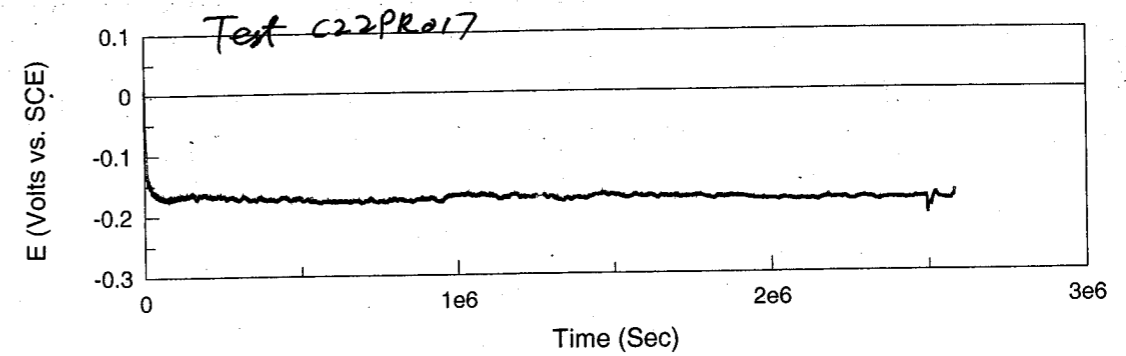
**Maximum penetration depth:** 360 μm

**Specimen examination:**

One side of specimen is corroded

\* Specimen was cut ~ 5mm from the corroded front surface. The longer section without corrosion will be used for future tests. X.H 4/26/05

Xihua He 1/24/05



$$\text{Current density } CA (\text{cm}^2) = \frac{\text{Current } (A)}{0.0804 (\text{cm}^2)}$$

Xihua He 2/17/05

Calculated d from charge:

$$d = \frac{Q \cdot E \cdot W}{A \cdot P \cdot F} = 15.0 \times \frac{26.04}{0.0804 \times 96500 \times 8.69} \text{ cm}$$

$$= 5.79 \times 10^{-3} \text{ cm}$$

$$= 57.8 \text{ } \mu\text{m}$$

Xihua He 2/12/05

Localized Corrosion  
C-22 Propagation Rate Measurement

Alloy/Specimen: Hastelloy C-2000 alloy with Heat 2316-1-8122  
*Alloy C22, Heat # XX19778611 (Page #36) X.H. 5/23/05*

Specimen Preparation: Four 1-mm wires was sealed in resin. 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.

Torque Screwdriver: Snap-on USA SN: 1001200319  
Cal: 09/03/04 Due: 3/03/05

Test ID: C22PR018

Solution: 4M MgCl<sub>2</sub>, same solution as test C22PR001 (Page 8)

Reagents measured with *2033-1 g MgCl<sub>2</sub> 6H<sub>2</sub>O + D.I H<sub>2</sub>O to 2.5 L X.H. 5/23/05*  
Lot # 04703 Model: OHAUS SN: 2883  
Cal: 1/14/05 Due: 7/14/05

Initial pH: 2.31 Model: Orion EA 940 SN: 2330  
Final pH: 5.66 Cal: 7/21/04 Due: 7/21/05

pH Probe: #13-620-296 SN: 4079126P

Test Temperature: 110°C → 60°C → 40°C → r.t.  
Measured with Thermocouple SN: 330  
Cal: 07/20/04 Due: 01/20/05

Counter Electrode: Platinum Flag with surface area 261 mm<sup>2</sup>

Reference Electrode: Fisher 13-620-52 SN: 4028023 (red wire potential)  
SN: 0066119 (blue wire potential)  
SN: 0251439 (yellow wire potential)

Multi-channel Potentiostat: SI1480 Cal: 12/03/04 Due: 06/03/05

Cell set up: Two channels for each electrode, one channel to measure the galvanic coupling current, the other channel for measuring the potential. Each electrode is coupled to a separate Pt foil with same surface area of 261 mm<sup>2</sup>.

Data Files: C22PR0125Ia, C22PR0125Ea, C22PR0125Ib, C22PR0125Eb, C22PR0127Ib, C22PR0127Eb, C22PR0128I, C22PR0128E, C22PR0131I, C22PR0131E

*channels 1 & 2 (blue), channels 5 & 6 (red) channels 7 & 8 (yellow)*

Test dates: 01/25/05 ~ 02/02/05

Test length

Crevice area: 0.785 mm<sup>2</sup> (each wire) yellow *d<sub>max</sub> = 57 μm*  
*blue d<sub>max</sub> = 180 μm one side is deeply corroded*

Maximum penetration depth:

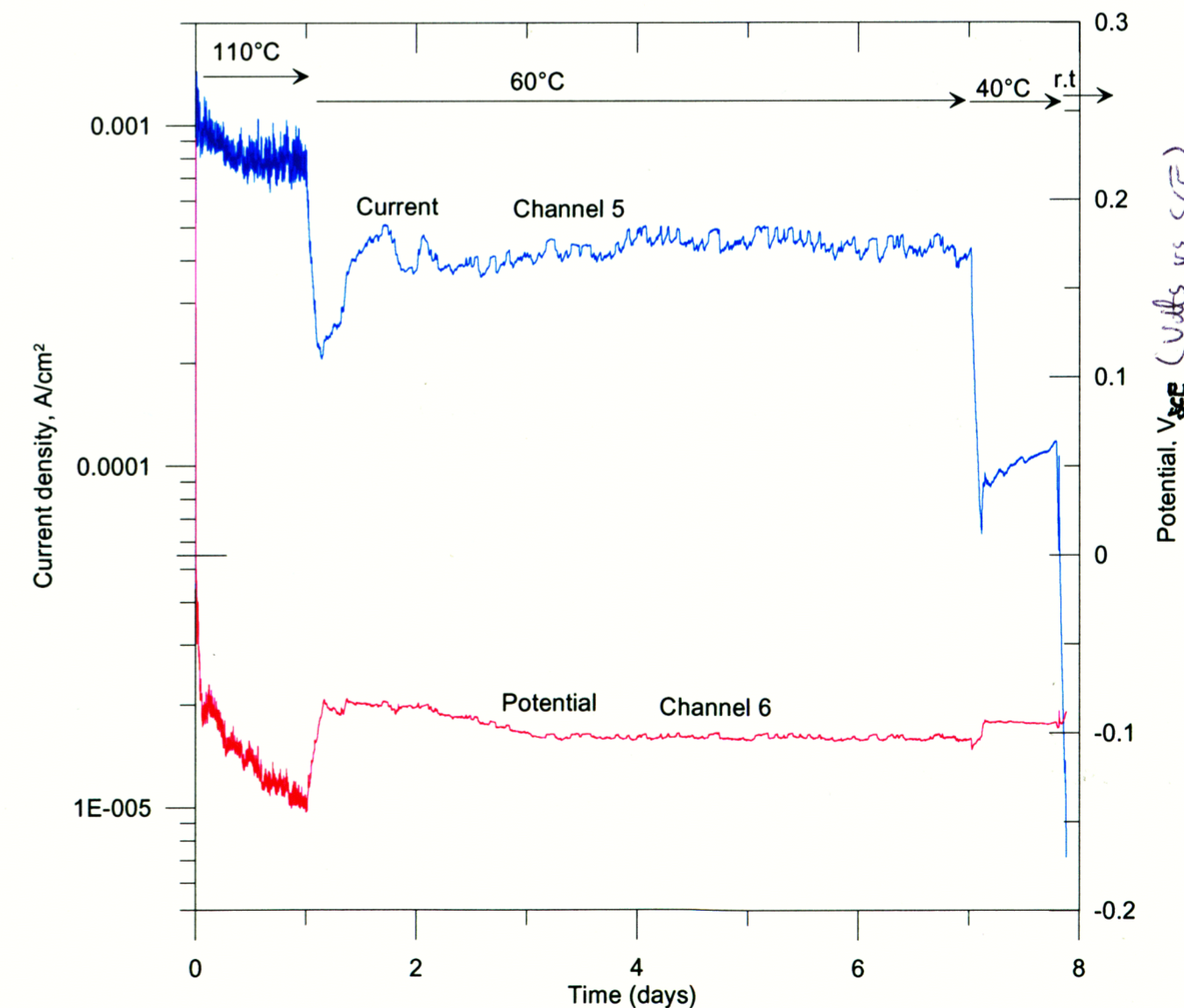
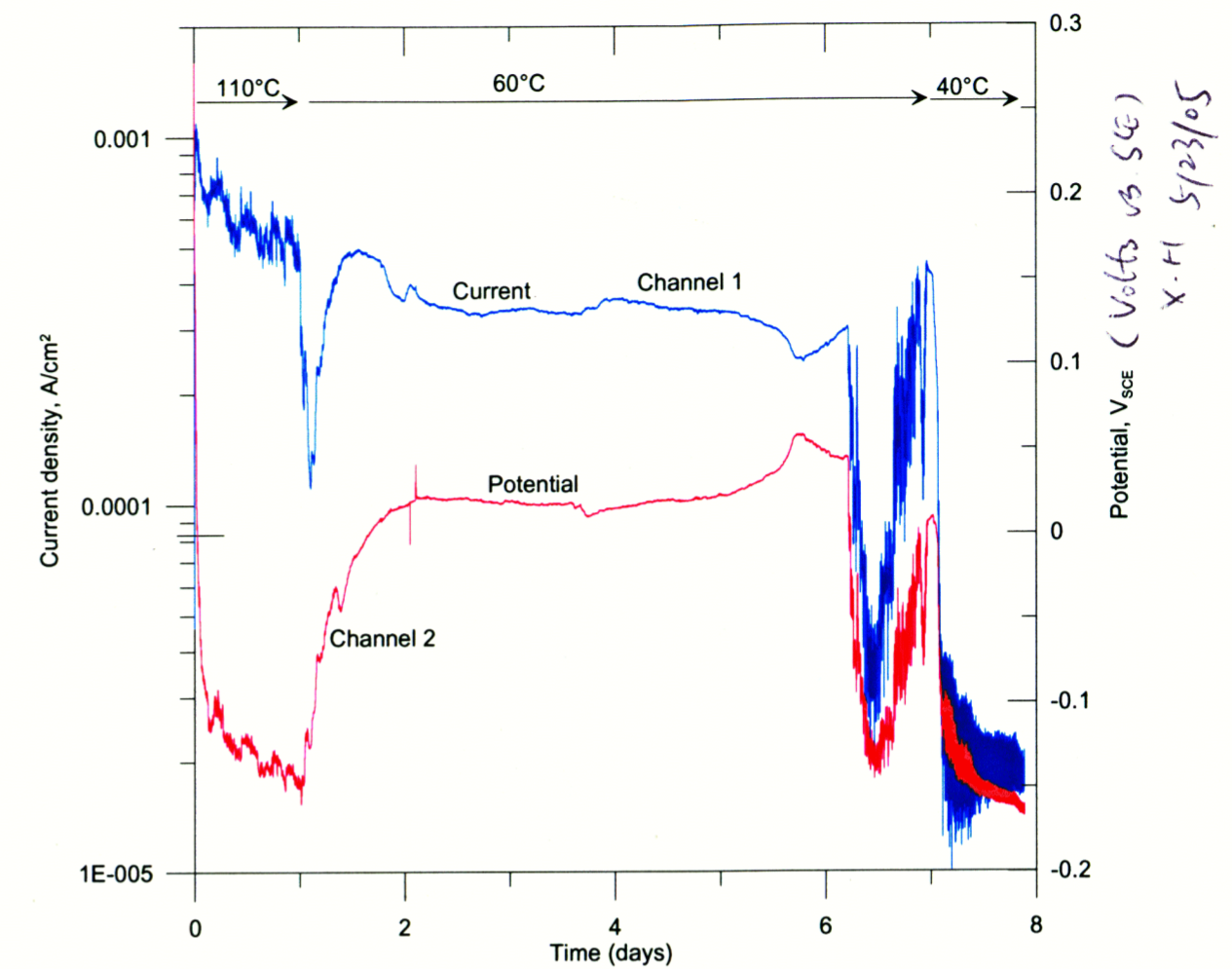
Specimen examination:

*One specimen is not corroded because problem with Pt electrode. The other three wires are corroded.*

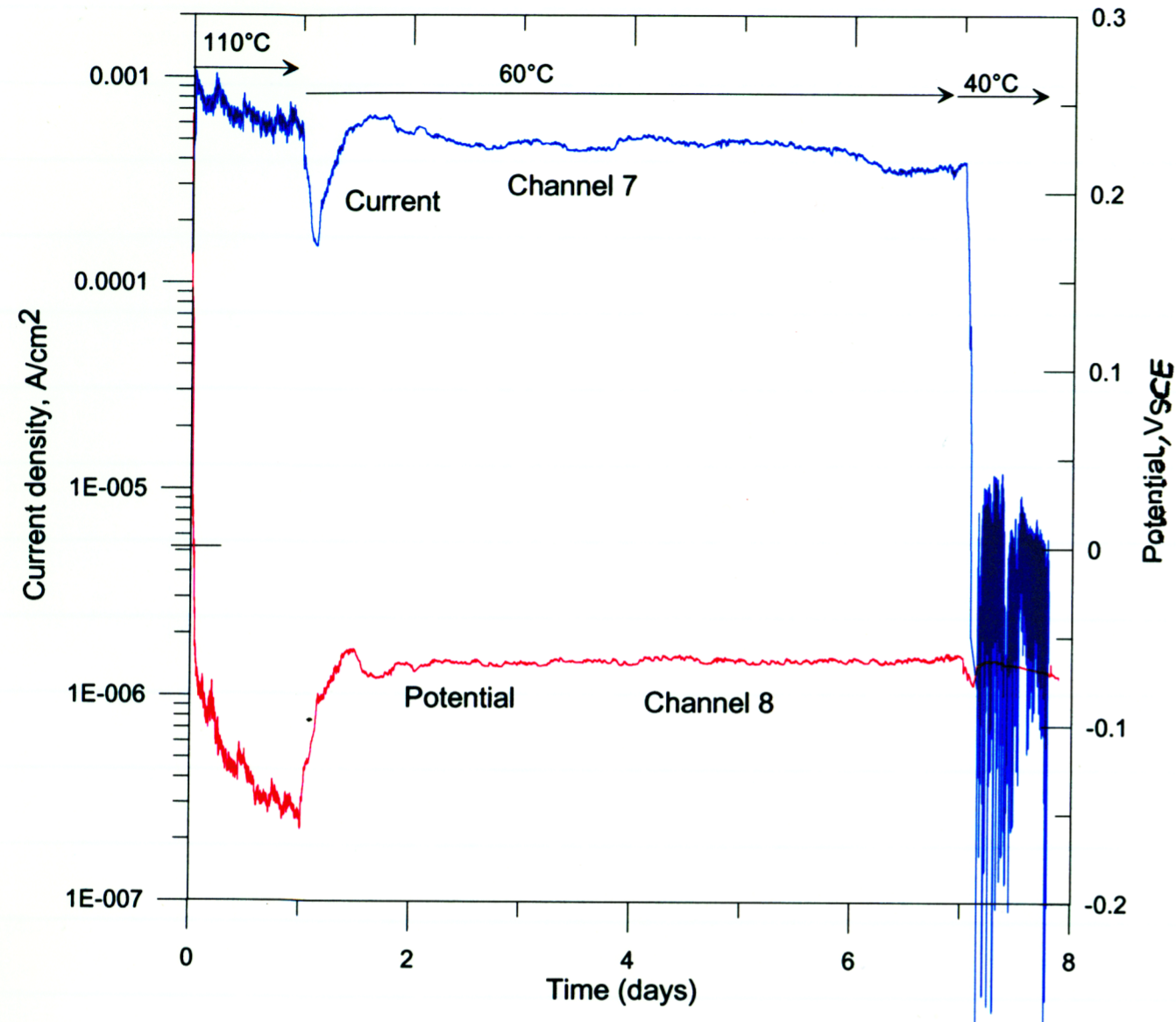
*One side of red wire is heavily corroded.*

*Xihua He 1/25/05*

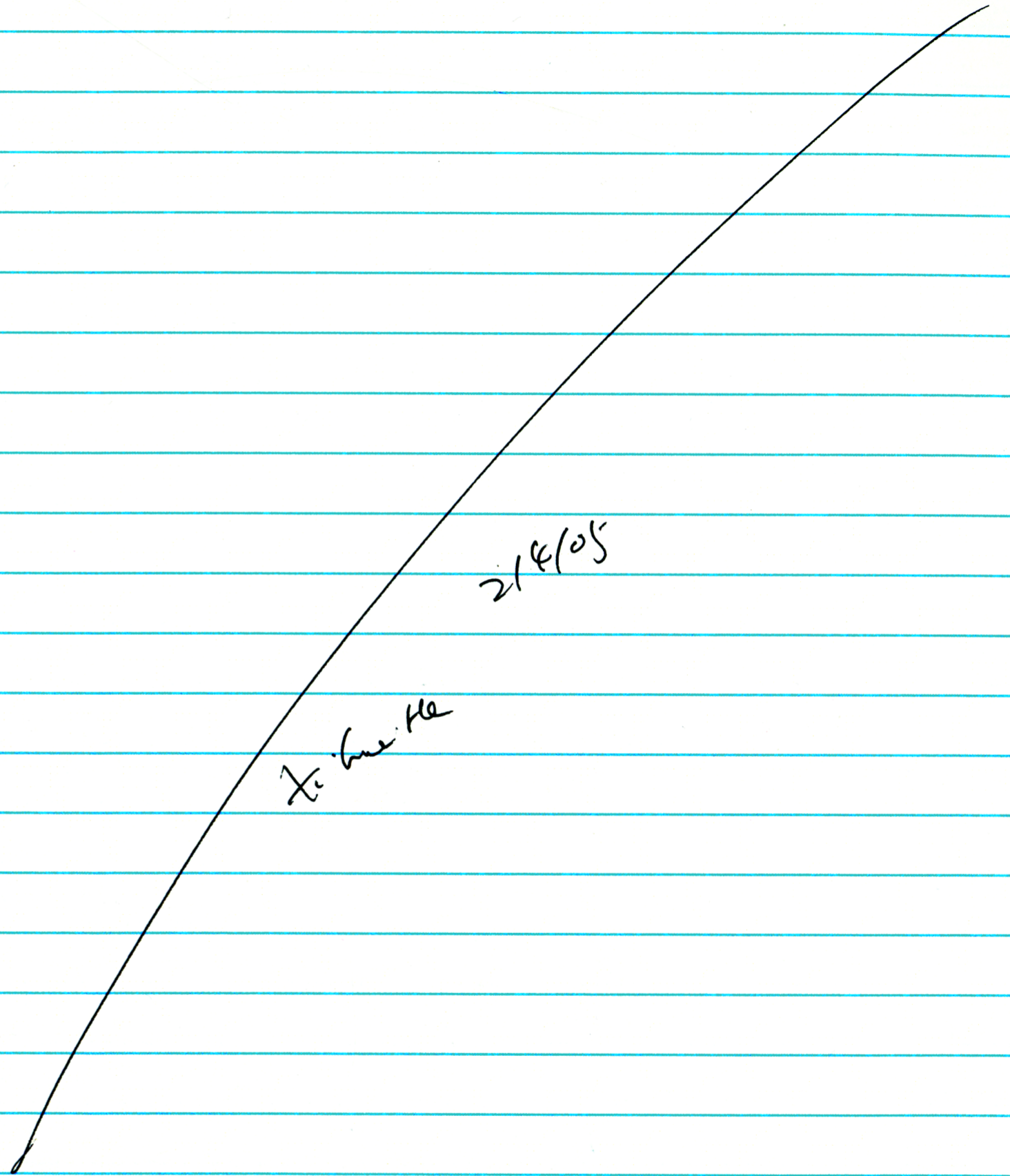
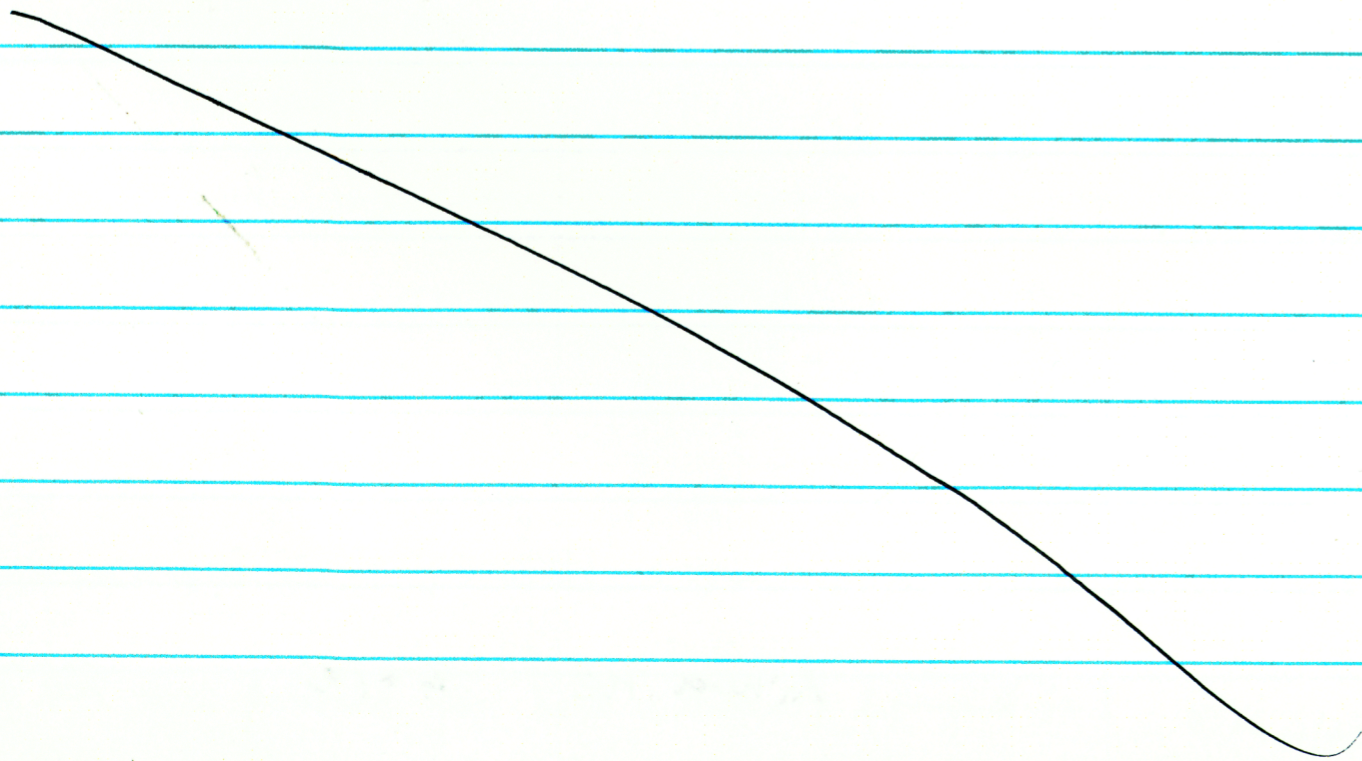
Probe after test was polished for Test C22PR019 (Page #54) X.H. 5/23/05



*Xihua He 2/4/05*



*Xihua He 2/4/05*



Localized Corrosion x.H 5/23/05  
C-22 Propagation Rate Measurement

Alloy 622, Heat # XX19778611 (Page # 36)

Alloy/Specimen: Hastelloy C-2000 alloy with Heat 2316-T-8122 x.H 5/23/05

Specimen Preparation: Four 1-mm wires was sealed in resin. 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.

Torque Screwdriver: Snap-on USA SN: 1001200319  
Cal: 09/03/04 Due: 3/03/05

Test ID: C22PR019

Solution: 4M MgCl<sub>2</sub>, same solution as test C22PR001 (Page 8)

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

Initial pH: 2.31 Model: Orion EA 940 SN: 2330  
Final pH: 4.28 Cal: 7/21/04 Due: 7/21/05

pH Probe: #13-620-296 SN: 4079126P

Test Temperature: 110°C Measured with Thermocouple SN: 330 329

Cal: 2/2/05 Due: 8/2/05

Counter Electrode: Pt foil with surface area of 261 mm<sup>2</sup>. Alloy 22 cathode with surface area of 19.90 cm<sup>2</sup>

Reference Electrode: Fisher 13-620-52 SN: 0066119 (red wire potential)  
SN: 4028023 (blue wire potential)

Multi-channel Potentiostat: SI1480 Cal: 12/03/04 Due: 06/03/05

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

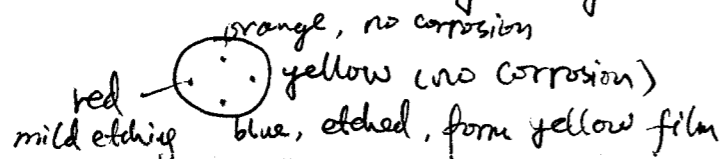
Data Files: Channels 1&2 (red wire) C22PR0204Ia, C22PR0204Ea, C22PR0206I, C22PR0206E, C22PR0207Ia, C22PR0207Ea, C22PR0207Ib, C22PR0207Eb, C22PR0209I, C22PR0209E  
Channels 1&2 (blue wire) C22PR0204Ia#5, C22PR0204Ea#6, C22PR0204Ib#5, C22PR0204Eb#6, C22PR0206I, C22PR0206E, C22PR0208I, C22PR0208E, C22PR0209I, C22PR0209E

Test dates: 2/4/2005 ~ 2/11/2005

Test length

Crevised area: 0.785 mm<sup>2</sup>

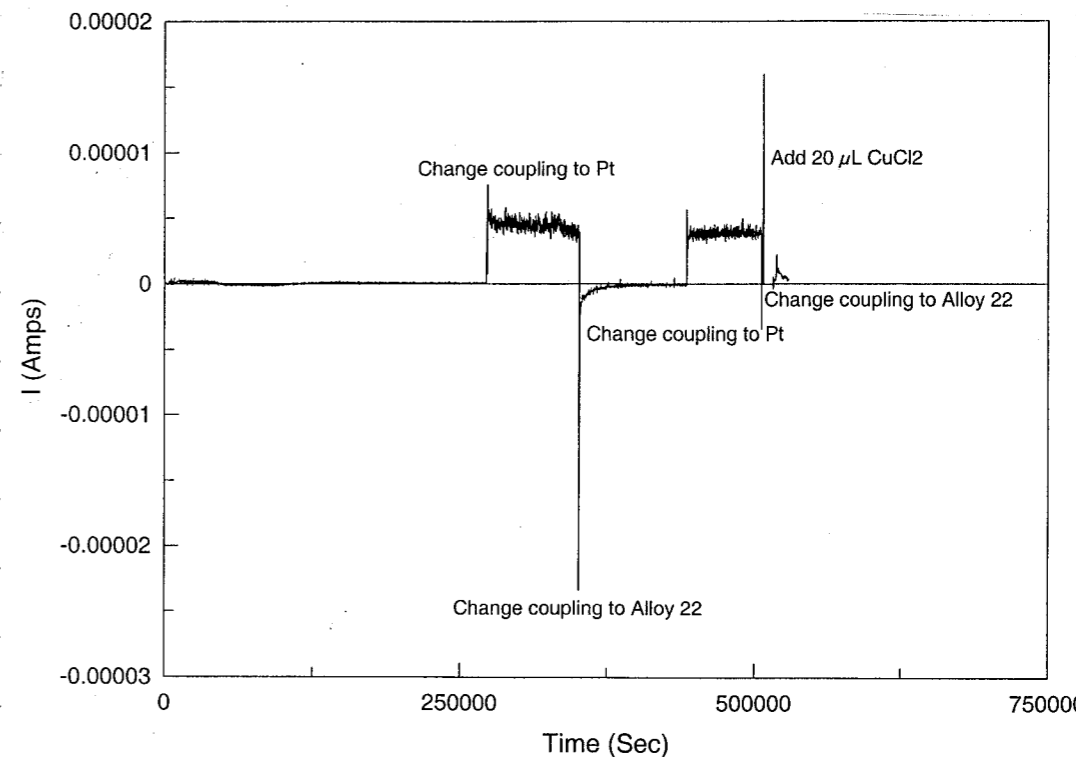
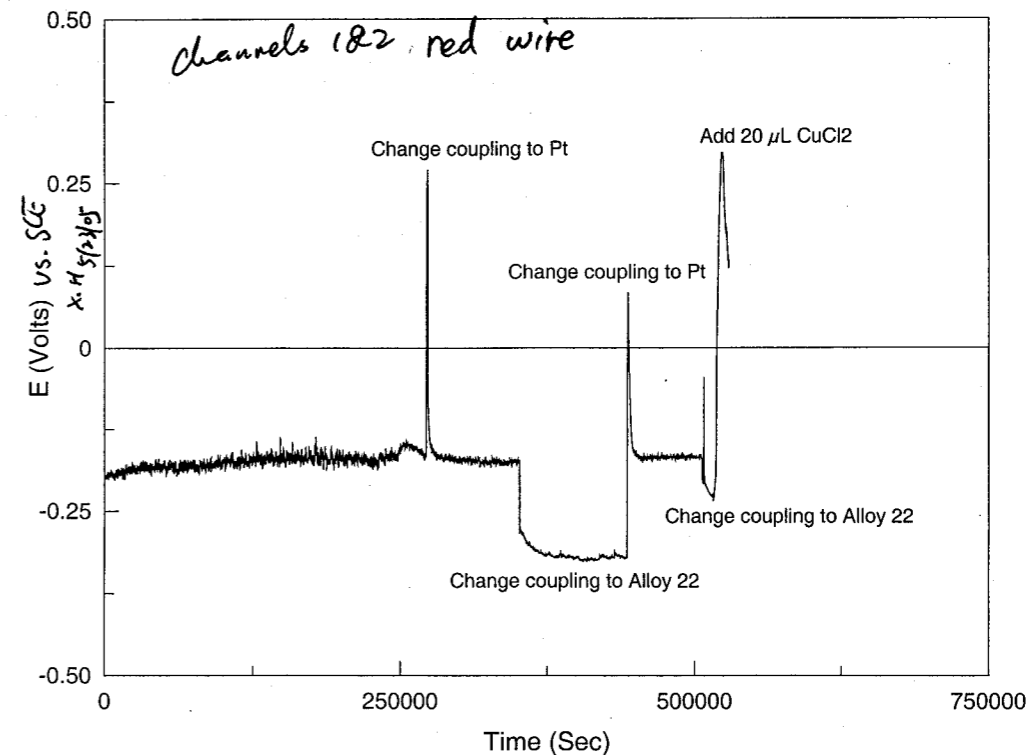
Maximum penetration depth: The electrodes are only mildly etched.  
Specim examination:



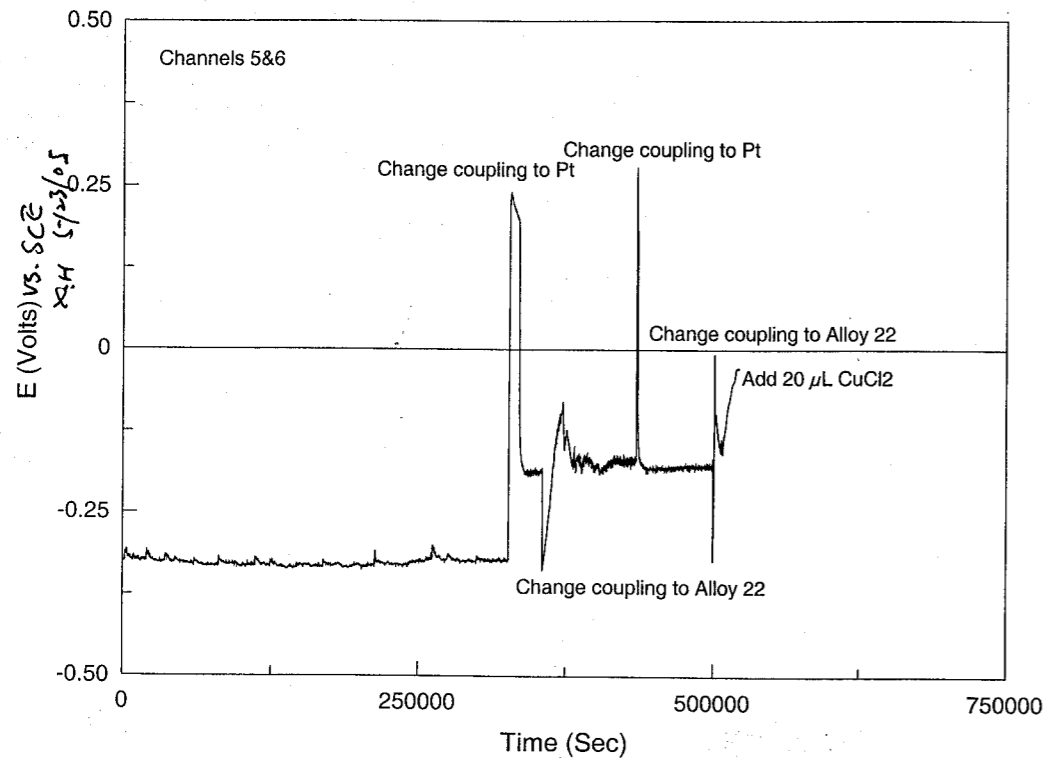
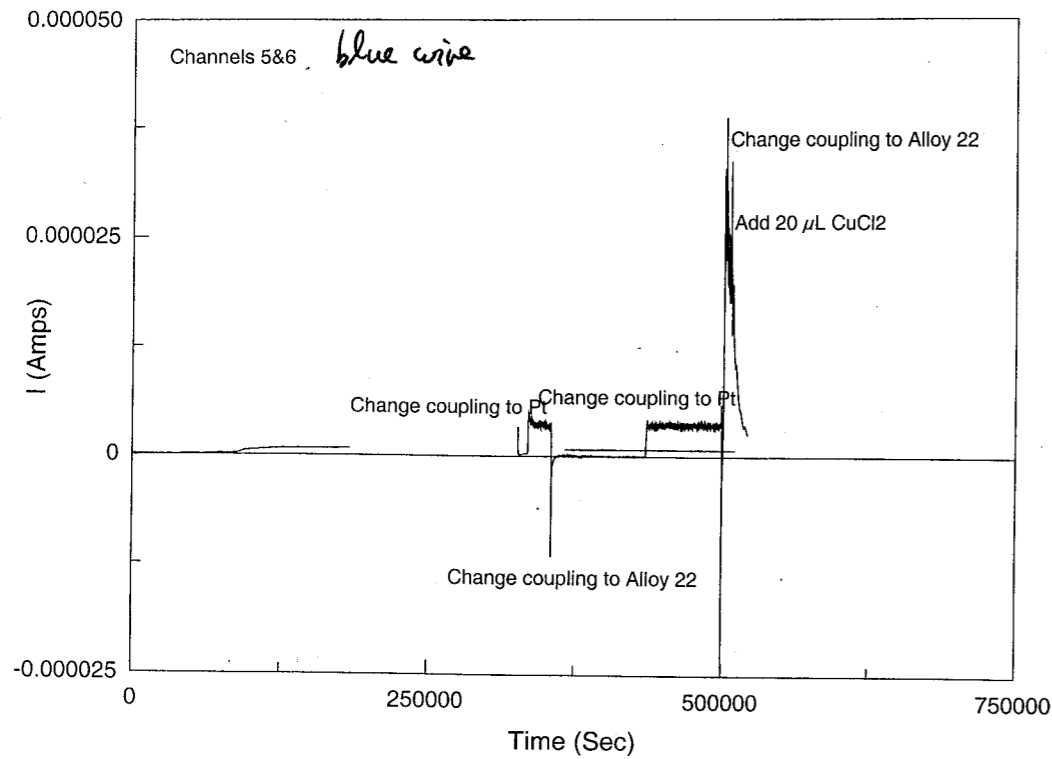
Xihua He 2/11/2005

The probe probe is polished for future use.  
X.H 9/6/05

X.H 5/23/05



Xihua He 2/14/05



Xihua He 2/14/05

Localized Corrosion  
C-22 Propagation Rate Measurement

**Alloy/Specimen:** Hastelloy C-2000 alloy with Heat 2316-1-8122 Alloy C22, Heat # xx17718611 (Page #36)  
**Specimen Preparation:** Four 1-mm wires were sealed in resin. 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 5/23/05

**Torque Screwdriver:** Snap-on USA SN: 1001200319  
 Cal: 09/03/04 Due: 3/03/05

**Test ID: C22PR020**

**Solution:** 5 M NaCl 584.83g 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:** 7.123 Model: Orion EA 940 SN: 2330  
**Final pH:** 5.751 Cal: 7/21/04 Due: 7/21/05

**pH Probe:** #13-620-296 SN: 4079126P

**Test Temperature:** 90°C Measured with Thermocouple SN: 329  
 Cal: 2/2/05 Due: 8/2/05

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

**Multi-channel Potentiostat:**

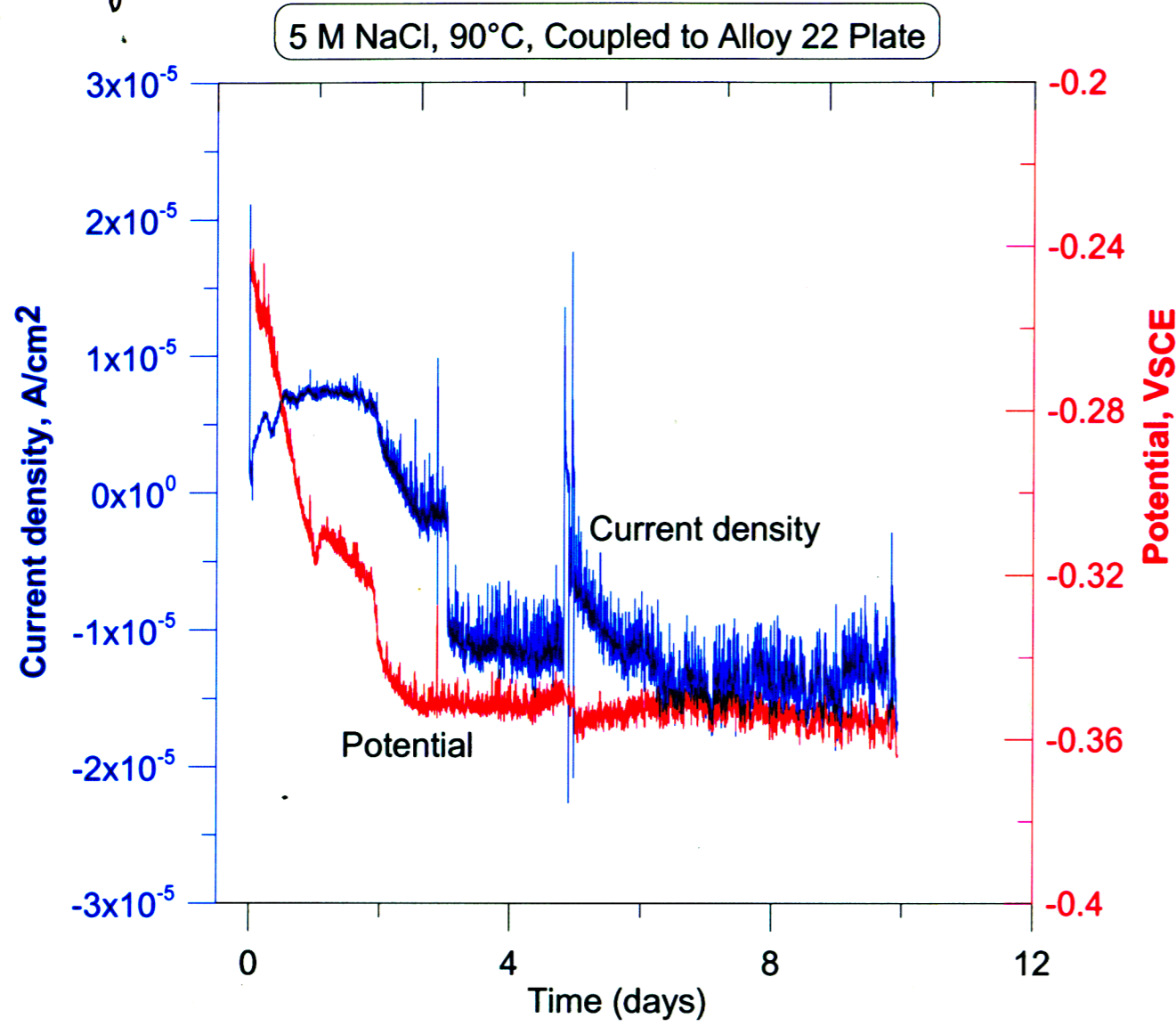
SI1480 Cal: 12/03/04 Due: 06/03/05

Wire color coded in red	Wire color coded in orange	Wire color coded in blue
<b>Channels 1&amp;2</b> Counter Electrode: Pt foil with surface area of 261 mm <sup>2</sup> .	<b>Channels 5&amp;6</b> Counter electrode: Alloy 22 plate with surface area of 19.90cm <sup>2</sup>	<b>Channels 5&amp;6</b> Counter Electrode: Pt foil with surface area of 19.90 mm <sup>2</sup> .
<b>Reference Electrode:</b> Fisher 13-620-52 SN: 4028023	<b>Reference Electrode:</b> Fisher 13-620-52 SN: 3329075	<b>Reference Electrode:</b> Fisher 13-620-52 SN: 0066119
<b>Data Files:</b> C22PR021I, E, a, C22PR021I, E, b, C22PR0214I, E, C22PR0217I, E, C22PR0220I, E, C22PR0223I, E, C22PR0226I, E, C22PR0301I, E, C22PR0304I, E, C22PR0307I, E, C22PR0313I, E, C22PR0316I, E, C22PR0318I, E, C22PR0321I, E, C22PR0324E, I, C22PR0321I, E, C22PR0330E, I, C22PR0401E, I, C22PR0403E, I, C22PR0406E, I	<b>Data Files:</b> C22PR021I, E, a, C22PR021I, E, b, C22PR0214I, E, C22PR0217I, E, C22PR0220I, E, C22PR0301I, E, C22PR0304I, E, C22PR0307I, E, C22PR0310E, I, C22PR0313E, I, C22PR0316E, I, C22PR0318E, I, C22PR0321E, I, C22PR0324E, I, C22PR0325E, I, C22PR0327E, I, C22PR0330E, I, C22PR0401E, I, C22PR0403E, I, C22PR0406E, I	<b>Data Files:</b> C22PR022I, E, I, C22PR0223E, I, C22PR0226E, I, C22PR0301E, I, C22PR0304E, I, C22PR0307E, I, C22PR0310E, I, C22PR0313E, I, C22PR0316E, I, C22PR0318E, I, C22PR0321E, I, C22PR0324E, I, C22PR0325E, I, C22PR0327E, I, C22PR0330E, I, C22PR0401E, I, C22PR0403E, I, C22PR0406E, I
<b>Test dates:</b> 2/11/05 ~ 4/8/05	<b>Test dates:</b> 2/11/05 - 2/21/05	<b>Test dates:</b> 2/21/05 - 4/8/05
<b>Test length:</b> 4.81 x 10 <sup>5</sup> seconds	<b>Test length:</b> 8.58 x 10 <sup>5</sup> seconds	<b>Test length:</b> 3.96 x 10 <sup>6</sup> seconds
<b>Crevice area:</b> 0.785 mm <sup>2</sup>	<b>Crevice area:</b> 0.785 mm <sup>2</sup>	<b>Crevice area:</b> 0.785 mm <sup>2</sup>
<b>Maximum penetration depth:</b> d <sub>max</sub> is not available. Corrosion is around the edge.	<b>Maximum penetration depth:</b> 0	<b>Maximum penetration depth:</b> d <sub>max</sub> can not be determined. Corrosion is around the edge.
<b>Specimen examination:</b> X-H 5/23/05 Corrosion is around the edge. Front face is etched.	<b>Specimen examination:</b> X-H 5/23/05 Mild etching on specimen surface.	<b>Specimen examination:</b> X-H 5/23/05 Corrosion is around the edge. Front face is etched and discolored.
<b>Charge = 28.8 coulombs</b>		

He He 2/11/05

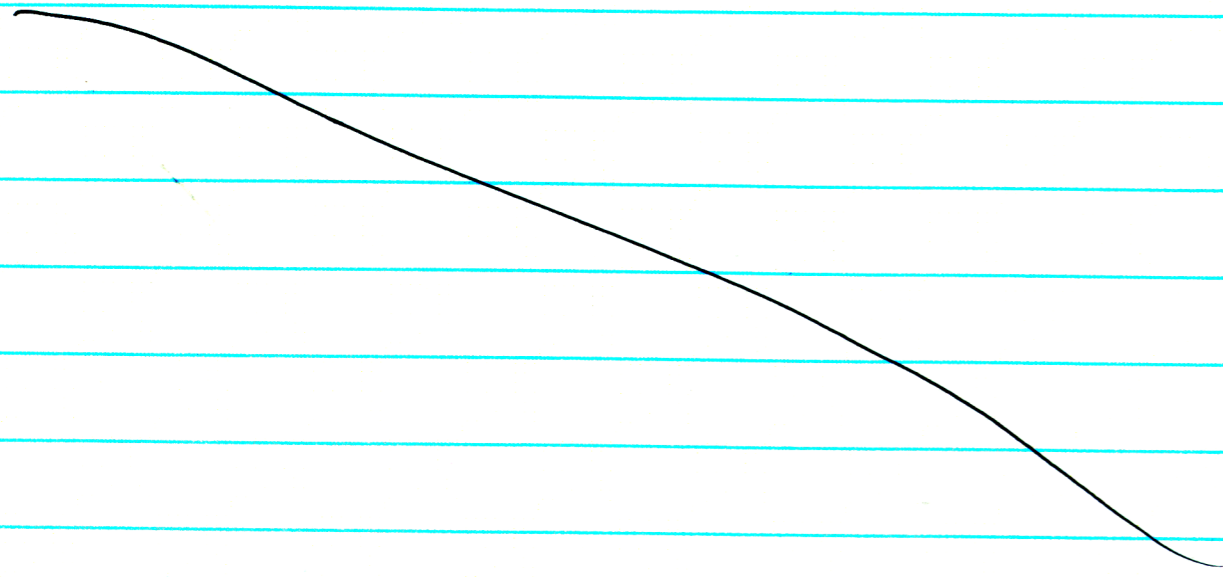
orange wire

channels 5 & 6



Note: Corrosion was not initiated by coupling to Alloy 22 plate in ~10 days

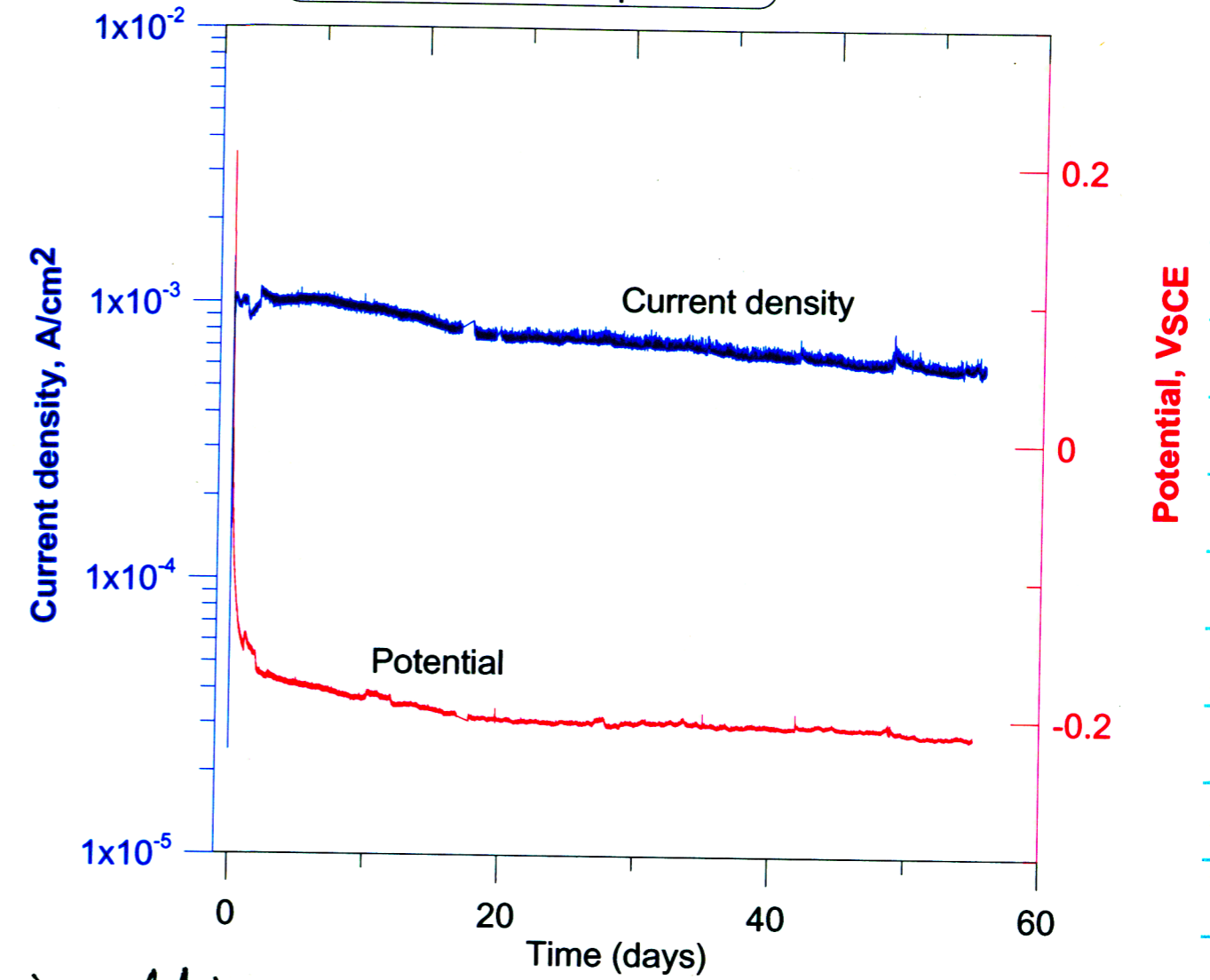
Xi-hua He 12/25/2005



Wire coded in red

5 M NaCl, 90°C, Coupled to Pt

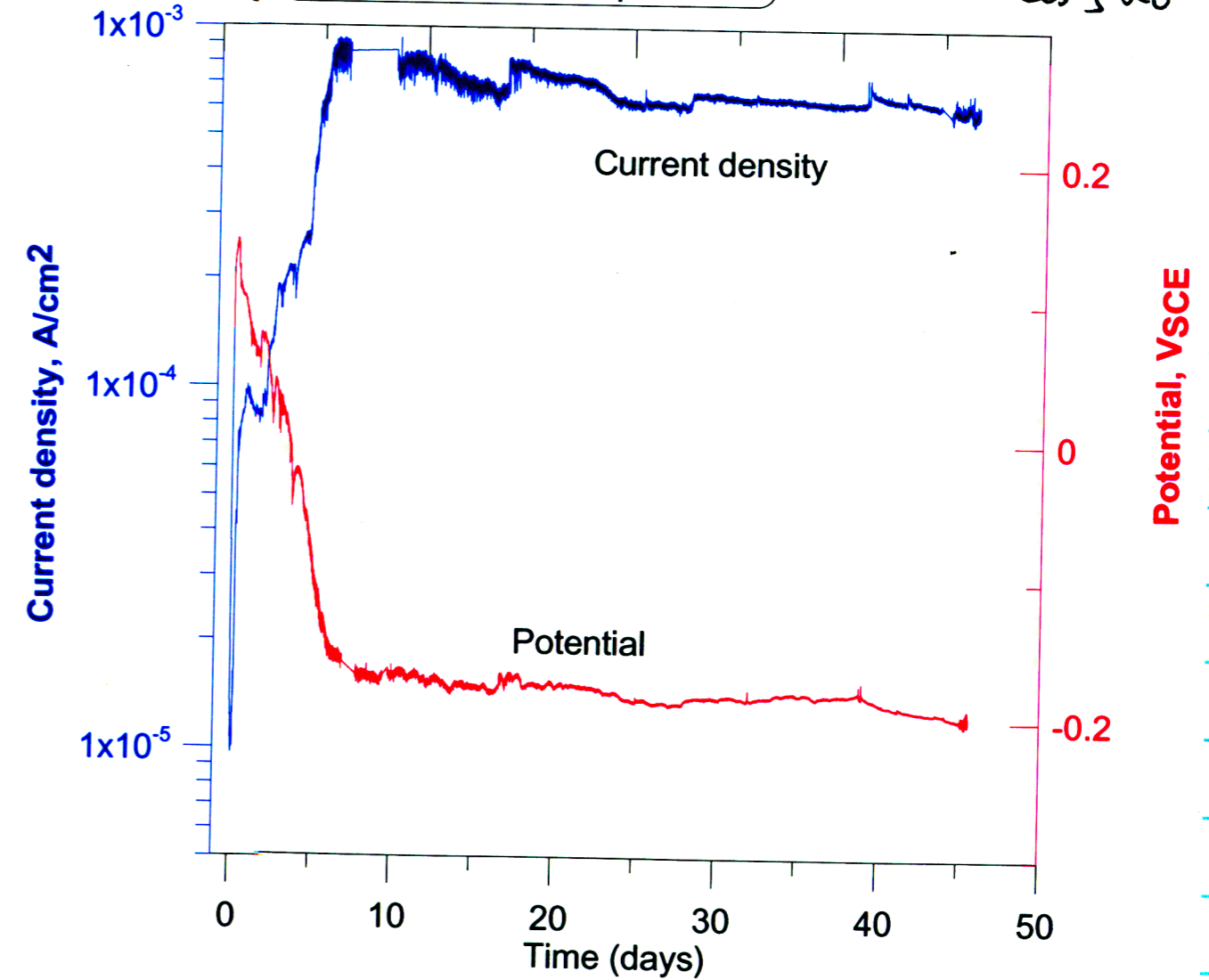
channels 1 & 2



wire coded in blue

5 M NaCl, 90°C, Coupled to Pt

channels 5 & 6



Xi-hua He 4/15/2005



Localized corrosion

C-22 Propagation Rate Measurement

Alloy/Specimen: Hastelloy C-2000 alloy with Heat 2316-1-8122  
 Specimen Preparation: Four 1-mm wires were sealed in resin. 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.

Torque Screwdriver: Snap-on USA SN: 1001200319  
 Cal: 09/03/04 Due: 3/03/05  
 Test ID: C22PR021 406.68 g MgCl<sub>2</sub> Lot # 041703 + DI water to 2Ls  
 Solution: 1 M MgCl<sub>2</sub>  
 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: 4079126P  
 Measured with Thermocouple SN: 327  
 Cal: 2/7/05 Due: 8/5/05  
 Test Temperature: 90°C

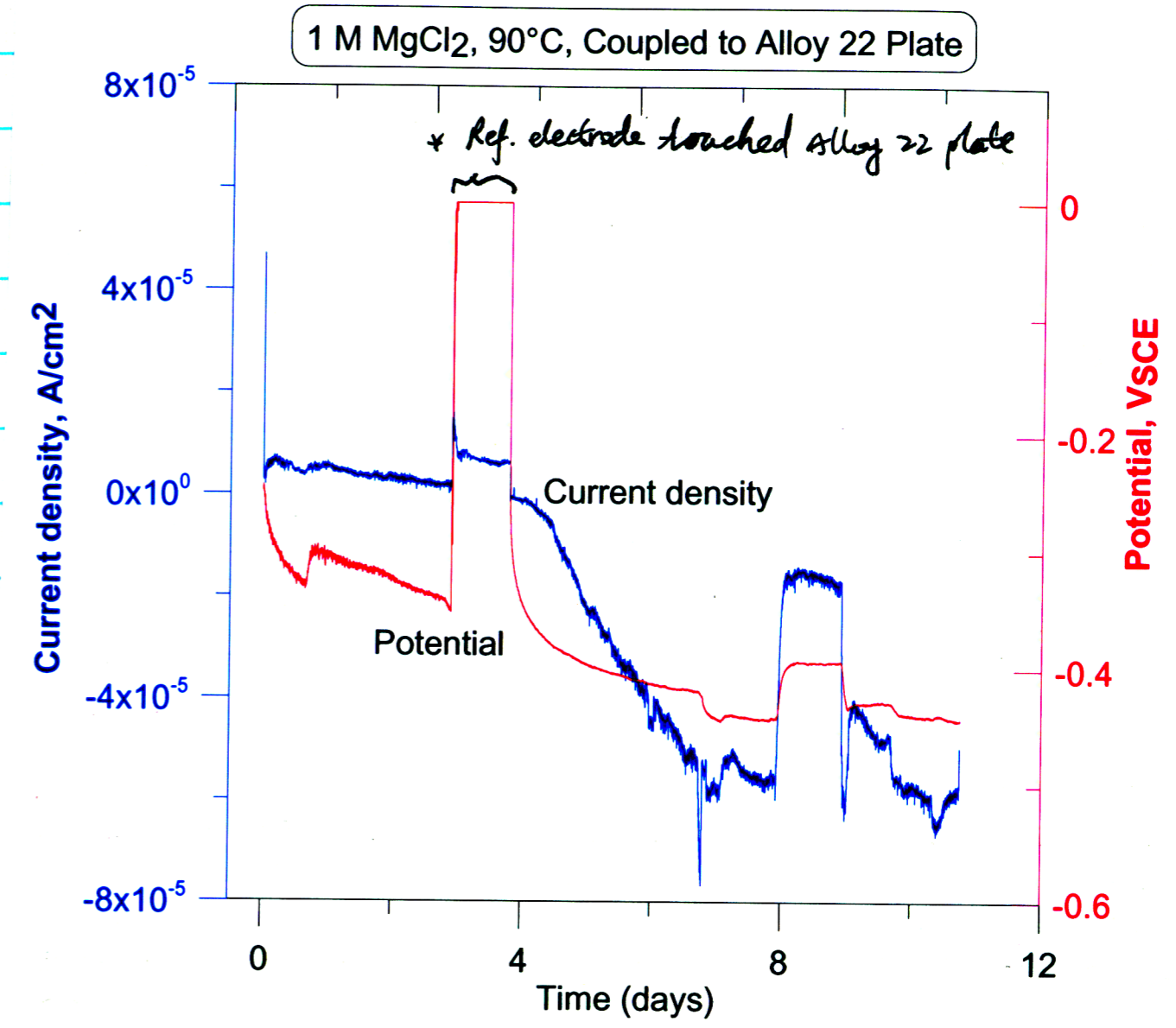
Cell set up: Two channels for each electrode, one channel to measure the coupling current, the other channel to measure the potential.

Multi-channel Potentiostat: SI1480 Cal: 12/03/04 Due: 06/03/05

Wire color coded in yellow	Wire color coded in orange	Wire color coded in red
Channels 3 & 4	Channels 7 & 8	Channels 7 & 8
Counter Electrode: Pt foil with surface area of 0.2x10 <sup>2</sup> mm <sup>2</sup> .	Counter electrode: Alloy 22 plate with surface area of 367 cm <sup>2</sup>	Counter Electrode: Pt foil with surface area of 0.2x10 <sup>2</sup> mm <sup>2</sup> .
Reference Electrode: Fisher 13-620-52 SN: 0199568	Reference Electrode: Fisher 13-620-52 SN: 8131148	Reference Electrode: Fisher 13-620-52 SN: 8131148
Data Files: C22PR0214Ia, C22PR0214Ea, C22PR0214Ib, C22PR0214Eb, C22PR0217I, C22PR0217E, C22PR0220I, C22PR0220E, C22PR0223I, C22PR0223E	Data Files: C22PR0214Ia, C22PR0214Ea, C22PR0214Ib, C22PR0214Eb, C22PR0217I, C22PR0217E, C22PR0220I, C22PR0220E, C22PR0223I, C22PR0223E	Data Files: C22PR0225I, C22PR0225E, C22PR0226I, C22PR0226E, C22PR0301I, C22PR0301E, C22PR0303I, C22PR0303E, C22PR0304I, C22PR0304E
Test dates: 2/14 - 3/13/05	Test dates: 2/14/05 - 2/25/05	Test dates: 2/25/05 - 3/31/05
Test length 3.35x10 <sup>6</sup> seconds	Test length 9.29x10 <sup>5</sup> seconds	Test length 2.42x10 <sup>6</sup> seconds
Crevice area: 0.785 mm <sup>2</sup>	Crevice area: 0.785 mm <sup>2</sup>	Crevice area: 0.785 mm <sup>2</sup>
Maximum penetration depth: It is difficult to determine since the corrosion is around the resin.	Maximum penetration depth: It is difficult to determine since the corrosion is around the edge near to the resin.	Maximum penetration depth: It is difficult to determine since the corrosion is around the edge near to the resin.
Specimen examination: See page #63	Specimen examination: See page #63	Specimen examination: See page #63

He XH 2/14/05

Wire in orange



More data files for channels 3 & 4

- C22PR0307I, C22PR0307E
- C22PR0310I, C22PR0310E
- C22PR0313I, C22PR0313E
- C22PR0316I, C22PR0316E
- C22PR0318I, C22PR0318E
- C22PR0321I, C22PR0321E
- C22PR0324I, C22PR0324E

More data files for channels 7 & 8 (red wire)

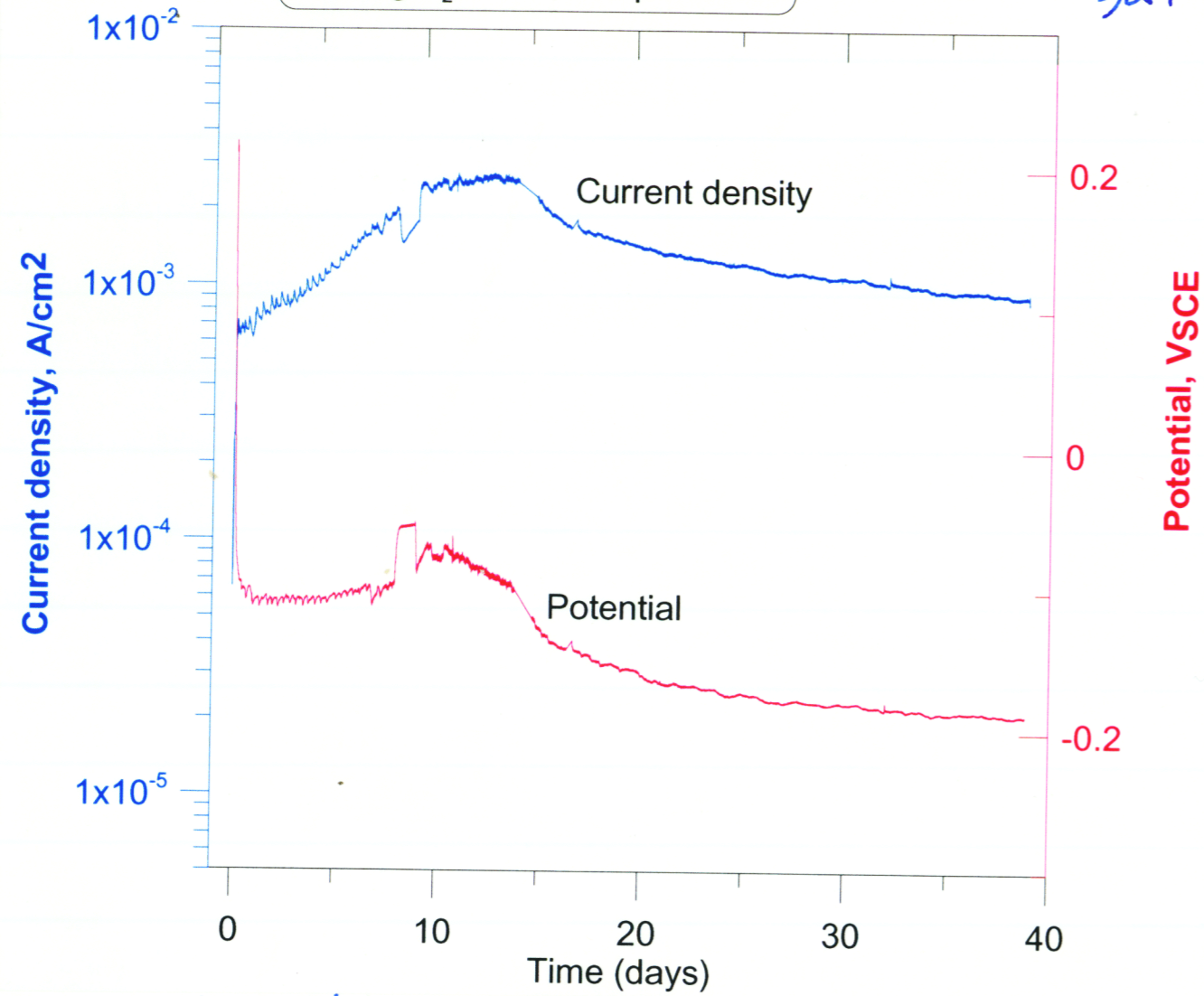
- C22PR0321I, C22PR0321E
- C22PR0324I, C22PR0324E

Xihua He 4/14/2005

wire coded in yellow

1 M MgCl<sub>2</sub>, 90°C, Coupled to Pt

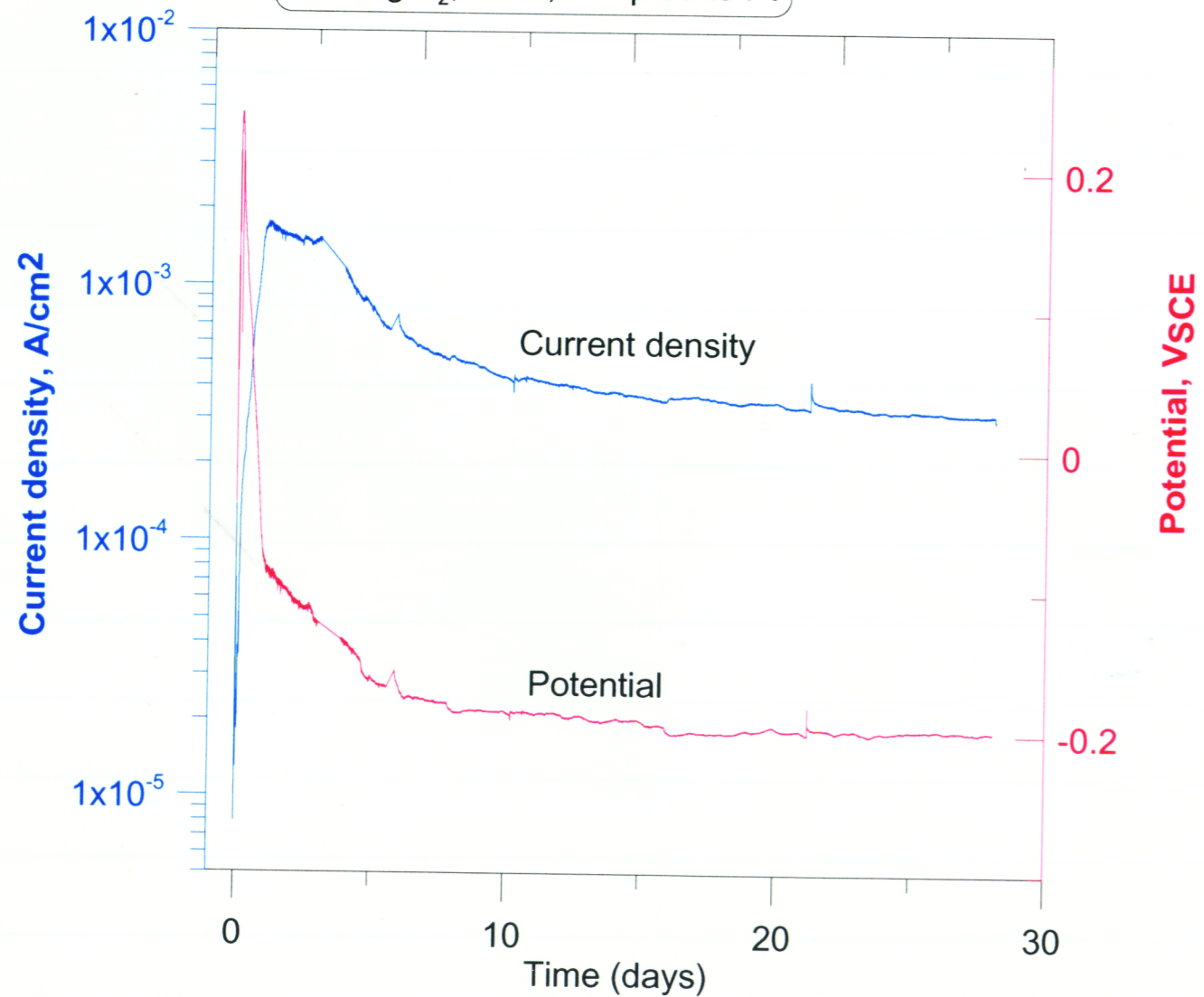
channels 3 & 4  
x-4 4/14/05



wire coded in red

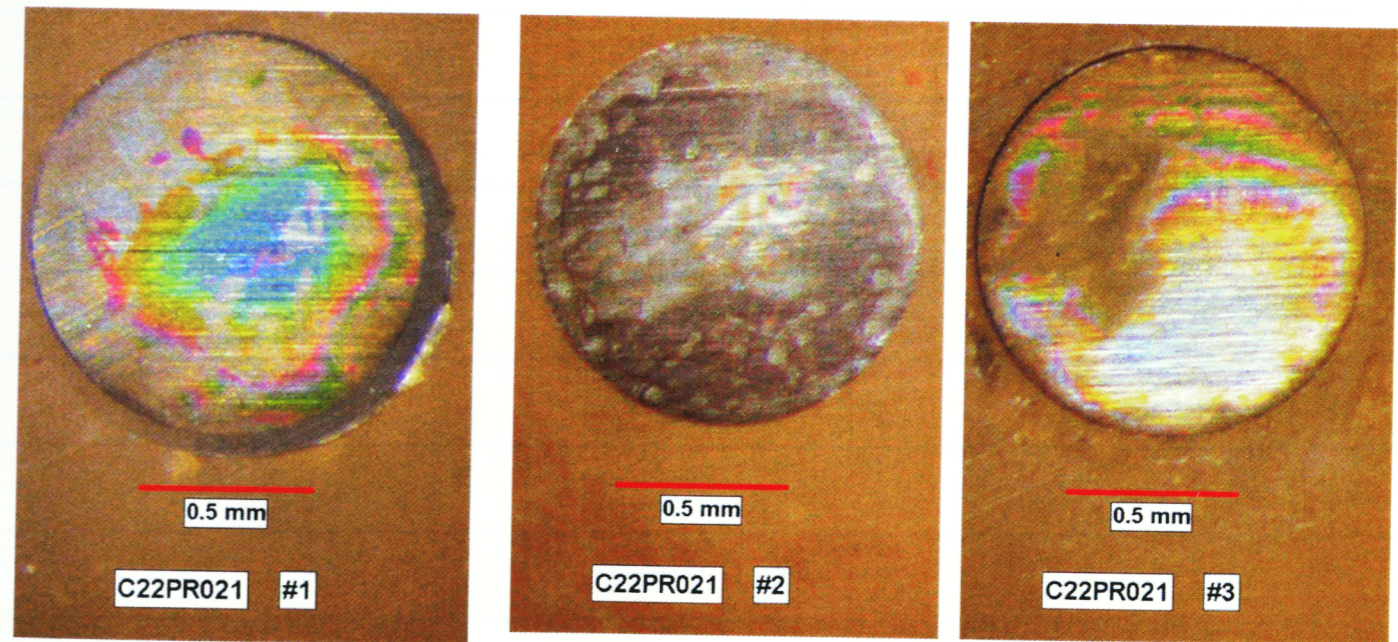
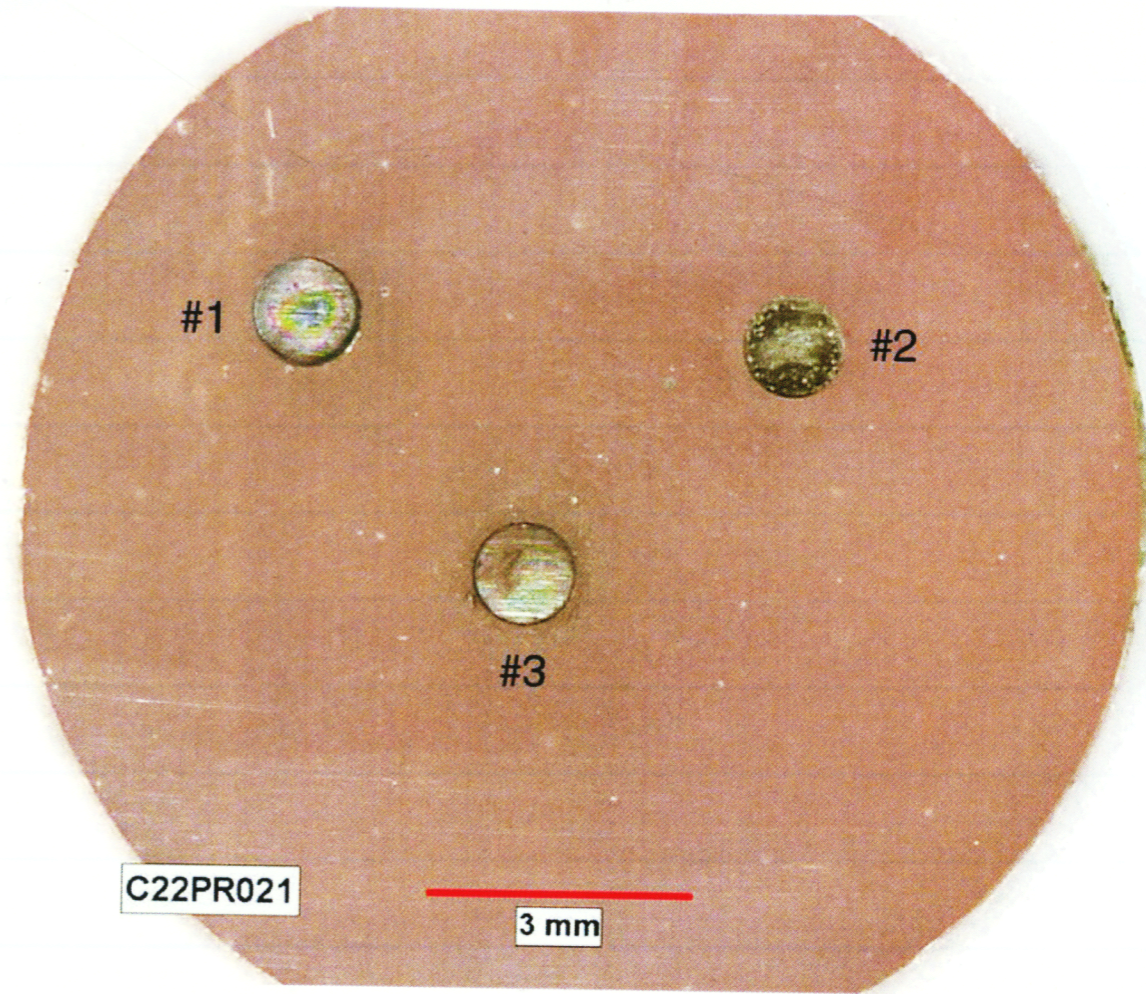
1 M MgCl<sub>2</sub>, 90°C, Coupled to Pt

channels 7 & 8



Xihua He  
4/14/2005

Post-test examination



Notes: All the wires front face is etched, but polishing lines are still visible. Corrosion is preferentially around the edge.

Xihua He 4/14/2005

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. #20-940571.dj.  
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.

Torque Screwdriver: Snap-on USA SN: 1001200319  
Cal: 09/03/04 Due: 3/03/05

Test ID: C22PROP22

Initial weight: 12.48314g Model: Sartorius Genius SN: 12809099  
Final weight: 12.48382g Cal: 11/10/04 Due: 05/10/05

Solution: 1 M MgCl<sub>2</sub> (same solution as page 60) 406.68g MgCl<sub>2</sub> Lot #041703  
+ D.I water to 2Ls X.H 5/23/05

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

Initial pH: 4.285 Model: Orion EA 940 SN: 2330  
Final pH: 4.913 Cal: 7/21/04 Due: 7/21/05  
pH Probe: #13-620-296 SN: 4079126P

Test Temperature: 90°C Measured with Thermocouple SN: 333  
Cal: 2/7/05 Due: 8/5/05

Counter Electrode: Alloy 22 plate with surface area of 36.9 cm<sup>2</sup> SN: 9250078

Reference Electrode: Fisher 13-620-52 Cal: 10/6/04 Due: 04/06/05

Potentiostat: SI1287

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to C-22 plate, CE unused

Data Files: C22PROP-0217a, C22PROP-0217b, C22PROP-0220, C22PROP-0221

Test dates: Feb. 17, 2005 ~ Feb. 22, 2005

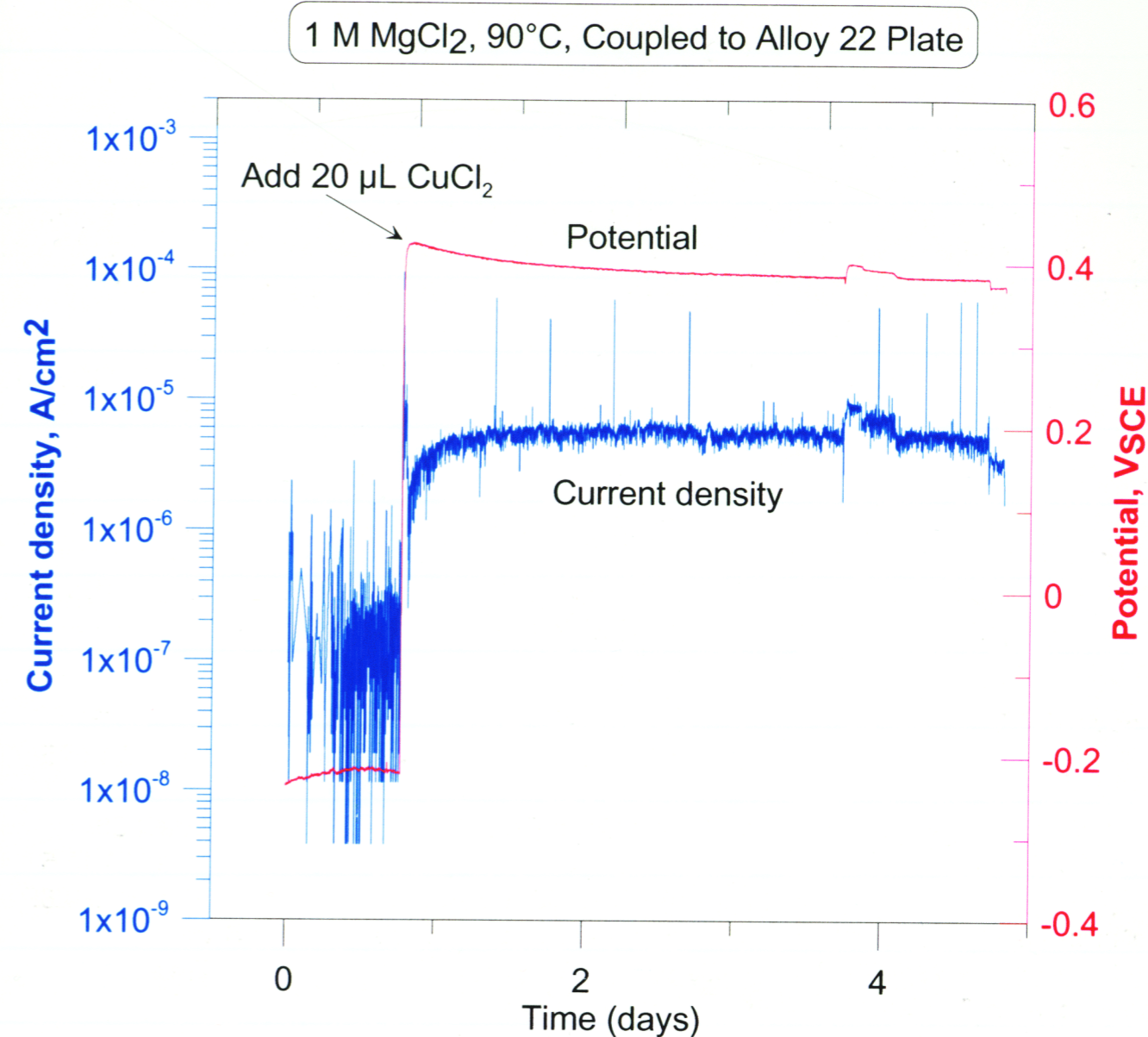
Test time: 4.17 x 10<sup>5</sup> seconds = 4.82 days

Crevice area: 8.04 mm<sup>2</sup>  
Estimated crevice corroded area: 0

Maximum penetration depth: 0

No corrosion and etching on specimen.

Xihua He 2/21/2005  
X.H 5/23/05



Notes: Crevice corrosion is not initiated even with CuCl<sub>2</sub> addition.  
Original concentration of CuCl<sub>2</sub> 1.175 M

So: Concentration in 300ml test solution [CuCl<sub>2</sub>] = 0.78 x 10<sup>-4</sup> M  
X.H 2/23/04

Xihua He 2/23/05  
X.H 11/4/05

Localized Corrosion  
C-22 Propagation Rate Measurement

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

Specimen Preparation: Specimen machined to dimensions 1.917" x 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.

Torque Screwdriver: Snap-on USA SN: 1001200319  
Cal: 09/03/04 Due: 3/03/05

Test ID: C22PR023

Initial weight: 12.46941 g Model: Sartorius Genius SN: 12809099

Final weight 12.46941 g Cal: 11/10/04 Due: 05/10/05

Solution: 1 M MgCl<sub>2</sub> (Same solution as page 60)

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

Initial pH: 4.285 Model: Orion EA 940 SN: 2330

Final pH: 5.32 Cal: 7/21/04 Due: 7/21/05

pH Probe: #13-620-296 SN: 4079126P

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

Counter Electrode: Alloy 22 plate

Reference Electrode: Fisher 13-620-52 SN: 9250078

Potentiostat: SI1287 Cal: 10/6/04 Due: 04/06/05

Cell set up: WE+RE2 = C-22 specimen, RE1 to SCE, GROUND to C-22 plate, CE unused

Data Files: C22Prop-0223a, C22Prop-0223b, C22Prop-0226, C22Prop-0228, C22Prop-0301

Test dates: 2/23/2005 ~ 3/3/2005

Test time: 7.84 days = 6.77 x 10<sup>5</sup> seconds

Crevice area: 8.04 mm<sup>2</sup>

Estimated crevice corroded area: 0 x.H 5/23/05

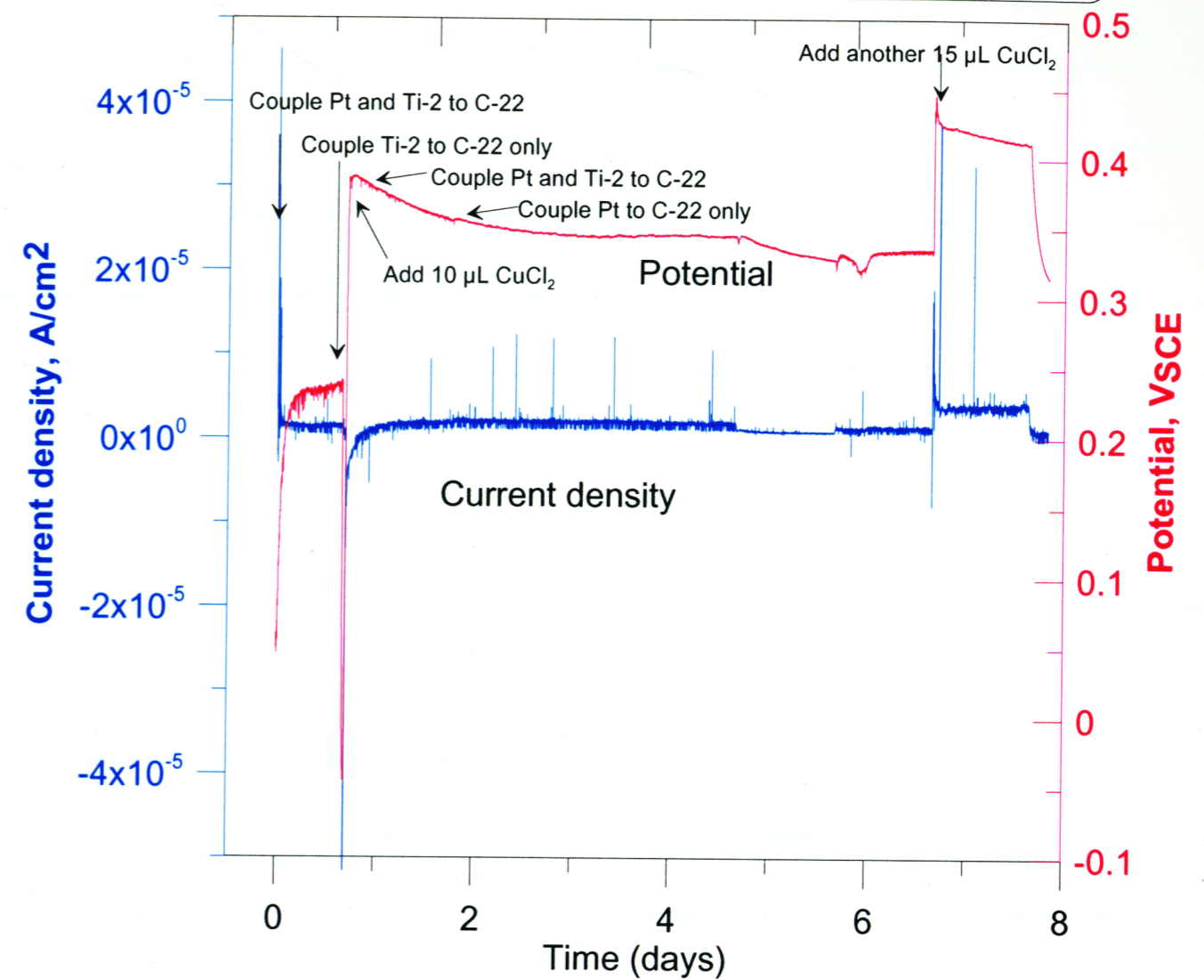
Maximum penetration depth: 0 x.H 5/23/05

Only the edge is etched, but no corrosion

He XH 2/28/05

\* Specimen was cut ~5mm from the front surface. The longer section without corrosion will be used for future tests. x.H 4/26/05

1 M MgCl<sub>2</sub>, 95°C, Couple to Ti-2 plate and Pt alternatively



\* Corrosion is not initiated even with addition of CuCl<sub>2</sub> and coupling to Pt.

X.Hua He 6/9/06

X.Hua He 3/4/2005

Potentiodynamic Polarization of Alloy 22

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

Specimen Preparation: Specimen machined to dimensions 1.917"\*0.250" specified in CNWRA Drawing # 20-01402-57.017. 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.

Torque Screwdriver:

PROTA® 1604 MFD USA  
Cal: 9/29/2004

SN: 139072  
Due: 3/29/2005

Test ID: C22PRO24

Initial weight: 12.44486 g

Model: Sartorius Genius

SN: 12809099

Final weight 12.41818 g

Cal: 11/10/04

Due: 05/10/05

Surface area: ~~10.6 mm² (creviced)~~ x-H 5/23/05

Solution: 4 M MgCl₂ 2033.1g MgCl₂·6H₂O + D.I water to 2.5L

Lot # 041703

x-H 5/23/05

Reagents measured with

Model: OHAUS

SN: 2883

Cal: 1/14/05

Due: 7/14/05

Initial pH: 2.31

Model: Orion EA 940

SN: 2330

Final pH: 5.97

Cal: 7/21/04

Due: 7/21/05

Test Temperature: 110°C

pH Probe: #13-620-296

SN: 4079126P

Counter Electrode: Pt

Measured with Thermocouple

SN: 333

Reference Electrode: Fisher 13-620-52

Cal: 2/7/05

Due: 8/5/05

Potentiostat: SI1287

Cal: 10/6/04

SN: 9250078

Polarization potential range: -200 mV vs. OCP → 0.24 V vs. SCE → -0.70 V vs. SCE

Due: 04/06/05

Scan rate: 0.167 mV/s

x-H 3/4/2005

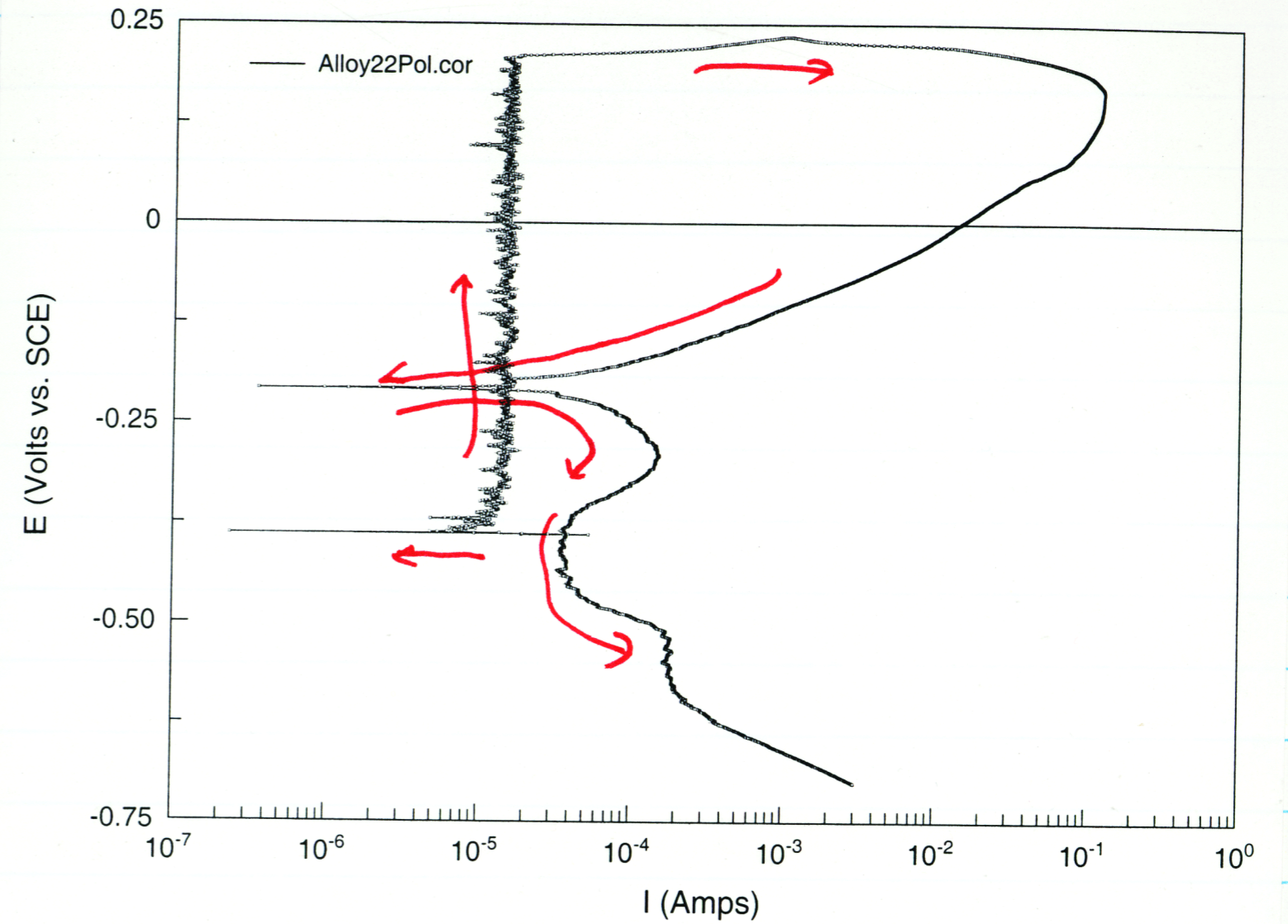
Data File: Alloy 22 Pol

Crevice area: 8.04 mm²

Specimen examination:

The crevice area is protected from corrosion, but the rest of the surface is corroded.

file [signature] 3/4/2005



x-Hua He 6/9/06

file [signature] 3/4/2005