308 - - - Q200409290007

Scientific Notebook No. 320: Effect of Environment on Localized Corrosion and Passive Dissolution of Ti-7 (03/26/1999 through 12/07/2001)

21
300

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CLST 20-1402-571

Ti CORROSION STUDIES

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Steve Clay

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Brian Derby

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Initial Scientific notebook entry for Titanium Grade 7 Corrosion Studies.

Title: Effect of Environment on Localized Corrosion and Passive Dissolution of Ti-7

Tests Performed by: Sean Brossia, Steve Clay, other personnel will be identified as they begin work on specific tests. – Jerry Stewart · Orian K. Derby · [illegible]

Objectives: Determine the conditions under which localized corrosion of Ti-7 takes place, including the effect of weldments. Examine the effect of environmental variables on the passive dissolution rate of Ti-7.

Equipment: Specific equipment lists provided in initial entries or in individual test entries. Equipment will be identified and calibrated prior to testing.

Materials: Titanium Grade 7 specimens procured from Metal Samples: TIMET Heat #R5835

Ti (wt%)	C (wt%)	Fe (wt%)	N (wt%)	O (wt%)	H2 (ppm)	Pd (wt%)
bal	0.009	0.115	0.007	0.140	50	0.155

Sean Brossia 3/26/99

Effect of Environment on Localized Corrosion of Ti-7

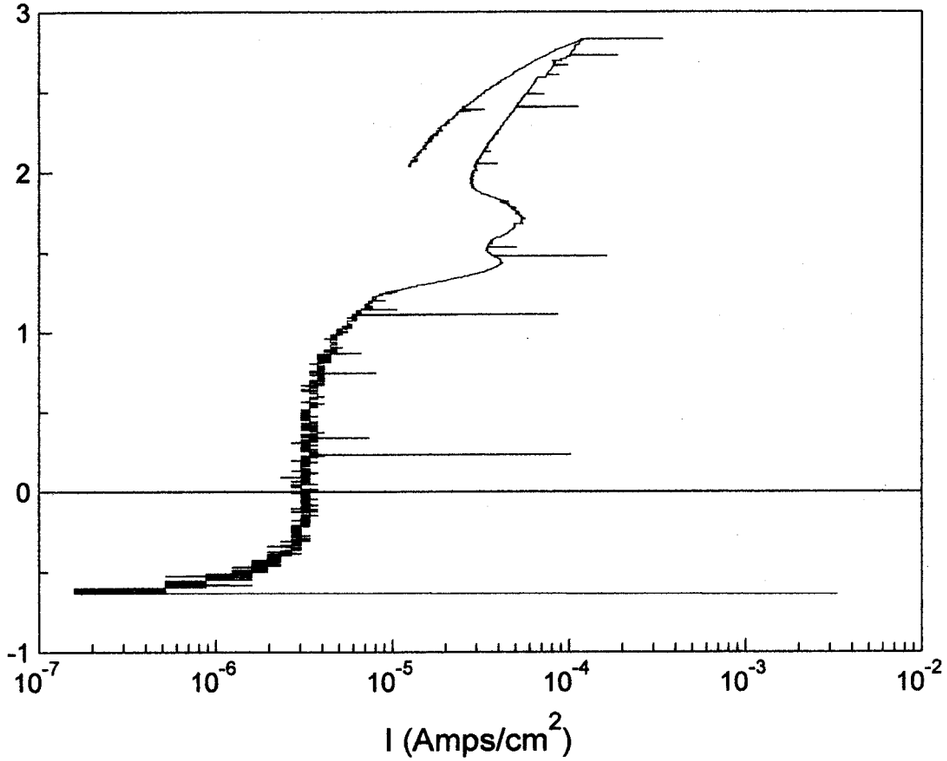
Objective: Determine conditions conducive to localized corrosion of Ti-7 by performing cyclic potentiodynamic polarization tests as described in ASTM G61 using creviced specimens in accordance with ASTM G48. The main parameters of interest are the critical chloride concentration necessary for the onset of localized corrosion, the temperature and the critical potentials (E_{crev} and E_{rcrev}).

Equipment:

Solartron 1287 potentiostat = 00148500
Corrware for Windows NT software
Reference electrode (SCE) = Accumet 13-620-51 S/N 4349
Thermometer = Fisher S/N H98-182

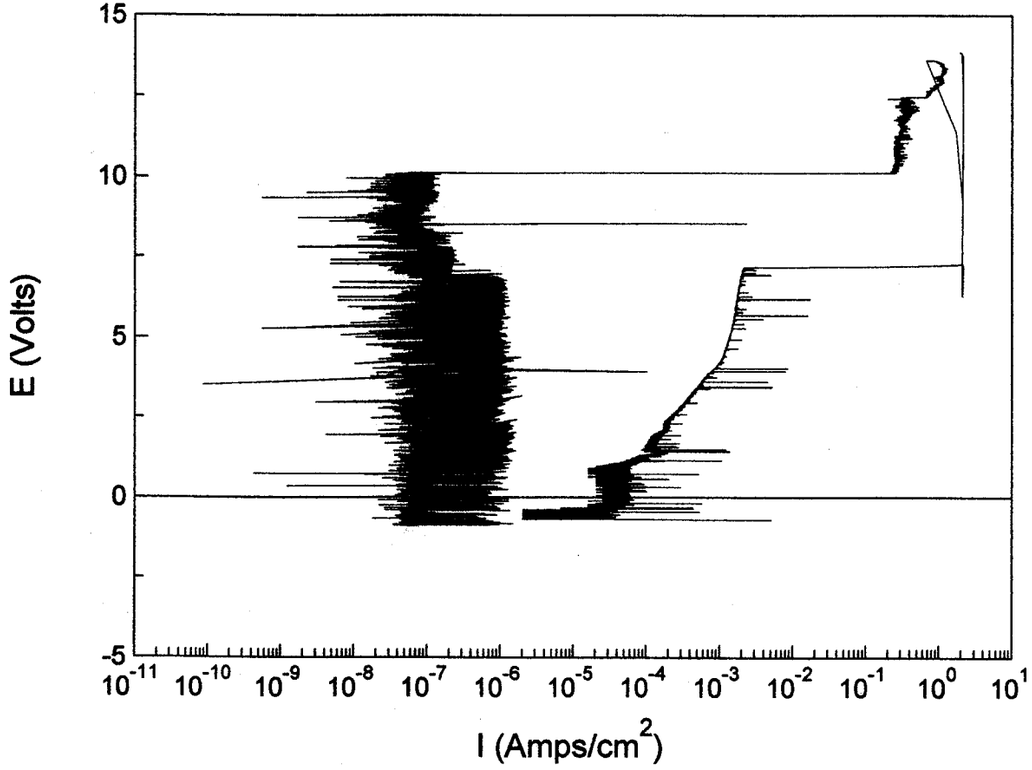
3-26-99

TIPD001.DAT
T=95°C
Stock Solution
1 M → NaCl → 116.8844g/2Lt Fisher Lot# 985302
PH= 5.831
Specimen - crevice specimen of Titanium stock non welded.
Polished to 600 grit + ultrasonically cleaned in Acetone
Crevice foot ultrasonically cleaned in ethanol.
Init wt = 16.84665g
Final wt = 16.84725g 3-29-99
Final PH = 8.118 3-29-99
Observations - discolored but no pitting/test run twice computer locked up



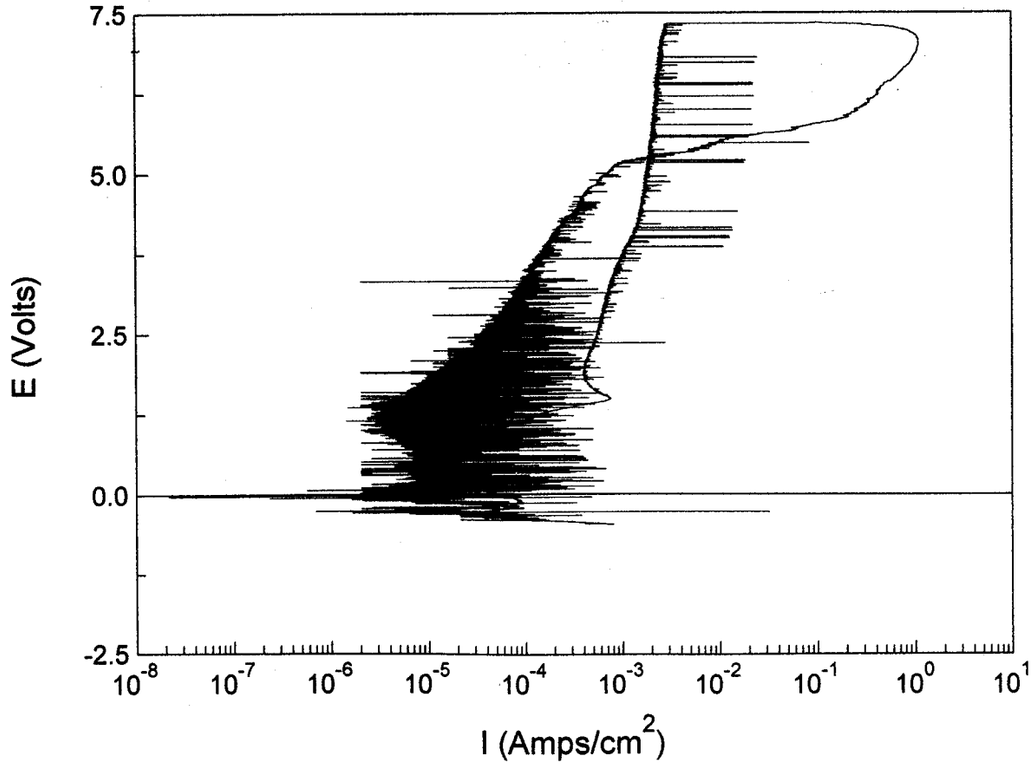
3-26-99

TIPD002.DAT
T=95°C
Stock Solution
4M → NaCl → 467.5191g/2Lt Fisher # 985302
PH= 5.610
Specimen is pitting specimen polished to 600 grit + ultrasonically cleaned in Acetone
Init wt= 6.39112g
Final wt: No sample to weigh, dissolved in solution 3-30-99
Final PH: 4.03 3-30-99
Observations
Sample dissolved in solution 3-30-99



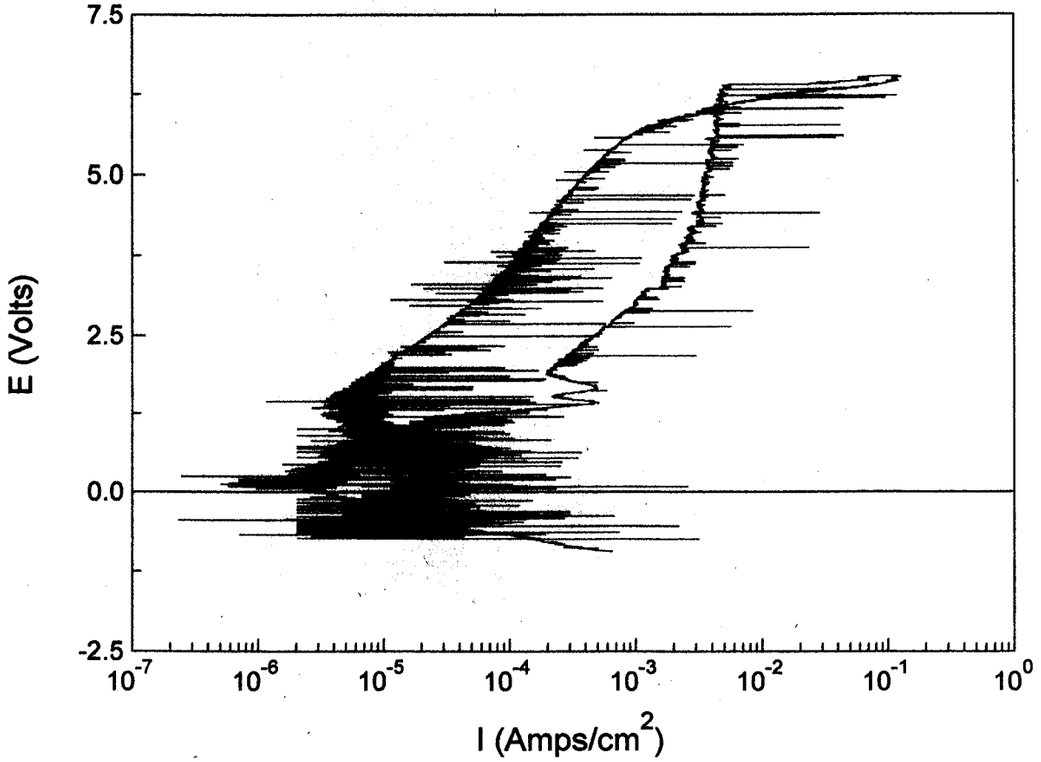
3-29-99

TIPD003.DAT
Stock Solution
1M → NaCl → 116.8856/2Lt Fisher # 985302
PH= 5.373
T=95°C
Specimen is pitting specimen polished to 600 grit + ultrasonically cleaned in Acetone 5/8/116/2000 ← date on box
Init wt= ~~6.40757g~~ 6.39936g 3-30-99
Final wt= 5.93086 3-31-99
Final pH= 4.230 3-31-99
Observations:
Pitting occurred on lower 2/3 of area exposed to solution. Oxide was formed on pitted area.
3-31-99



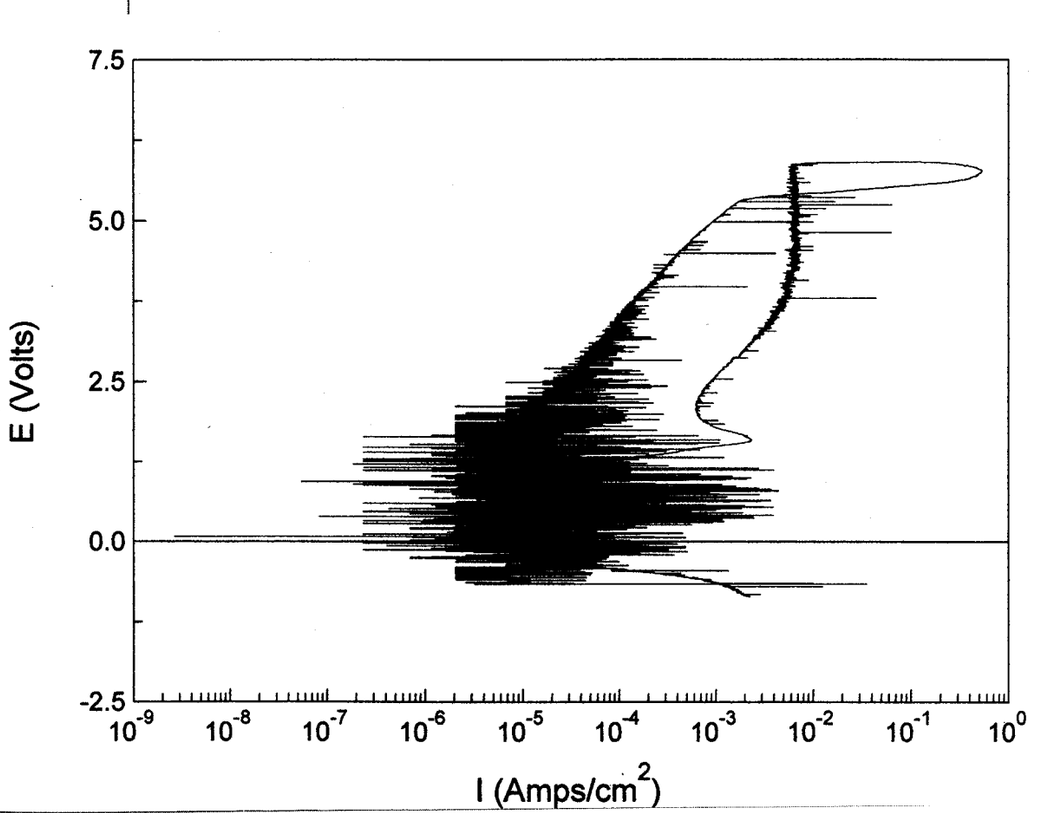
3-30-99

TIPD004.DAT
T = 95°C
Stock Solution
1M → NaCl → 116.8805 g/2Lt Fisher # 985302
PH = 5.190
Specimen is crevice non welded polished to 600 grit + ultrasonically cleaned in Acetone
Init wt = 16.74525g
Final wt = 16.7394g 4-1-99
Final pH = 5.430 4-1-99
Observations
No apparent crevice pitting. Some attack on edges and on one corner of specimen 4-1-99



3-31-99

TIPD005.DAT
T = 95°C
Stock Solution 584.4 SB 4/2/99
5 ~~SB 4/2/99~~ M → NaCl → ~~46.5200~~ g/2Lt Fisher # 9722774
PH = 5.450
Specimen is crevice non welded polished to 600 grit ultrasonically cleaned in Acetone
Init wt = 16.78772g
Final wt = 16.71996g 4-2-99
Final PH = 4.102 4-2-99
Observations
No apperent crevice pitting, Attack occurred on edges of both bottom sides of specimen 4-2-99



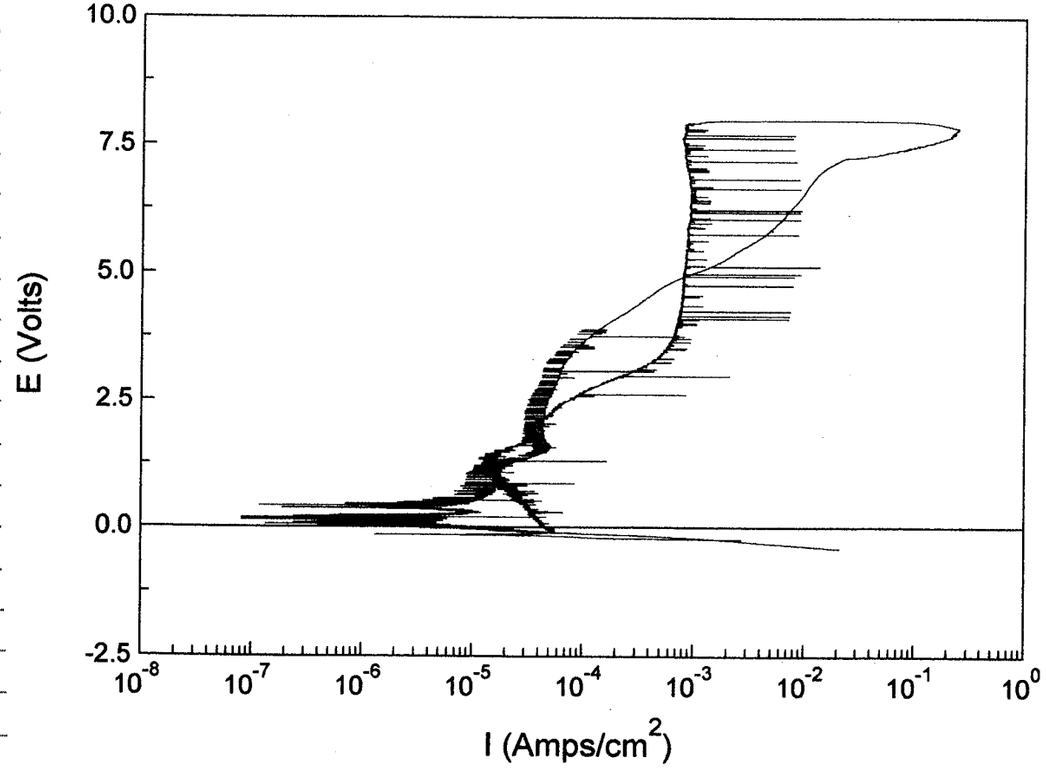
4-1-99

TIPD006.DAT
T=95°C
Stock Solution
10M → LiCl → 847.8025g/2Lt Fisher #987641
PH: 2.850
Specimen is crevice non welded, polished to 600 grit with edges & corners polished and ultrasonically cleaned in Acetone
Init wt: 16.74523g
Final wt: 16.33738g 4-6-99
Final PH: 1.810 4-6-99
Observations
Localized attack at edges and corners. Local attack at area between feet and at crevice lide. No pitting under feet 4-6-99

4-5-99

TIPD007.DAT
T=95°C
Stock Solution Init PH= 0.363
3.9m → NaCl → 455.8320g/2Lt
.1m → HCl → 16.5ml/2Lt
Specimen is non welded, polished to 600 grit with edges & corners polished and ultrasonically cleaned in Acetone
Init wt: 16.70236g
Final wt: 16.70159g 4-7-99
Final PH: .124 4-7-99
Observations
Mild crevice staining. No Local Attack 4-7-99

TIPD008.DAT
T=95°C
Stock Solution — Fisher #
9.9M → LiCl → 839.3220 g/2Lt — 987641
.1M → HCl → 16.5ml/2Lt
pH: -2.630
Specimen polished to 600 grit with edges rounded and polished then ultrasonically cleaned in Acetone
Init wt: 16.72634g
Final wt: 16.19834g 4-15-99
Final pH: -2.280 4-15-99
Observations:
Local attack at edges & corners. Dark staining of surface below waterline. No crevice pitting. 4-15-99



4-14-99

~~Tcopol.DAT~~ SB — 6/4/99 — 6/4/99

Tips001x.DAT, where x = a (-250 mV), b (0 mV), c (+250 mV), d (+500 mV)
J-13 + 1M Cl⁻ @ 95 °C.
Ti pitty spec.
E: -250, 0, +250, +500 mV sce

Solution (2 L)

50 mL J-13 stock soln A
50 mL J-13 stock soln B
116.88 g NaCl (Lot #~~990437~~) 986519 SB — 6/4/99
SB 6/4/99
→ ocp monitored ~~for up to~~ 10 min (tips01ocp.dat)

Initial pH = 8.255
Initial spec wt = 6.3761 g

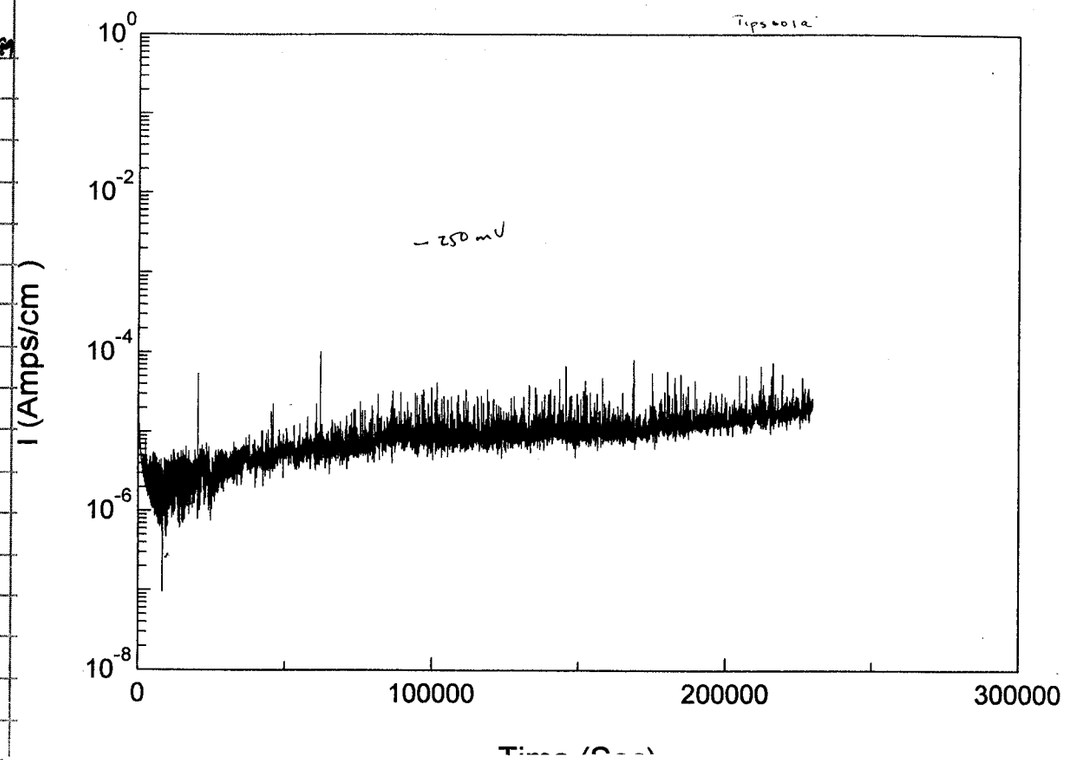
- note: @ end of "a" (-250 mV), no attack in submerged region but brown/black/green discoloration/corrosion product obs in vapor phase
ultrasonically cleaned in acetone, dried, wt = 6.37340

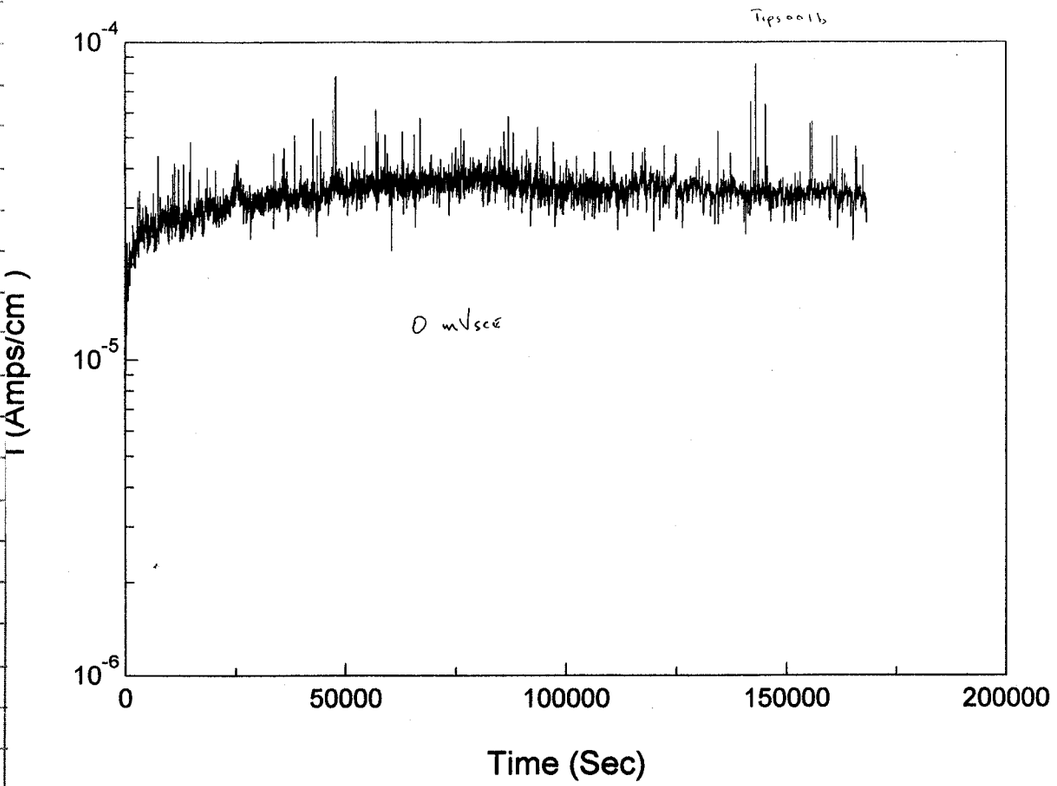
- expt restarted @ E = 0 Vsce (TIPS001b.dat) SB — 6/7/99
at end of "b", wt = ~~8.3981~~ SB 6/9/99 6.39811 SB — 6/9/99
- expt restarted @ E = +250 mV (TiPS001c.dat)

final wt: 6.37443 g SB — 6/14/99
final pH = 8.531

SB — 6/4/99

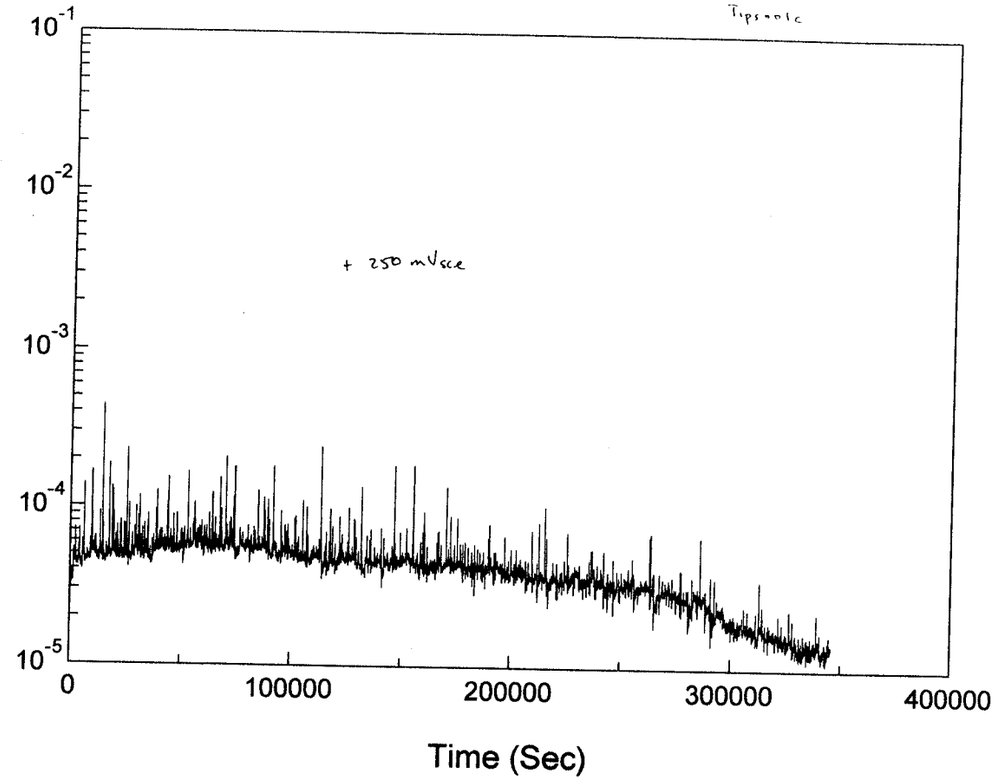
6/4/99





SB 6/4/99

Tips001c



SB 6/4/99

6/7/99 Long-term pstat testy

Cell 1 - J-13 (25 mL stock A & 25 mL stock B per L) + 1 M Cl, 95°C, E = +750 mVsce
Cell 2 - J-13 + 1 M Cl, 95°C, E = +500 mVsce
Cell 3 - J-13 + 1 M Cl, 95°C, E = +250 mVsce
Cell 4 - J-13 + 1 M Cl + 20 mM CO_3^{2-}, E = +500 mVsce
Cell 5 - J-13 + 1 M Cl + 0.01 M HCl, E = +500 mVsce
Cell 6 - J-13 + 1 M Cl, aerated, ocp

all Cl = NaCl lot # 986519
all CO_3^{2-} = Na_2CO_3 lot # 960685
all HCl = HCl lot # 971828

sample wts and	initial pH	file name	RE S/N
Cell 1 = 16.67356	8.312	Tips001.asc	8238325
Cell 2 = 16.51419	8.319	Tips002.asc	7079123
Cell 3 = 16.61432	8.281	Tips003.asc	8238334
Cell 4 = 16.71241	10.393	Tips004.asc	8238333
Cell 5 = 16.57801	2.053	Tips005.asc	7079122
Cell 6 = 16.66067	8.283	Tips006.asc	8210502

→ all samples are crevice samples (11.35 cm^2 area) w/ torque to 50 in-oz.

Cell 1 (J-13 + 1M Cl, 95°C, +750 mV) 6/7/99

observations:

Tips001.asc
Final pH = 8.633
Final wt = 16.64667 g
No pitting or local corrosion

7-7-99

6/1/99 Cell 2 (J-13 + 1 M Cl, 95°C, +500 mV)

observations:

Ti PS 002. asc

Final pH = 8.878

Final wt = 16.50392

Specimen has no pitting or local corrosion. Yellow coloring below vapor line except under crevice area.

7-7-99

Cell 3 (J-13 + 1 M Cl, 95°C, +250 mV) 6/7/99

observations:

Ti PS 003. asc

Final pH = 8.665

Final wt = 16.61357

No pitting or corrosion

7-7-99

6/7/99 Cell 4 (J-13 + 1M Cl + 20mM CO_3^{2-}, 95°C, +500mV)

observations

Ti PS 004. asc

Final pH = 9.573

Final wt = 16.71157

No pitting or local corrosion. Some white film at vapor line.

7-7-99

Cell 5 (J-13 + 1M Cl + 0.01M HCl, 95°C, +500mV) 6/7/99

observations:

Ti PS 005. asc

Final pH = 2.305

Final wt = 16.57644

Some rusting appearance under crevice feet. Specimen stained yellow except under crevice area which has blue ring around crevice. Color normal under crevice area.

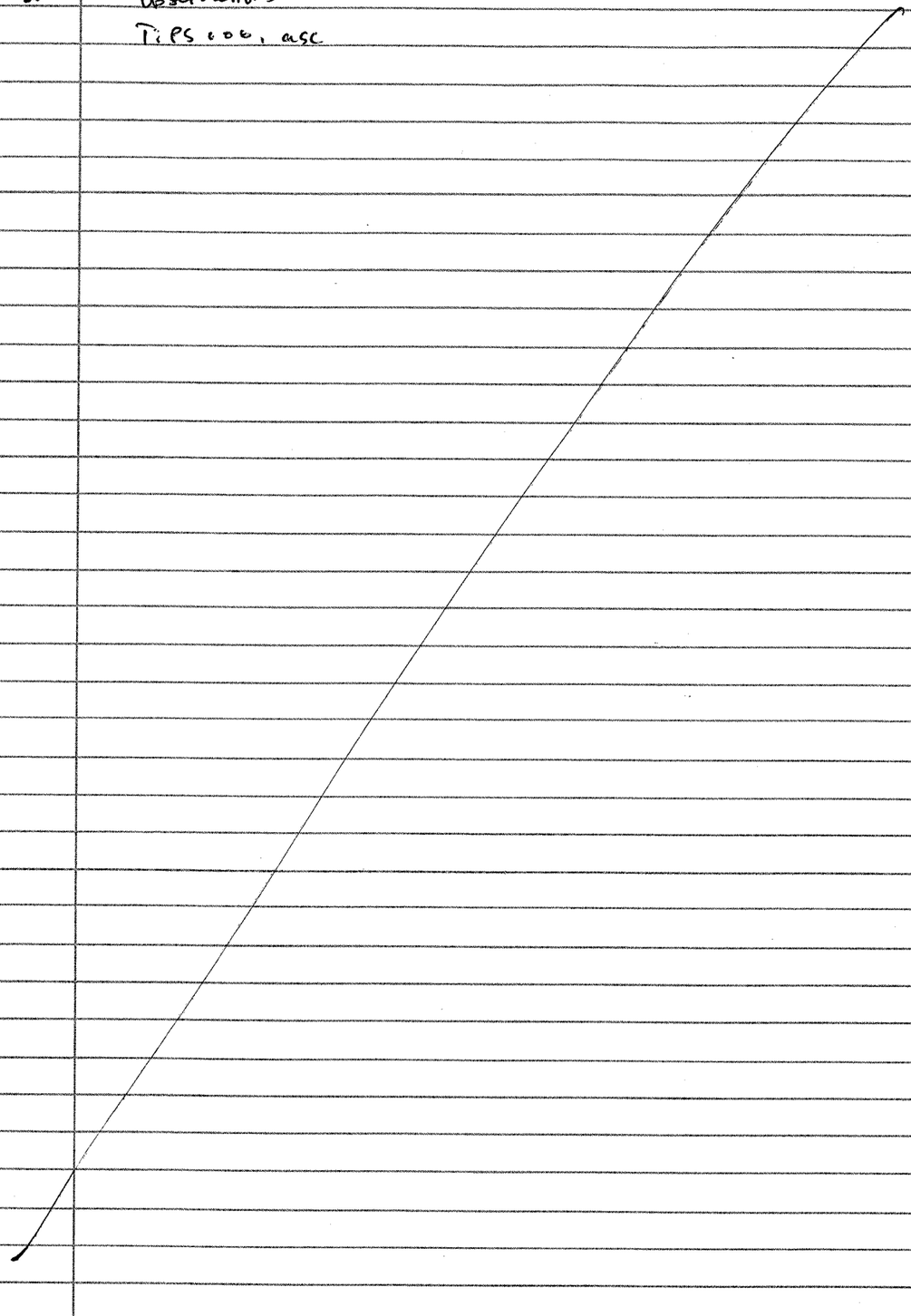
7-9-99

6/7/99

Cell 6 (J-13 + 1 M Cl, 95°C, air-saturated, ocp)

observations

Tips 006, asc



6/14/99

potentiostatic hold → ipass

6/14/99

Tips002a, b, c = -250, 0, +250 mVsce

95°C, J-13 + 1 M Cl + 20 mM CO_3^{2-}, deaerated

→ 2L : 50 mL stock A

50 mL stock B

116.88 g NaCl (Lot # 986519)

4.239 g Na_2CO_3 (Lot # 960685)

spec wt a = 6.43982g

init pH = 10.294

spec wt end of a = 6.43893g — 6-17-99 @ 8:30 Am

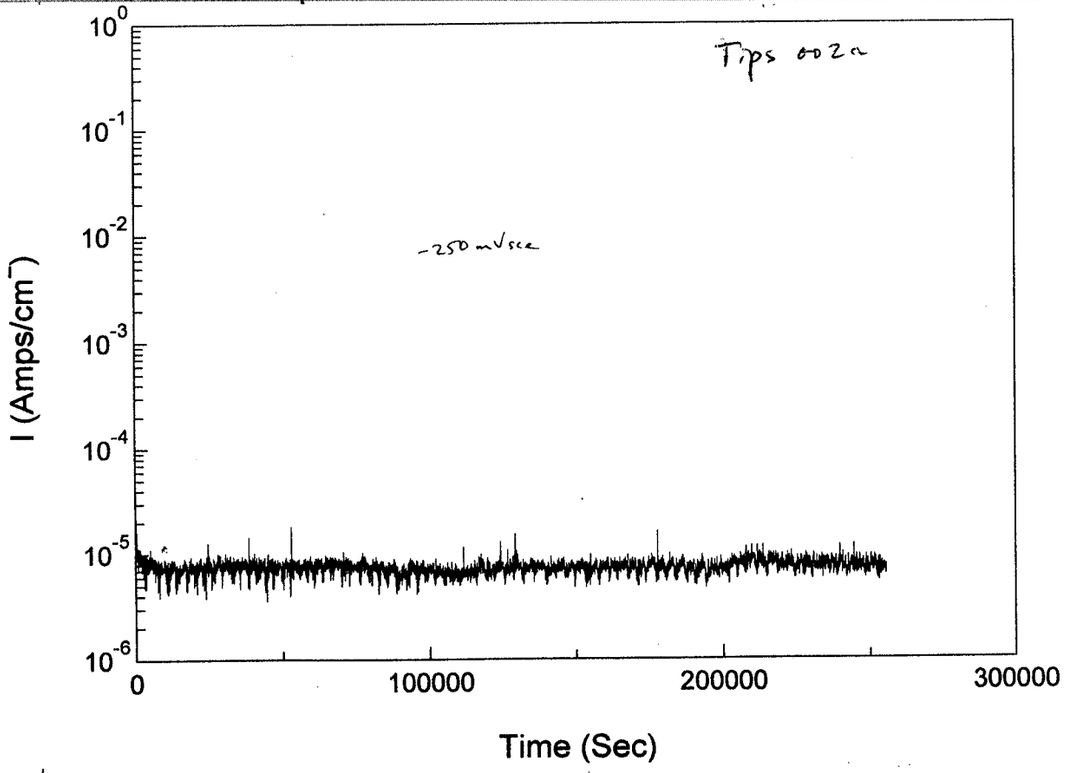
observation - no pitting or local attack — 6-17-99 @ 8:30 Am

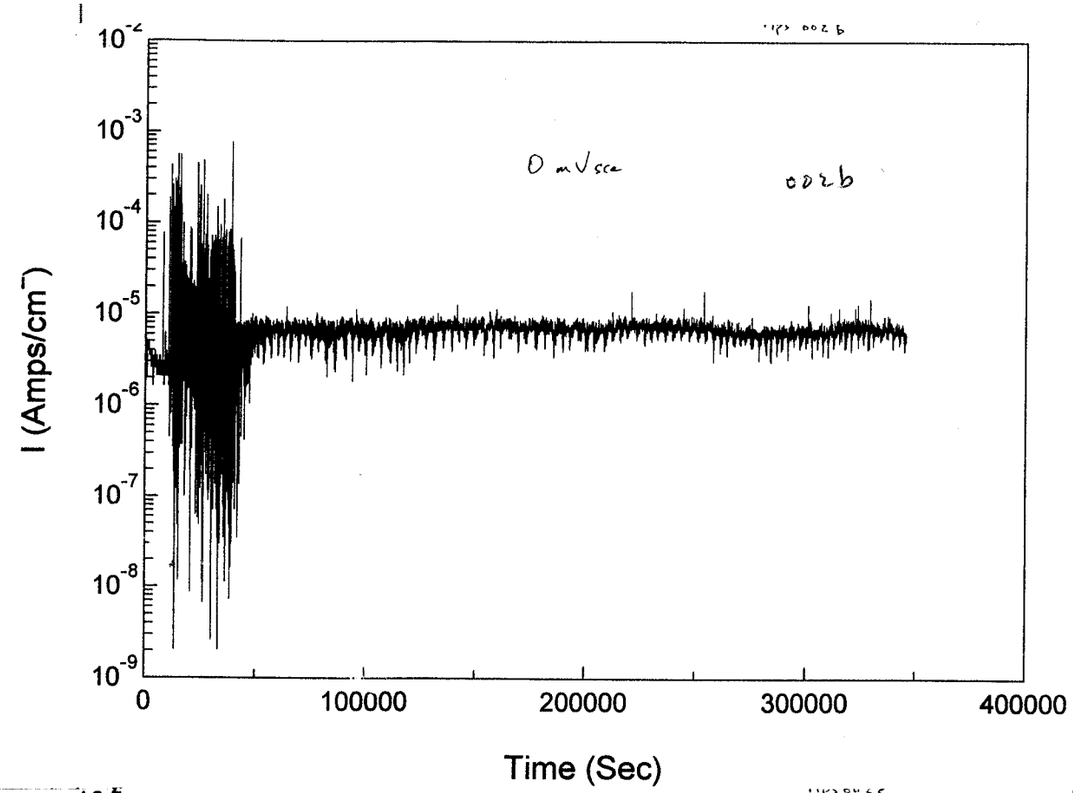
spec wt end of b = 6.43894g — 6-23-99 @ 8:00 Am

observation - no pitting or local attack

final wt = 6.44181 g

final pH = 10.698





potentiostatic ipass measurements 6/25/99

→ J-13 + 1 NaCl + 0.01 M HCl, 95°C

Tips 003a, b, c = -250, 0, +250 mVsce

2 L: 50 mL stock A
50 mL stock B
116.88 g NaCl lot # 986519
1.65 mL HCl lot # 971828

initial pH= 2.142

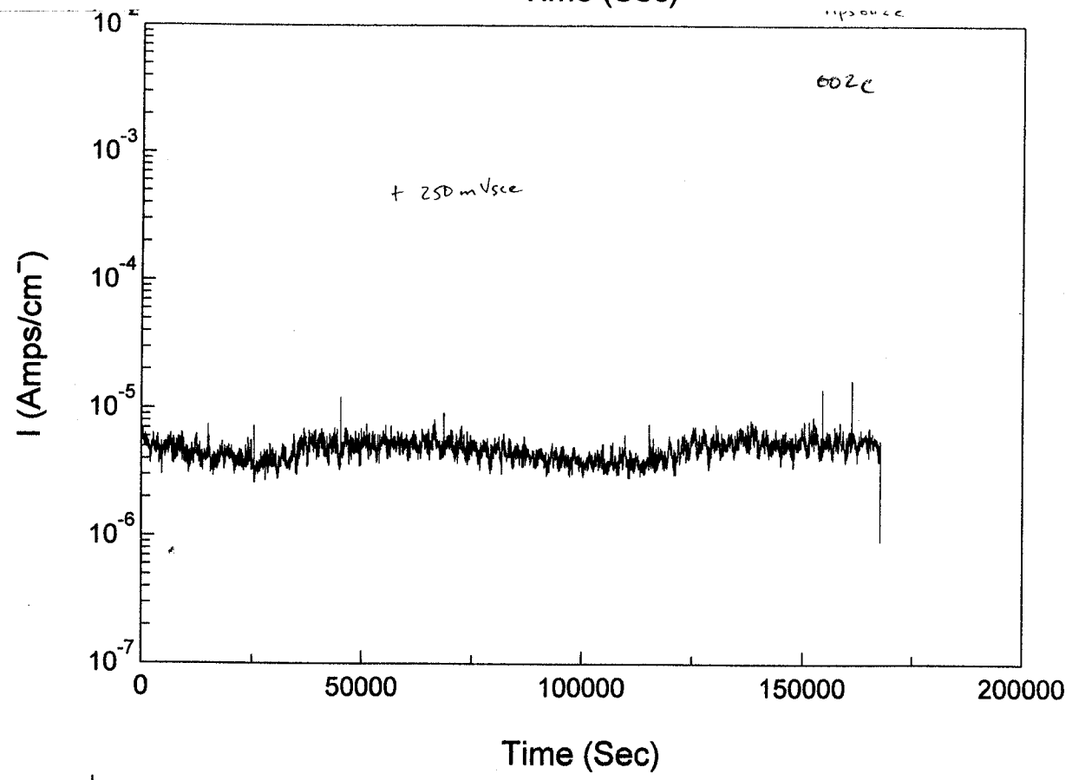
initial sample wt: 6.38384 g

6/28/99 wt ~~final~~ @ a = 6.37136 g - sample cleaned in MeOH ultrasonically

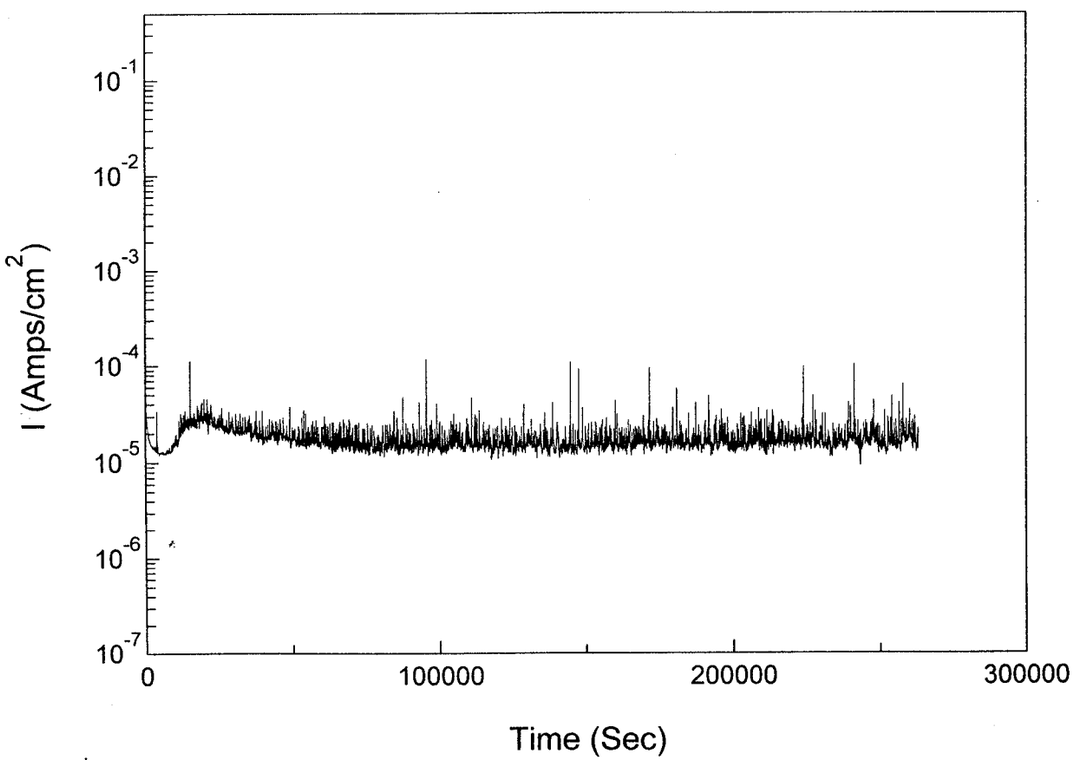
6/30/99 specimen wt @ b = 6.37128 g - Sample cleaned in methanol ultrasonically

7/2/99 specimen wt @ c = 6.37142 g - Sample cleaned in methanol ultrasonically

Final pH= 2.161 7-2-99



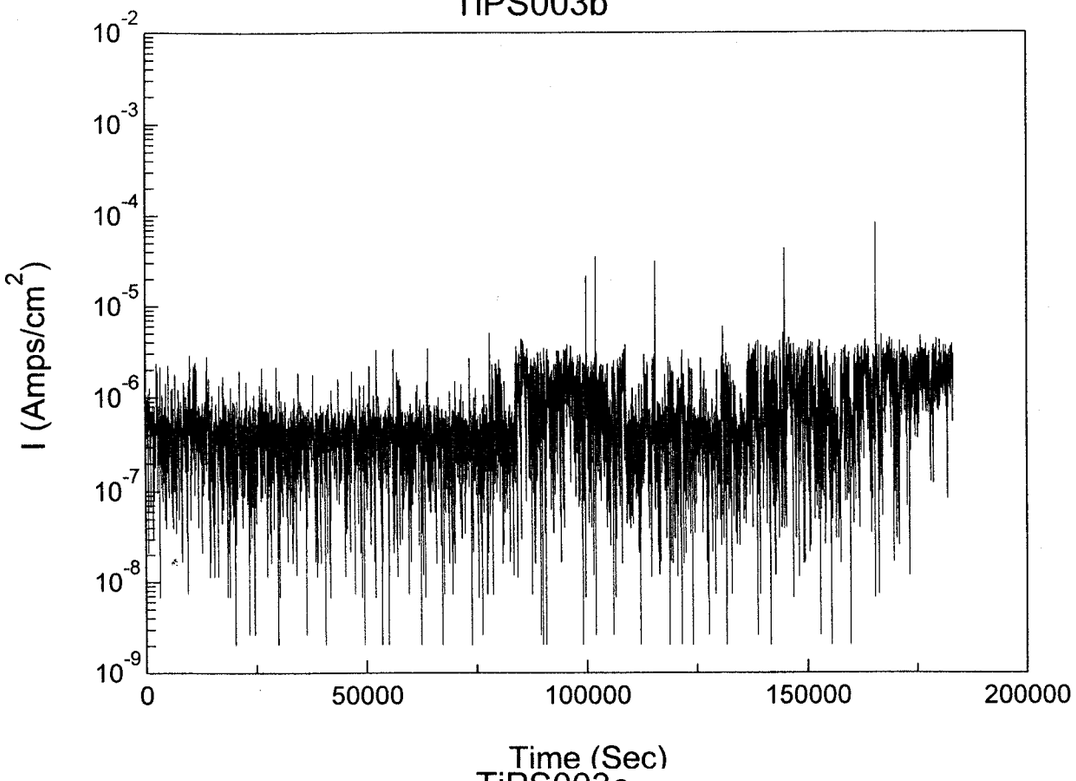
TiPS003a

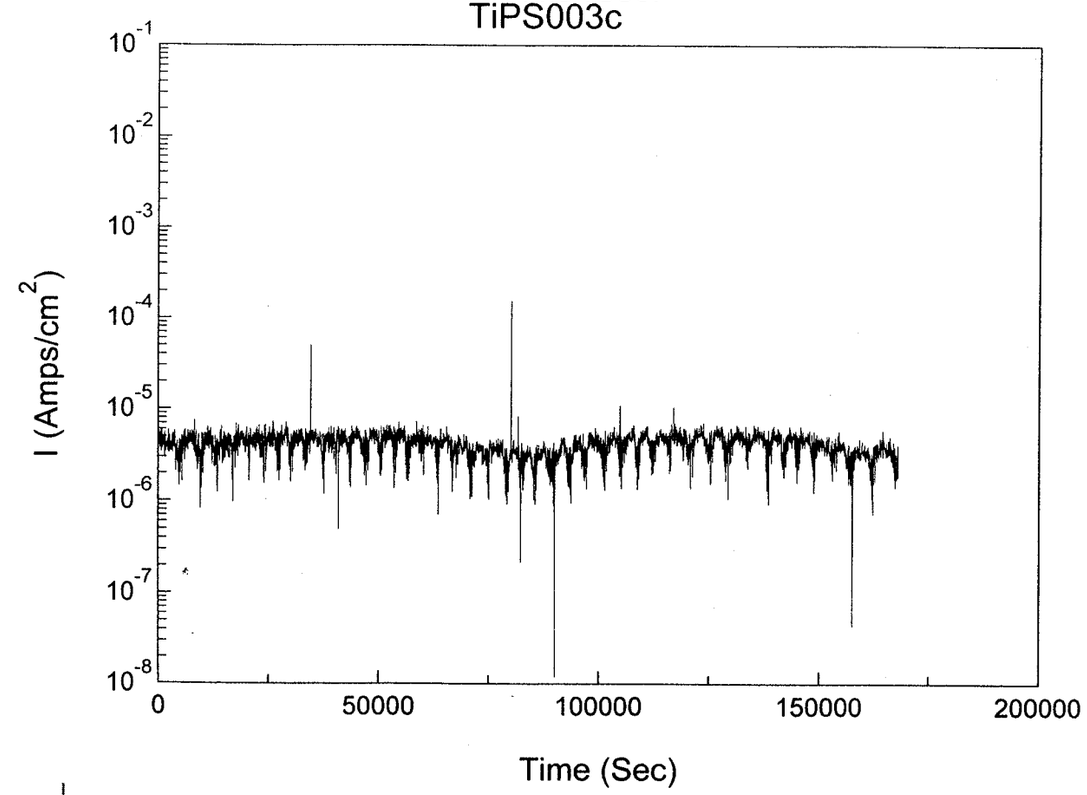


cont on p 57 SB 2/14/00

SB 6/14/99

CSB 6/25/99





6/25/99 SBrossia

cont to p557. SB

TIPD009.DAT
T=95°C
Stock Solution
10 M → LiCl → 847.8025g / 2Lt Fisher 987641
PH= 4.325
Specimen is welded both sides, polished to 600# methanol ultrasonically cleaned.
Init wt: 20.[illegible]9188g
Final wt: 20.20785g 7-9-99
Final PH: 3.635 7-9-99
Observations
No Crevice pitting. Local corrosion occurred on bottom and edges of specimen and on one side at approx weld location that is rather deep. 7-9-99

7-9-99

TIPD010.DAT
T=95°C
Stock Solution
5 ~~M~~ ⇒ NaCl ⇒ ~~468.52~~ 578.1g /2Lt # 985302 SB 7/14/99
SB 7/14/99
pH= ~~6.623~~ 6.230 7-12-99 - date on line SB 8/16/2000
Specimen is welded both sides, polished to 600grit ultrasonically cleaned in methonal
Init wt= 20.77479g
Final wt= 20.73065g
Final pH= 4.206
Observations
Some overall discoloration. Local corrosion on one edge/corner of specimen @ approx location of weld.
7-13-99

7-13-99

TIPD011.DAT
T=95°C
Stock Solution
1M ⇒ NaCl ⇒ 116.8805g /2Lt # 985302
pH= 5.928
Specimen is welded both sides, polished to 600grit ultrasonically cleaned in methonal
Init wt= 20.80934g
Final wt= 20.79550g
Final pH= 5.520
Observations
Overall discoloration. Local corrosion on two edge corners @ approx weld location. Not as severe as 4M test TIPD010
7-14-99

7-14-99

T1Ø95BØØ-.DAT & T1Ø95BØ1-.DAT
1.0M SOLUTION X1 AT 95°C
7/26/99
IRE/SCE = 44.4 mV S/N 5087374
INIT. WT 16.7397g FINAL WT 16.7192g JB 7/28/99

INIT PH: 7.507 @ 22.5°C FINAL PH: 8.750 @ 27.9°C JB 7/27/99

8:18 AUTOCLAVE LOADED
8:23 E_{CORR} = -418 mV, E_{PT} = -55 mV
8:26 START DEAERATE, 10:26 STOP - TOTAL TIME 2 HRS
10:29 START HEATING
7/27/99
7:14 INTERNAL TEMP 93.0°C
E_{CORR} = -235 mV, E_{PT} = -199 mV
7:38 START CPP
13:04 WE DISCONNECTED - TRIPPED AUTO REVERSE
NEW FILE: T1Ø95BØ1-.DAT
SCAN RATE CHANGED TO 1.0 mV/s
13:08 RESTART

16:11 STOP - START COOL DOWN

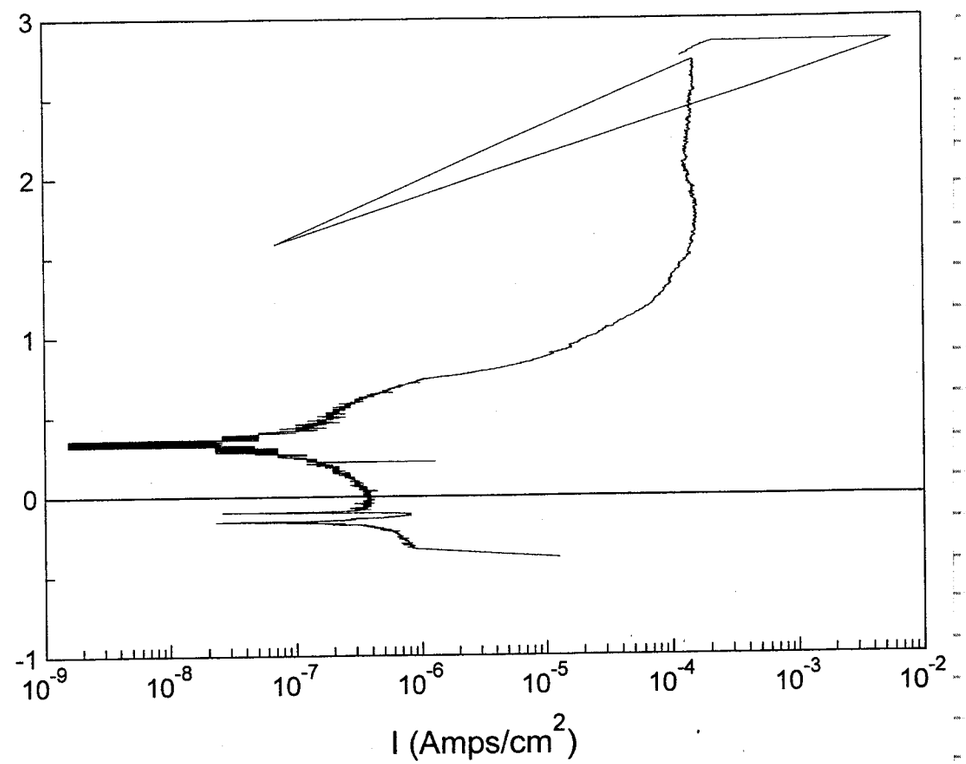
7/28/99 INTERNAL TEMP: 28.4°C
E_{CORR} = 98 mV, E_{PT} = -89 mV

IRE/SCE = 36 mV S/N 5087374

OVERALL DISCOLORATION - ALL CORROSION AT TOP OF STEM

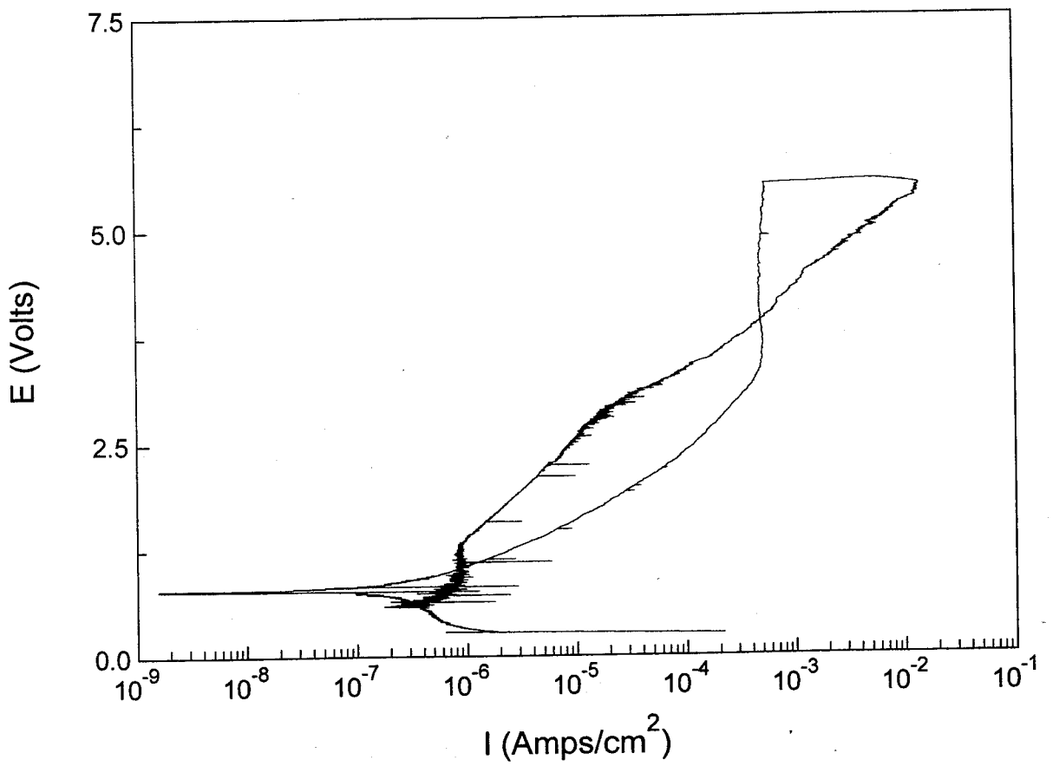
Jerry Sturd 7/28/99

T1Ø95BØØ-.DAT



Jerry Sturd 7/28/99

T1Ø95BØ1-.DAT



Jenny Scott 7/28/99

T1125BØ2-.DAT
1-OM SOLUTION No.1 AT 125°C
7/28/99
SCE/SCE = 44.9mV S/N 5087374

INITIAL WT. 16.7901g, FINAL WT. 16.7904g JS 8/2/99

INITIAL pH 7.816 @ 22.9°C, FINAL pH 9.391 @ 23.7°C JS 8/2/99

7/29/99
7:57 E_{CORR} = -454mV, E_{PT} = -53mV
7:53 START DEAERATE, 9:53 STOP - TOTAL TIME 2HRS
E_{CORR} = -263mV, E_{PT} = -126mV
9:55 START HEATING - SET POINT 118°C

7/30/99 7:14 INTERNAL TEMP. 119.1°C
VALVE ON DIP TUBE IS LEAKING - CAPPED
RAISE S.P TO 122°C
8:18 INTERNAL TEMP 121.7°C
E_{CORR} = -179mV E_{PT} = -170mV
8:34 E_{CORR} = -187mV
8:35 START CPP

7/31/99 10:21 INTERNAL TEMP 122.9°C
E_{CORR} = -196mV, E_{PT} = -208mV

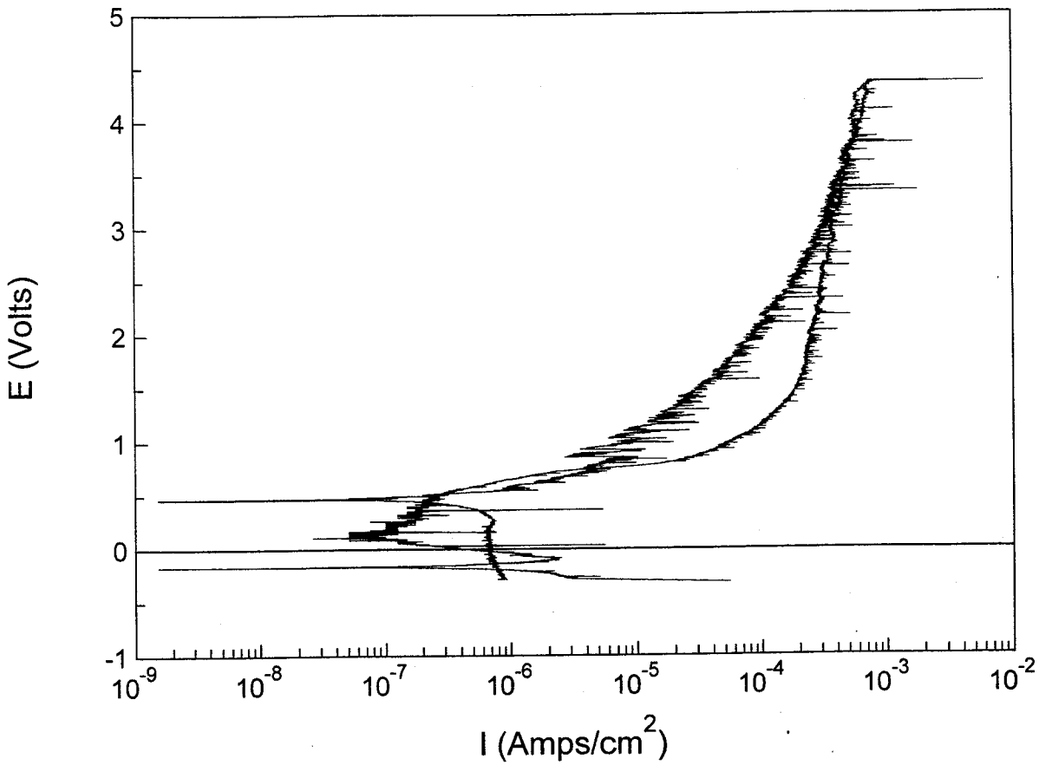
COMPUTER IS LOCKED UP - START COOL DOWN
8/2/99
7:18 INTERNAL TEMP 23.9°C
E_{CORR} = -226mV, E_{PT} = -76mV

LOST MORE LIQUID THAN FIRST THOUGHT - ONLY ~68% OF SPECIMEN WAS COVERED

Jenny Scott 8/2/99

T:\125B02_.DAT

TRE/SCE = 20 mV S/N 5087374



Kenny Sewell 8/2/99

T:\125B03_.DAT

1.0M SOLUTION NO. 1 AT 125°C

TRE/SCE = 45.5 mV S/N 5087374

RE POLISHED SAMPLE FROM PAGE 35

INITIAL WT: 16.7812g, FINAL WT: 16.6167g 8/19/99 KS

INITIAL pH: 7.741 @ 23.0°C, FINAL pH: 6.853 @ 23.9°C 8/19/99 KS

8:52 E_{CORR} = -220 mV, E_{PT} = -42 mV

8:52 START DEAERATE, 12:10 STOP - TOTAL TIME 3HRS 14MIN -
E_{CORR} = -122 mV, E_{PT} = -53 mV

12:13 START HEATING, SET POINT 118°C

8/17/99 7:18 INTERNAL TEMPERATURE 120.4°C
E_{CORR} = -180 mV, E_{PT} = -53 mV

7:25 START CPP

8/18/99 7:16 INTERNAL TEMP 120.8°C
COMPUTER LOCKED UP -
E_{CORR} = -60 mV, E_{PT} = -71 mV

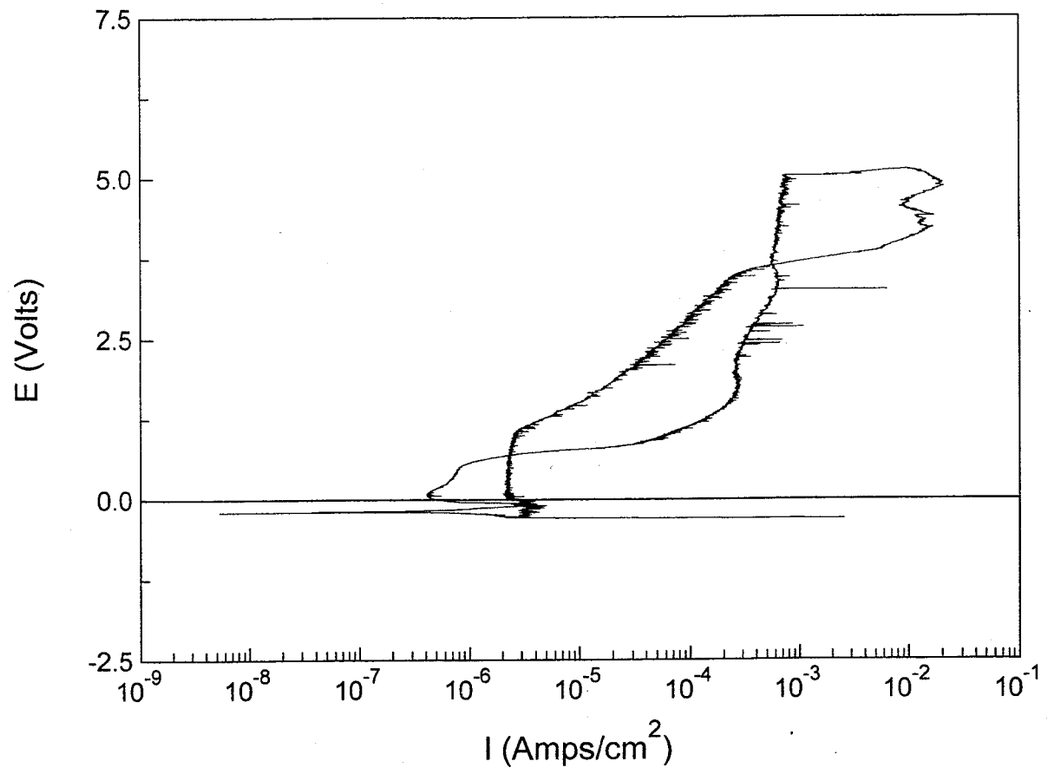
8:16 START COOL DOWN

8/19/99 7:18 INTERNAL TEMP: 24.2°C
E_{CORR} = -58 mV, E_{PT} = -58 mV

TRE/SCE = 14 mV S/N 5087374

Kenny Sewell 8/19/99

T1125B03_.DAT



OBSERVATIONS:
NO CREVICE PITTING UNDER TEFLON WASHER —
LOCAL CORROSION ON SIDES CLOSEST TO COUNTER ELECTRODE - SOME CRACKS IN CORROSION PRODUCTS —

Jenny Stewart 8/19/99

T1140B04_.DAT

1.0M SOLUTION No-1 AT 140°C

$E_{REF/SCE}$ = 45.7mV S/N 6087374

8/20/99

INITIAL WT. 16.7407g, FINAL WT. 14.3161 8/23/99

INITIAL PH: 7.670@22.5°C - NO FINAL PH TAKEN VLS 8/23/99

8:39 E_{CORR} = -414mV, E_{PT} = -58mV

8:36 START DEAERATE 10:48 STOP. TOTAL TIME, 2HR 12MIN.
E_{CORR} = -314mV, E_{PT} = -138mV

10:50 START HEATING, SP 138°C

8/21/99 9:43 INTERNAL TEMP 137.7°C

E_{CORR} = -234mV, E_{PT} = -210mV

9:49 START CPP

8/22/99 10:41 INTERNAL 23.1°C ??

COMPUTER HUNG — ELECTROMETER FLASHING

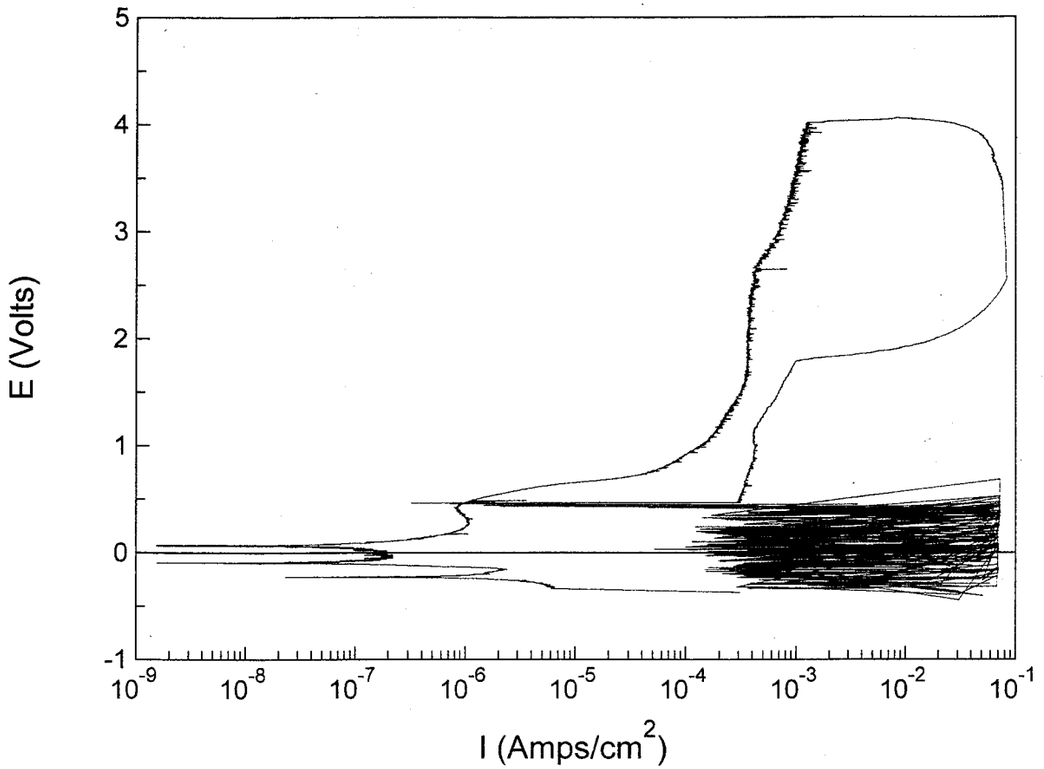
TC WELL HAS BLOWN OUT OF AUTOCLAVE —
AUTOCLAVE IS STILL HOT —

START COOL DOWN

8/23/99 MAJOR DAMAGE TO SPECIMEN WHICH PROBABLY HAPPENED NEAR END OF CPP RUN

Jenny Stewart 8/23/99

TI140B04_.DAT



Jerry Sewell 8/23/99

TI165B05_.DAT

1.0M SOLUTION #1 AT 165°C

IRE/SCE = 44.2mV S/N 5087374

8/31/99

INIT. WT 16.8206 g, FINAL WT 16.7577 JS 9/2/99

INITIAL PH 7.722 @ 22.4°C, FINAL PH 7.216 @ 25.0°C JS 9/2/99

12:05 E_{CORR} = -297mV, E_{PT} = 199mV
1208 START DEAERATE 2:12 STOP TOTAL TIME 2HR 4MIN
2:14 START HEATING SP 165°C

9/1/99 7:25 INTERNAL 155°C SP↑ 175°C E_{CORR} = -221mV
9:15 INTERNAL 162°C E_{CORR} = -221mV, E_{PT} = -688mV
SOLARTRON CONNECTED E_{CORR} = -217 mV
9:25 START CPP ENDED AFTER 2 OR 3 PTS
9:28 RESTART - NO CHANGES TO PARAMETERS -
3:05 RUN HALTED
3:07 E_{CORR} = -438mV, E_{PT} = -712mV
3:08 START COOL DOWN

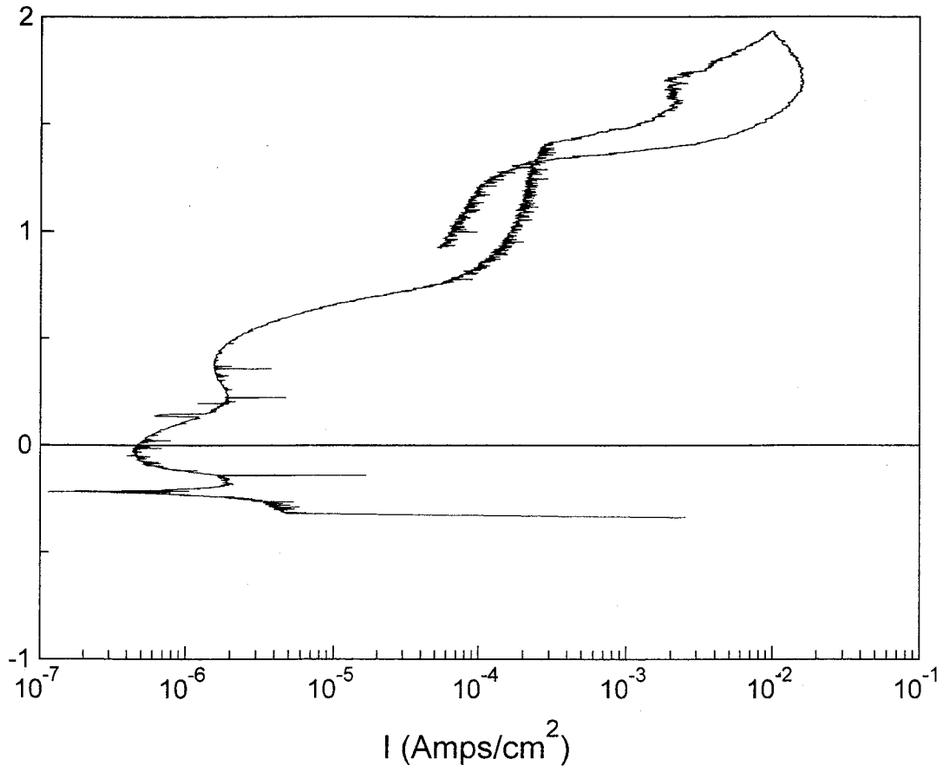
9/2/99 7:21 INTERNAL 25.9°C
E_{CORR} = -83mV E_{PT} = -44mV

IRE/SCE = 14mV S/N 5087374

NO PITTING UNDER TEFLON WASHER -
GENERAL CORROSION ON SIDES AND BOTTOM

Jerry Sewell 9/2/99

T1165B05-.DAT



Jerry Schmidt 9/2/99

T1165B06W.DAT
1.0M SOLUTION # 1 AT 165°C WELDED SPECIMEN

IRB/SCB = 43.6mV S/N 5087374

9/2/99
INITIAL WT 20.8398g, FINAL WT 20.8222g JS 9/4/99

INIT PH 7.755 @22.7°C, FINAL PH 6.723@24.9°C JS 9/9/99

9:34 E_{CORR} = -340mV, E_{PT} = -91mV
9:42 START DEAERATE, 12:05 STOP — TOTAL TIME 2HR 23MIN
12:07 START HEATING, E_{CORR} = -118mV

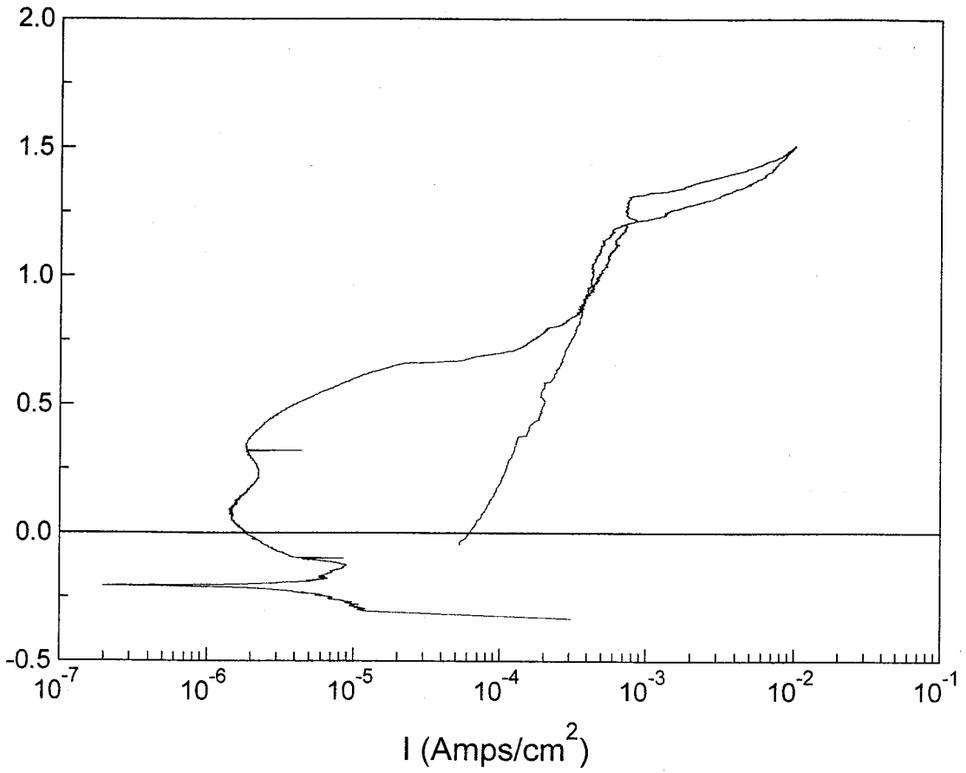
9/8/99 7:16 INTERNAL TEMP 164.3°C
E_{CORR} = -204mV, E_{PT} = -151 mV
7:20 START CPP
10:28 SOLARTRON FLASHED "ERROR" AT REVERSAL
1:07 STOP
1:09 START COOL DOWN

9/9/99 7:30 INTERNAL TEMP 25.3°C
E_{CORR} = -652mV, E_{PT} = -155mV

GENERALIZE CORROSION ON STEM AND UPPER EDGES — ALSO ON I/P TUBE —

Jerry Schmidt 9/9/99

11165B00W.DAT



Jerry Stewart 9/9/99

TI140B07W.DAT

1.0M SOLUTION No.1 AT 140°C - WELDED SPECIMEN

IRE/SCE = 45.5mV S/N 5087374

9/16/99

INITIAL WT 20.8311g, FINAL WT 18.5090g 9/20/99

INITIAL PH 7.767@22.7°C, FINAL PH 6.721@22.4°C 9/20/99

E_{CORR} = -395mV, E_{PT} = -38mV

10:09 START DEAERATE, 12:31 STOP. TOTAL TIME 2 HRS 22 MIN

E_{CORR} = -82mV, E_{PT} = -61mV

12:33 START HEATING SP 138°C

9/17/99 7:08 INTERNAL 120°C SPT 157°C

9:00 133°C

9:30 134°C SPT 162°C

10:13 138°C

E_{CORR} = -266mV, E_{PT} = -252mV

SOLARTRON CONNECTED E_{CORR} = -345mV

10:18 START CPP RUN

9/18/99

9:57 UNLOCK COMPUTER & SAVE DATA

E_{CORR} = 178mV, E_{PT} = 112mV

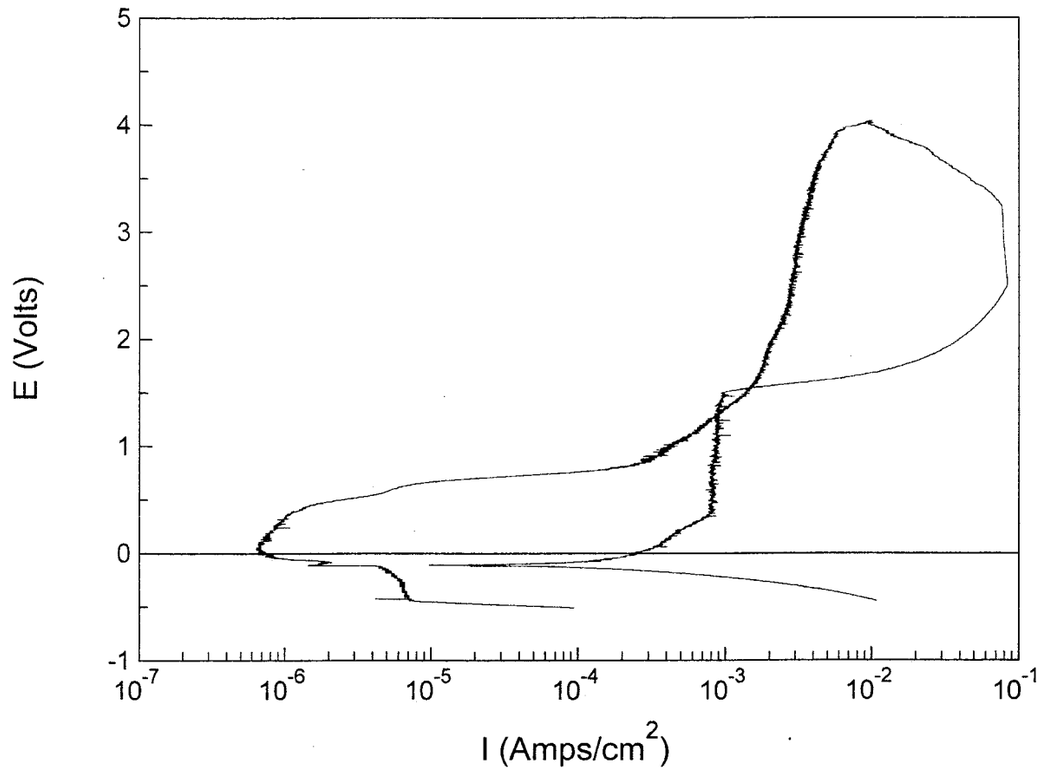
9:59 START COOL DOWN

9/20/99 7:31 INTERNAL TEMP 22.7°C

E_{CORR} = -549mV, E_{PT} = -505mV

IRE/SCE = -52mV S/N 5087374

Jerry Stewart 9/20/99



Jerry Sumrall 9/20/99

T#125B08W.DAT

1.0M SOLUTION No. 1 AT 125°C - WELDED SPECIMEN

IRE/SCE = 483mV S/N 5087374

10/4/99

INITIAL WT. 20.76666g, FINAL WT. 20.71547g JLS 10/6/99

INITIAL pH 7.641 @ 22.6°C, FINAL pH 6.899 @ 22.8°C JLS 10/6/99

E_{CORR} = -308mV, E_{PT} = 62mV

8:11 START DEAERATE, 10:11 STOP TOTAL TIME 2 HRS
E_{CORR} = -110mV, E_{PT} = 52mV

10:12 START HEATING, SP 122°C
302 INTERNAL TEMP 124.3°C - START CPP

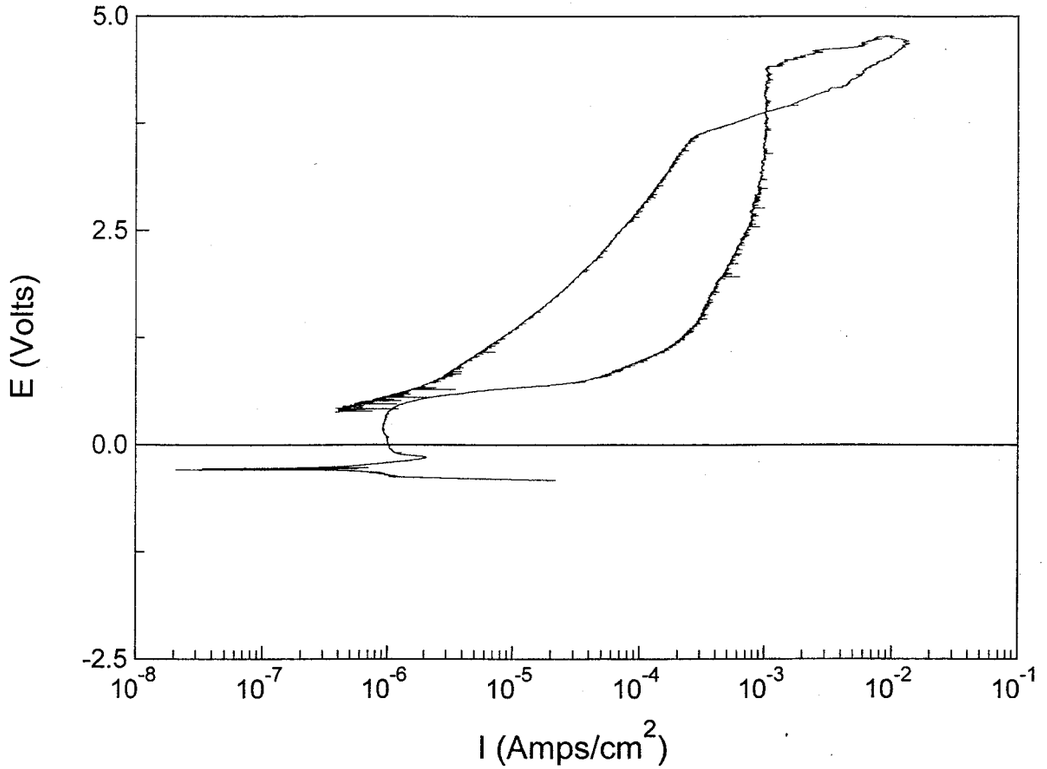
10/5/99 7:17 125.2°C - STILL RUNNING
7:19 STOP RUN
7:22 START COOL DOWN

10/6/99 7:26 INTERNAL TEMP 23.1°C

E_{CORR} = -630mV, E_{PT} = -3mV

IRE/SCE = 20mV S/N 5087374

Jerry Sumrall 10/6/99



LOCAL CORROSION ONLY – NO PITTING UNDER TEFLON WASHER –

~~Jerry Stewart~~ 10/6/99

T1095B09W.DAT

1.0M SOLUTION No. 1 AT 95°C – WELDED SPECIMEN

~~X~~RE/SCE = 44.4mV S/N 5087374

10/19/99

INITAL WT. 20.8467g, FINAL WT. 20.2986g 10/22/99 TVS

INITAL PH 7.589 @ 19.9°C, FINAL PH 6.365 @ 21.5°C 10/22/99 TVS

E_{CORR} = -258mV, E_{PT} = 109mV

8:27 START DEAERATE, 10:27 STOP – TOTAL TIME 2 HRS

E_{CORR} = -97mV, E_{PT} = 70mV

10:29 START HEATING SP 92°C

2:41 INTERNAL 96.4°C SP + 91°C

10/20/99 7:09 INTERNAL TEMP. 96.1°C

E_{CORR} = -205mV, E_{PT} = -4mV

7:18 START CPP

10/21/99 7:09 INTERNAL TEMP 97.1°C COMPUTER HUNG

E_{CORR} = -576mV, E_{PT} = -714mV

START Cool Down

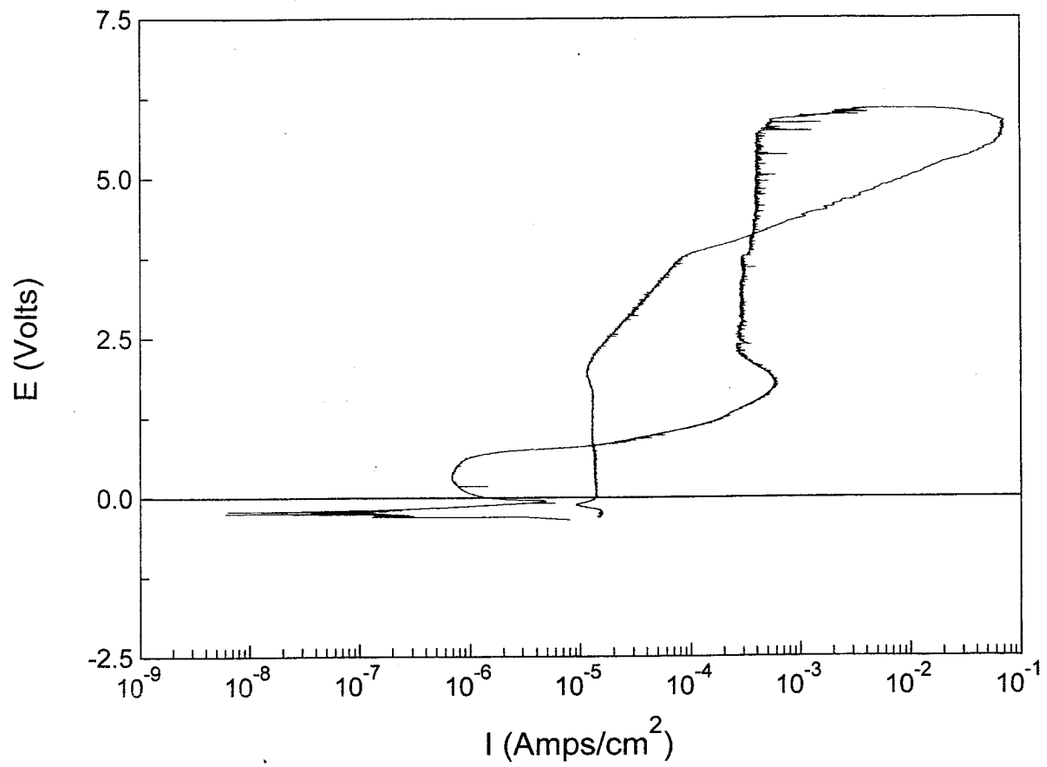
10/22/99 7:16 INTERNAL TEMP 18.7°C

E_{CORR} = -1.157V, E_{PT} – NO STEADY READING

SMALL LEAK THRU ~~I~~RE FITTING

~~X~~RE/SCE = 15mV S/N 5087374

~~Jerry Stewart~~ 10/22/99



Jerry Schwarz 10/22/99

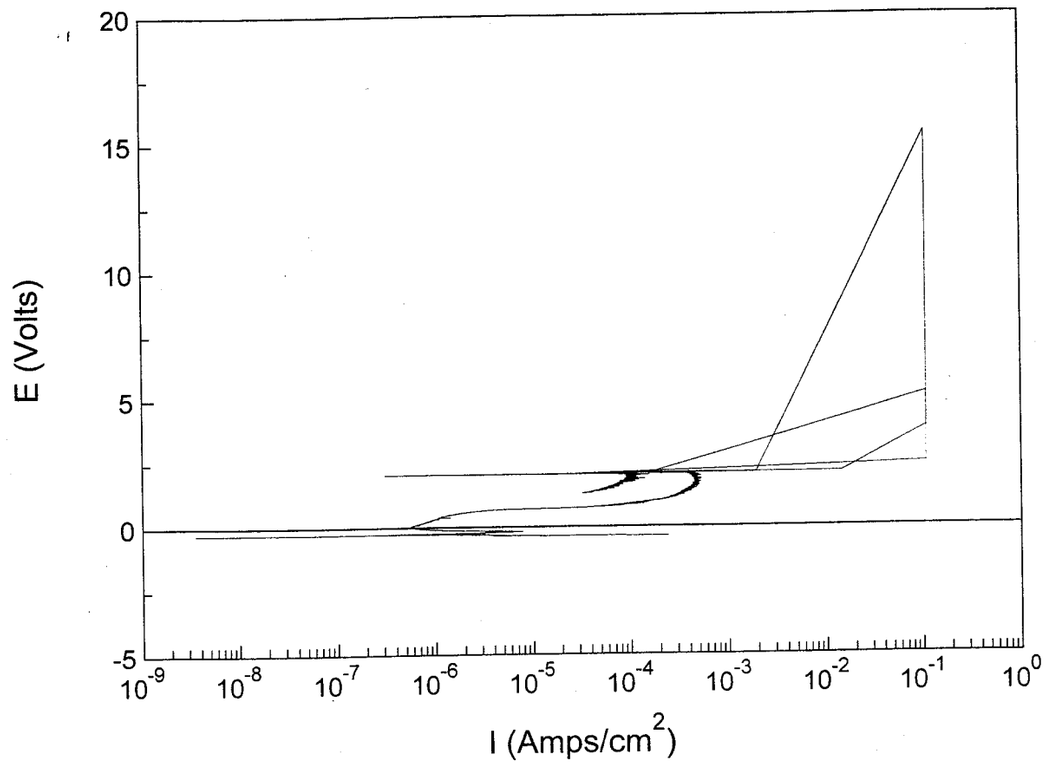
T1133B10W.DAT
1.0M SOLUTION NO-1 AT 133°C - WELDED SAMPLE
IREF/SCE = 43.1 mV S/N 5087374
10/26/99
INITIAL WT. 20.8193g FINAL WT. 20.8192g 10/28/99 JS
INITIAL pH 7.631 @ 21.1°C FINAL pH 6.838@24.5°C 10/28/99 JS
E_{CORR} = -431 mV, E_{PT} = -30 mV
8:16 START DEAERATE, 10:16 STOP TOTAL TIME 2 HRS
E_{CORR} = -144 mV, E_{PT} = -102 mV
10:17 START HEATING SP 130°C
3:04 133.6°C SP + 129°C

10/27/99 INTERNAL TEMP 134.3°C
E_{CORR} = -250 mV, E_{PT} = -99 mV
7:19 START CPP
12:55 133.3°C STOP RUN - NOT SURE WHAT'S GOING ON -

10/28/99 7:13 INTERNAL TEMP 24.5°C
E_{CORR} = 345 mV, E_{PT} = -194 mV
RUBBER WASHER SPLIT - SAMPLE IS LOOSE ON HOLDER - NO DAMAGE TO SPECIMEN OTHER THAN SLIGHT TEXTURE CHANGE IN AFEW AREAS -
RE POLISH & RERUN
IREF/SCE = 4 mV S/N 5087374

Jerry Schwarz 10/28/99

T1133B10W.DAT



Jerry Stewart 10/28/99

T1133B11W.DAT

1.0M SOLUTION No.1 AT 133°C - WELDED SPECIMEN - REPEAT
RE POLISHED SPECIMEN - SEE PAGE 51.

IRE/SCE = 45.0mV S/N 5087374

11/1/99

INITAL WT. 20.8111g, FINAL WT. 20.6995g 11/4/99 JS

INITAL PH 7.601 @ 21.1°C, FINAL PH 6.790 @ 21.4°C 11/4/99 JS

E_{CORR} = -385mV, E_{PT} = -46mV

10:02 START DEAERATE, 12:02 STOP - TOTAL TIME 2HRS
E_{CORR} = -157mV, E_{PT} = -118mV

12:03 START HEATING SP 129°C
15:17 128.1°C

11/2/99 7:06 INTERNAL TEMP 133.8°C
E_{CORR} = -241mV, E_{PT} = -154mV
7:10 START CPP
15:04 REVERSAL

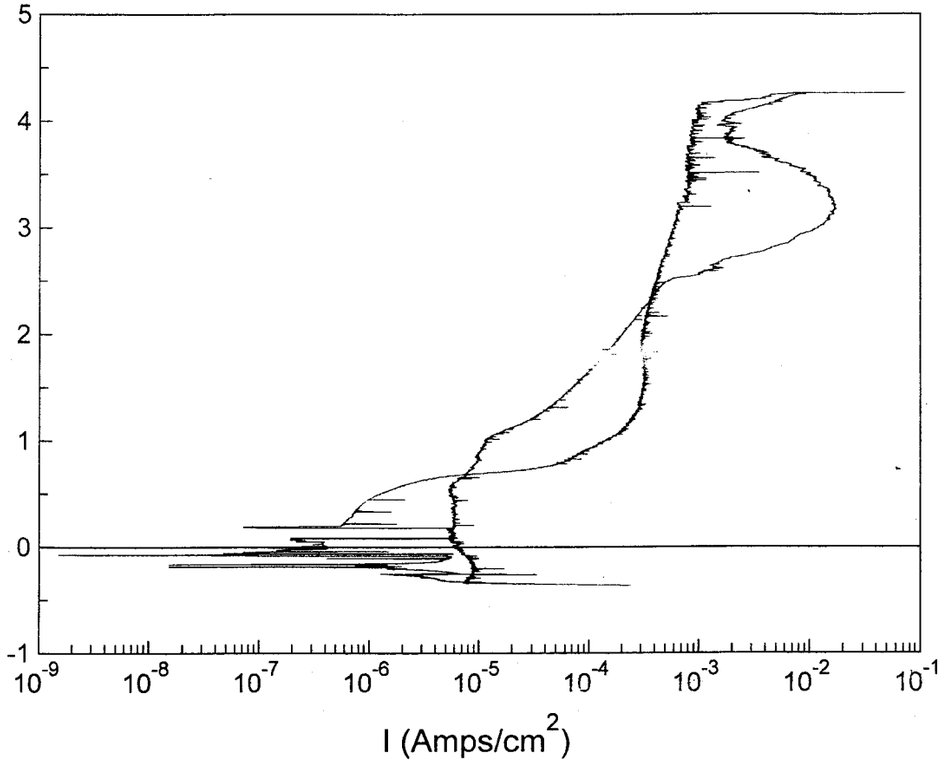
11/3/99 7:12 INTERNAL TEMP 132.8°C
E_{CORR} = -746mV, E_{PT} = -769mV
START COOL DOWN

11/4/99 7:56 INTERNAL TEMP 21.8°C

E_{CORR} = -674mV, E_{PT} = -590mV

IRE/SCE = 6mV S/N 5087374

Jerry Stewart 11/4/99



LOCAL ATTACK LOWER HALF AND BOTTOM
ALL SITES ARE OUTSIDE WELD

Jerry Stewart 11/4/99

TI 129 B12W.DAT
1.0M SOLUTION No.1 AT 127°C - WELDED

FREE/SCE = 45.2mV S/N 5087374

11/16/99

INITIAL WT 20.8370g FINAL WT 20.7904g JTS 11/19/99

INITIAL PH 7.691 @ 20.6°C FINAL PH 6.793@22.7°C JTS 11/19/99

E_{CORR} = -362mV, E_{PT} = 54mV

8:00 START DEAERATE 10:30 STOP - TOTAL TIME 2HRS 30MIN
E_{CORR} = -284mV, E_{PT} = -133mV

10:34 START HEATING SP 125°C
14:26 128.6°C SP+ 122°C

11/17/99 7:07 INTERNAL TEMP 127.3°C
E_{CORR} = -199mV, E_{PT} = -32mV

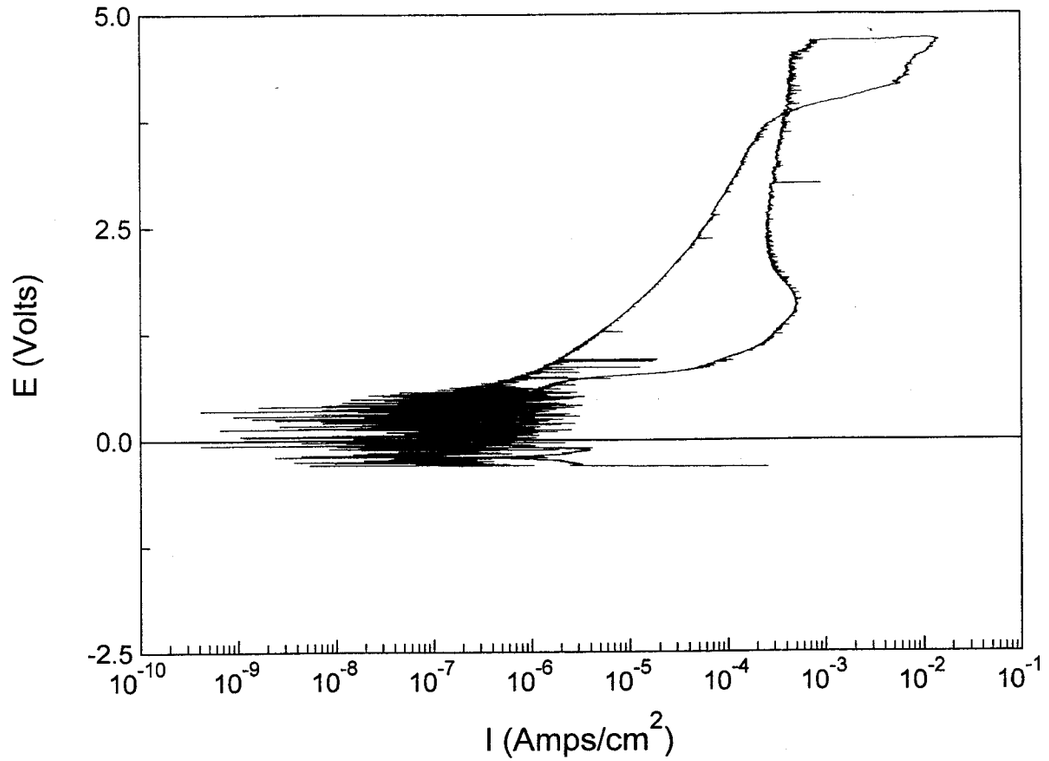
7:13 START CPP
15:30 REVERSE

11/18/99 7:04 INTERNAL TEMP 127.4°C
E_{CORR} = -637mV, E_{PT} = -706mV
START COOL DOWN

11/19/99 12:47 INTERNAL TEMP 22.8°C
E_{CORR} = -208mV, E_{PT} = -83mV

FREE/SCE = 14mV S/N 5087374

Jerry Stewart 11/19/99

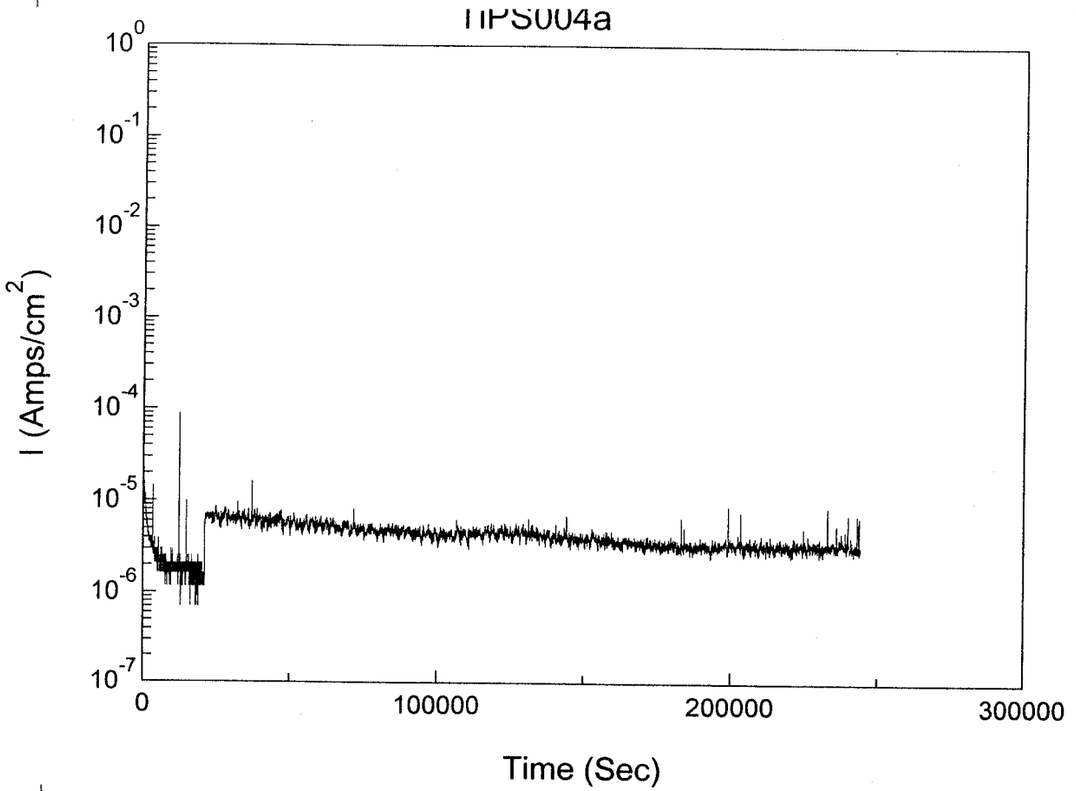


Kenny Sieradzki 11/19/99

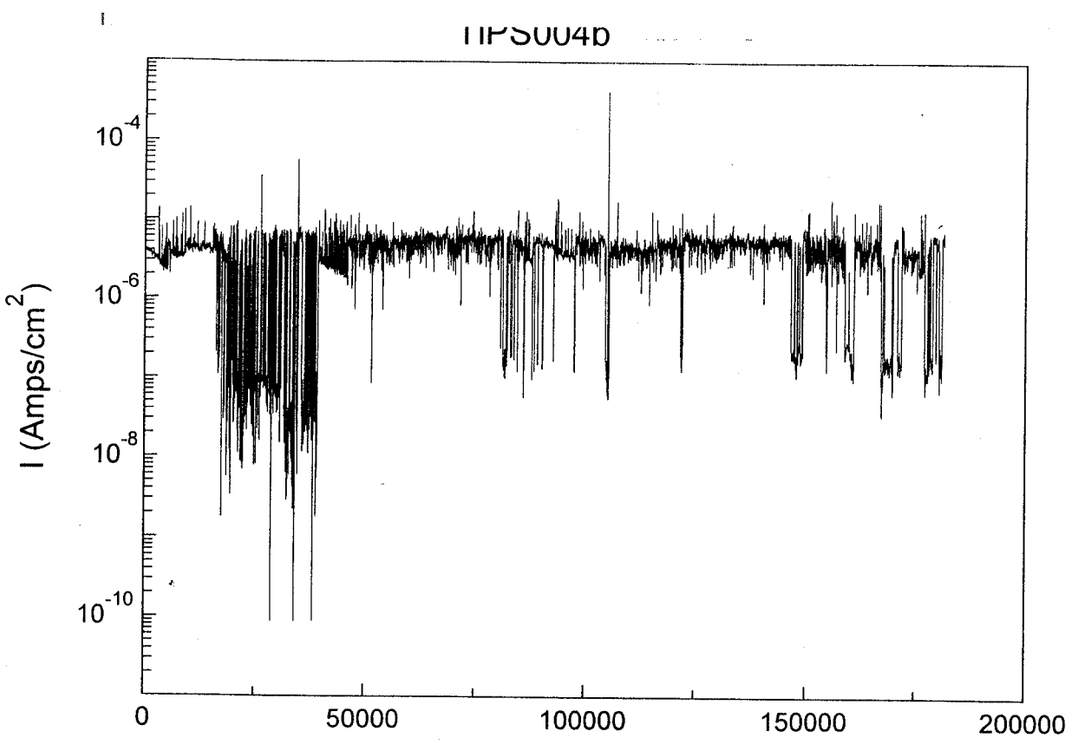
Continuation of passive current density measurements discussed on pg ~~26~~ 28 SB 2/14/00

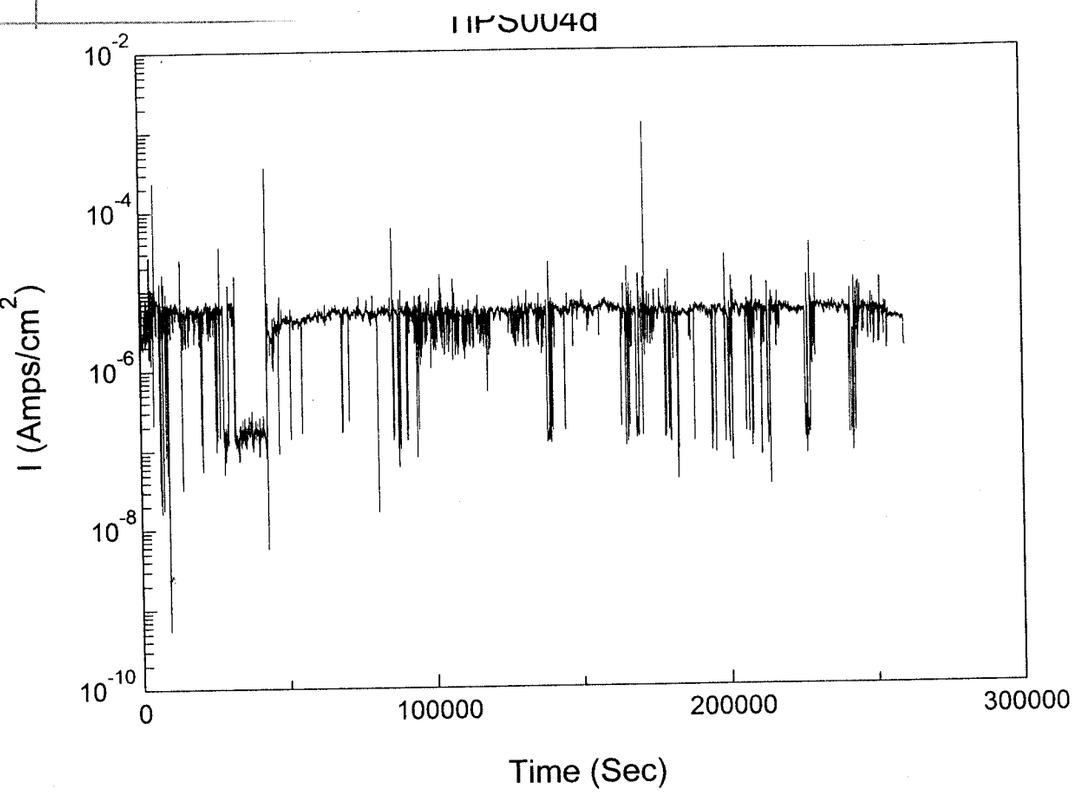
0.1 M NaCl 95°C Lot #985302 pH_i = 6.092
wt_i = 6.38830 g pH_f = 5.983

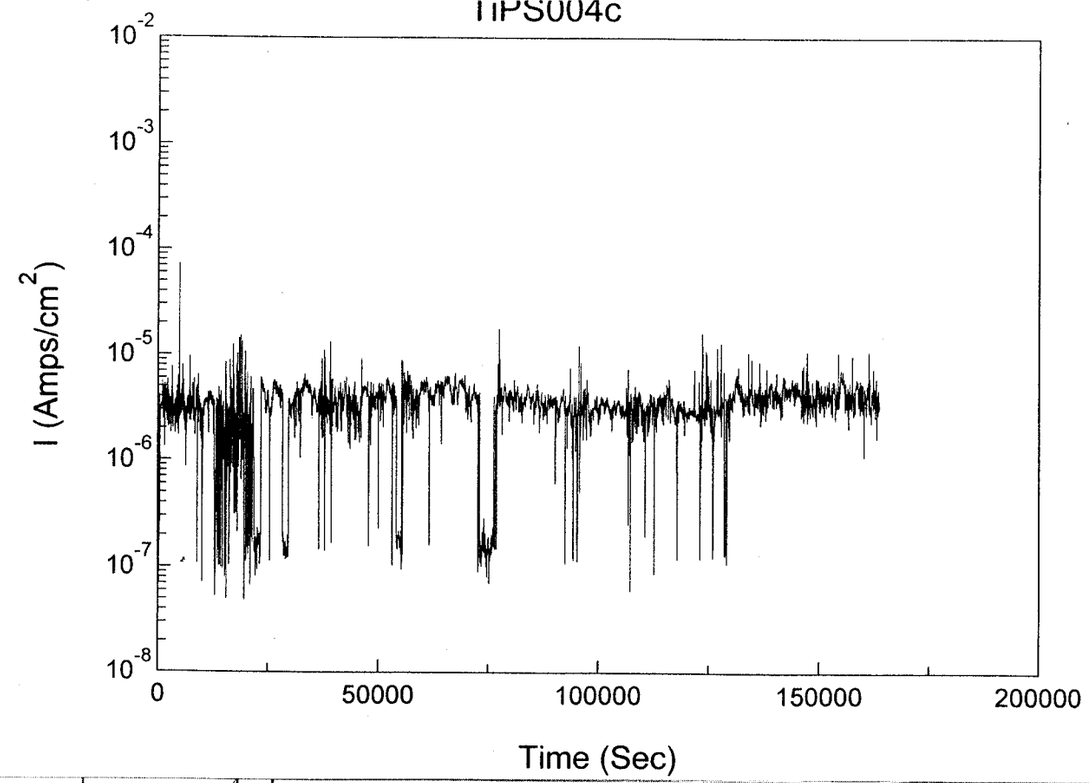
$E_{appl.}$	i_{ss} ($\mu A/cm^2$)	wt_f	file name
-250 mV	1.6-3.3	6.38828	tips004a
0	5	6.38823	" b
+250	5.4	6.38829	" c
+500	4.8-5.2	6.38897	" d



SB → 8/16/99







SB 8/16/99

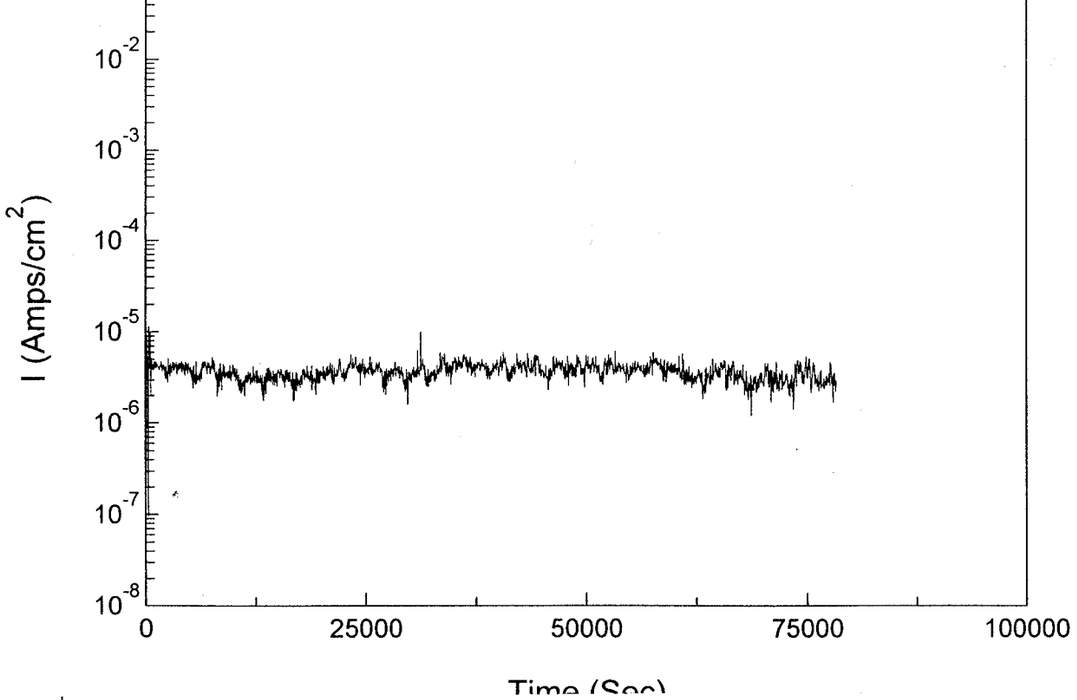
SB 8/16/99

Pstat ipass measurement of Ti-Grade 7

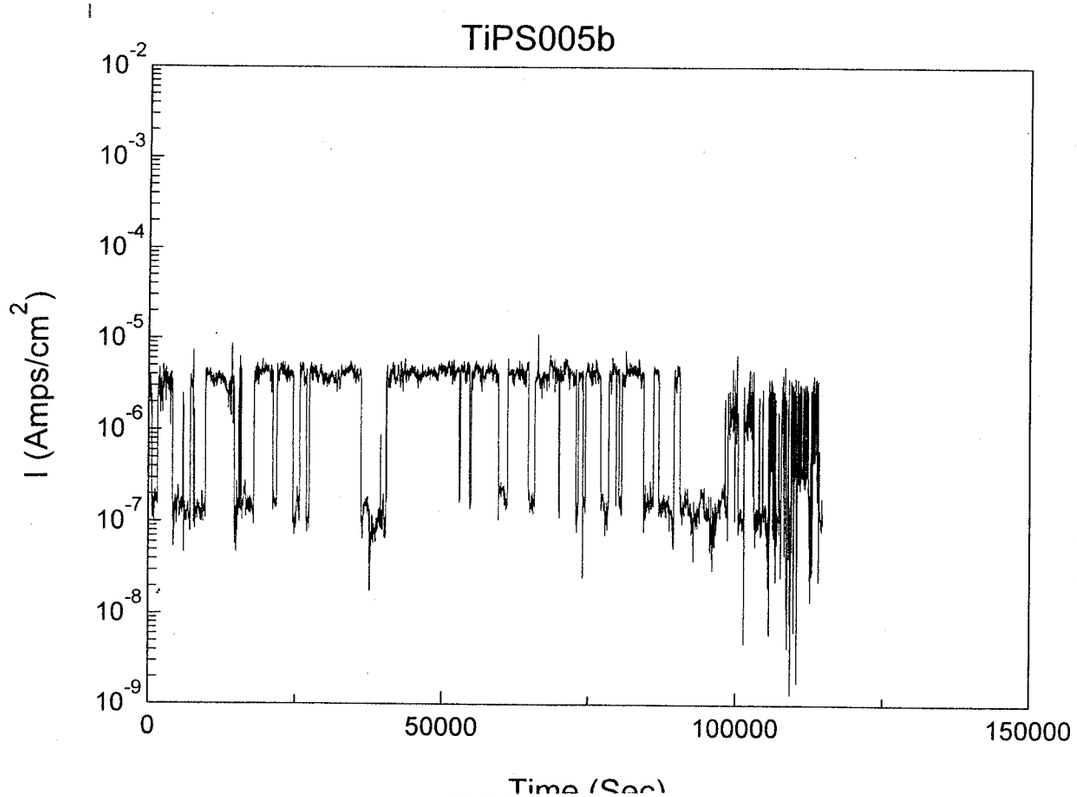
0.1 M NaCl + 20mM Na_2CO_3 95°C pHi: 10.980
#985302 #960685 pHf = 10.400
(deaerated)

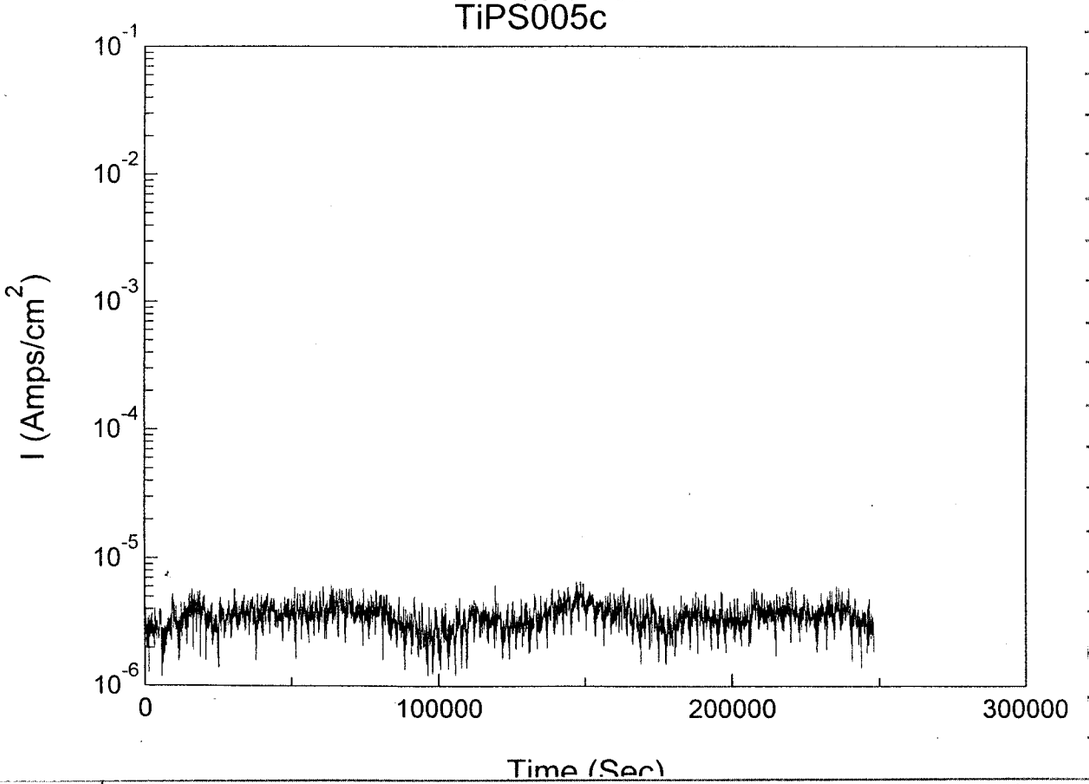
wti = 6.42762
SB SB 8/16/2000

Eappl.	iss (μA/cm²)	wtf	file
-250	2.6 - 5.6	N/A	tips005a
0	3.1 - 5.4	N/A	— b
250	2.2 - 5.8	6.42687	— c
500	5.2 - 8.1	N/A	— d
750 mV/sce	0.23 - 7.8	N/A	— e

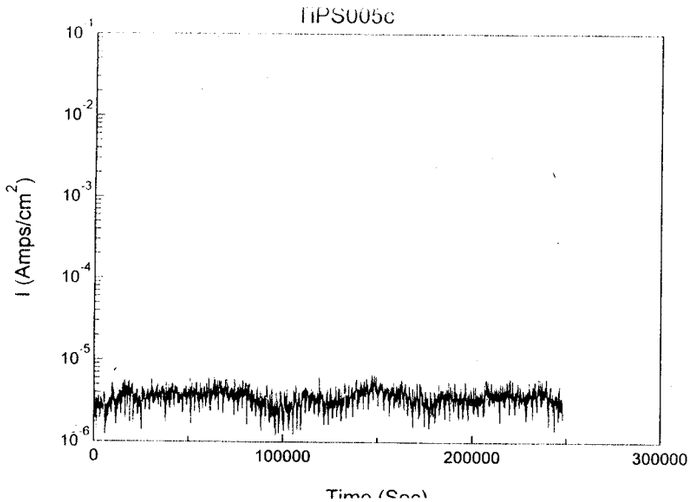


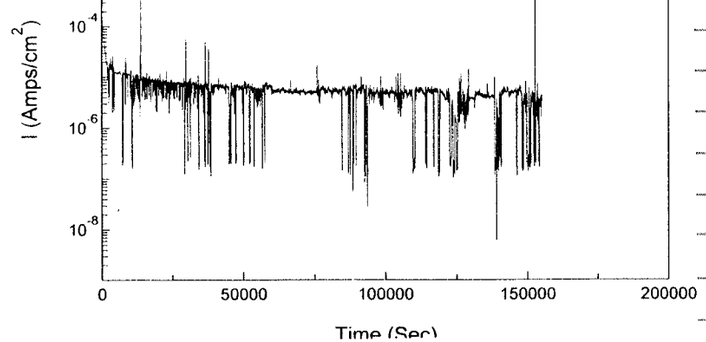
SB 8/25/99

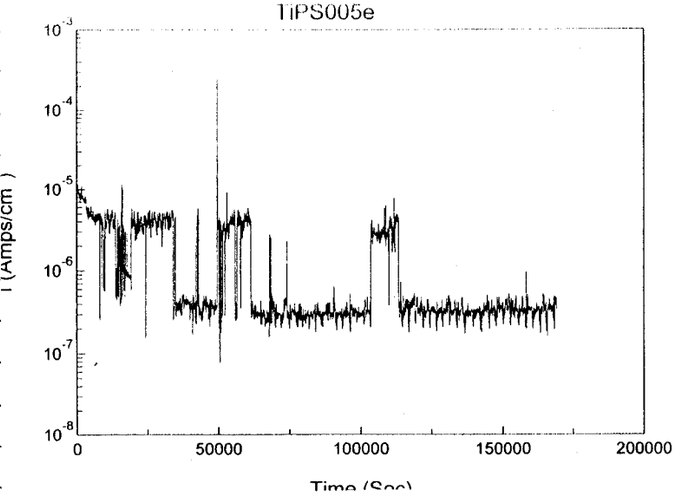




SB 8/25/99







SB e 8/25/99

63 SB 8/16/2000

Potent SB Polarization of Ti-Gr 7 in ~~F^{-2}~~ SB F^- solutions

0.01 M NaF lot # 896405 0.8398 g - deaerated

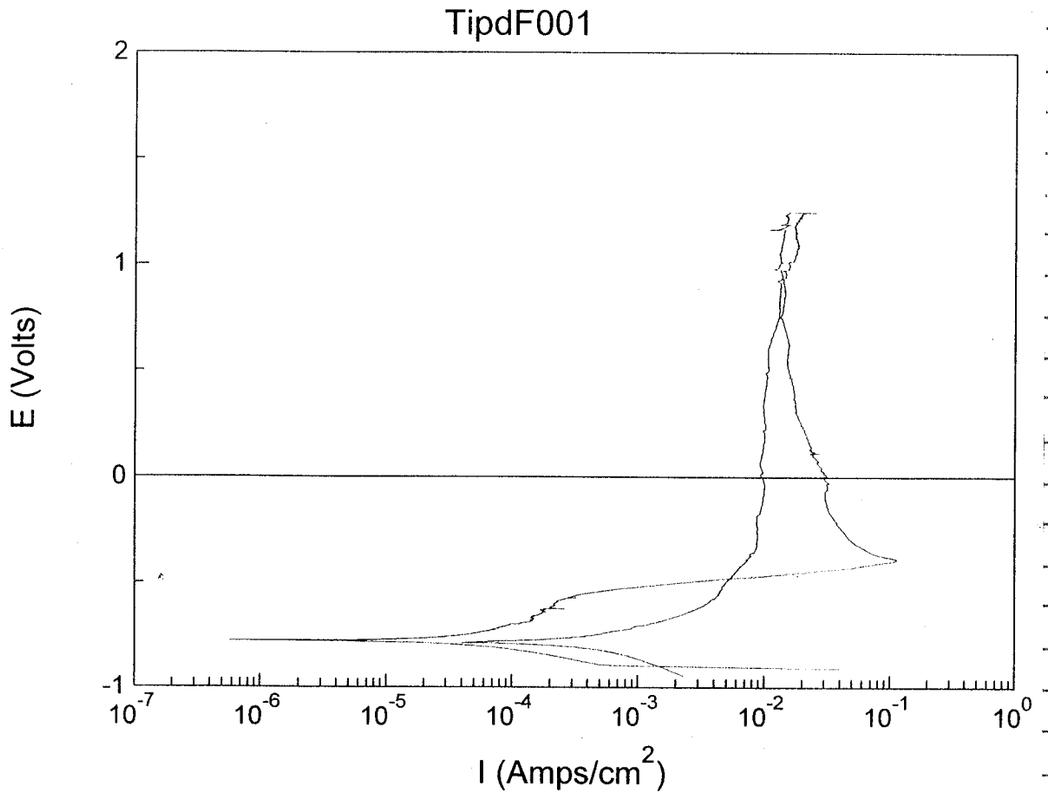
T: PdF001.dat - 95°C

pH_i = 6.46

pH_f = 8.840

wt_i = 16.70537

wt_f = 16.6863



SB 9/15/99

Ti-Gr7 in F^- solutions cont'd

1 M NaF, 95°C same lot as on pg 63

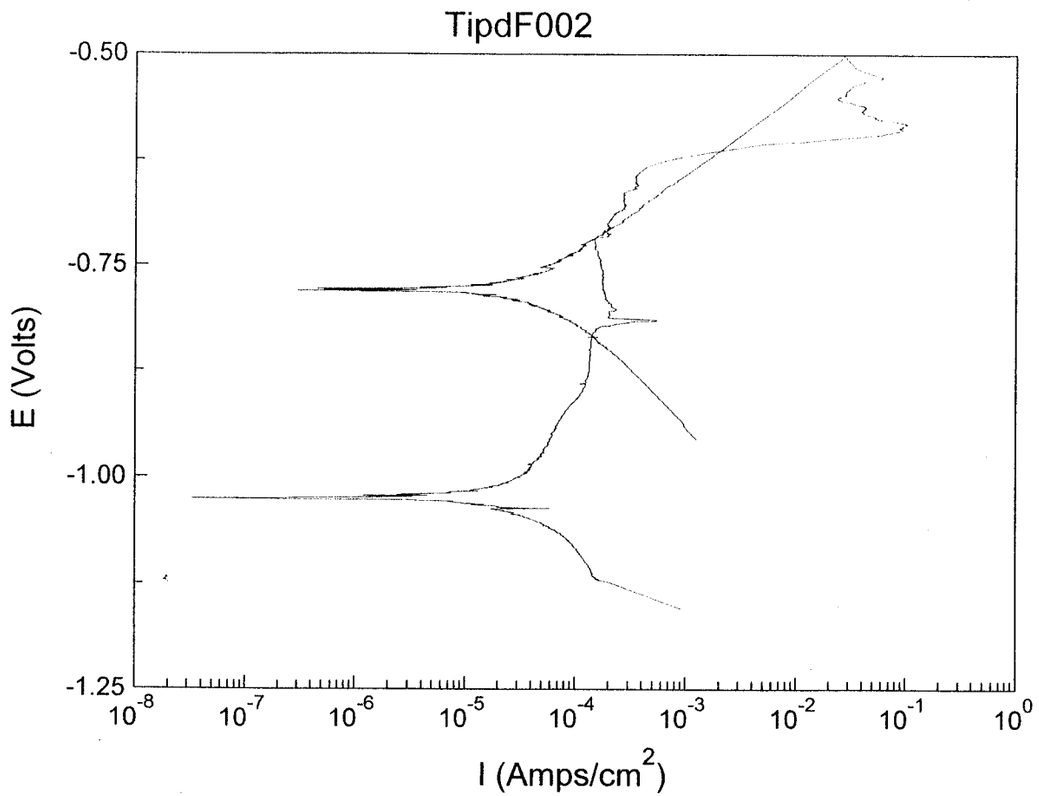
pH_i 10.152

pH_f 8.808

wt_i 6.40490

wt_f 6.39558

Tipdf002.dat



SR 9/28/99

1 M NaF + 1 M NaCl

same as p63 #972274

95°C, deaerated

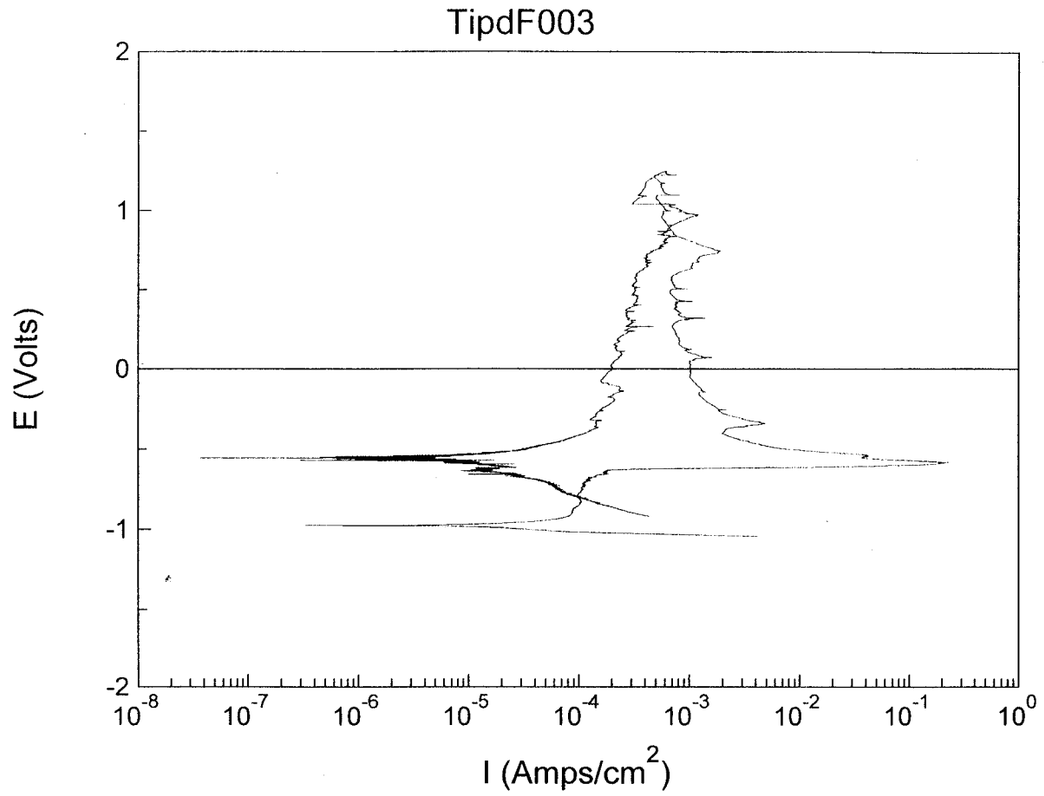
pH_i 9.447

pH_f 8.5686 SB SB 8/16/2000

wt_i 6.44746

wt_f 6.45142

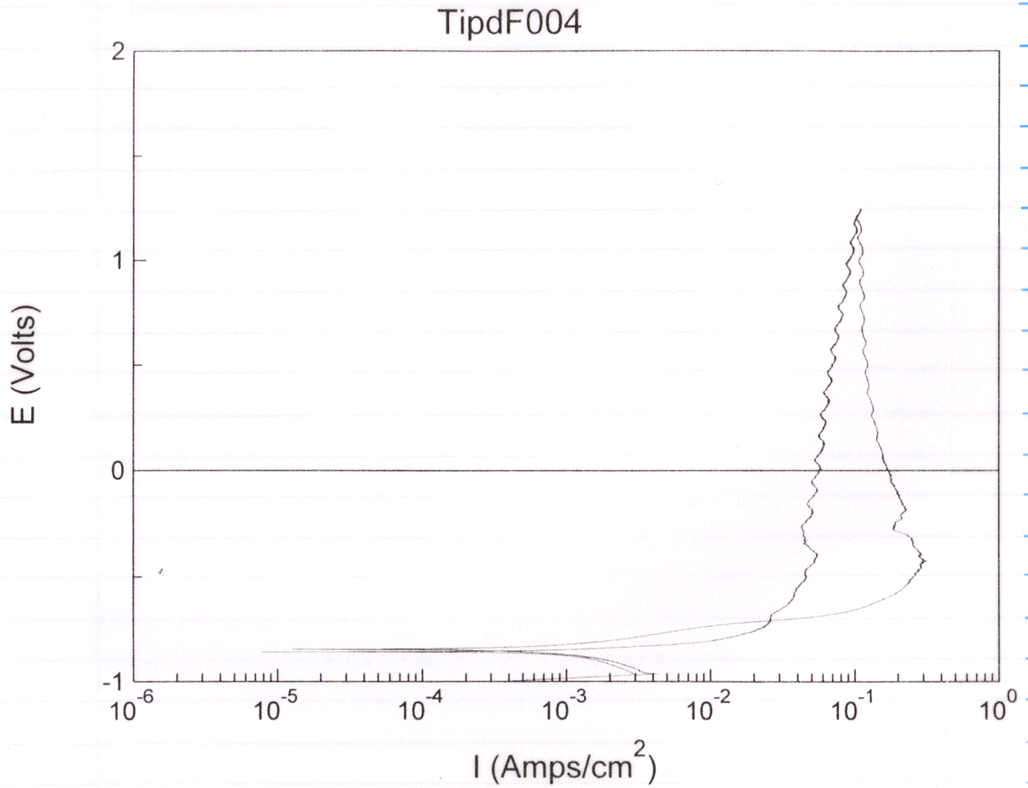
Tipdf003



SR 9/29/99

1M NaF + 0.1 M HCl - Lot# 993517
(same as pg 63) (8.3 mL/L)

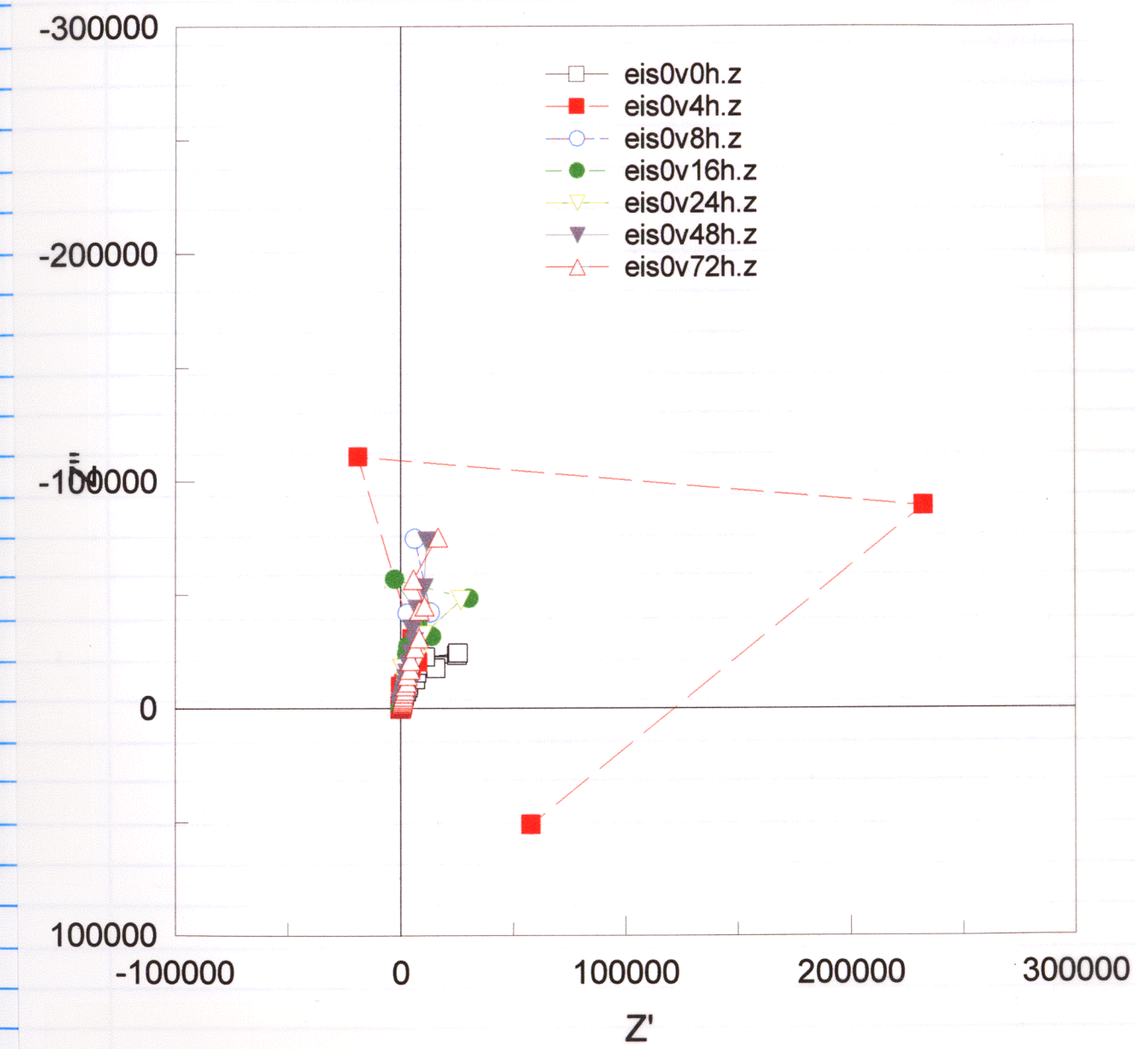
95°C, deaerated
pH_i 4.571
pH_f 7.199
wt_i 6.40863
wt_f 6.19869
TipdF004 SB



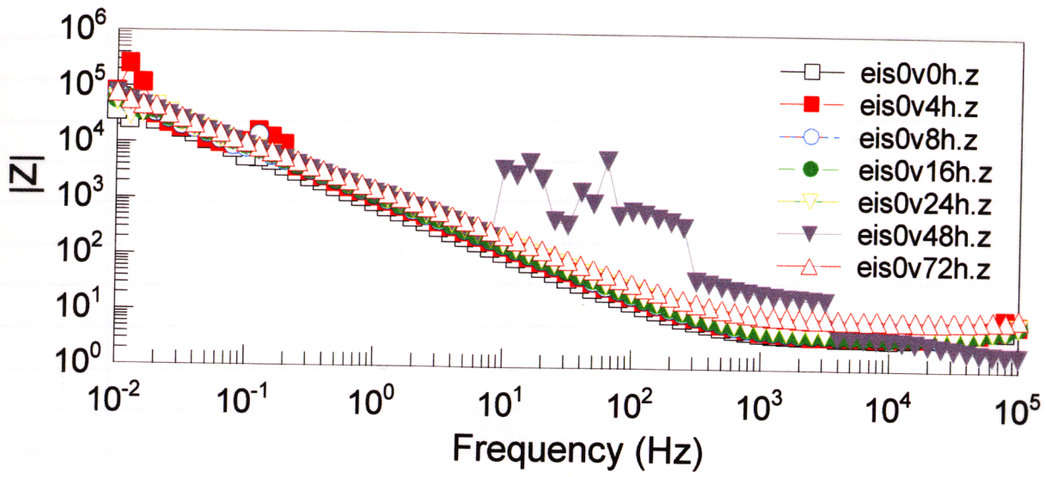
SB 9/30/99

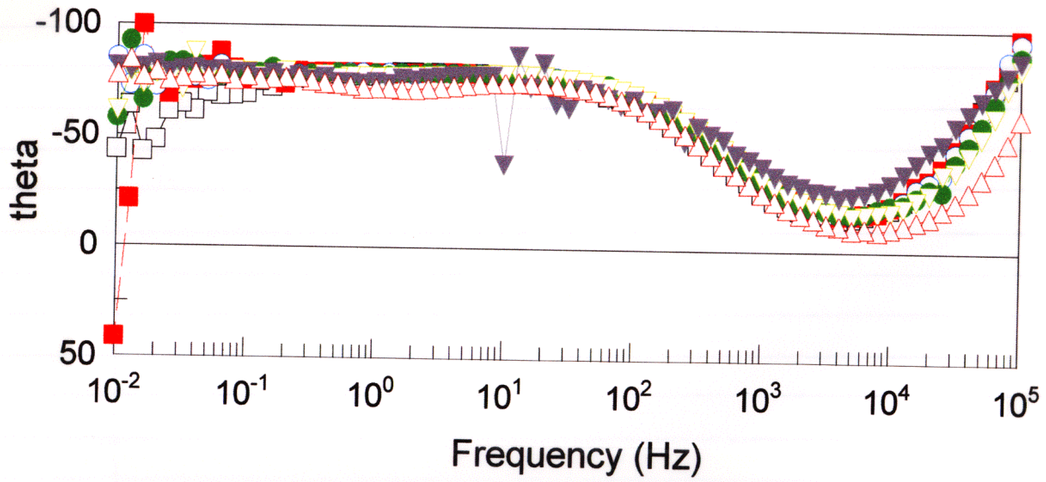
EIS to study oxide properties @ 0 VSCE vs time

0.1 M NaCl (995718)
95°C deaerated
pH_i = 6.855



SB 12/29/99





12/21/99

12/16/99

Ti-Gr7 crevice specimen ~ 1M NaCl + 1M NaF

995718 896405

wt_i = 16.75370

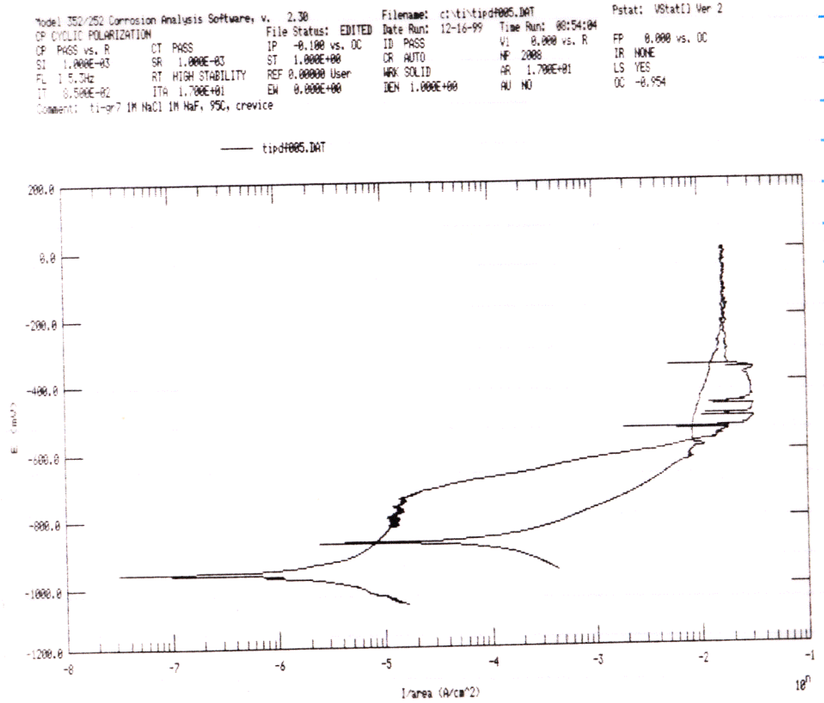
wt_f = 16.73488

pH_i = 9.865

pH_f = 9.013

some pitting noticed under crevice feet

Tipdf005

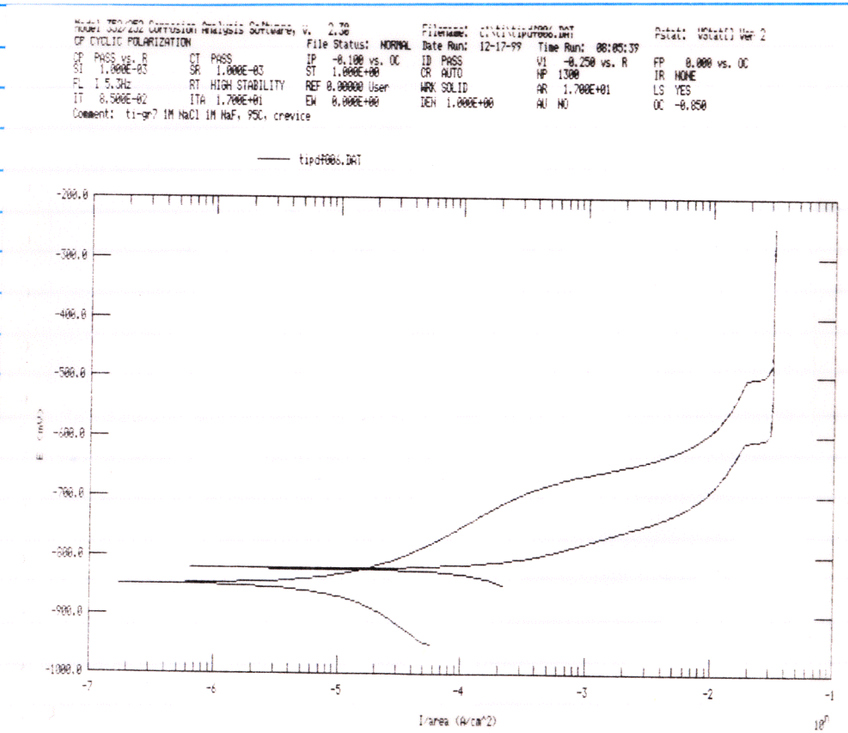


12/16/99

Ti PdF006 Ti-Gr7 Crevice in 1M NaF + 0.1M HCl
89645 943517

pHi 4.808
pHf 5588
wti 16.78810
wtf ~~16.74~~ 16.73453 SB SB 8/16/2000

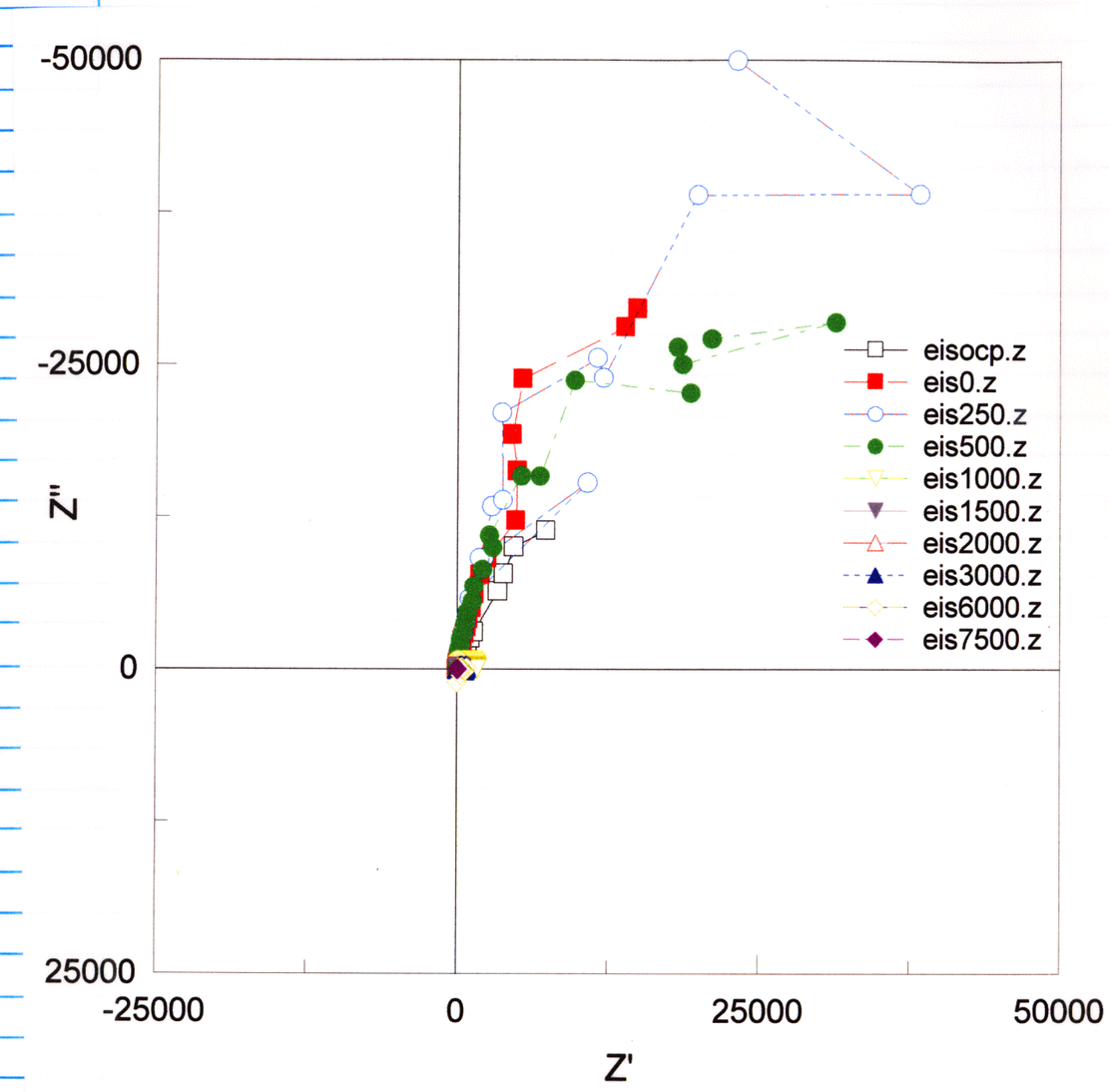
Sample dark, gas evolution @ ocp, pits under crevice



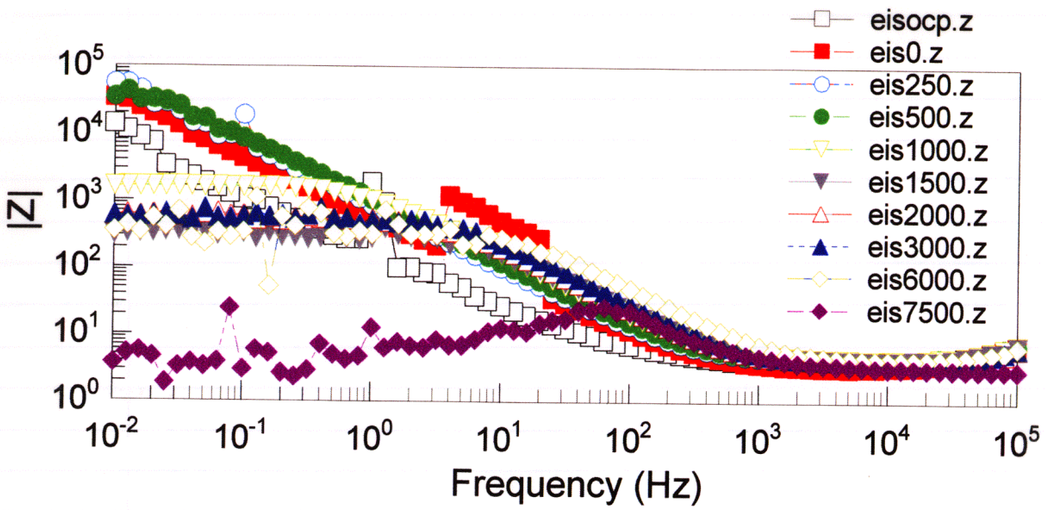
SB 12/17/99

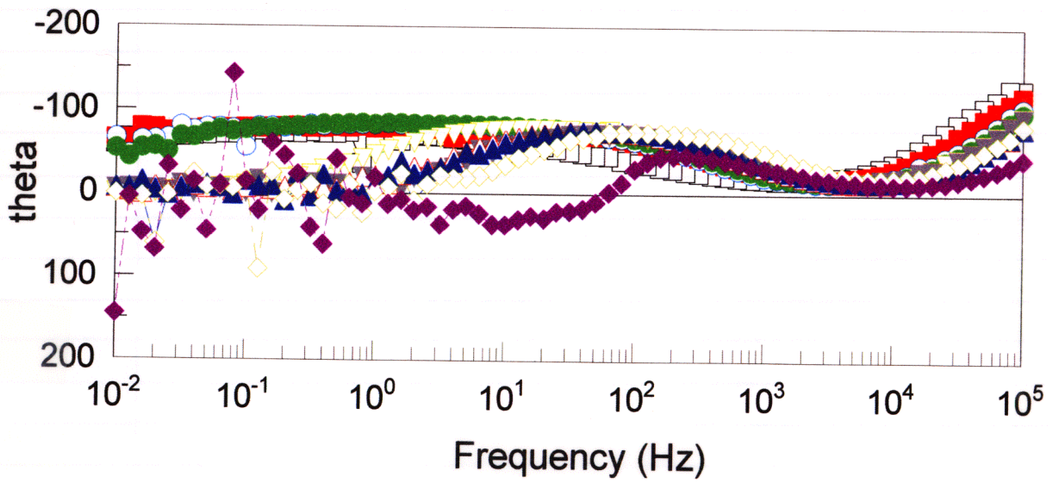
EIS/oxide props of Ti-Gr 7 @ Diff. E

- same conditions at p 67 except Eappl.
24 hr hold btwn potential changes (except 7500 - only 4 hrs)



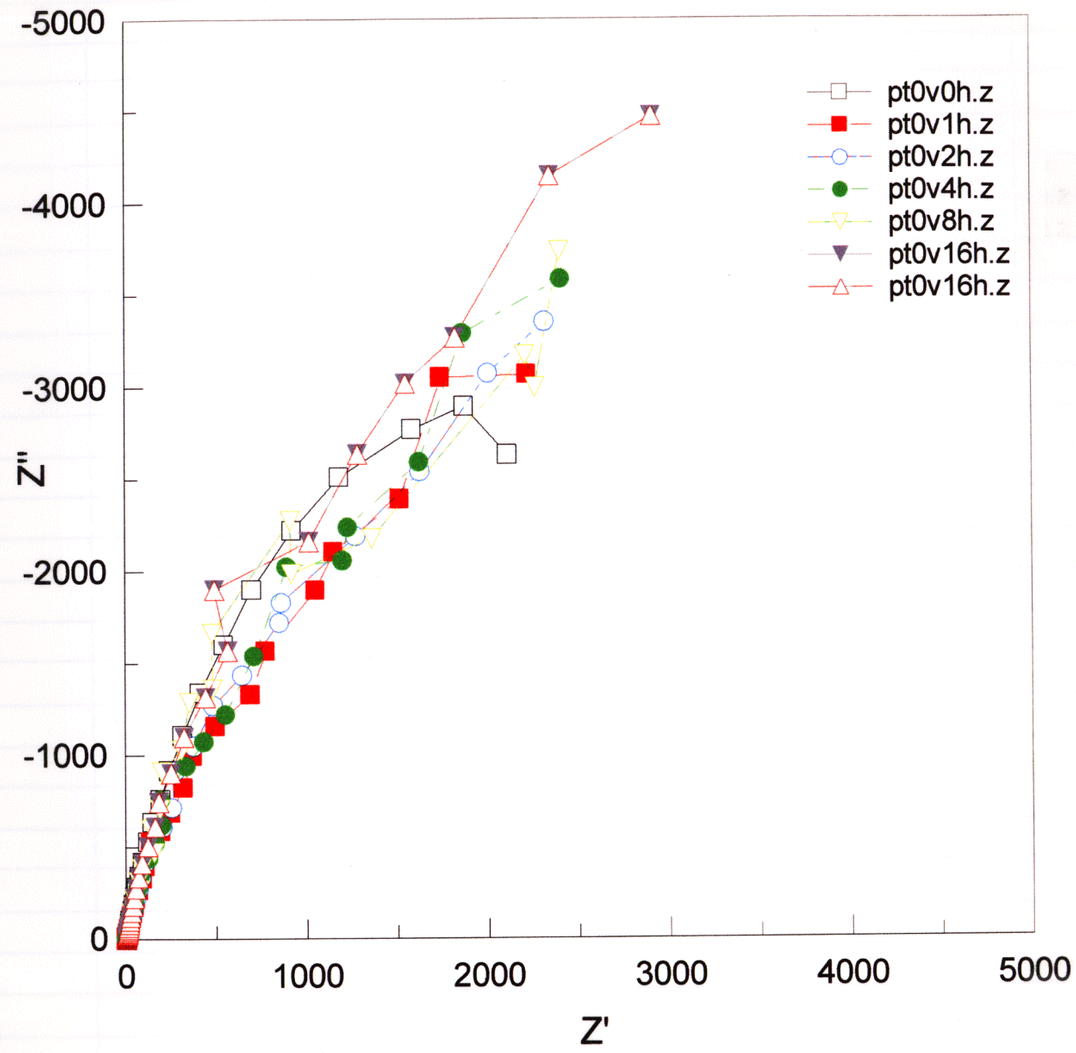
SB 1/4/00



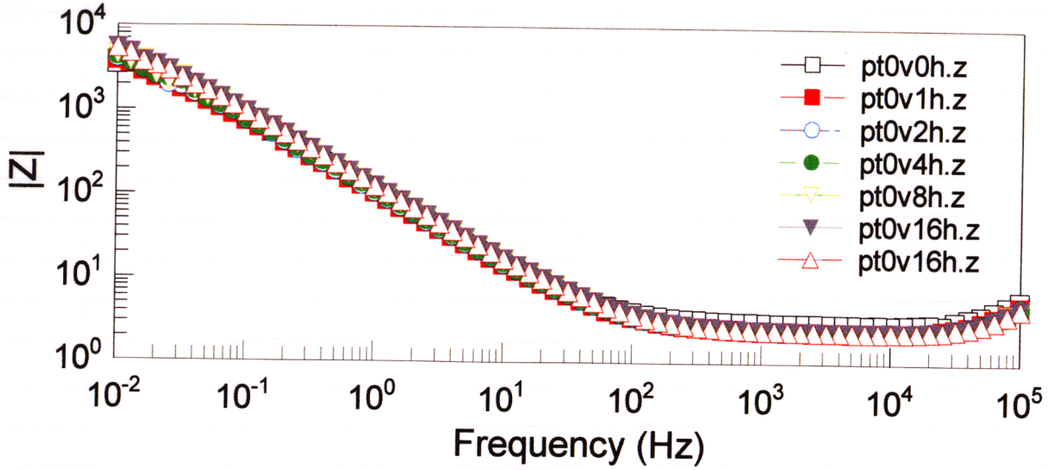


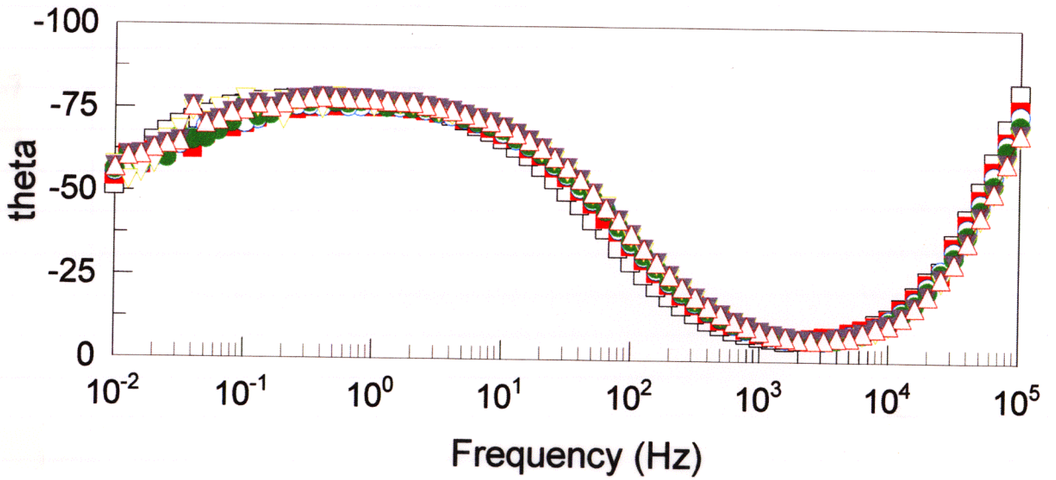
SBe 1/4/00

EIS of Pt in same conditions as p67
6V sca vs time



SBe 1/13/00

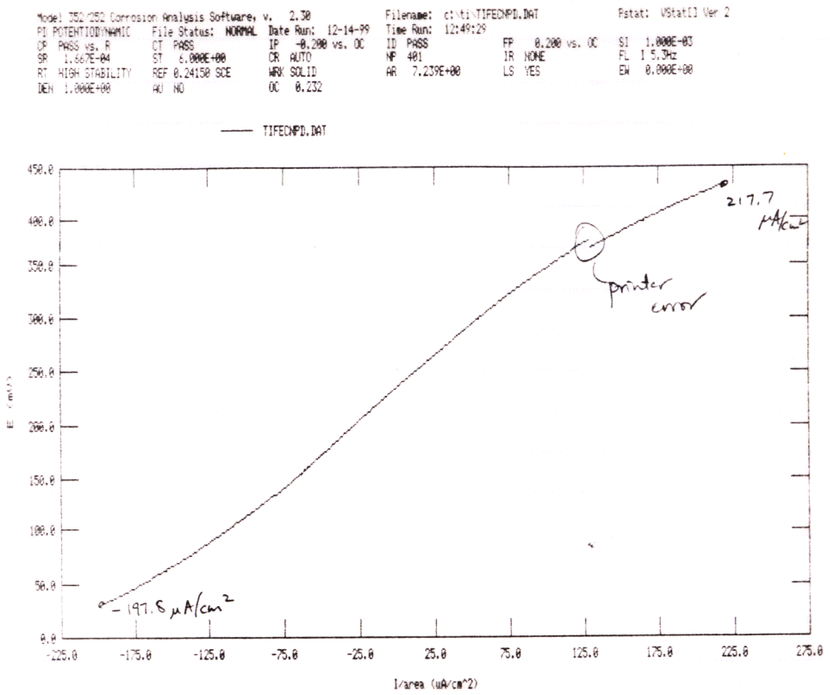




SRB 1/13/00

12/14/99

Used 0.1 M Na_2SO_4 + 0.1 M $K_3Fe(CN)_6$ & 0.1 M $K_4Fe(CN)_6$ (SRB)
to study electronic conduction through Ti-Pd oxide
-E = -200 → 200 mV vs ocp



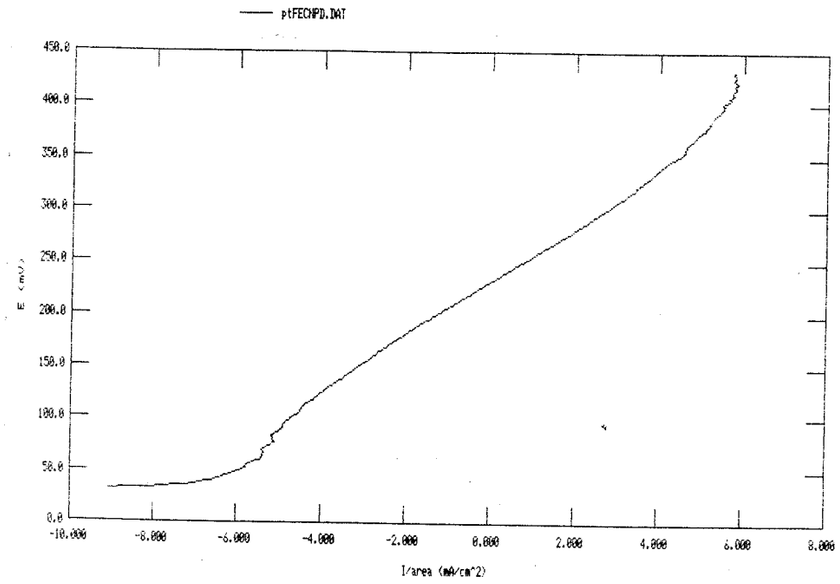
SRB 12/14/99

same conditons as #75 but w/ Pt flag electrode

Model 352/252 Corrosion Analysis Software, v. 2.30
PD POTENTIODYNAMIC File Status: NORMAL Date Run: 12-14-99
EF PASS vs. R CT PASS IP -0.200 vs. OC
SR 1.000E-03 ST 1.000E+00 CR AUTO
RT HIGH STABILITY REF 0.24158 SCE WRK SOLID
DEN 1.000E+00 AU NO OC 0.231

Filename: c:\ti\ptFECNPD.DAT
Time Run: 13:43:13
ID PASS FP 0.200 vs. OC
NP 401 IR NONE
AR 1.868E+01 LS YES

Pstat: VStat[] Ver 2
SI 1.000E-03
FL I 5.3Hz
EH 0.000E+00



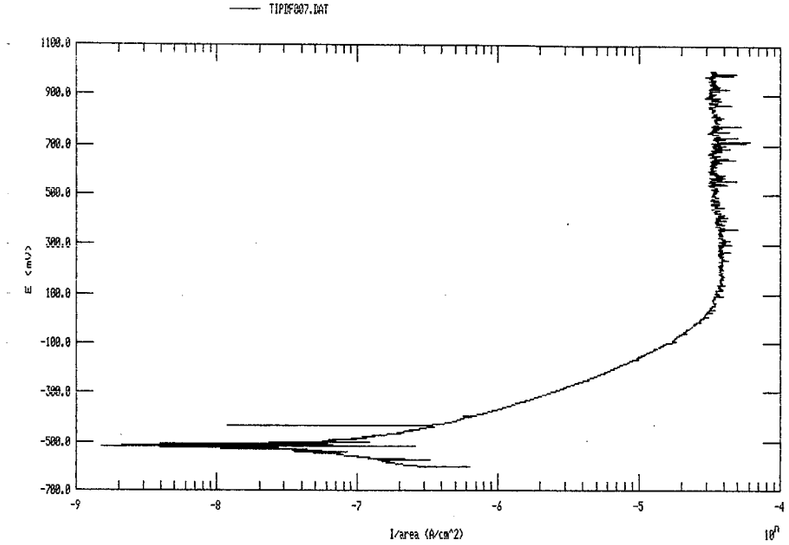
12/14/99

Ti - F
Lot 993517 | Lot 896405
Ti Gr 7 95°C, 0.1 M Cl, 0.1 M F

Model 352/252 Corrosion Analysis Software, v. 2.30
PD POTENTIODYNAMIC File Status: NORMAL Date Run: 02-29-00
CP PASS vs. R CT PASS IP -0.100 vs. OC
SR 1.670E-04 ST 5.988E+00 CR AUTO
RT HIGH STABILITY REF 0.00000 User WRK SOLID
DEN 0.000E+00 AU NO OC -0.585

Filename: \ti\TIPDF007.DAT
Time Run: 09:42:53
ID PASS FP 1.000 vs. R
NP 1686 IR NONE
AR 3.308E+00 LS NO

Pstat: VStat[] Ver 2
SI 1.000E-03
FL NONE
EH 0.000E+00



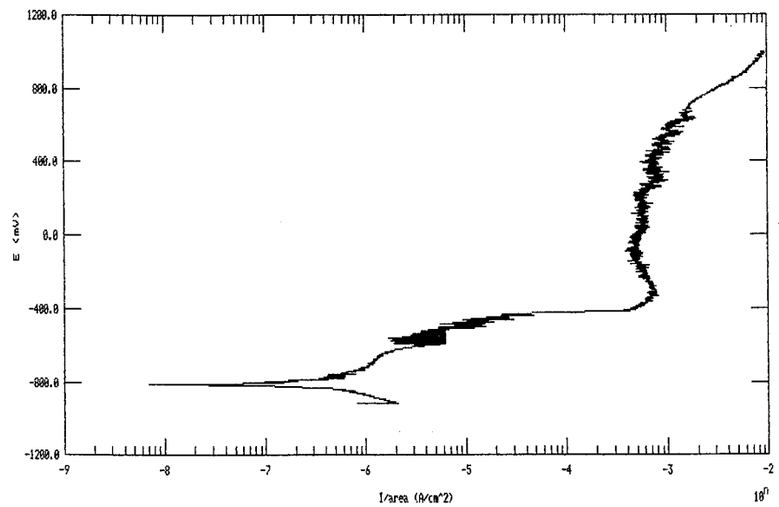
2/29/00

Fluoride Ti Gr 7 95 C 0.1MCl 1MF
Same lots as p77

Model 352/252 Corrosion Analysis Software, v. 2.30
PD POTENTIODYNAMIC File Status: NORMAL Date Run: 03-01-00
CP PASS vs. R CT PASS IP -0.100 vs. OC
SR 1.670E-04 ST 5.988E+00 CR AUTO
RT HIGH STABILITY REF 0.00000 User WRK SOLID
DEN 0.000E+00 AU NO OC -0.813

Filename: \ti\TIPDF008.DAT
Time Run: 10:01:00
ID PASS FP 1.000 vs. R
NP 1914 IR NONE
AR 3.300E+00 LS NO

Pstat: VStat1 Ver 2
SI 1.000E-03
FL NONE
EW 0.000E+00



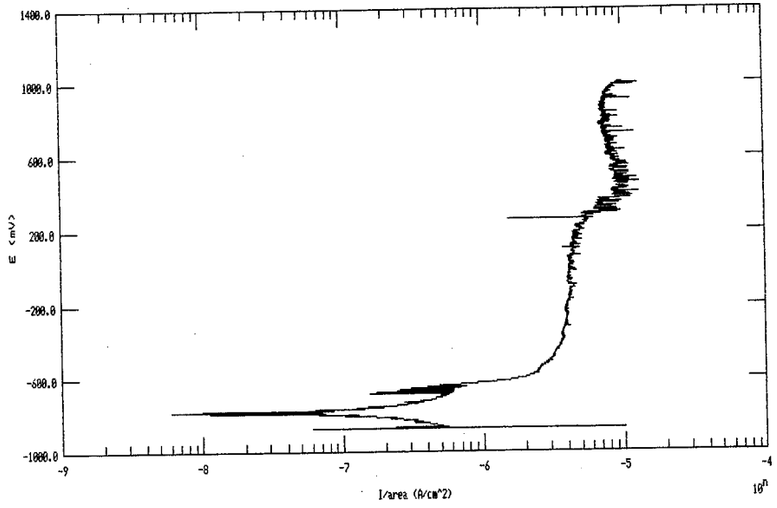
3/1/00

Ti 7, 0.1MCl, 0.01MF 95°C
same as p77
Fluor. Le

Model 352/252 Corrosion Analysis Software, v. 2.30
PD POTENTIODYNAMIC File Status: NORMAL Date Run: 03-02-00
CP PASS vs. R CT PASS IP -0.100 vs. OC
SR 1.670E-04 ST 5.988E+00 CR AUTO
RT HIGH STABILITY REF 0.00000 User WRK SOLID
DEN 0.000E+00 AU NO OC -0.773

Filename: \ti\TIPDF009.DAT
Time Run: 13:05:14
ID PASS FP 1.000 vs. R
NP 1874 IR NONE
AR 3.300E+00 LS NO

Pstat: VStat1 Ver 2
SI 1.000E-03
FL NONE
EW 0.000E+00



3/2/00

95°C, Ti7, 0.1 M Cl, 0.05 M F
same as 77

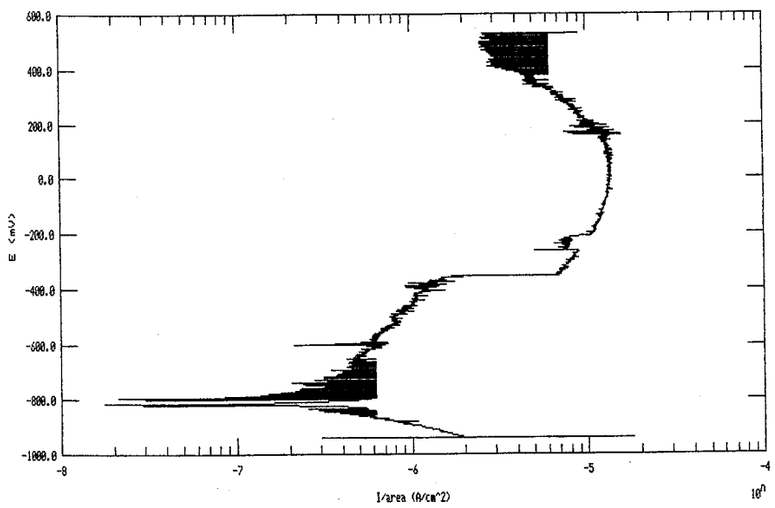
F^-

Model 352/252 Corrosion Analysis Software, v. 2.30
PD POTENTIODYNAMIC File Status: NORMAL Date Run: 03-03-00
CP PASS vs. R CT PASS IP -0.100 vs. OC
SR 1.670E-04 ST 5.988E+00 CR AUTO
RT HIGH STABILITY REF 0.00000 User WRK SOLID
DEN 0.000E+00 AU NO OC -0.840

Filename: \ti\TIPDF810.DAT
Time Run: 09:53:01
ID PASS FP 1.000 vs. R
NP 1473 IR NONE
AR 3.300E+00 LS NO

Pstat: VStat[] Ver 2
SI 1.000E-03
FL NONE
EW 0.000E+00

—— TIPDF810.DAT



3/3/00

Ti 7, 95C, 1 M Cl, 0.005 F
same as 77

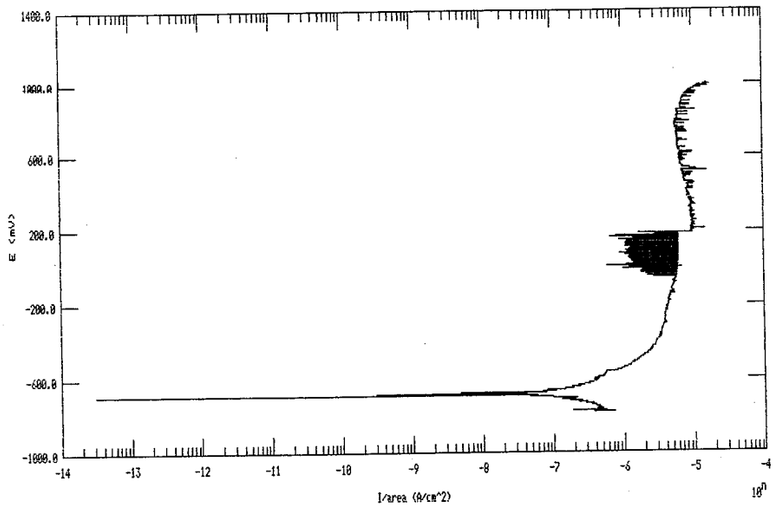
F^-

Model 352/252 Corrosion Analysis Software, v. 2.30
PD POTENTIODYNAMIC File Status: NORMAL Date Run: 03-04-00
CP PASS vs. R CT PASS IP -0.100 vs. OC
SR 1.576E-04 ST 5.988E+00 CR AUTO
RT HIGH STABILITY REF 0.00000 User WRK SOLID
DEN 0.000E+00 AU NO OC -0.678

Filename: c:\ti\tipdf811.dat
Time Run: 12:04:26
ID PASS FP 1.000 vs. R
NP 1779 IR NONE
AR 3.300E+00 LS NO

Pstat: VStat[] Ver 2
SI 1.000E-03
FL NONE
EW 0.000E+00

—— tipdf811.dat



1/0.005

3/3/00

Ti7, 95 C. 1 M Cl, 0.1 M F
same as 77

F⁻

Model 352/252 Corrosion Analysis Software, v. 2.30
CP POTENTIODYNAMIC
CP PASS vs. R
SR 1.676E-04
RT HIGH STABILITY
DEN 0.000E+00

File Status: NORMAL
CT PASS
ST 5.988E+00
REF 0.00000 User
AU NO

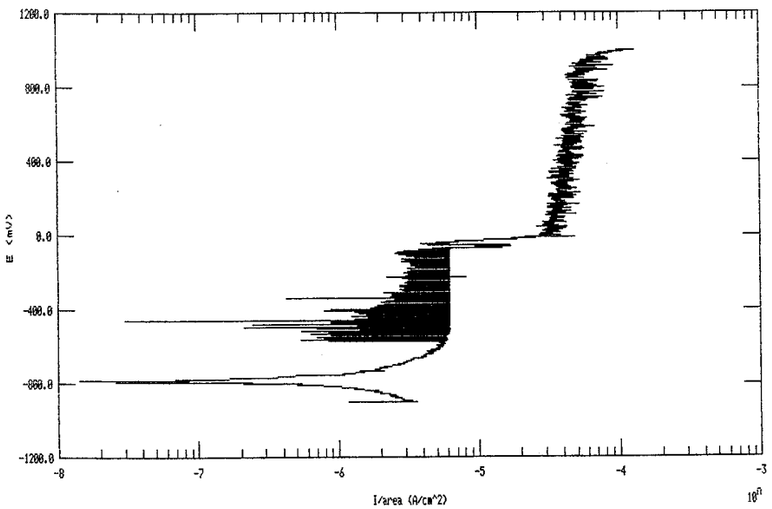
Date Run: 03-05-00
IP -0.100 vs. OC
CR AUTO
WRK SOLID
OC -0.001

Filename: c:\ti\tipdf012.dat
Time Run: 10:55:46
ID PASS
AR 3.300E+00

FP 1.000 vs. R
LS NO

Pstat: VStat[] Ver 2
SI 1.000E-03
FL NONE
EW 0.000E+00

tipdf012.dat



3/6/00

Repeat of pg 82 - pstat error

F⁻

Model 352/252 Corrosion Analysis Software, v. 2.30
PD POTENTIODYNAMIC
CP PASS vs. R
SR 1.676E-04
RT HIGH STABILITY
DEN 0.000E+00

File Status: NORMAL
CT PASS
ST 5.988E+00
REF 0.00000 User
AU NO

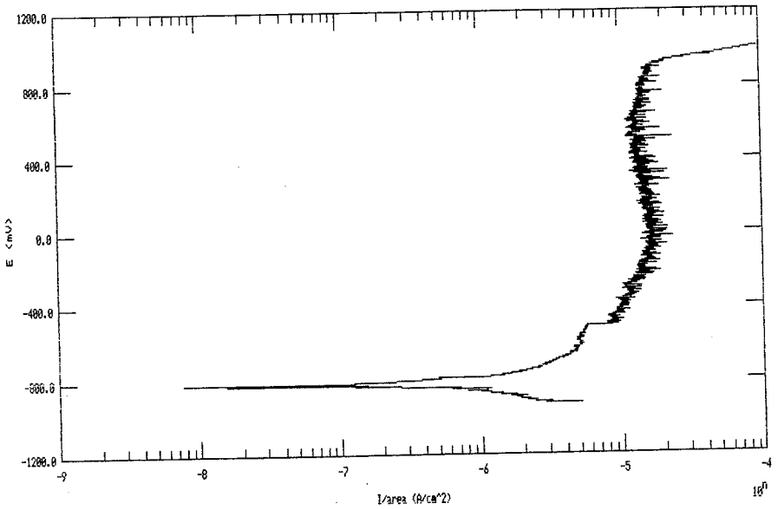
Date Run: 03-06-00
IP -0.100 vs. OC
CR AUTO
WRK SOLID
OC -0.820

Filename: c:\ti\tipdf013.dat
Time Run: 10:16:27
ID PASS
HP 1921
AR 3.300E+00

FP 1.000 vs. R
IR NONE
LS NO

Pstat: VStat[] Ver 2
SI 1.000E-03
FL NONE
EW 0.000E+00

tipdf013.dat



3/6/00

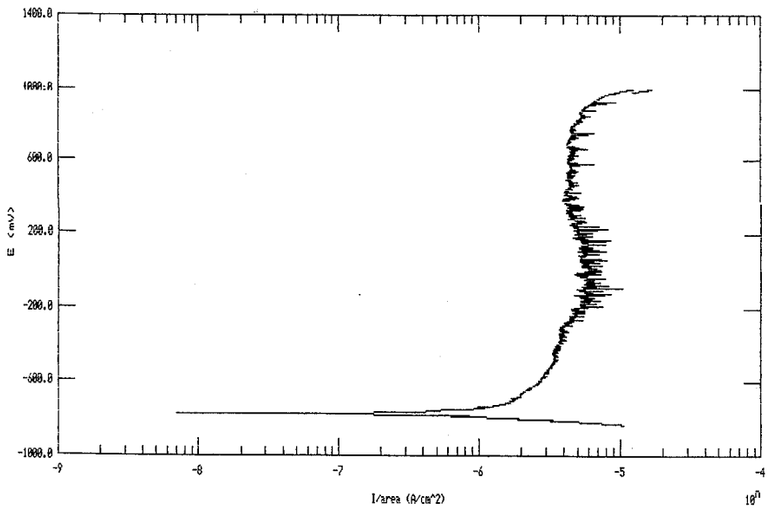
Ti Gr 7 95C, 1M Cl, 0.01F
F-
Same as 77

Model 352/252 Corrosion Analysis Software, v. 2.30
PD POTENTIODYNAMIC File Status: NORMAL Date Run: 03-07-00
CP PASS vs. R CT PASS IP -0.100 vs. OC
SR 1.57E-04 ST 5.98E+00 CR AUTO
RT HIGH STABILITY REF 0.00000 User WRK SOLID
DEN 0.000E+00 AU NO OC -0.731

Filename: c:\ti\tipdf014.dat
Time Run: 14:23:04
ID PASS FP 1.000 vs. R
NP 1852 IR NONE
AR 3.300E+00 LS NO

Pstat: VStat1 Ver 2
SI 1.000E-03
FL NONE
EN 0.000E+00

tipdf014.dat



3/7/00

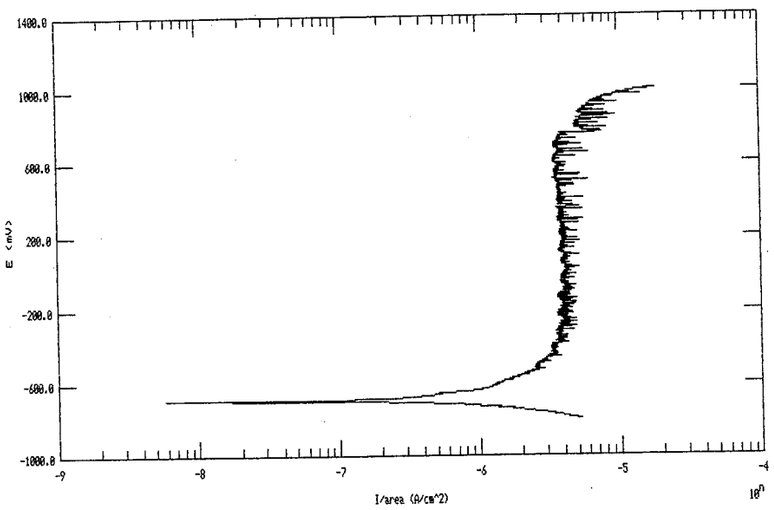
repeat of p 84
F-

Model 352/252 Corrosion Analysis Software, v. 2.30
PD POTENTIODYNAMIC File Status: NORMAL Date Run: 03-08-00
CP PASS vs. R CT PASS IP -0.100 vs. OC
SR 1.67E-04 ST 5.98E+00 CR AUTO
RT HIGH STABILITY REF 0.00000 User WRK SOLID
DEN 0.000E+00 AU NO OC -0.695

Filename: c:\ti\tipdf015.dat
Time Run: 10:32:32
ID PASS FP 1.000 vs. R
NP 1796 IR NONE
AR 3.300E+00 LS NO

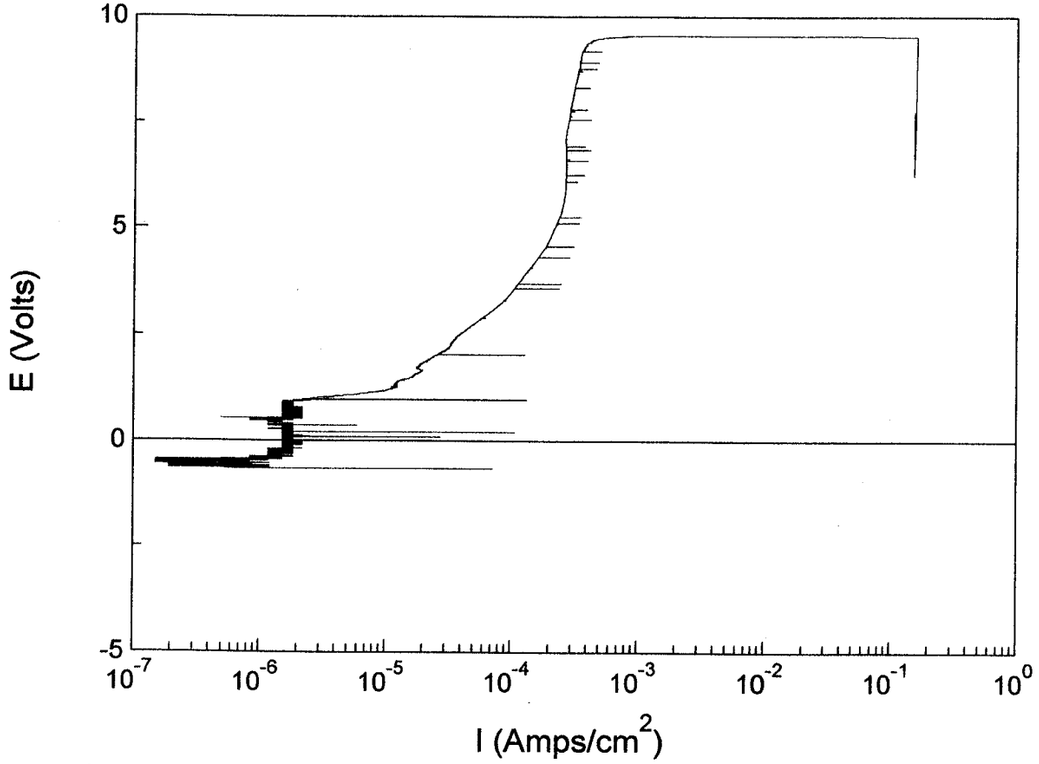
Pstat: VStat1 Ver 2
SI 1.000E-03
FL NONE
EN 0.000E+00

tipdf015.dat



3/8/00

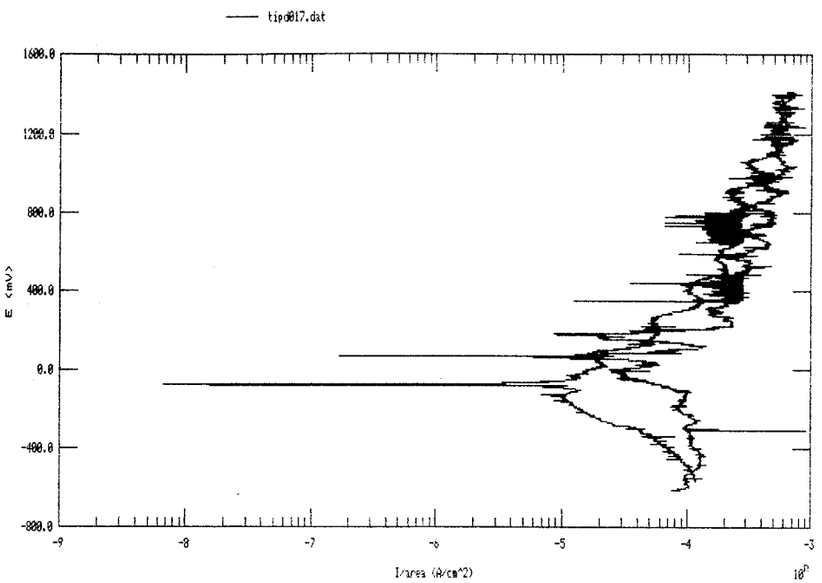
TIPD012.DAT
T=95°C
Stock Solution
10M → LiCl → 424g / lt Fisher 972239
PH= 6.550
Specimen is crevice welded Ti grade 7 polished to
600 grit + ultrasonically cleaned in methanol
Init wt= 20.724720g
Final wt= 17.3898g 4-7-00
Final pH= 3.736 4-7-00
Observations
Test went to approx 10v and current went very
high. Specimen suffered extreme attack.



4-6-00

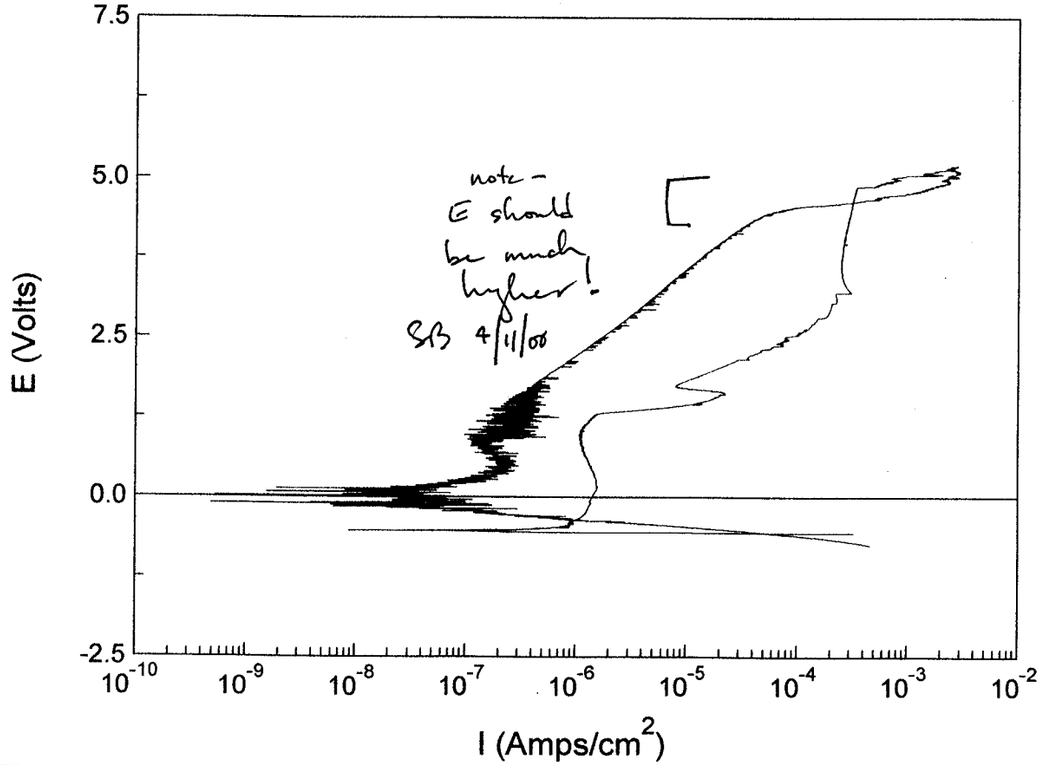
TiPD017.DAT
T = 95°C
Stock Solution
10M → LiCl → 424g/Lt Fisher 972239
pH= 6.550
Specimen is Ti CPP polished to 600grit & ultrasonicall,
cleaned in methanol
Init wt = 6.38137g
Final wt = 6.38323g 4-7-00
Final pH= 6.390 4-7-00
Observations
No visible pitting, slight discoloration
4-7-00

Model 352/252 Corrosion Analysis Software, v. 2.10 Filename: c:\titipd017.dat Pstat: VStat[] Ver 2
CP CYCLIC POLARIZATION File Status: NORMAL Date Run: 03-13-00 Time Run: 09:53:02
CP PASS vs. R CT PASS IP -0.050 vs. OC ID PASS VI 0.000 vs. R FP 0.000 vs. OC
SI 1.000E-03 SR 1.667E-04 ST 6.000E+00 CR AUTO NP 3999 IR NONE
FL I 5.3Hz RT HIGH STABILITY REF 0.00000 User WRK SOLID AR 7.200E+00 LS YES
IT 3.600E-02 ITA 7.200E+00 EW 0.000E+00 DEN 1.000E+00 AU NO OC -0.562
Comment: ti-gr7 10M LiCl, 95C, cpp



4-6-00

TIPD003.DAT
T=95°C
Stock Solution
.1M → NaCl → 11.6884g/2Lt Fisher
PH= 5.938
Specimen is crevice welded .TI g7 polish to 600 grit + ultrasonicall, cleaned in methanol
Init wt = 20.85336g
Final wt = 20.84997g 4-11-00
Final PH = 6.231 4-11-00
Observations
Pitting noted along weld transition to be small to medium in quantity, also one small spot of attack on one edge 4-11-00



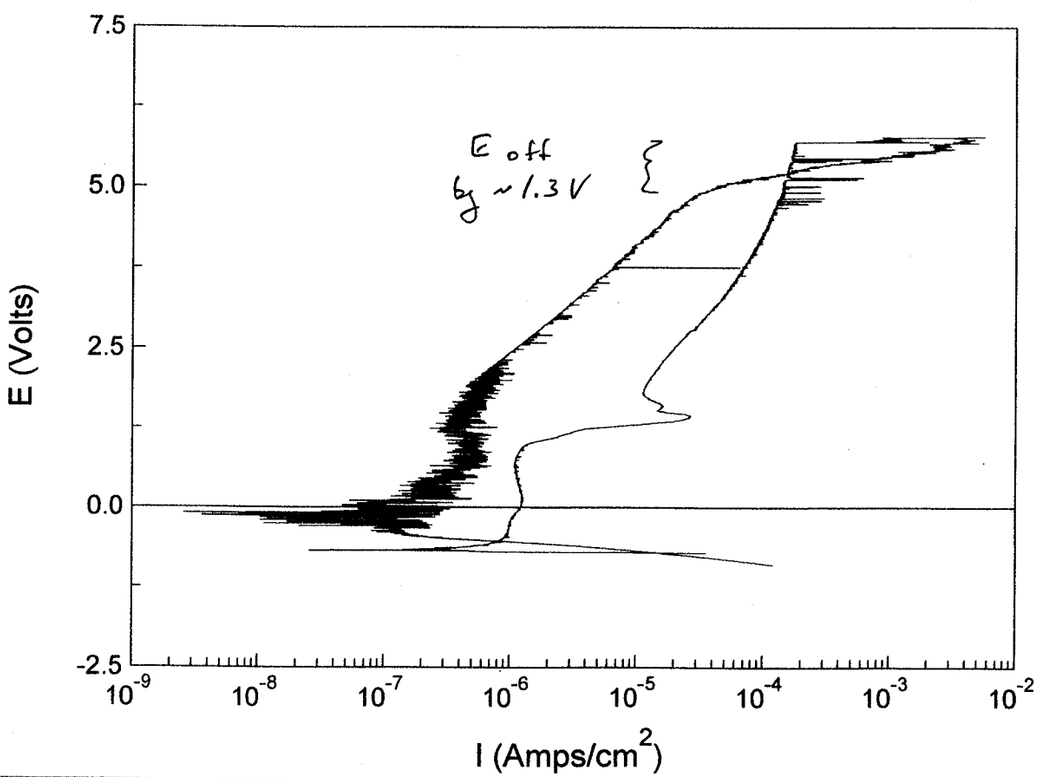
4-7-00

TIPD018.DAT
T=95°C
Stock Solution
.1M → NaCl → 11.6889g/2Lt Fisher
PH= 5.942 CPP 4-7-00
Specimen is ~~crevice welded~~ TI g7 polished to 600 grit + ultrasonically cleaned in methanol
Init wt = 6.39486g
Final wt = 6.39995g 4-11-00
Final PH = 6.314 4-11-00
Observations
Discoloration below vapor line, no pitting noticed by eye 4-10-00

4-7-00

TIPD014.DAT — Solatron

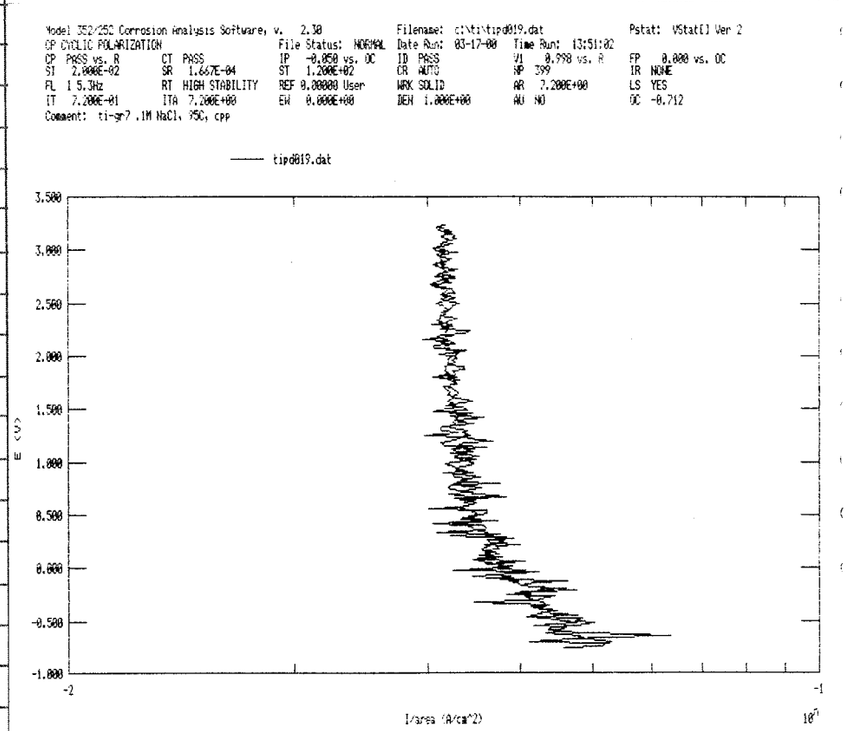
T=95°C
Stock Solution
.5 M → NaCl → 58.44 g/2Lt
PH = 5.938
Specimen is TI7 welded crevice without former
polished to 600 grit
Init wt = 20.83803 g
Final wt = 20.83340 g } 4-12-00
Final PH = 6.930
Observations
Pitting Attack at thru hole in location of weld. 4-12-00



4-11-00

TI PD 019.DAT — Versastat

T = 95°C
.5 M → NaCl
PH 5.942
Specimen is CPP TI7 polished to 600 grit
ultrasonically cleaned in methanol
Init wt = 6.39595 g 4-12-00
Final wt = 6.39590 g 4-12-00
Final PH = 6.240
Observations:
Discoloration below vapor line, no pitting to the eye 4-12-00



4-11-00

TIPD021.DAT Versestat

T=95°C

Stock Solution SB 8/16/2000

1M → NaCl → ~~58.44~~ g 116.88g /2Lt

.005M → NaF → .4199 g /2Lt

pH= 7.640

Specimen is TI grade 7 welded polished to 600 grit
ultrasonically cleaned in methanol w/ former

Init wt= 20.84781

Final wt= 20.84703 } 4-13-00

Final pH= 7.690 ↑7.690 SB

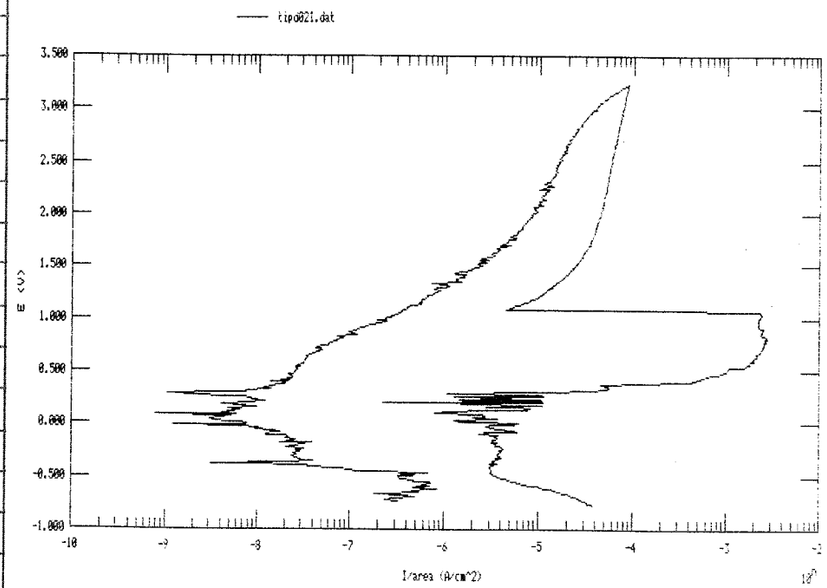
Observations

Overall sample discoloration, heavy staining at crevice test area

Model 352/252 Corrosion Analysis Software, v. 2.20 Filename: c:\ti\tipd021.dat Pstat: PStat[] Ver 2
CP CYCLIC POLARIZATION File Status: NORMAL Date Run: 03-18-00 Time Run: 12:46:51

CP	PASS vs. R	CT	PASS	IP	-0.850 vs. OC	ID	PASS	VI	1.247 vs. R	FP	0.000 vs. OC
SI	1.000E-02	SR	1.667E-04	ST	6.000E+01	CR	AUTO	NP	796	IR	NONE
FL	5.3Hz	RT	HIGH STABILITY	REF	0.00000 User	WRK	SOLID	AR	1.000E+01	LS	YES
IT	9.000E-02	ITA	1.000E+01	EW	0.000E+00	DEN	1.000E+00	AU	NO	OC	-0.723

Comment: ti-gr7 1M NaCl, .005 NaF, 95C, crevice welded w/former



4-12-00

TIPD015.DAT Solatron

T=95°C

Stock Solution

1M → NaCl → 116.88 g/2Lt

pH= 6.130

Specimen is welded TI gr 7 polished to 600 grit
ultrasonically cleaned in methanol

Init wt= 20.73609

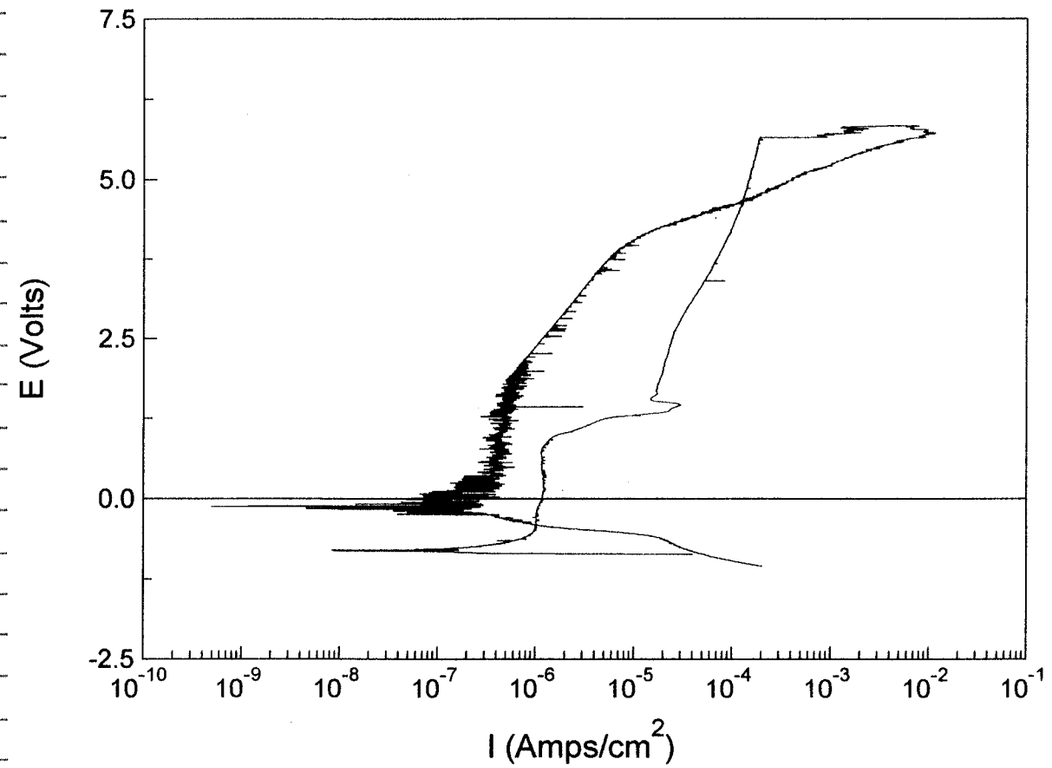
Final wt= 20.69958 } 4-13-00

Final pH= 7.120

Observations

Sample discoloration pitting + attack at weld SB 8/16/2000
crown weld location, attack at one ~~edge~~ side
crown weld location

4-13-00



4-12-00

TIPD022.DAT Versastat

T=95°C

Stock Solution

1M → NaCl → 116.88g/2Lt

.01 → NaF → .8398g/2Lt

pH= 7.136

Specimen is Ti g7 welded polished to 600 grit
& ultrasonicell, cleaned in methanol w/former

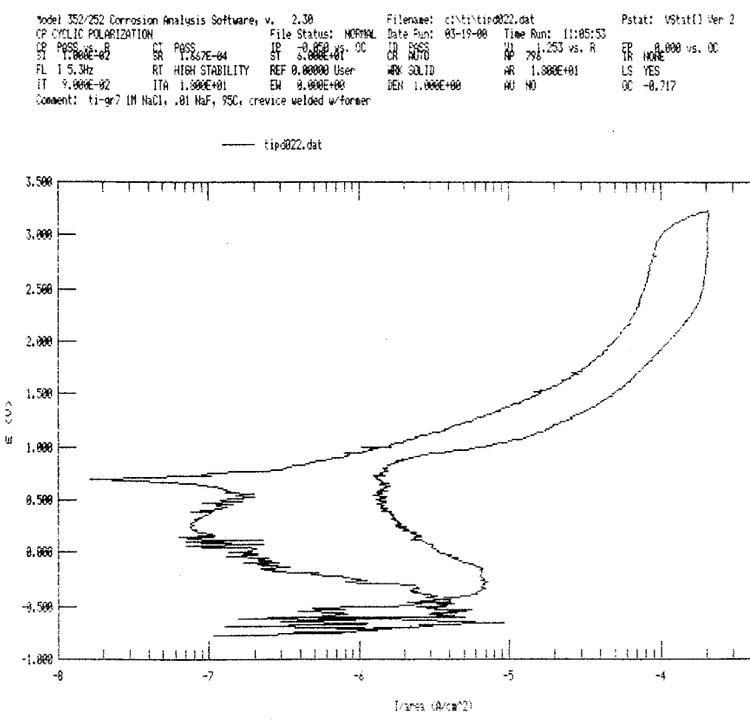
Init wt= 20.82357g

Final wt= 20.82358g } 4-14-00

Final pH= 8.039

Observations

Staining at end ground crevice test otherwise
No signs of pitting. 4-14-00



4-13-00

TIPD016.DAT Sdartron

T=95°C

Stock Sdut.~~ion~~ SB 8/16/2000

5M → ~~NaCl~~ LiCl → 423.900g/2Lt 972239

pH: ~~7.31~~ 7.43 SB 8/16/2000

Specimen is Ti g7 welded polished to 600 grit
& ultrasonicell, cleaned in methanol

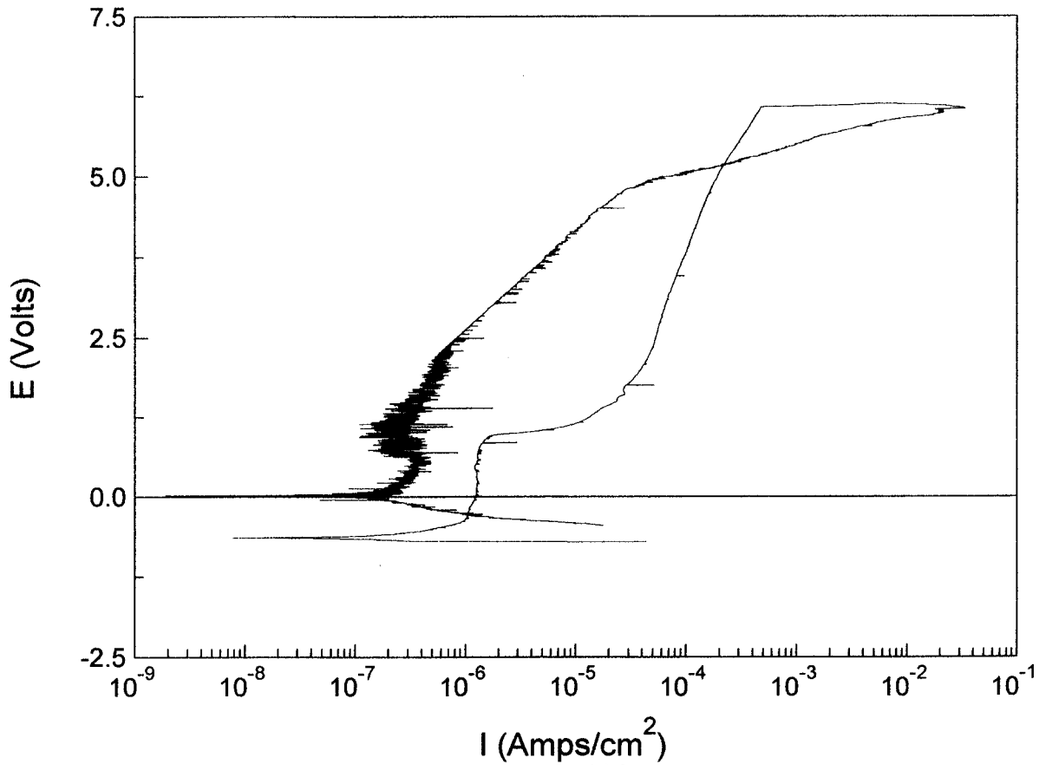
Init wt= 20.85007g

Final wt= 20.78268g } 4-14-00

Final pH= 5.953

Observations

Specimen is discolored overall, pitting & general
attack noted to be more aggressive than
previous test @ 1M. From thru hole across
weld line to side edge. 4-14-00



4-13-00

TIPD023.DAT Vesestat

T=95°C

Stock Solution

1M NaCl → 116.88g /2Lt Fisher# 975121

.05M NaF → 4.199g /2Lt Fisher# 896405

pH= 7.449

Specimen Ti g7 welded crevice polished to 600 grit + ultrasonically cleaned in methanol w/former

Init wt = 20.777757g

Final wt: 20.764765g } 4-18-00

Final pH 8.450

Observations

Specimen is heavily stained or discolored. Some possible pitting at edges of crevice foot area.

4-18-00

Model 750 252 Corrosion Analysis Software, v. 2.30 Filename: c:\ti\tipd023.dat Pstat: VStat11 Ver 2

CP CYCLIC POLARIZATION File Status: NORMAL Date Run: 03-21-00 Time Run: 08:56:16

CP	PASS vs. R	CT	PASS	IP	-0.050 vs. OC	ID	PASS	V1	1.254 vs. R
II	1.000E-02	SR	1.667E-04	ST	6.000E+01	CR	AUTO	HP	595
FL	5.0Hz	RT	HIGH STABILITY	REF	0.00000 User	WRK	SOLID	AR	1.300E+01
IT	5.000E-02	ITA	1.000E+01	EW	0.000E+00	DEN	1.000E+00	AU	NO

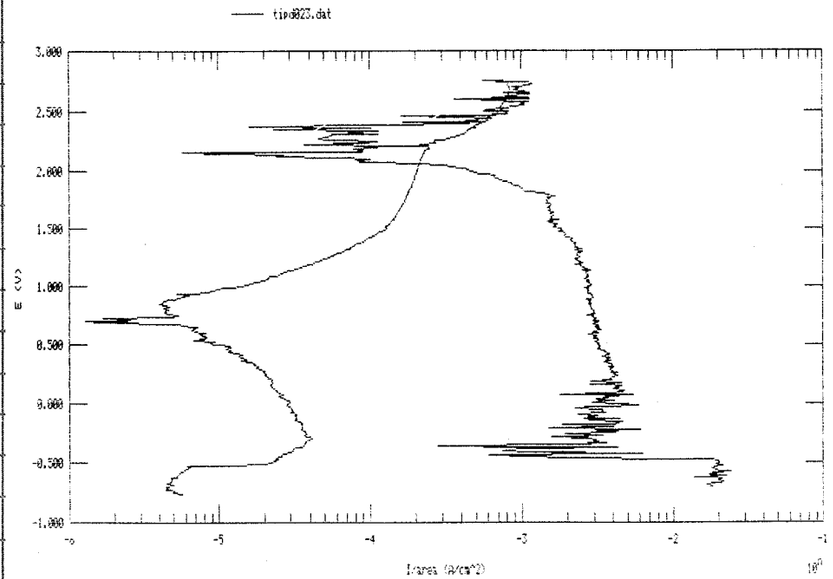
FP 0.200 vs. OC

IR NONE

LS YES

OC -0.706

Comment: ti-gr7 1M NaCl, .05 NaF, 95C, crevice welded w/former



4-17-00

TIPD020.DAT Solstra

T=95°C

Stock Solution

1M NaCl → 116.88g/2Lt Fisher# 975121

pH= 6.379

Specimen Ti g7 epp polished to 600 grit + ultrasonically cleaned in methanol

Init wt = 6.407094g

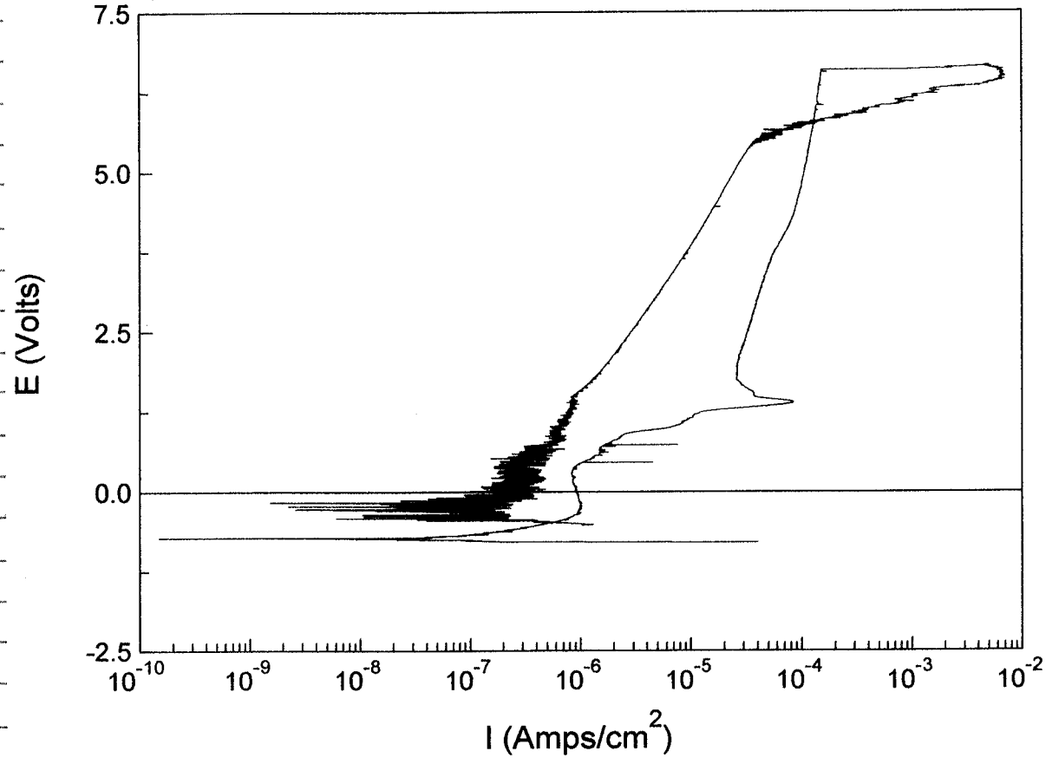
Final wt: 6.380945g } 4-18-00

Final pH = 7.610

Observations

Attack noted at the vapor line of specimen only partial of circumference.

4-18-00



4-17-00

TIPD024.DAT Vesstat

T=95°C

Stock Solution

1M → NaCl → 116.88g/2Lt Fisher# 975121

.1M → NaF → 8.398g/2Lt Fisher# 896405

pH: 8.850

Specimen Ti gr7 welded polished to 600grit + ultrasonically cleaned in methanol w/former

Init wt = 20.83673g

Final wt = 20.60990g

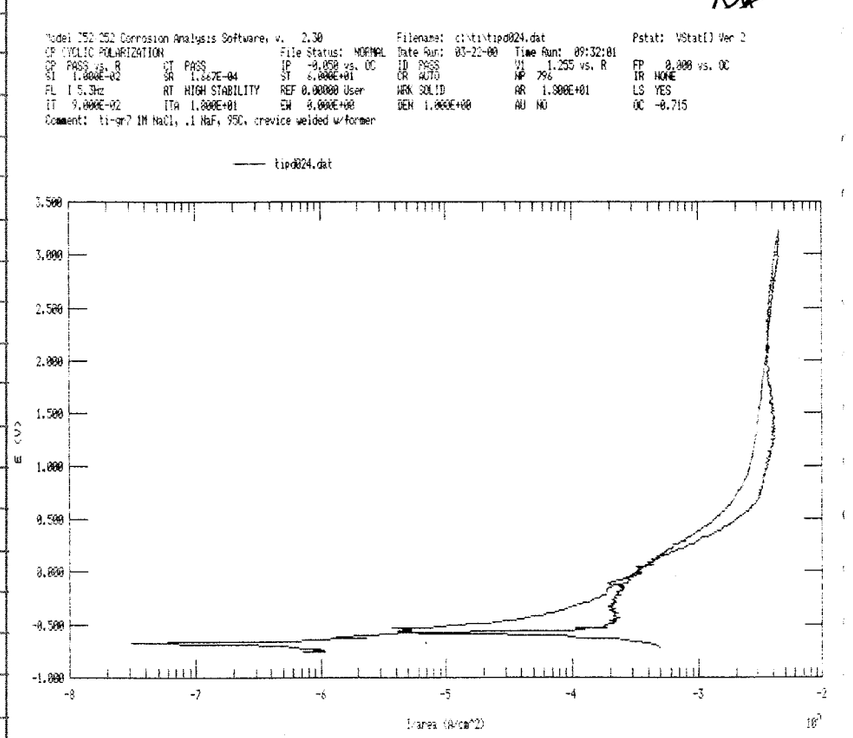
Final pH: 7.715

4-19-00

Observations

Heavy attack of specimen, except under crevice foot which appears to have protected from attack.

4-19-00



4-18-00

TIPD027.MT Soletron

T=95°C

Stock Solution pH 4-18-00

5M → ~~NaF~~ → LiCl → 423.900g/2Lt Fisher 972239

pH: 7.311

Specimen is CPP Ti gr7 polished to 600grit + ultrasonically cleaned in methanol

Init wt = 6.36504

Final wt = 5.36662g

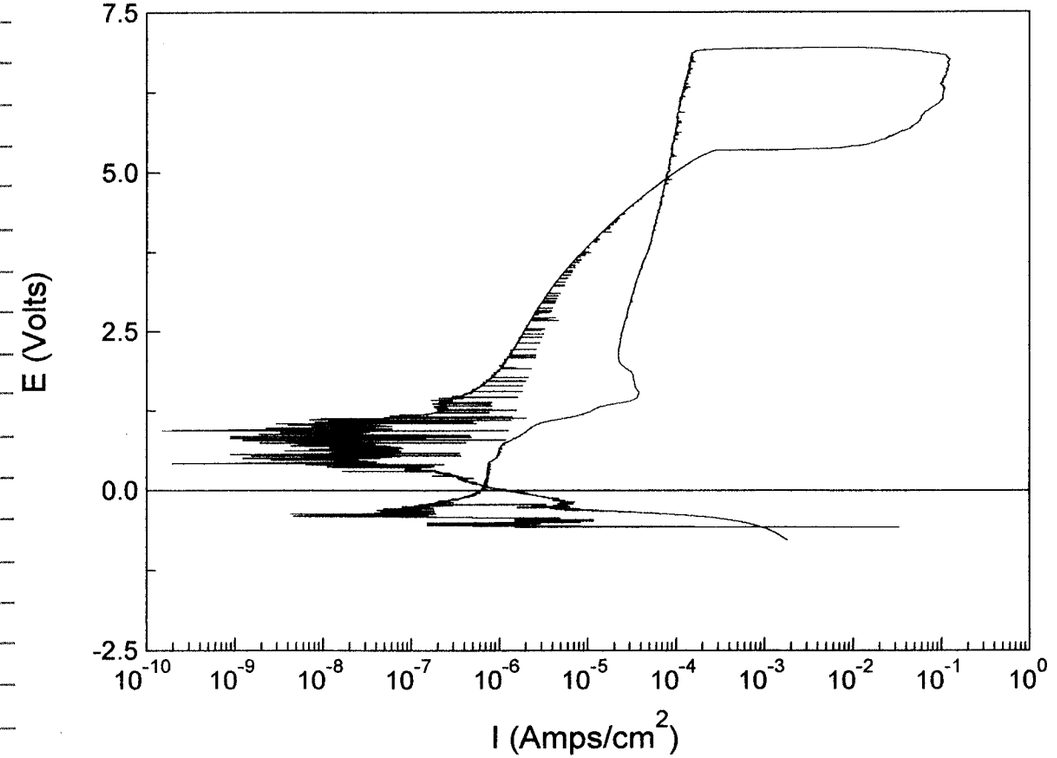
Final pH = 2.732

4-20-00

Observations

Heavy attack below upper line, surface white + crusty.

4-20-00



4-18-00

TIPD025.DAT Versastat

T=95°C

Stock Solution

1M → NaCl → 116.88g/2Lt Fisher # 975121

.5M → NaF → 41.99g/2Lt Fishers # 991559

pH= 9.816

Specimen T1 gr7 welded polished to 600 grit + ultrasonically cleaned in methonal w/former

Init wt= 20.82172g

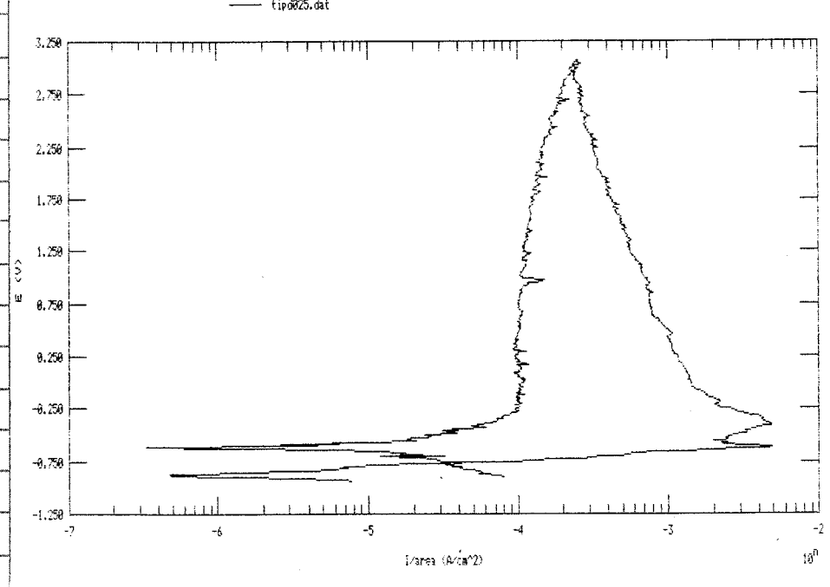
Final wt= 20.81697g } 4-20-00

Final pH= 8.730

Observations

General attack over all of specimen except under crevice foot + above vapor line. 4-20-00

```
Model 352/252 Corrosion Analysis Software, v.  2.30          Filename:  c:\ti\tipd025.dat          Pstat:  VStat[] Ver 2
CP CYCLIC POLARIZATION                        File Status:  NORMAL  Date Run:  03-23-00  Time Run:  08:45:52
CP  PASS vs. R      CT  PASS                  IP  -0.850 vs. OC   ID  PASS          V1   1.250 vs. R     FP   0.000 vs. OC
SI  1.000E-02       SR  1.667E-04             ST   6.000E+01    CR  AUTO          NP  796              IR  NONE
FL  1 5.0Hz         RT  HIGH STABILITY        REF 0.00000 User  WRK SOLID       AR   1.000E+01        LS  YES
IT  9.000E-02       ITA 1.000E+01             EN  0.000E+00     DEN 1.000E+00   AU  NO                OC  -0.898
Comment:  ti-gr7 1M NaCl, .5 NaF, 95C, crevice welded w/former
```



4-19-00

TIPD026.DAT Versastat

T=95°C

Stock Solution

1M → NaCl → 116.88g/2Lt

1M → NaF → 83.98g/2Lt

pH= 8.940

Specimen T1 gr7 welded polished to 600 grit + ultrasonically cleaned in methonal w/former

Init wt = 20.82048g

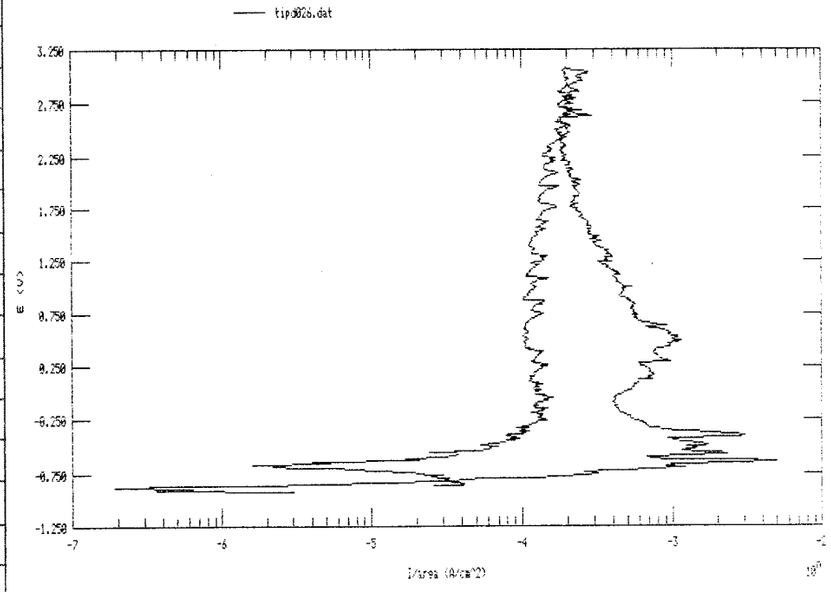
Final wt = 20.82812g } 4-21-00

Final pH= 8.815

Observations

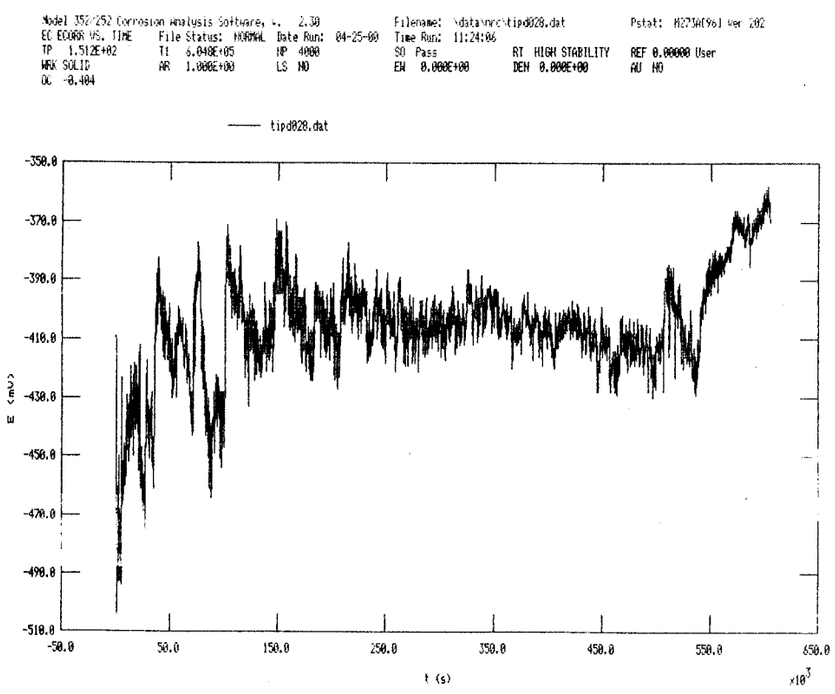
General attack over all specimen less above vapor line + under crevice foot. some deposits left on specimen not removed by ultrasonic cleaning which caused weight to be greater. 4-21-00

```
Model 352/252 Corrosion Analysis Software, v.  2.30          Filename:  c:\ti\tipd026.dat          Pstat:  VStat[] Ver 2
CP CYCLIC POLARIZATION                        File Status:  NORMAL  Date Run:  03-24-00  Time Run:  09:39:15
CP  PASS vs. R      CT  PASS                  IP  -0.850 vs. OC   ID  PASS          V1   1.248 vs. R     FP   0.000 vs. OC
SI  1.000E-02       SR  1.667E-04             ST   6.000E+01    CR  AUTO          NP  796              IR  NONE
FL  1 5.0Hz         RT  HIGH STABILITY        REF 0.00000 User  WRK SOLID       AR   1.000E+01        LS  YES
IT  9.000E-02       ITA 1.000E+01             EN  0.000E+00     DEN 1.000E+00   AU  NO                OC  -0.872
Comment:  ti-gr7 1M NaCl, 1 NaF, 95C, crevice welded w/former
```



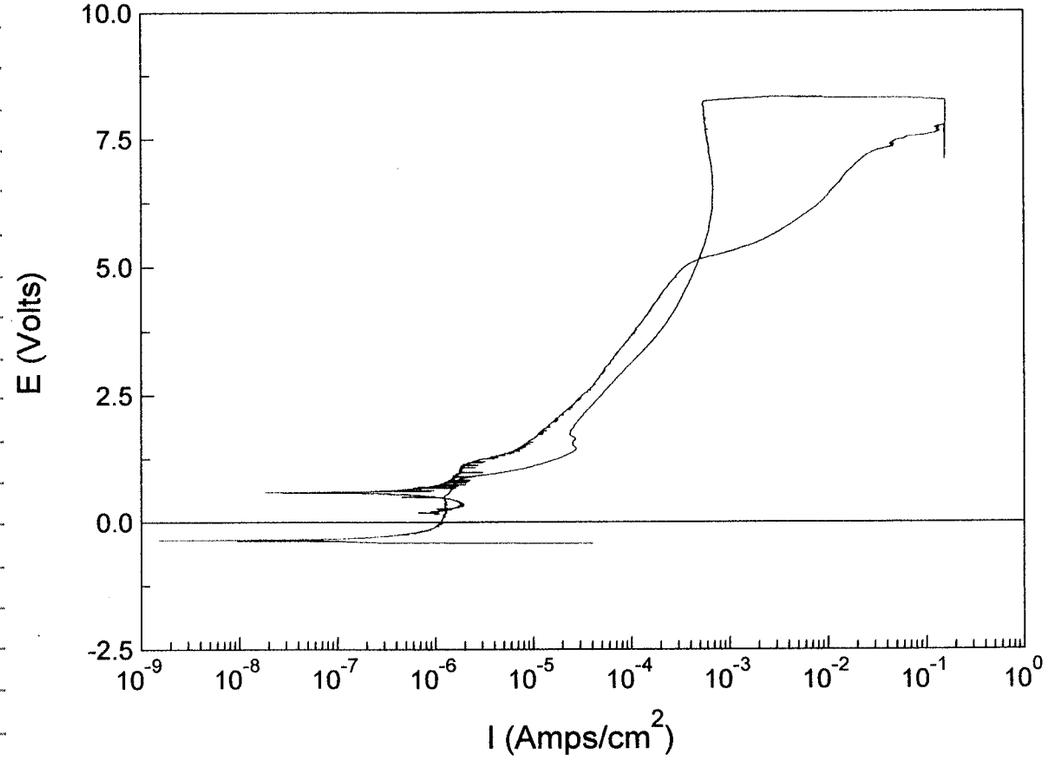
4-20-00

TIPD028.DAT OCP 1wk in Airpurge
T=95°C
.1M → NaCl → 11.688g/2Lt
.1M → NaF → 8.398g/2Lt
pH= 7.478
Specimen is Ti g7 CPP polished to 600 grit & ultrasonically cleaned in methanol.
Init wt=6.39060g
Final wt= 6.35095g
Final pH= 8.773
5-2-00
Observations
No pitting observed, discoloration overall, staining and deposits noted at vapor line. Possible slight attack at vapor-liquid transition.
5-2-00



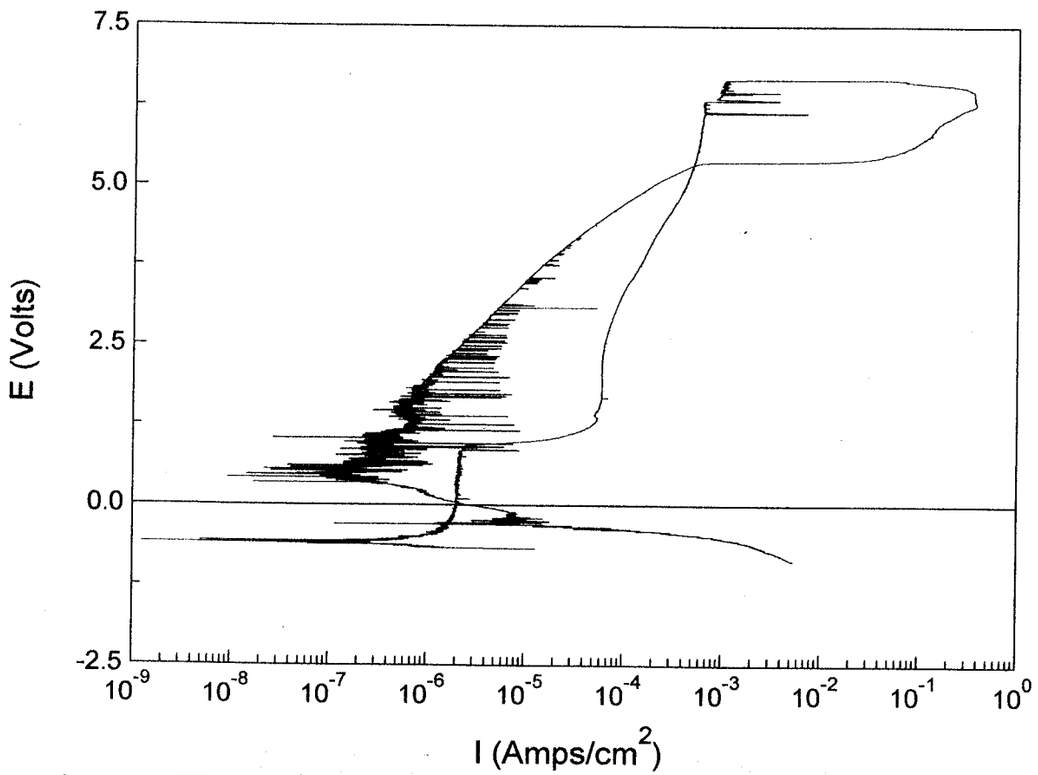
4-25-00

TIPD029.DAT Re Run of TIPD012 on Solution
T=95°C
10 M → LiCl → 827.80g/2Lt
pH= 5.401
Specimen is Ti g7 welded polished to 600 grit and ultrasonically cleaned in methanol
Init wt = 20.80951g
Final wt = 19.55866g
Final pH = 1.893
4-27-00
Observations
General attack & pitting heaviest at weld area around thru hole, also attack noted at edges and corners.
4-27-00



4-26-00

TIPD030.PAT
T=95°C
5M → LiCl → 423.40 g/Lt
pHt= ~~6.39280~~ STE 7.014 STE 5-4-00
Specimen is Ti gr 7 CPP polished to 600 grit & ultrasonically cleaned in methanol
Init wt= 6.39294g
Final wt= 5.54220g } 5-5-00
Final pHt: 2.910
Observations
Heavy Attack below vapor line. Surface white & crusty. 5-5-00



5-4-00

CONAM KAWIN
194 Internationale Blvd., Glendale Heights, IL 60139
Telephone + 1 630-681-0008
Facsimile + 1 630-871-5520

SOUTHWEST RESEARCH INST. 7010
6220 CULEBRA RD
P. O. DRAWER 28510
SAN ANTONIO TX 78284
SEAN BROSSIA

P. O. # 50138

DESCR 01-25-00 PO# X94367X
REG# 505956

REPORT DATE: 02/15/2000

LAB NO: 0128-005 / 03 JOB NO:

ASTM A265 GR 7 WELD WIRE TI-GR 7 HEAT# BN4591
weld wire

CHEMICAL ANALYSIS

C	.027	Ti	REMAINDER	Fe	.03
H	17.6PPM	N	.0011	O	.046
Pd	.13				

TEST METHODS: ASTM E 663 ; ASTM E 1019 ; ASTM E1447 ; ASTM E 1409 ;

QA INSPECTOR

ALL CHEMICAL TEST RESULTS ARE REPORTED IN WEIGHT PERCENT UNLESS OTHERWISE NOTED.

SB 6/15/00

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P. O. DRAWER 28510
SAN ANTONIO TX 78284
SEAN BROSSIA

P. O. # 50138

DESCR 01-25-00 PO# X94367X
REG# 505956

REPORT DATE: 02/15/2000

LAB NO: 0128-005 / 01

JOB NO:

ASTM B265 GR 7 WROUGHT TI-GR 7 HEAT# R5835

base metal

CHEMICAL ANALYSIS

[illegible]	.023	Ti	REMAINDER	Fe	.15
[illegible]	58PPM	N	.020	O	.20
[illegible]d	.14				

TEST METHODS: ASTM E 663 ; ASTM E 1019 ; ASTM E1447 ; ASTM E 1409 ;

QA INSPECTOR

ALL CHEMICAL TEST RESULTS ARE REPORTED IN WEIGHT PERCENT UNLESS OTHERWISE NOTED.

PAGE 1 OF 16

5/15/00

CONAM KAWIN

194 Internationale Blvd., Glendale Heights, IL 60139
Telephone + 1 630-681-0008
Facsimile + 1 630-871-5520

SOUTHWEST RESEARCH INST. 7010
6220 CULEBRA RD
P. O. DRAWER 28510
SAN ANTONIO TX 78284
SEAN BROSSIA

P. O. # 50138

DESCR 01-25-00 PO# X94367X
REG# 505956

REPORT DATE: 02/15/2000

LAB NO: 0128-005 / 02

JOB NO:

ASTM B265 GR 7 WELDED TI-GR 7 HEAT# R5835 & BN4591

weldment

CHEMICAL ANALYSIS

C	.026	Ti	REMAINDER	Fe	.08
H	32PPM	N	.0049	O	.10
Pd	.14				

TEST METHODS: ASTM E 663 ; ASTM E 1019 ; ASTM E1447 ; ASTM E 1409 ;

QA INSPECTOR

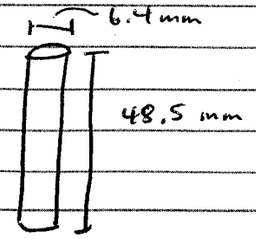
ALL CHEMICAL TEST RESULTS ARE REPORTED IN WEIGHT PERCENT UNLESS OTHERWISE NOTED.

PAGE 2 OF 16

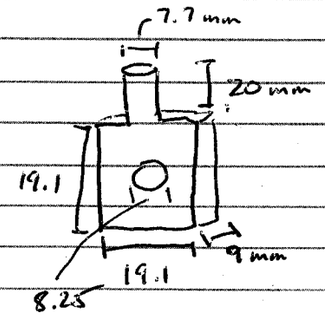
5/15/00

Inspection of New Ti-2 Specimens PO X86114S

CPP Specimens -



Crevice specimens:



05/15/2000 10:41 2563584515 ALSPI PAGE 01

Metal Samples
Corrosion Monitoring Systems

Metal Samples Corrosion Monitoring Systems
a division of Alabama Specialty Products, Inc.
152 Metal Samples Rd. P.O. Box 8
Munford, AL 36268
Phone: (256) 358-4202 Fax: (256) 358-4515
e-mail: benl@alspi.com Internet: www.alspi.com

Fax Transmission from Benjamin Lackey

Recipient	Sean Brossia
Company	Southwest Research Institute
Fax Number	1-210-522-5184
Subject	MTR's for your order# X86114S
Date	05/15/2000
Number of Pages (including cover)	5

Dear Sean,

Following are copies of the Metal Samples MTR sheet and the original manufacturer MTR's for the materials used on the above mentioned order.

Ti Gr2 – Metal Samples Lot# N843 – CPP Electrodes
Ti Gr2 – Metal Samples Lot# H801 – Crevice Repassivation Specimens
Zr4 – Metal Samples Lot# D830 – CPP Electrodes

Thank you for your order. If you have any questions, or need anything else, please let us know.

Best regards,
Benjamin Lackey

SB 6/1/00

05/15/2000 10:41 2563584515 ALSPI PAGE 02

MATERIAL TEST REPORT

DATE : 05/15/00
PAGE : 1
ORDER: 43363

Metal'Samples Company
P.O. Box 8
152 Metal Samples Road
Munford, AL 36268
Ph. (256)358-4202 Fx. (256)358-4515

Customer: 01482 SOUTHWEST RESEARCH INSTITUTE
Your PO#: X86114S

Lot No. N843 Mill: Our Order Line No. 1
Description: TIGR2 .375"RD X 639.75"(5@R/L
Chemical Properties:

C:0.011	Fe:0.080	H:0.0015	N:0.006
O:0.150	Ti:BALANCE		

Physical Properties:

Tensile-PSI:79,710	Elong-%:26.56
Yield-PSI:63,560	R/A-%:47.39
Condition:ANLD	

Lot No. H801 Mill: TICO TITANIUM, INC. Our Order Line No. 2
Description: TIGR.2 .375"X25"X48"
Chemical Properties:

C:0.032	Fe:0.080	H:0.004	N:0.002
O:0.110	Ti:BALANCE		

Physical Properties:

Tensile-PSI:66,900	Elong-%:25.6
Yield-PSI:44,600	Condition:ANLD

Lot No. D830 Mill: TELEDYNE WAH Our Order Line No. 3
Description: ZR4 .265 X 4.2 X 93
Chemical Properties:

Al:45 PPM	B:<0.250	C:110 PPM	Co:<10 PPM
Cr:0.110	Cu:<10 PPM	Fe:0.210	H:<5 PPM
Hf:70 PPM	Mg:<10 PPM	Mn:<25 PPM	Mo:<10 PPM
N:<24 PPM	Nb:<0.250	Ni:<35 PPM	Si:73 PPM
Sn:1.500	Ti:<25 PPM	U:<50 PPM	W:<50 PPM
Zr:BAL			

Physical Properties:
Not Available

We certify that the Material Test Report is correct to the best of our knowledge and that the material supplied meets your required P.O. specifications.

THANK YOU, Quality Control Dept. Larry Braden (KD)

SB 6/1/00

05/15/2000 10:41 2563584515 ALSPI PAGE 03

TEST REPORT

TITANIUM INDUSTRIES, INC.

181 E. Halsey Road, Parsippany, NJ 07054 • 973-428-1900 • Fax 973-428-7250
801 Stuart Dr., Wood Dale, IL 60191 • 708-860-2606 • Fax 708-860-2877
51 Sunbeam Rd., Suite 12, Jacksonville, FL 32257 • 904-730-2007 • Fax 904-730-0350
18030 S. Carmenita Rd., Cerritos, CA 90703 • 310-802-2888 • Fax 310-404-8972
North Hwy. 360, Suite 200, Grand Prairie, TX 75050 • 214-606-1121 • Fax 214-660-2178
427D Heydon Station Rd., Windsor, CT 06095 • 860-683-1820 • Fax 860-683-8861

DATE	OUR ORDER NO.	CUSTOMER ORDER NO.
06/09/98	JAX 1818	395214

CUSTOMER NAME: METAL SAMPLES CO.

CPP Specimens

MATERIAL DESCRIPTION	NO. PCS.	LINEAR FEET/WEIGHT	HEAT NO.
.375" DIA.	4	PCS.	BN5224

SPECIFICATION

ASME SB-348 GRADE 2

CHEMICAL ANALYSIS

N	C	H	Fe	O2	Al	V	Sn	Pd	Mo	Zr	Ni
0.0060	0.0110	0.0015	0.0800	0.1500							
RESIDUALS EACH	RESIDUALS TOTAL	Ti	Cr	Ta	Cb	Y	O PLUS Fe	Mn	Si	Mg	
		BAL.									

MECHANICAL PROPERTIES

TENSILE STRENGTH KSI	L	79.880	L	79.540
	T		T	
YIELD STRENGTH OFFSET (0.2%)	L	58.480	L	66.640
	T		T	
% ELONGATION (INCHES)	L	27.080	L	26.040
	T		T	
% REDUCTION IN AREA	L	46.610	L	46.160
	T		T	

HARDNESS MAT'L. I.D. NO. N843 P.O. NO. 395214
SPEC. INITIAL MBB
GRAIN SIZE TIG2 KT

BEND TEST	OTHER DATA
STATIC NOTCH STRESS RUPTURE	
ULTRASONIC TEST	ALSO VALID TO:
FLARE TEST	ASTM B348-95 GR-2,
IMPACT TEST	ASTM F67-95 GR-2
FLATTENING TEST	
HYDROSTATIC TEST	ANNEALED
EDDY CURRENT TEST	
PNEUMATIC TEST	
REVERSE FLATTENING TEST	
DYE PENETRANT	
RADIOGRAPHIC (X-RAY) TEST	
MICROSTRUCTURE PERFORMED	
MICROSTRUCTURE COMPLIANCE	
MACROSTRUCTURE PERFORMED	
MACROSTRUCTURE COMPLIANCE	

INSPECT MATERIAL BEFORE PROCESSING

Condition of Sale: Defective material will be replaced or credit will be allowed for the price thereof upon its return, but the seller shall not be liable for any claims for labor or consequential damages.

DATE 06/09/98

THIS IS TO CERTIFY THAT THE ABOVE TEST RESULTS ARE CORRECT AS CONTAINED IN THE RECORDS OF THE COMPANY.

SIGNED Bill Colon
Quality Assurance

QA131 10/05 R.O.

N843

SB 6/1/00

05/15/2000 10:41 2563584515 ALSPI PAGE 04

TICO TITANIUM, INC.

24581 Crestview Court • Farmington Hills, Michigan 48335
(800) 521-4392 • (313) 478-4700 • FAX (313) 478-0223

321 South Buncombe Rd. • Greer, South Carolina 29650
(803) 879-4277 • FAX (803) 879-3961

TO: MESAA
METAL SAMPLES COMPANY, INC.
P.O. BOX 8
MUNFORD, AL 36268

DATE: 1/30/92

CUSTOMER PO: 15632

CERTIFICATION OF TESTS

S.O. No: 023538

HEAT NO. 11044
SPECIFICATION: ASTM B-265-79 GRADE 2

DESCRIPTION: PLATE 3/8" X 25" X 48" - 1PC 72#

CREVICE SPECIMENS

CHEMISTRY

IRON	.08
OXYGEN	.11
NITROGEN	.002
CARBON	.032
HYDROGEN	.0019
FINAL PRODUCT	.0040

RESIDUAL ELEMENTS (EACH) LESS THAN .10
RESIDUAL ELEMENTS (TOTAL) LESS THAN .40
TITANIUM REMAINDER

TENSILE DATA	LONGITUDINAL TEST 1	LONGITUDINAL TEST 2	TRANSVERSE TEST 1	TRANSVERSE TEST 2
TENSILE PSI	66900	75000	70500	75300
YIELD 0.2% OFFSET	44600	55800	58600	61900
ELONG %	25.6	30.3	31.0	34.0

PRODUCT ANNEALED 1400 F FOR 1/2 HOUR, A.C.

MATERIAL FREE FROM MERCURY CONTAMINATION.

BONNIE BREY\CERTIFICATION CLERK

Signature Bonnie Brey

H801

SB 6/1/00

QW-482 SUGGESTED FORMAT FOR WELDING PROCEDURE SPECIFICATION (WPS)
(See QW-200.1, Section IX, ASME Boiler and Pressure Vessel Code)

Company Name METAL SAMPLES COMPANY By: BJL
Welding Procedure Specification No. 154668 Date 03/02/99 Supporting PQR No.(s)
Revision No. 1 Date 04/24/00
Welding Process(es) GTAW Type(s) MACHINE (Automatic, Manual, Machine, or Semi-Auto.)

JOINTS (QW-402) Details
Joint Design DOUBLE VEE GROOVE
Backing (Yes) (No)
Backing Material (Type) (Refer to both backing and retainers.)
☐ Metal ☐ Nonfusing Metal
☐ Nonmetallic ☐ Other

Sketches, Production Drawings, Weld Symbols or Written Description should show the general arrangement of the parts to be welded. Where applicable, the root spacing and the details of weld groove may be specified.

(At the option of the Mfgr., sketches may be attached to illustrate joint design, weld layers and bead sequence, e.g. for notch toughness procedures, for multiple process procedures, etc.)

***BASE METALS (QW-403)**
P-No. Group No. to P-No. Group No.
OR
Specification type and grade TITANIUM GRADE 7 ½" PLATE
to Specification type and grade TITANIUM GRADE 7 ½" PLATE
OR
Chem. Analysis and Mech. Prop.
to Chem. Analysis and Mech. Prop.
Thickness Range:
Base Metal: Groove Fillet
Pipe Dia. Range: Groove Fillet
Other

***FILLER METALS (QW-404)**
Spec. No. (SFA)
AWS No. (Class)
F-No. TITANIUM GRADE 7
A-No.
Size of Filler Metals 1/16" ϕ
Weld Metal
Thickness Range:
Groove
Fillet
Electrode-Flux (Class)
Flux Trade Name
Consumable Insert
Other

*Each base metal-filler metal combination should be recorded individually.

(12/91) This form (E00006) may be obtained from the Order Dept., ASME, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300. REPRINT 8/93

SBL 6/2/00

POSITIONS (QW-405)
Position(s) of Groove 1-G
Welding Progression: Up Down
Position(s) of Fillet

PREHEAT (QW-406)
Preheat Temp. Min.
Interpass Temp. Max.
Preheat Maintenance
(Continuous or special heating where applicable should be recorded)

POSTWELD HEAT TREATMENT (QW-407)
Temperature Range
Time Range

GAS (QW-408)

	Gas(es)	Percent Composition (Mixture)	Flow Rate
Shielding	ARGON	99.9%	35 CFH
Trailing	ARGON	99.9%	35 CFH
Backing			

ELECTRICAL CHARACTERISTICS (QW-409)
Current AC or DC DC Polarity STRAIGHT
Amps (Range) 130 - 135 Volts (Range) 14 - 16
(Amps and volts range should be recorded for each electrode size, position, and thickness, etc. This information may be listed in a tabular form similar to that shown below.)
Tungsten Electrode Size and Type (Pure Tungsten, 2% Thoriated, etc.)
Mode of Metal Transfer for GMAW (Spray arc, short circuiting arc, etc.)
Electrode Wire feed speed range

TECHNIQUE (QW-410)
String or Weave Bead STRING
Orifice or Gas Cup Size
Initial and Interpass Cleaning (Brushing, Grinding, etc.) ACETONE
Method of Back Gouging
Oscillation
Contact Tube to Work Distance
Multiple or Single Pass (per side) MULTIPLE → 8-10 PASSES PER SIDE.
Multiple or Single Electrodes
Travel Speed (Range) 6-8 IPM
Peening
Other

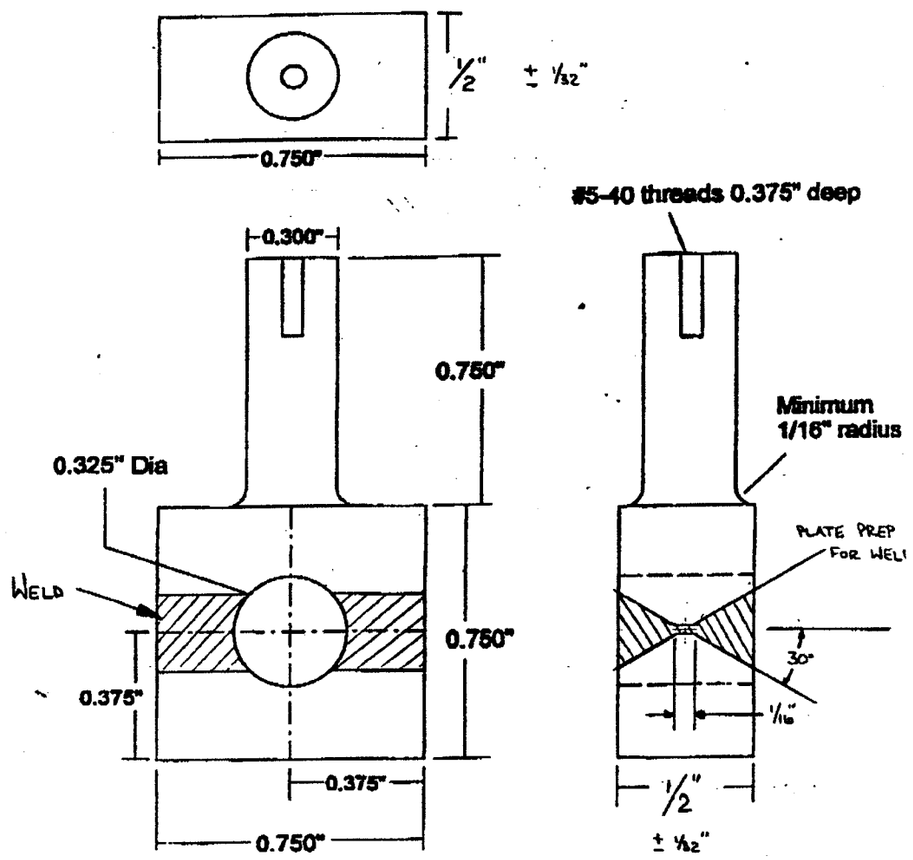
Weld Layer(s)	Process	Filler Metal Class	Filler Metal Dia.	Current Type Polar.	Current Amp. Range	Volt Range	Travel Speed Range	Other (e.g., Remarks, Comments, Hot Wire Addition, Technique, Torch Angle, Etc.)

SBL 6/2/00

SwRI - CNWRA
Bldg. 57
Ext. 6090

WELDED

CREVICE REPASSIVATION SPECIMEN
All Dimensions +/- 0.003", UNLESS NOTED



ALL FEATURES ARE ASSUMED TO BE ON CENTERLINE, PER CUSTOMER. D. DUNN/BJL 18 MAR 97

P/N CU014820109 1-24-99

Southwest Research

SBrossia 6/2/00

Sean Brossia

From: PorterRLP@aol.com
Sent: Tuesday, April 25, 2000 7:05 AM
To: sbrossia@swri.edu
Subject: Titanium Welding

Sean,

Thanks for your inquiry. Note that I my direct e-mail is porterrlp@aol.com. I am going to send you a copy of an RMI welding brochure, unfortunately the brocure is out of print and all that is available is a photocopy. Please review the brochure and call me 330-544-1145 or e-mail me with any questions that you might have. Also please note that some of the alloys in the brochure are outdated and not currently used, however the basic procedures are the same.
As for grades 2,, 7, 11, 16, 17, 26 and 27 guidelines for welding CP titanium will apply. Note that grades 16, 17, 26 and 27 are probably likely to be welded with ER Ti-7 weld wire as it is commercially available. While ER Ti-27 weld wire can be used for grades 26 and 27, it is likely that for the time being that ER Ti-7 will utilized. We have examined the corrosion resistance of weldments of Ti-Ru alloys autogenously welded and also those welded with Ti-Pd weld wire (ER Ti-7) . If you wish to obtain some material for welding such as Ti-Grade 26 (TiRu-26, Ti-0.1Ru) or Ti-Grade 27 (TiRu-27, Ti-0.1Ru) I will be happy to supply it. Also if you are interested in welding a material for which weld wire is not available we can make some strips that will serve the purpose quite nicely.

Look forward to hearing from you soon.

Rick Porter
Corrosion Engineer
RMI Titanium Company
1000 Warren Avenue
Niles, Ohio 44446
PH 330.544.1145
FAX 330.544.1002

1

SBrossia 6/2/00

Sean Brossia

From: Grauman, Jim [Jim.Grauman@TIMET.com]
Sent: Tuesday, April 25, 2000 12:21 PM
To: sbrossia@swri.edu
Subject: RE: TIMET WWW Technical Support Request

Dr. Brossia:

Some guidelines can be found in our Design Handbook, located in the 'Products' section of our web site. This manual can be downloaded or viewed on-line. The only specification I am aware of is an ANSI/AWS specification (D10.6) titled 'Rec. Practices for GTAW of Ti Pipe & Tubing'. There may be others-you could check with someone at the Edison Welding Institute of the International Titanium Association (www.titanium.org) <http://www.titanium.org)> .

Regards,

Jim Grauman

James S. Grauman
Manager-Corrosion & Analytical Technology
TIMET-Henderson Technical Laboratory
PO Box 2128 Henderson, NV 89009
702.566.4414 Voice
702.564.9038 FAX
Jim.Grauman@TIMET.com
http://www.timet.com

-----Original Message-----
From: sbrossia@swri.edu [SMTP:sbrossia@swri.edu]
Sent: None
To: technical.htl@timet.com
Subject: TIMET WWW Technical Support Request

Below is the result of your feedback form. It was submitted by (sbrossia@swri.edu) on Monday, April 24, 2000 at 10:06:33

---

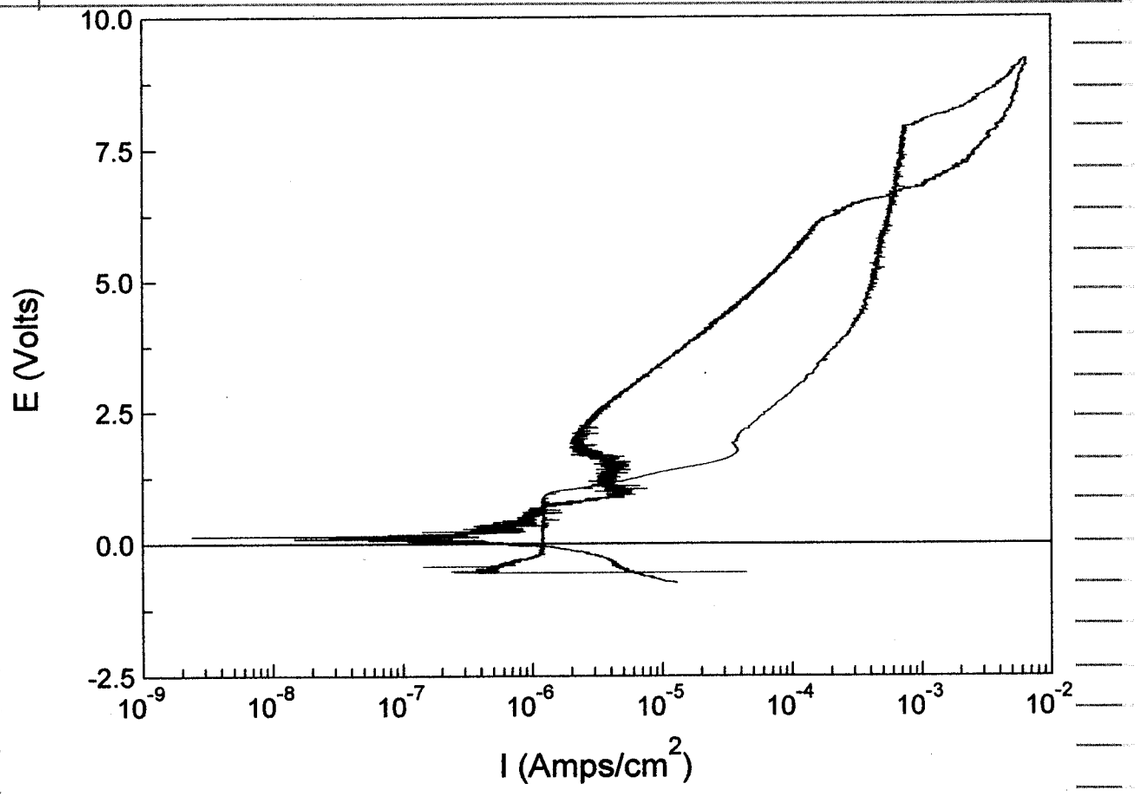
email: sbrossia@swri.edu

title_: Dr.
firstname: Sean
lastname: Brossia
company_name: Southwest Research Institute
address1: 6220 Culebra Rd
address2:
city: San Antonio
state/province: Texas
zip/postal: 78238
country: United States
other_country:
phone: 210-522-5797
fax: 210-522-5184
email: sbrossia@swri.edu
job_description: Technical/R&D
other_job_description:
industry: *Other
other_industry: contract research and development
Message: I am looking for specifications, standards, recomended practices for welding Ti. Specifically for grades 2, 7, and 16.

1

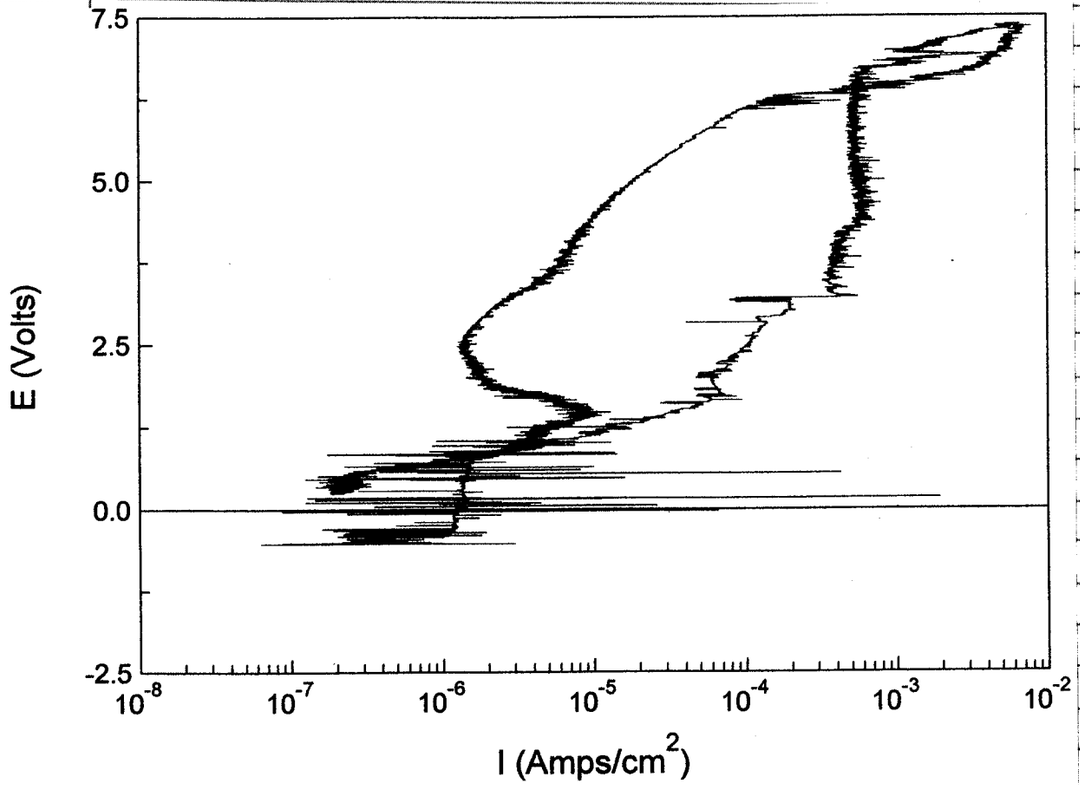
SB 6/2/00

TIPDG2-001.DAT
T=95°C
.01 M → NaCl → 1.1688g/2Lt Fisher # 000274
Init PH = 5.349
Specimen Ti G2 crevice specimen polished to 600grit
ultrasonically cleaned in methanol
Init wt = 15.9340g
Final wt = 15.83693g } lll 6-16-00
Final pH = 6.802
Observations
General corrosion on edges & corners of crevice, two feet had corrosion but appeared to have migrated from outside to in lll 6-16-00



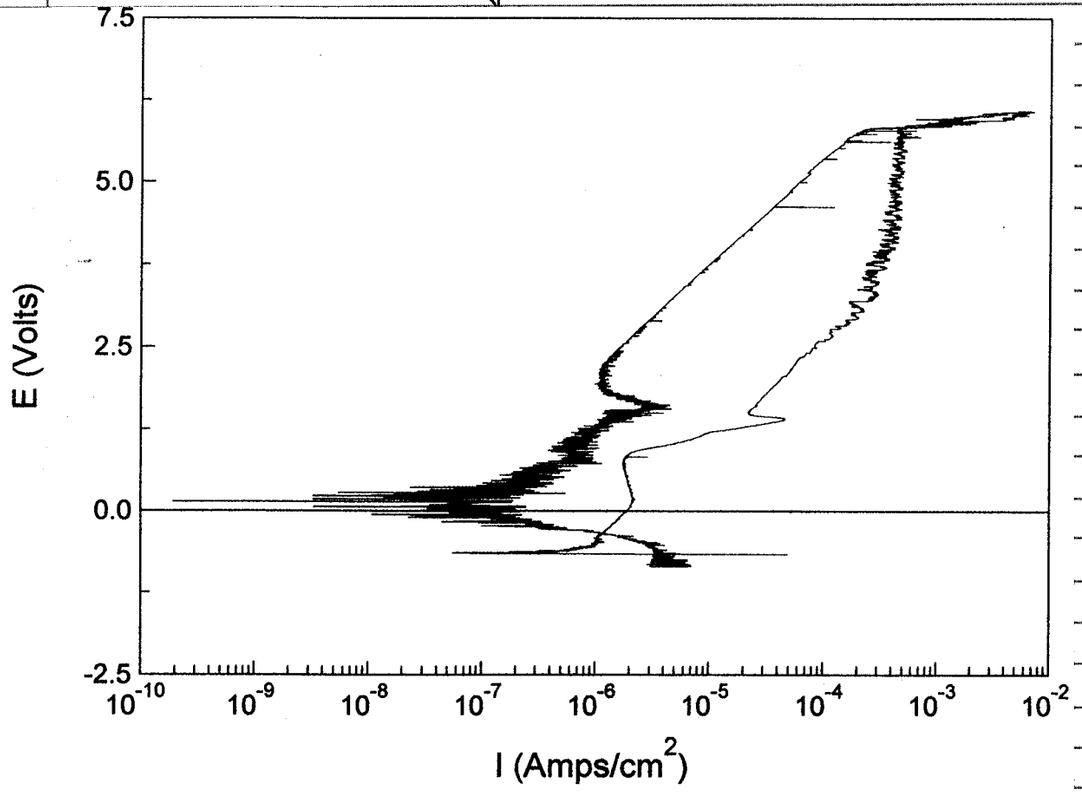
lll 6-15-00

TIPD62-002.DAT
T=95°C
.1 M → NaCl → 11.6880g/2Lt Fisher # 000274
Init pH = 5.930
Specimen Ti 62 crevice polished to 600 grit + ultrasonicall, cleaned in methonal
Init wt= 15.89263g
Final wt= 15.84512g } 6-22-00
Final pH= 6.659
Observations
General corrosion @ edges + corners 6-22-00



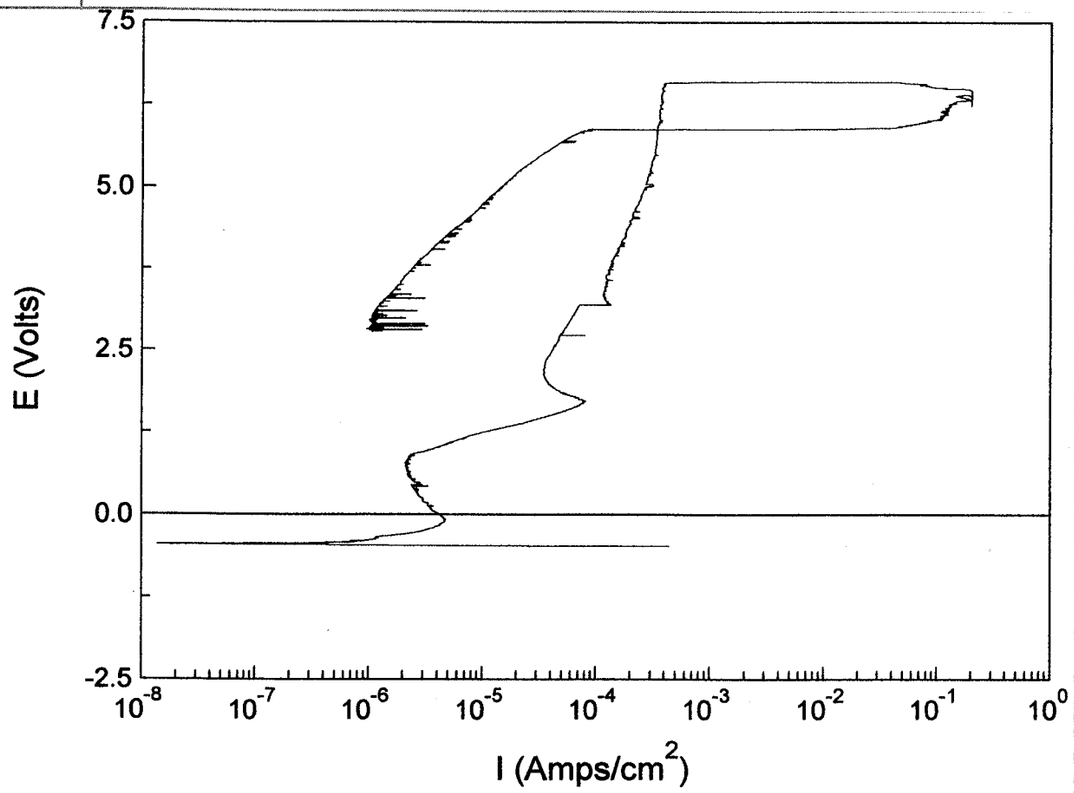
6-21-00

TIPD62-003.DAT
T=95°C
1 M → NaCl → 116.880g/2Lt Fisher #000274
Init pH= 6.208
Specimen Ti 62 crevice polished to 600 grit + ultrasonicall, cleaned in methonal
Init wt= 15.92873
Final wt= 15.91786 } 6-23-00
Final pH= 7.644
Observations
Minor general corrosion @ edges + corners, none under feet. 6-23-00



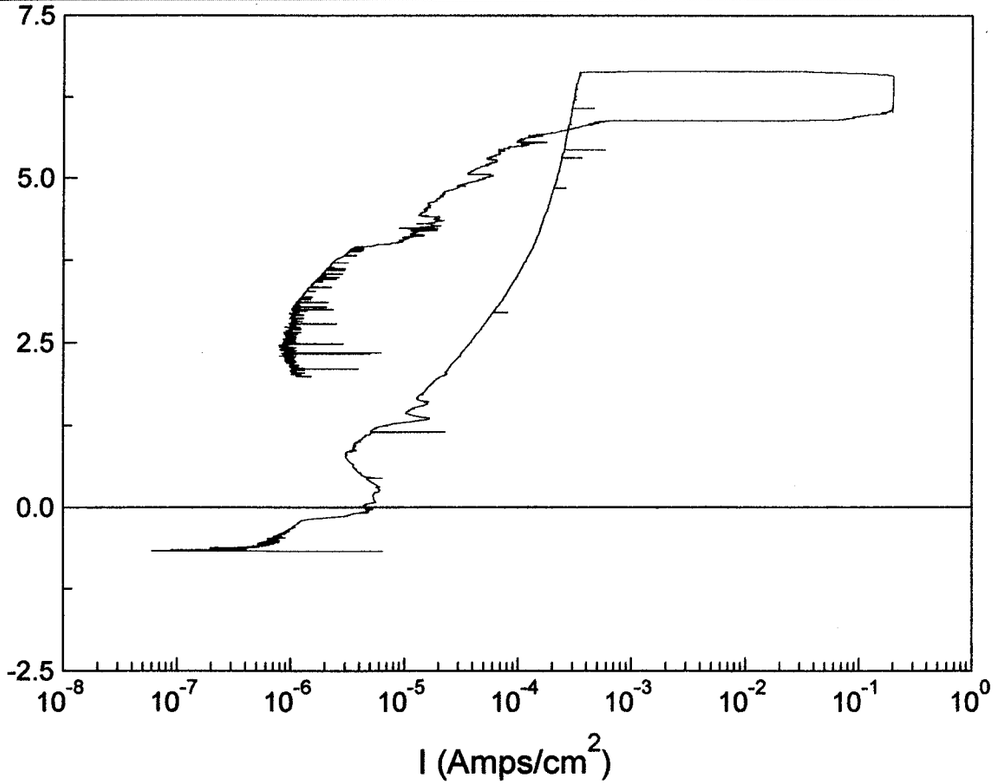
6-22-00

TIPD62-004.DAT
T=95°C
5M → NaCl → 584.400g/2Lt Fisher # 000274
Init pH: 7.450
Specimen T162 polished to 600 grit + ultrasonically cleaned in methanol
Init wt: 15.86149
Final wt: 14.96003 } 6-27-00
Final pH: 3.514
Observations
Heavy corrosion @ edges + corners, none under crevice
6-27-00



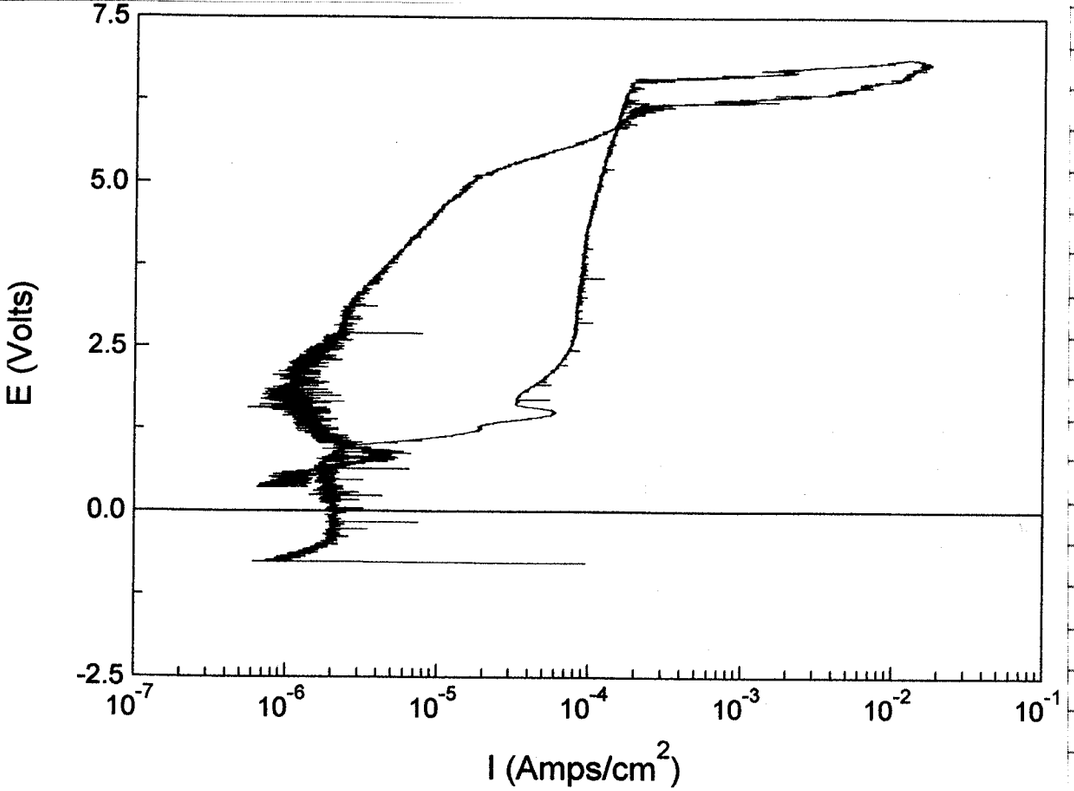
6-26-00

TIPD62-005.DAT
T=95°C
5M → NaCl → 584.400g/2Lt Fisher # 000274
Init pH: 7.250
specimen T162 polished to 600 grit + ultrasonically cleaned in methanol. Crevices reversed
Init wt: 15.94431g
Final wt: 14.61072g } 6-28-00
Final pH: 3.298
Observations
Heavy corrosion @ edges + corners, none under foot
6-28-00



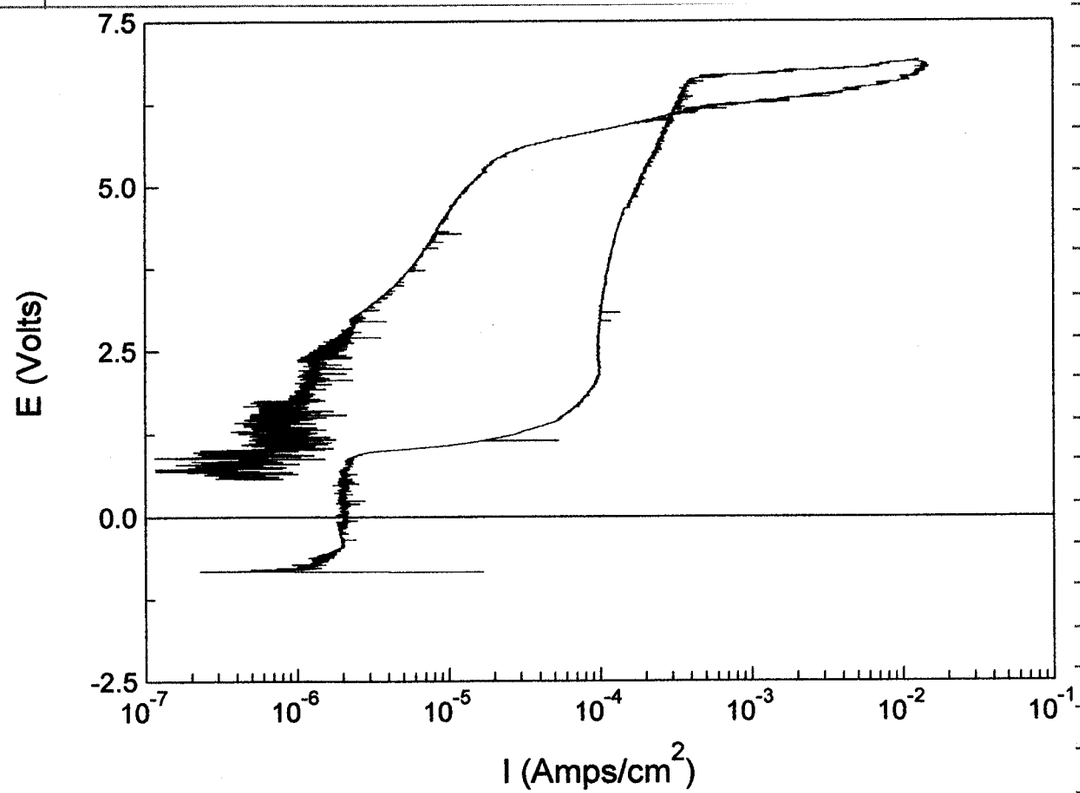
6-27-00

TIPDG2-006.DAT
T=95°C
.1 M → NaCl → 11.6880g/2Lt Fisher # 000 274
.001 M → NaF → 0.0840g/2Lt 991559
Specimen TI G2 pitting specimen polished to 600 grit
+ ultrasonically cleaned in methanol
Init wt: 6.40553g
Final wt: 6.36846g } 6-29-00
Final pH: 7.180
Init pH: 5.973
Observations
Some pitting/corrosion streaks and staining
6-29-00



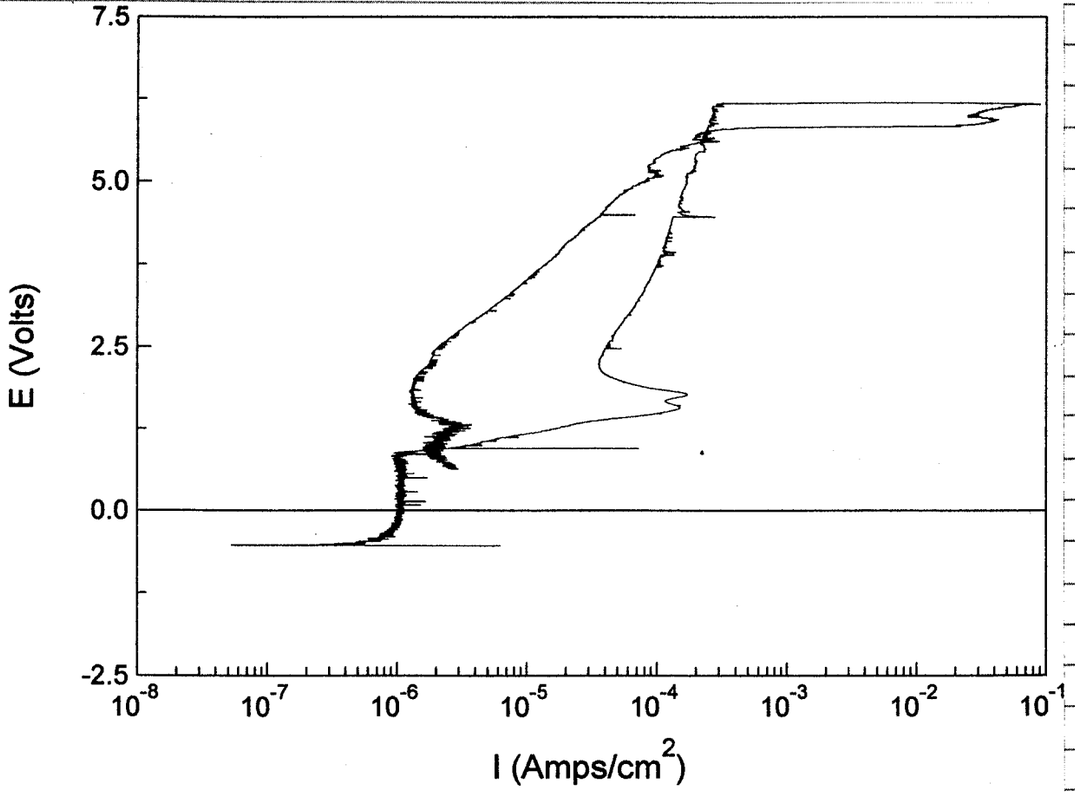
6-28-00

TIPDG2-007.DAT
T=95°C
.1 M NaCl → 11.6880g/2Lt Fisher # 000 274
.01 M NaF → 0.8398g/2Lt # 991559
Specimen is pitting specimen TI G2 polished to 600 grit
+ ultrasonically cleaned in methanol
Init pH = 6.591
Init wt = 6.38488g/2Lt
Final wt = 6.35433g/2Lt } 6-30-00
Final pH = 7.087
Observations
Some pitting/corrosion streaks + staining 6-30-00



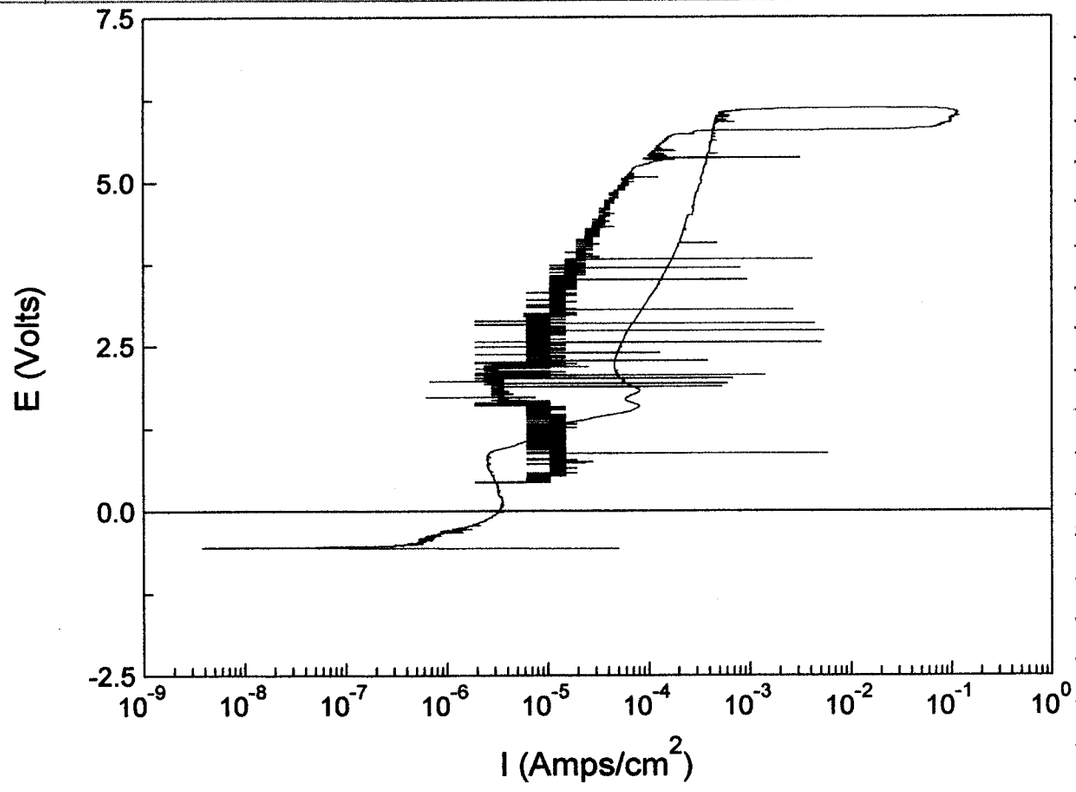
6-29-00

TIPDG2-008.DAT
T=95°C
5M → NaCl → 584.400g/2Lt Fisher #000274
Specimen is TI G2 crevice specimen polished to 600 grit
+ ultrasonically cleaned in methonal Solid sq teflon blocks 1.9x15cm
Init pH = 6.900
Init wt = 15.97895g
Final pH = 4.71
Final wt = 15.83877g } 7-7-00
Observations
No pitting under crevice, general corrosion at
edges & corners 7-7-00



7-6-00

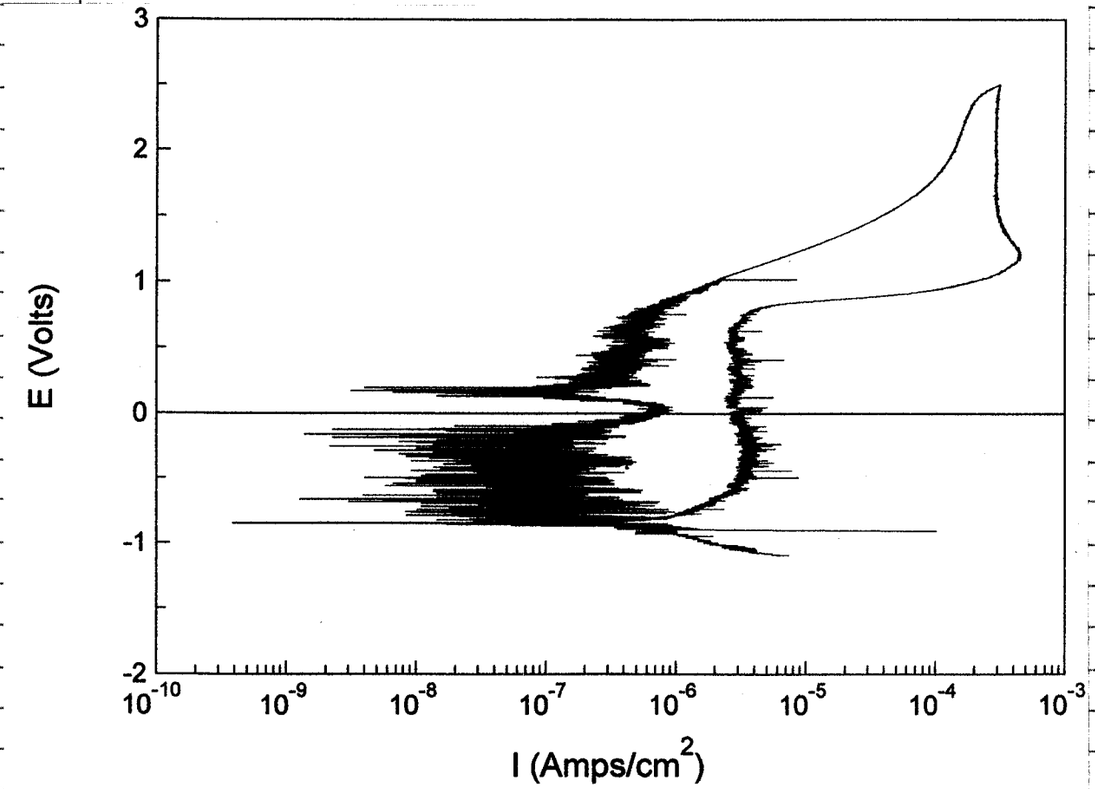
TIPDG2-009.DAT
T=95°C
5M NaCl → 584.400g/2Lt
Specimen is TIG2 polished to 600grit + ultrasonically cleaned
in methonal. Crevice is another TIG2 polished to 600
Init pH = 6.95
Init wt = 16.05231g
Init wt crevice = 16.05545g
Final pH = 4.02
Final wt = 15.74082 } 7-11-00
Final wt crevice = 16.05469
Observations
No pitting under crevice, general corrosion @
edges & corners. Crevice former had no
pitting or corrosion on it. 7-11-00



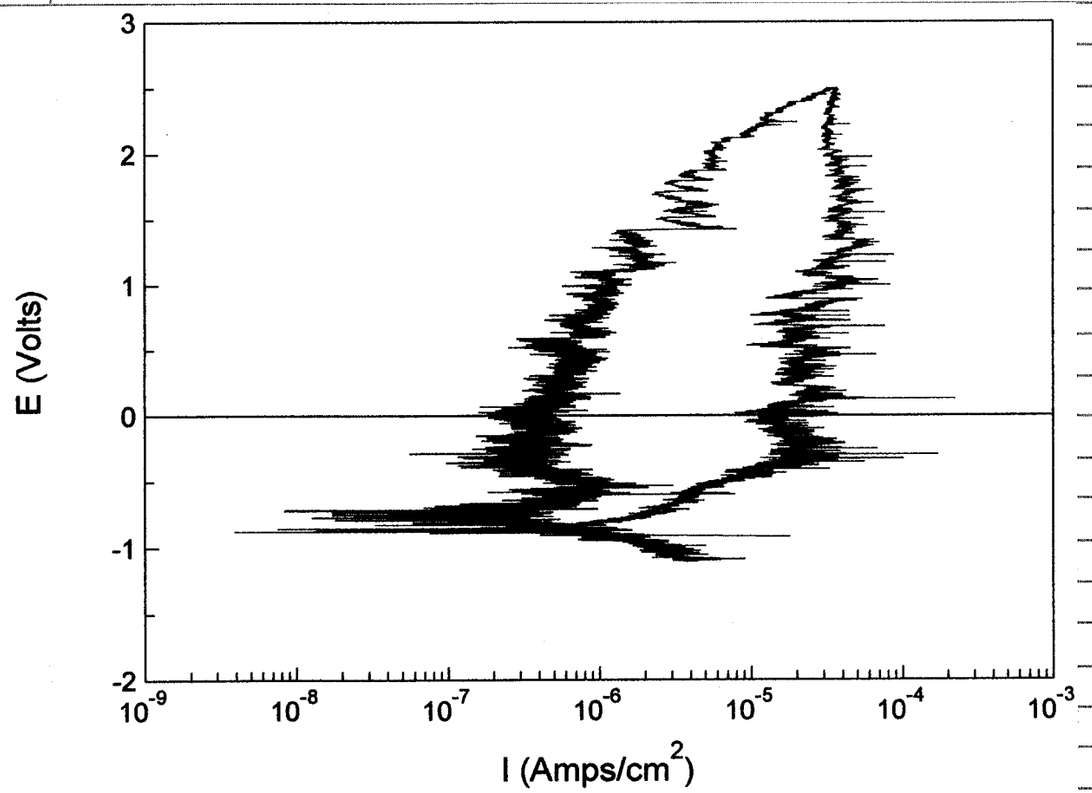
7-10-00

TIPD62-010.DAT
T=95°C
.1 M NaCl → 11.6880g/2Lt Fisher # 000274
.05M NaF → 4.1990 g/2Lt # 991559
Specimen is TIG2 pitting, polished to 600 grit
+ ultrasonicall, cleaned in methanol
Init pH: 6.990
Init wt: 6.39044g
Final pH: 8.690
Final wt: 6.38985g } 7-12-00
Observations
No pitting, some discoloration above vapor line 7-12-00

TIPD62-011.DAT
T=95°C
.1 M NaCl → 11.6880g/2Lt Fisher # 000274
.1 M NaF → 8.398 g/2Lt # 991559
Specimen is TIG2 pitting polished to 600 grit
+ ultrasonically cleaned in methanol.
Init pH = 6.860
Init wt = 6.34581
Final pH: 8.620
Final wt: 6.34577 } 7-14-00
Observations
No pitting, some discoloration above vapor line 7-14-00

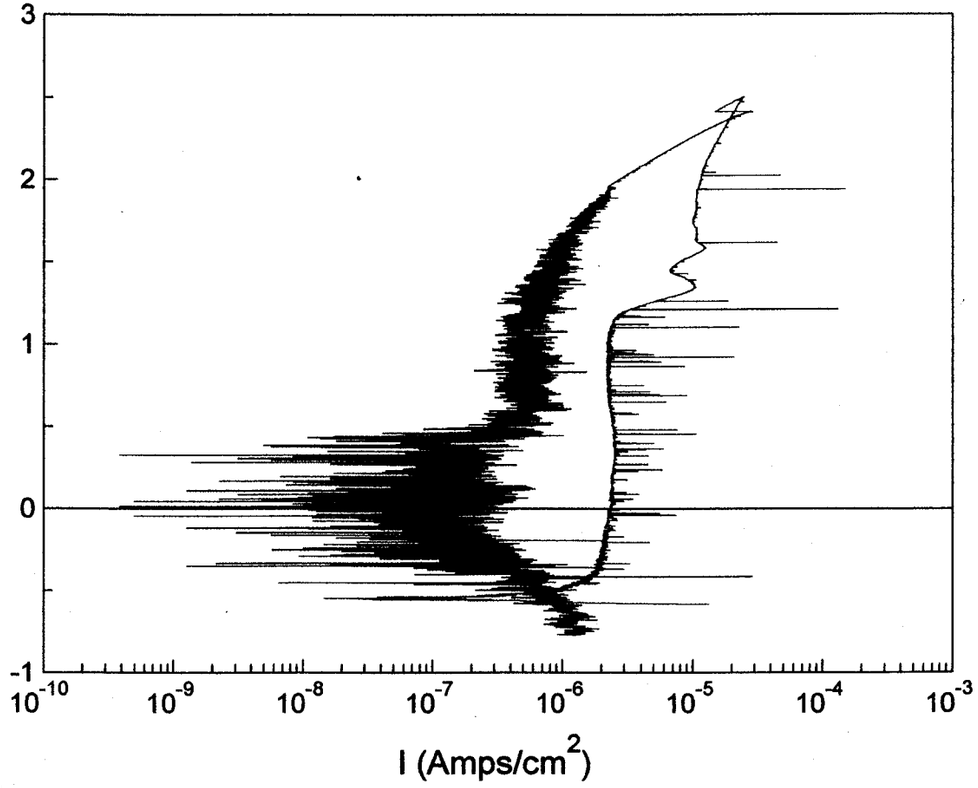


7-11-00



7-13-00

TIPD62-012.DAT
T = 95°C
SM NaCl → 584.400g/2Lt F.sh # 000274
Specimen is T162 crevice polished to 600 grit + ultrasonically cleaned in methanol, reversed crevice loosely tightened by hand
Init pH: 6.840
Init wt: 16.01398g
Final pH: 6.870
Final wt: 16.01372g } 7-19-00
Observations
No pitting or corrosion, some staining 7-19-00



7-18-00

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

SCIENTIFIC NOTEBOOK REVIEW CHECKLIST RECORD

Scientific Notebook No.: 320

Accomplished

YES	1. Initial entries per QAP-001
YES	2. Dating of entries
NO	3. Corrections (crossed out, one line through w/initials/date)
YES	4. White out not used
YES	5. Page number visible on original notebook
YES	6. In process entries per QAP-001
N/A	7. Figure numbers present
YES	8. Text visible
N/A	9. Electronic Scientific Notebook changes initialed and dated
YES	10. Permanent ink or type only
YES	11. Signing of entries (not required on each page)
N/A	12. Statement at the end of electronic Scientific Notebook print outs—"No original text removed"
N/A	13. Electronic media in the scientific notebook properly labeled

Discrepancies have been identified. Yes X No _____

Checker: [illegible] Date: 8/16/00

The discrepancies identified in this Scientific Notebook Review Checklist have been addressed by:

SB
Signature

8/16/2000
Date

CNWRA Form QAP-01 (8/2000)

SB 8/16/2000

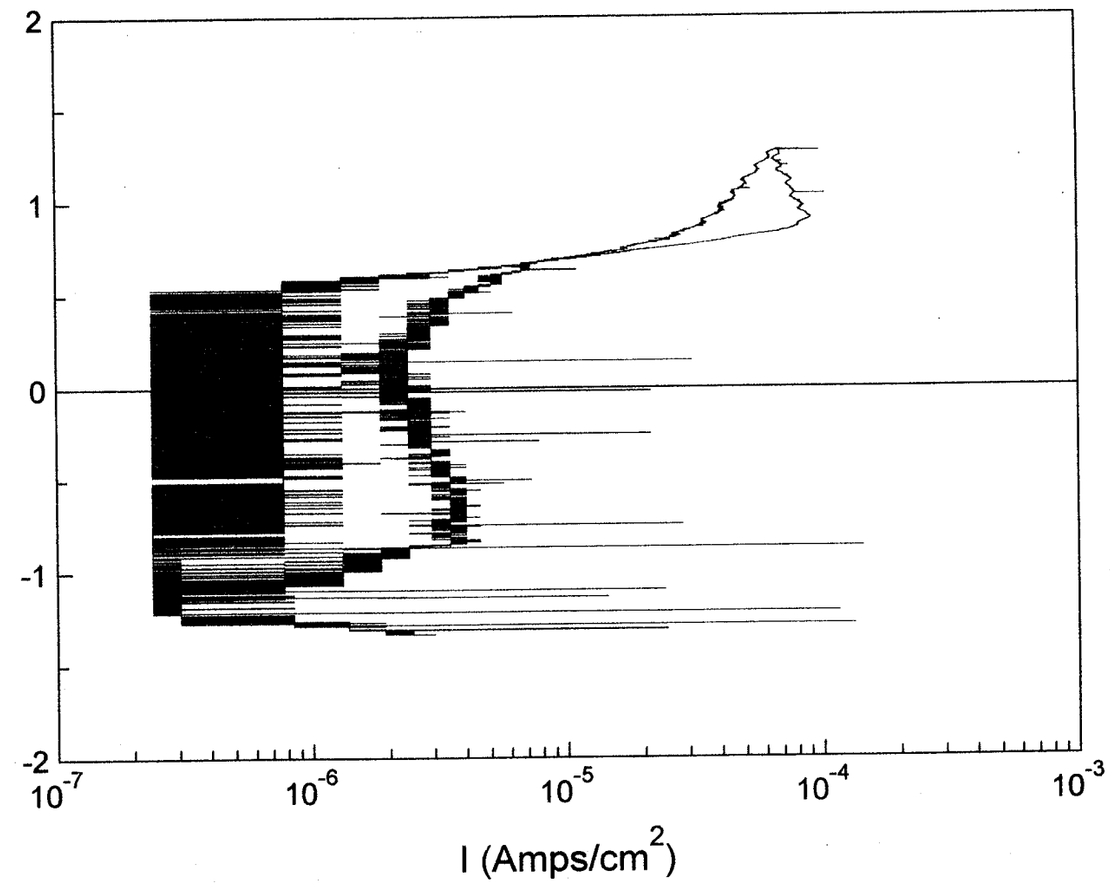
Copy of pages 77 - 129 sent to QA

9/5/2000

TiPdK001.dat DOE Basic Satd waters tests w/ Ti-Pd (Grade 7)

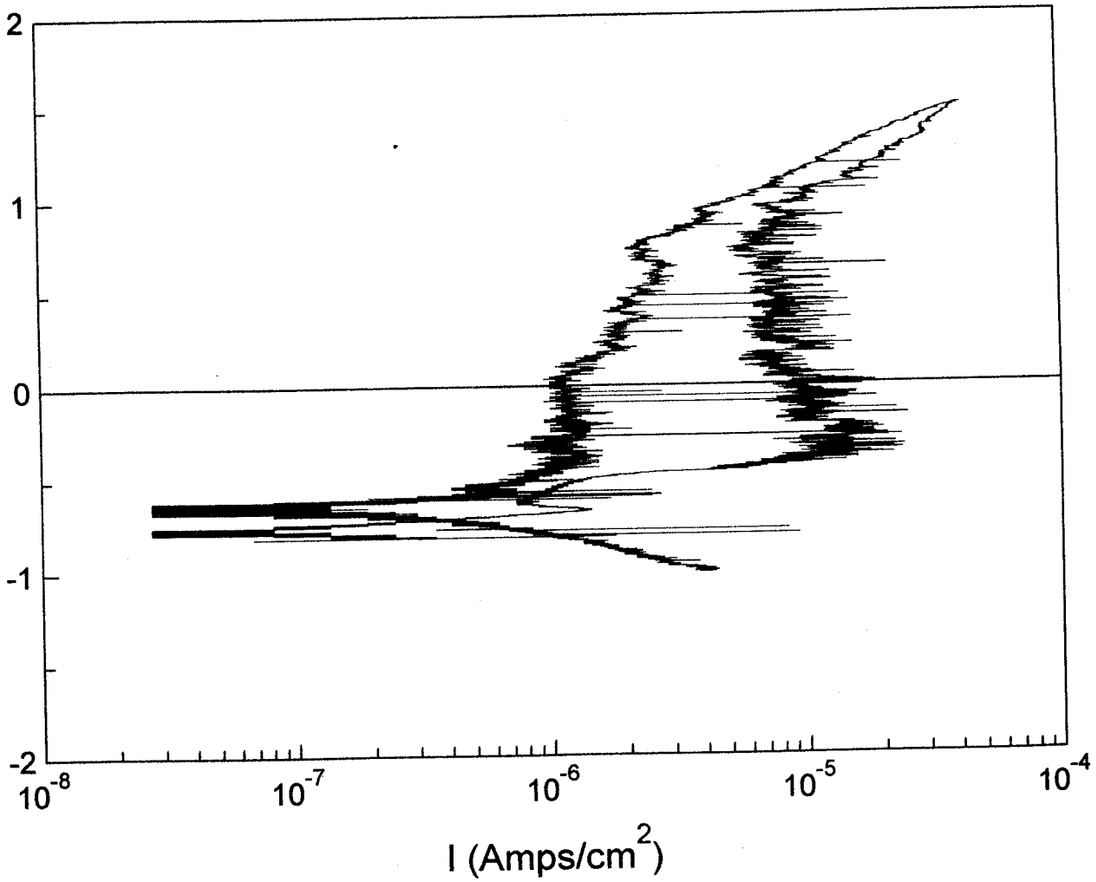
1.77 M KCl
2.05 M NaCl
0.072 M NaF
95°C
wt_i = 6.26938
wt_f = 6.26987
pH_i = 8.463
pH_f = 8.357

→ pg 131 — 134
all 95°C, deaerated w/ N_2



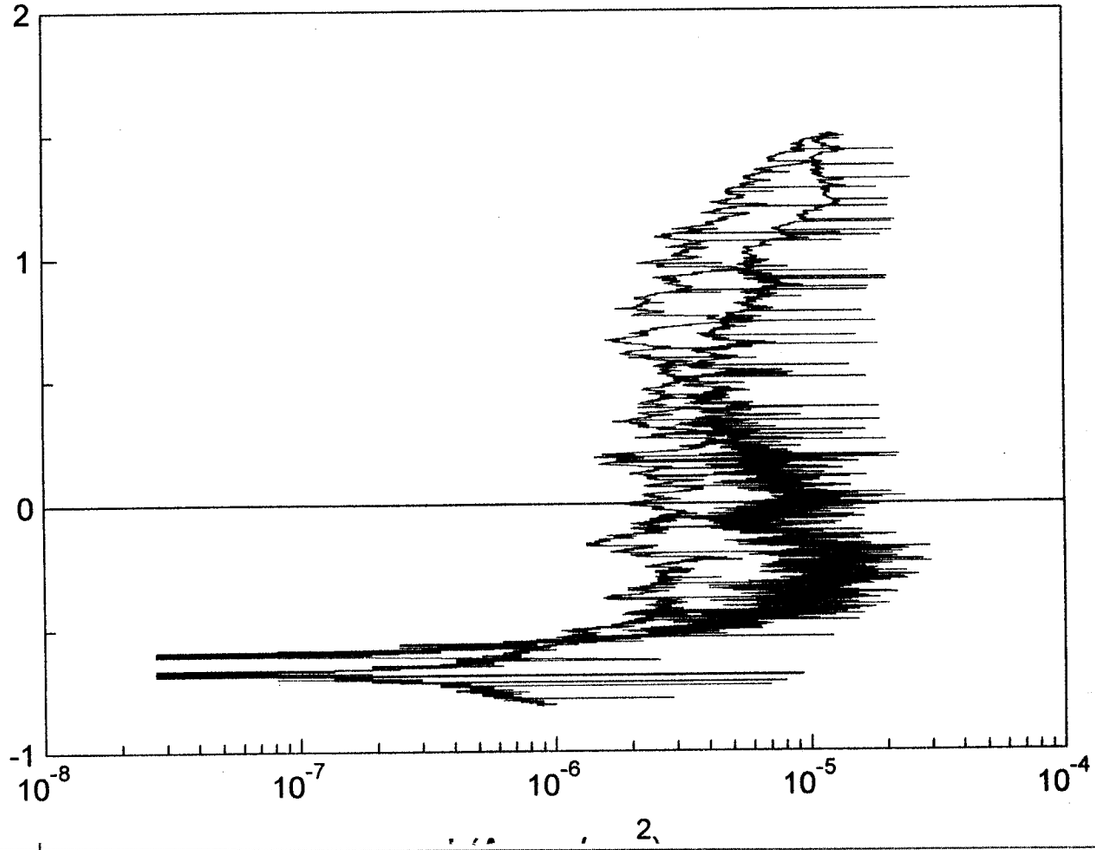
8/17/00

Ti Pd K002 . dat
1.77 M KCl
2.05 M NaCl
0.072 M NaF
0.03 M NaOH
wt_i = 6.32874
wt_f = 6.32848
pH_i = 12.283
pH_f = 12.336



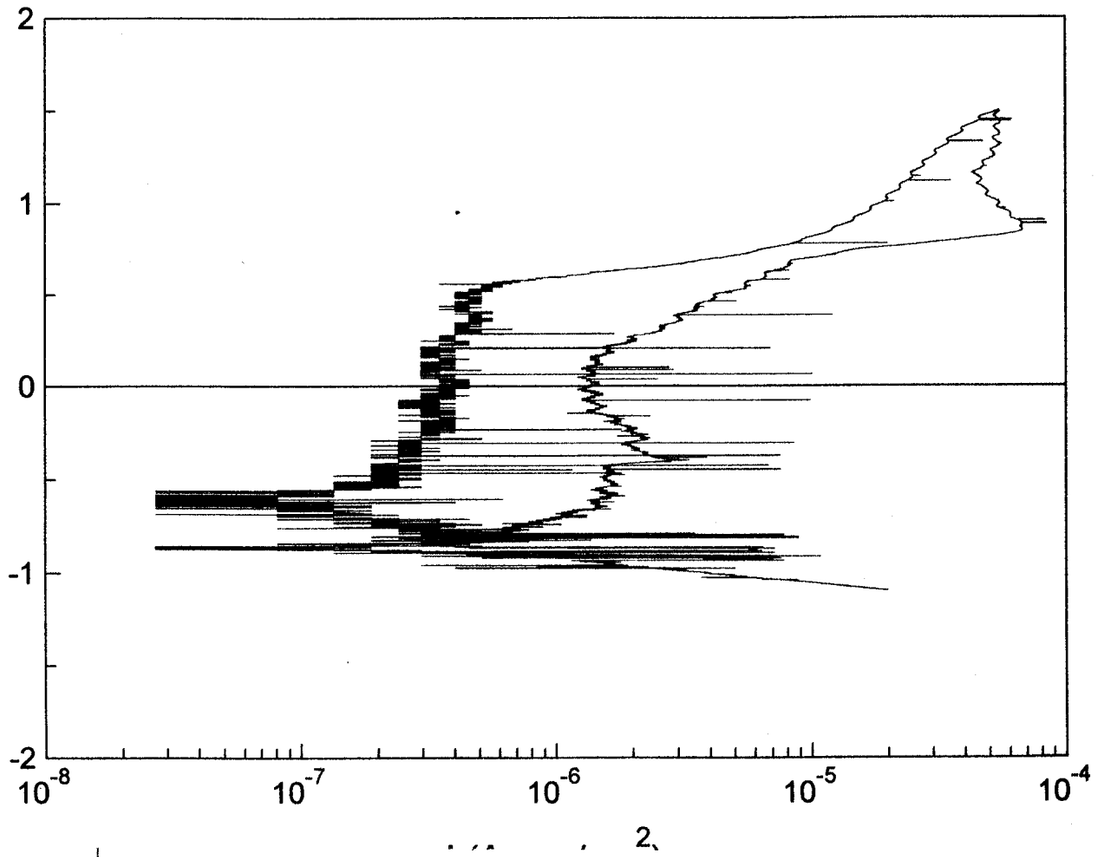
SB 8/22/2000

Ti Pd K003
1.77 M KCl
2.05 M NaCl
0.072 M NaF
2.3 M $NaNO_3$
~~0.15 M Na~~ SB 8/30/2000
wt_i = 6.25407
wt_f = 6.25436
pH_i = 8.525
pH_f = 8.742



SB 8/30/00

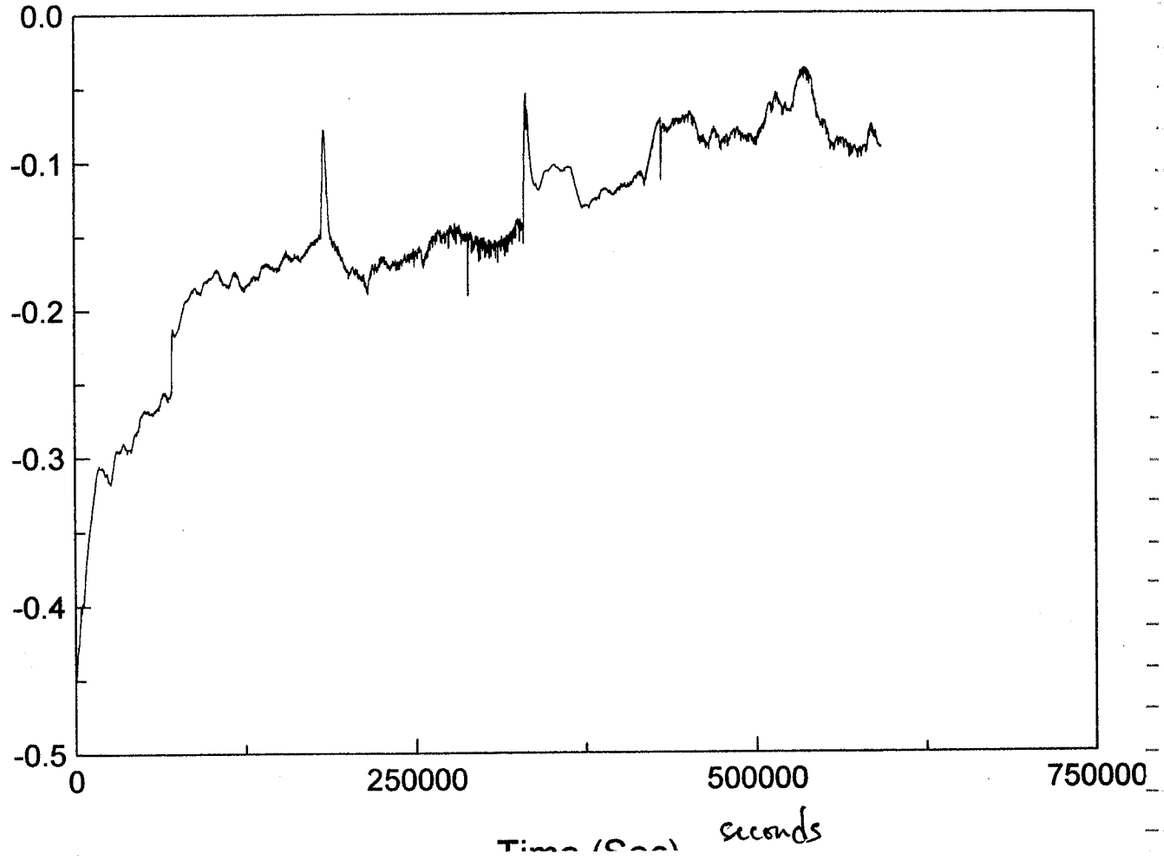
Ti:PdK004.dat
1.77 M KCl
2.05 M NaCl
0.072 M NaF
2.3 M $NaNO_3$
0.03 M NaOH
Wt_i 6.31533
Wt_f 6.31509
pH_i 12.359
pH_f 12.039



8/30/2000

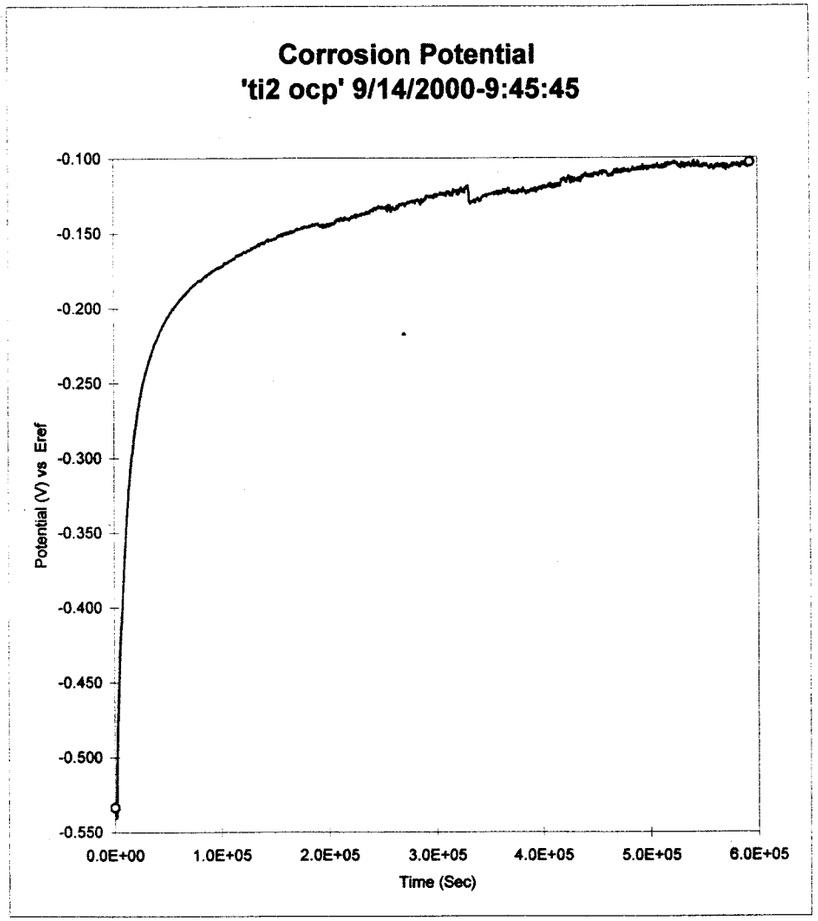
Simulated Groove Solution Tests pgs 135 – 144
– all tests:
5M LiCl
0.1M HCl
95°C
pH_i ~ -0.55 for all (bulk batch solution for all tests)

Ti:7 OCP



9/21/00

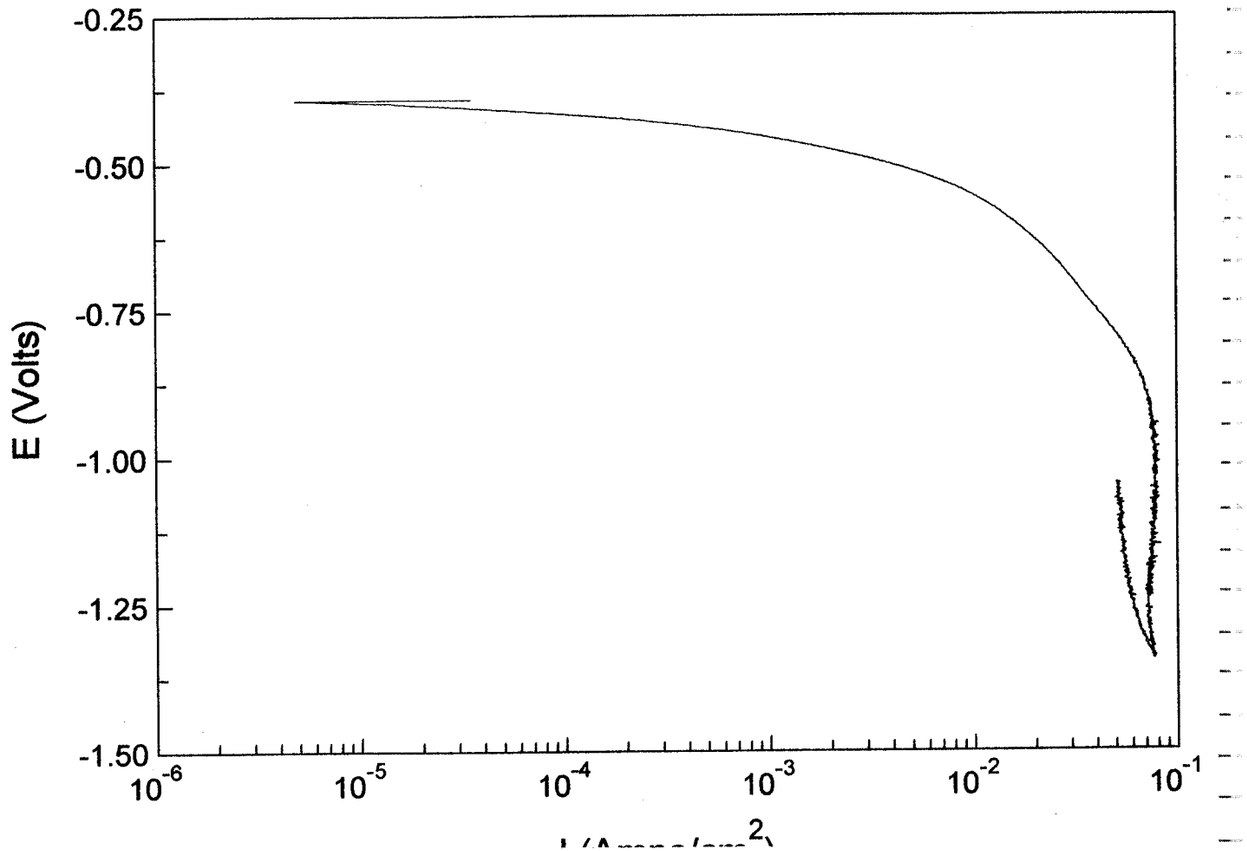
Ti 2 OCP



SB 9/21/00

solution
crevice/polic

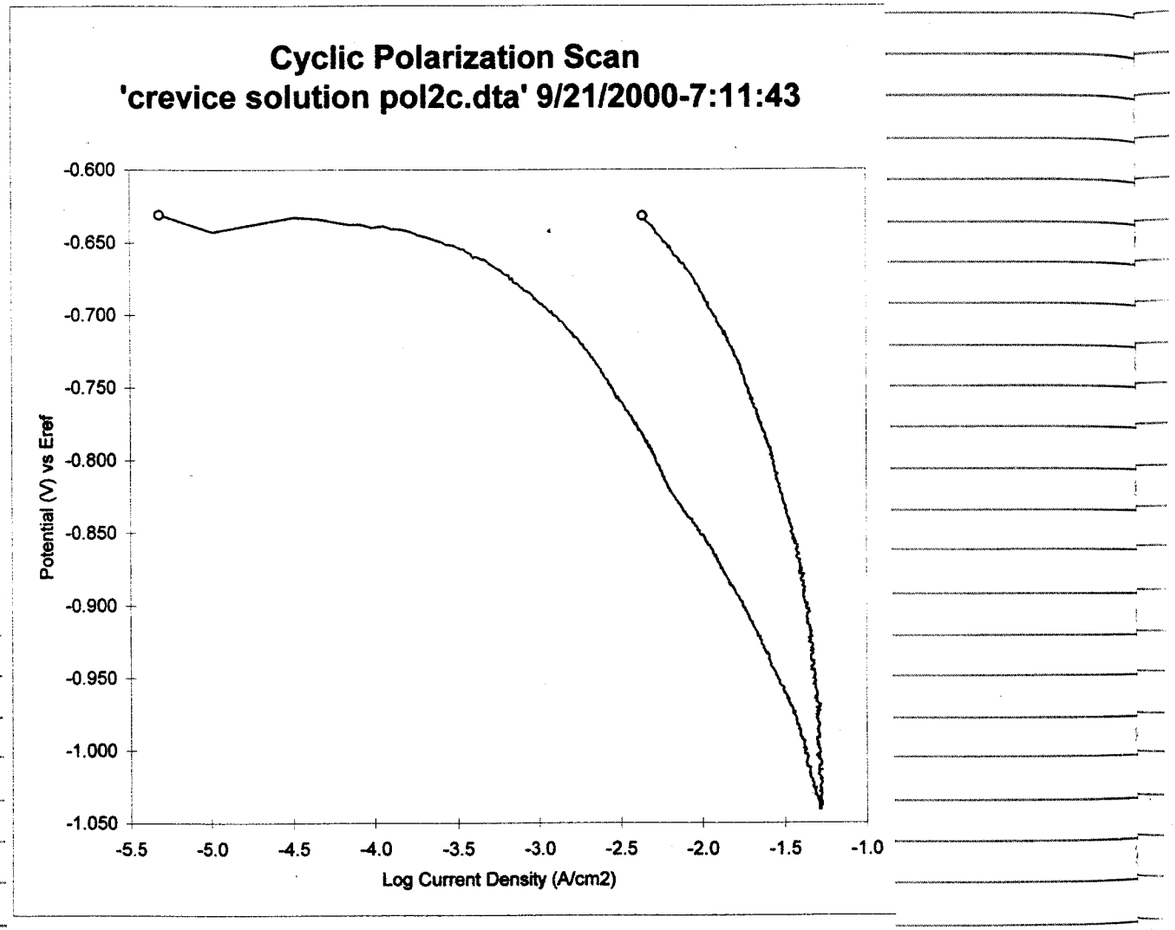
Ti Grade 7 — cathodic



SB 9/21/00

crevice solution pol 2c

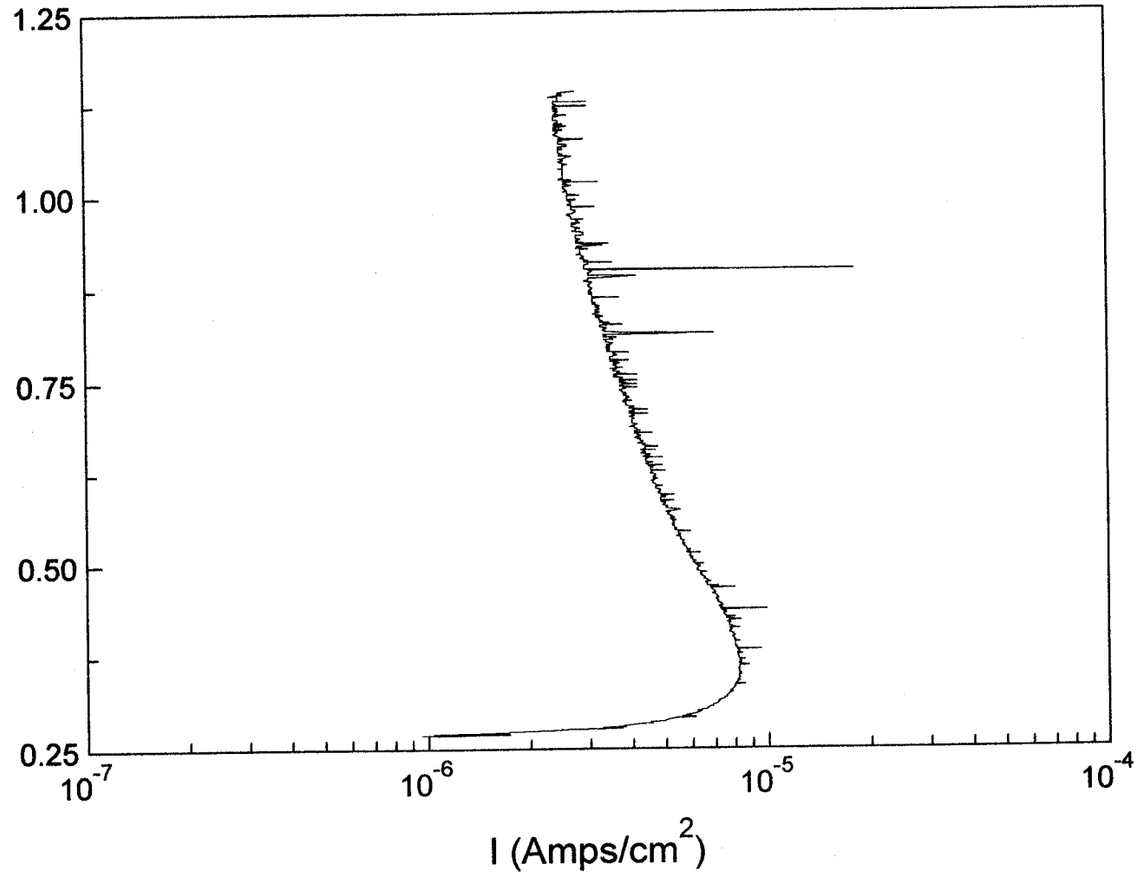
Ti Grade 2 — cathodic



SB 9/21/00

crevice solution pol 7a

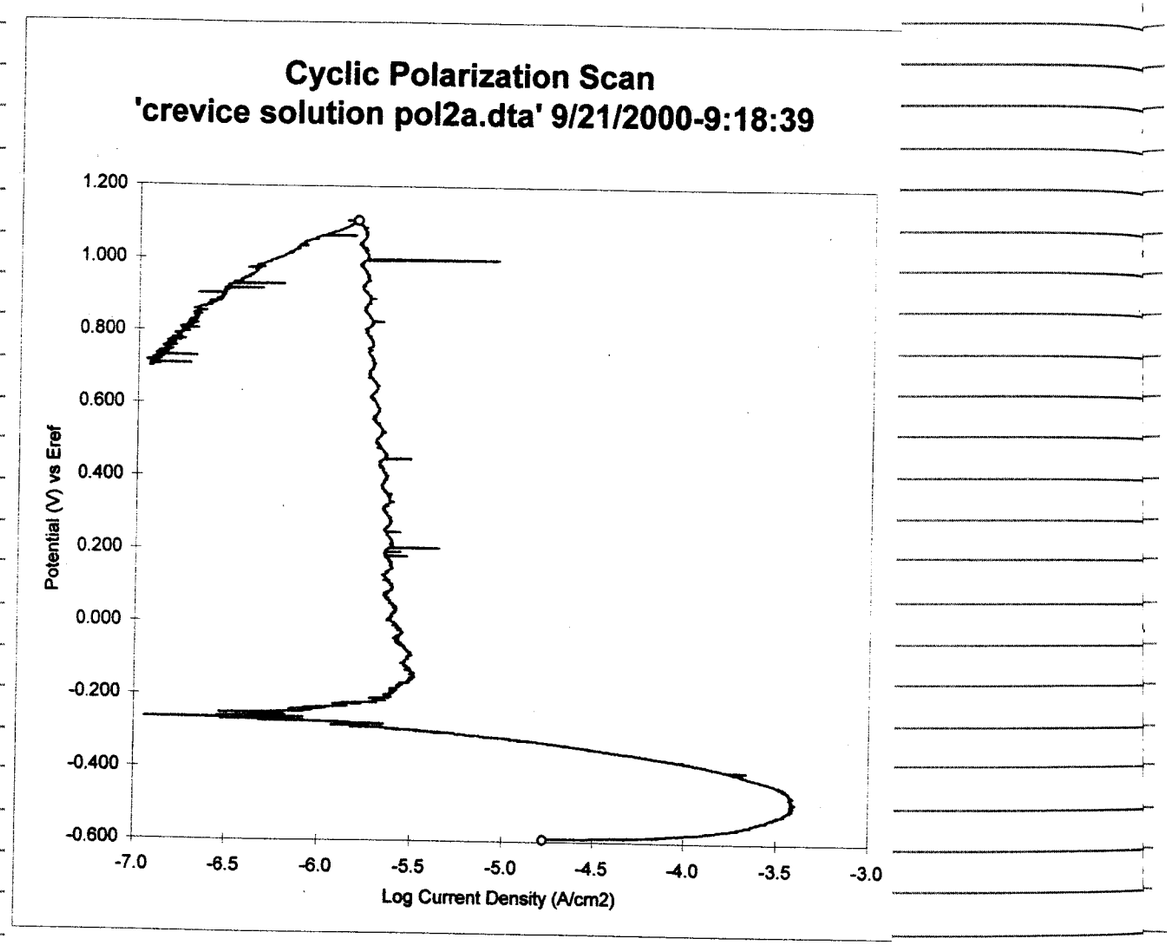
Ti Grade 7 — Anodic



SB 9/21/00

crevice solution pol 2a

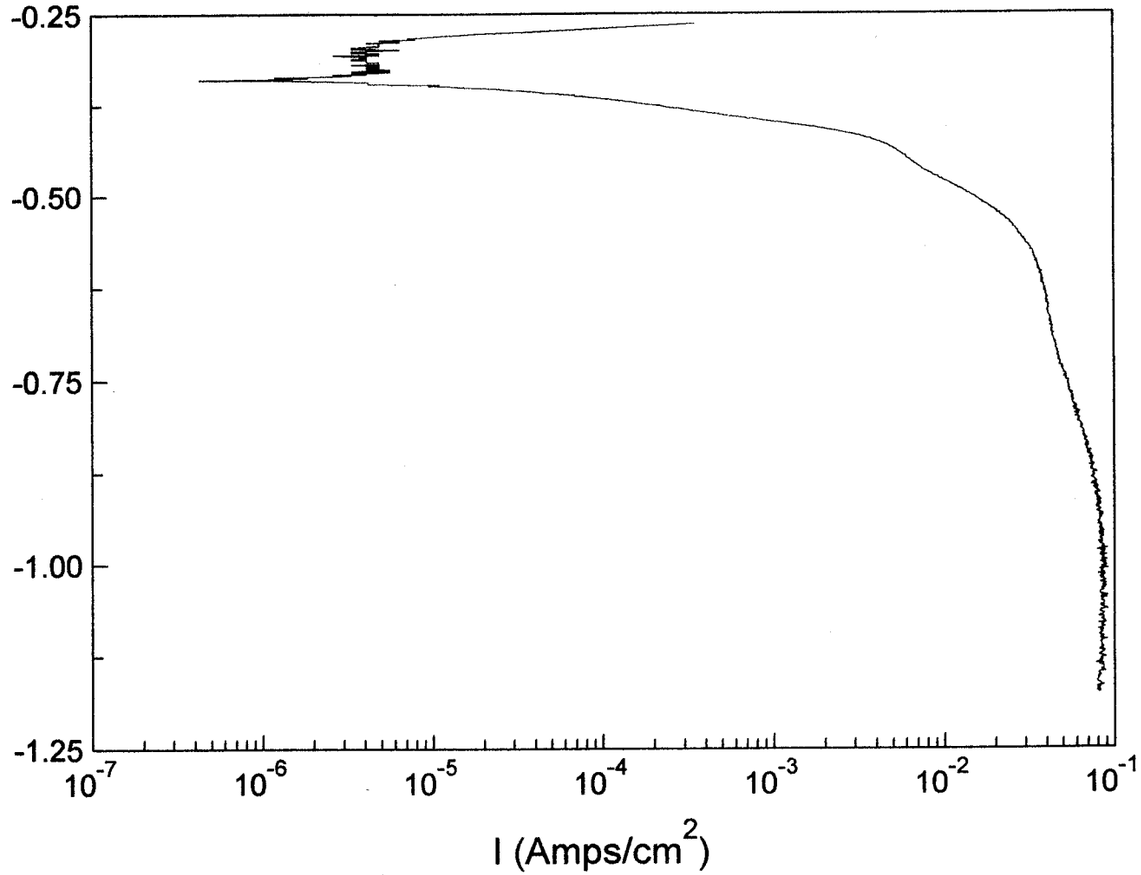
Ti Grade 2 - anodic



CSB 9/21/00

crevice solution pol 7c 3

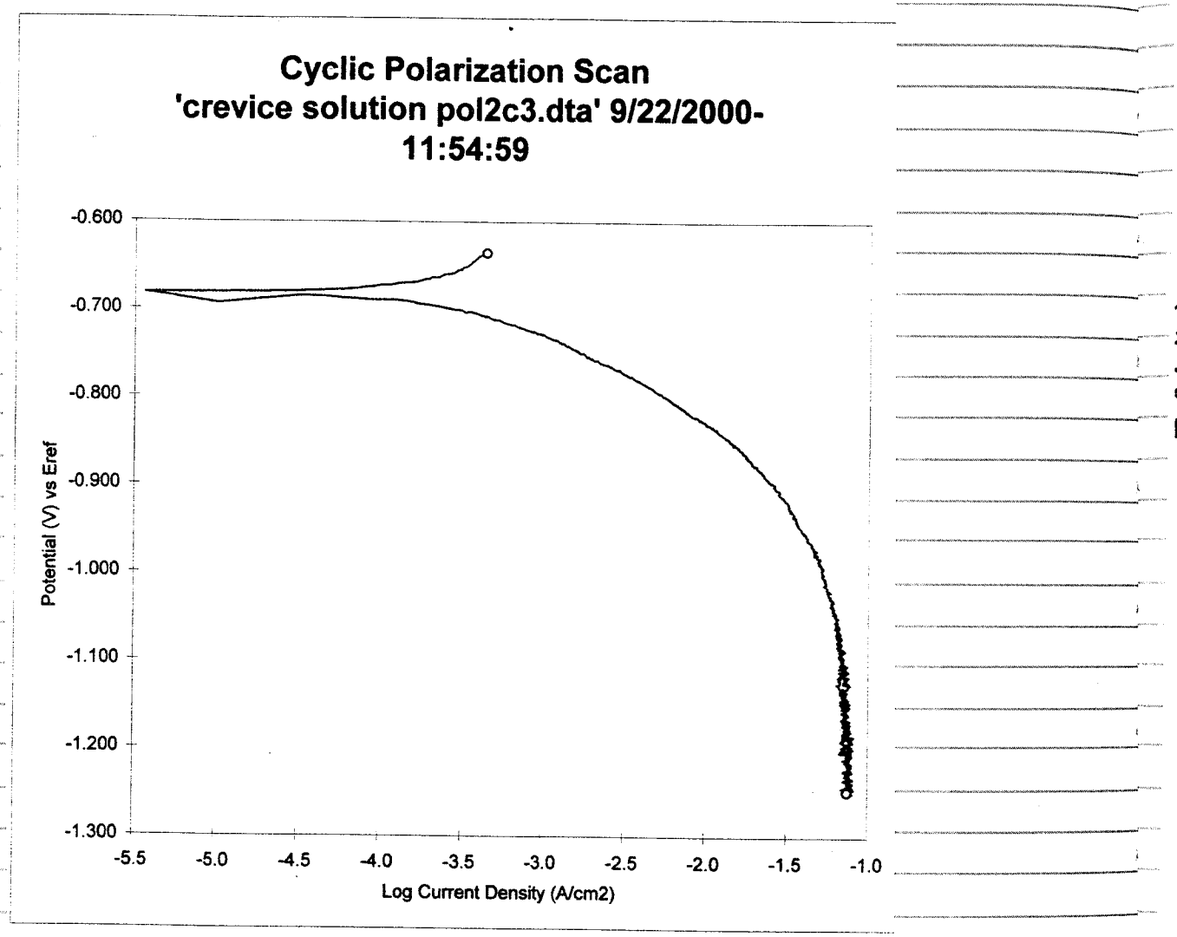
- duplicate of pg 137



CSB 9/22/00

crevice solution pol 2c 3

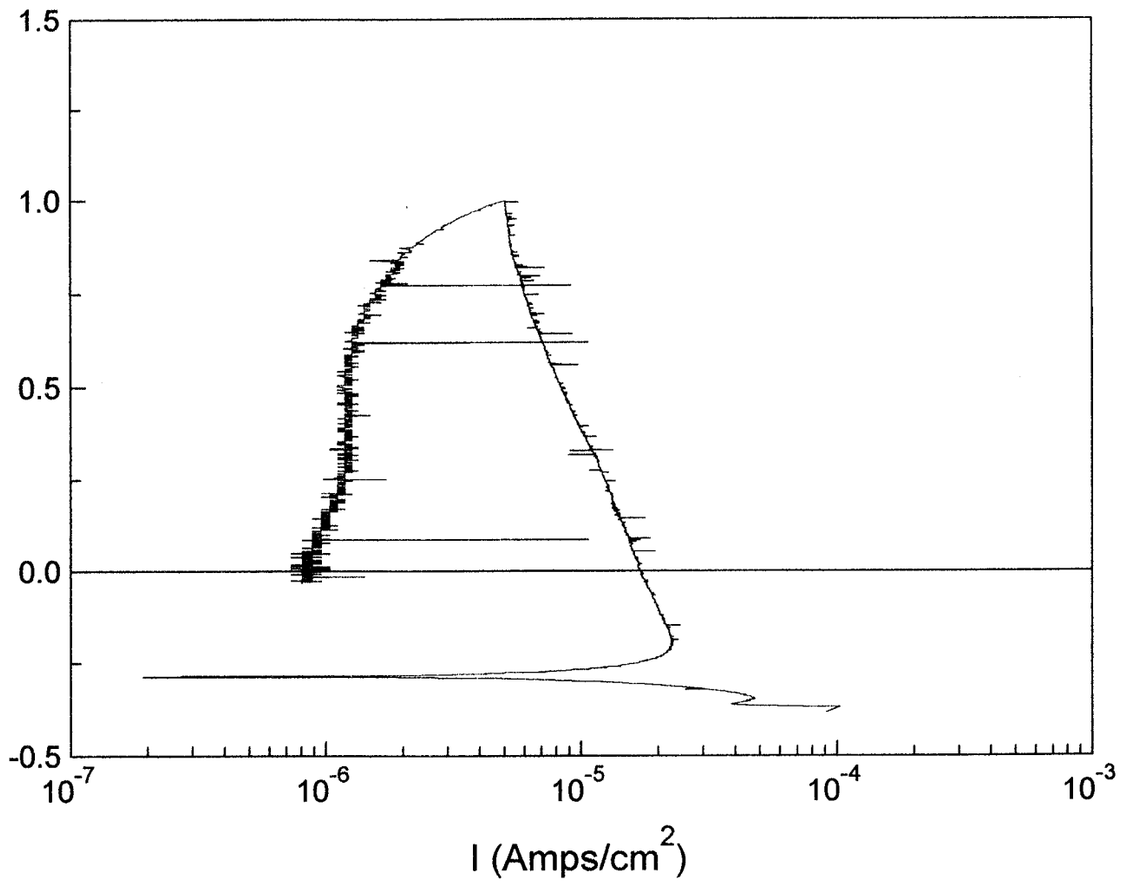
duplicate of pg 138



SRE 9/22/00

crevice solution pol 7a 3

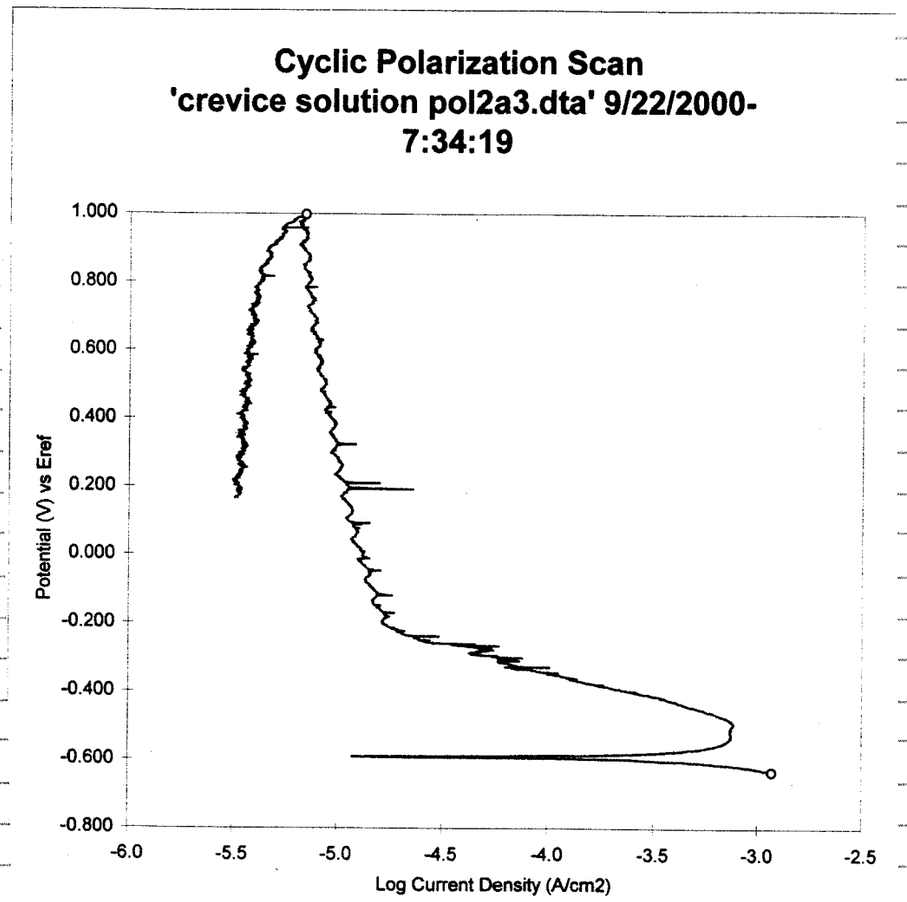
duplicate of pg 139



SRE 9/22/00

crevice solution pol 2a3

duplicate of pg 140



SB 9/22/00

Long-term polarization of Ti-Grade 2 & 7 pgs 145–

start 8/3/00 → all at E = 0 V_{SCE}, 95°C,

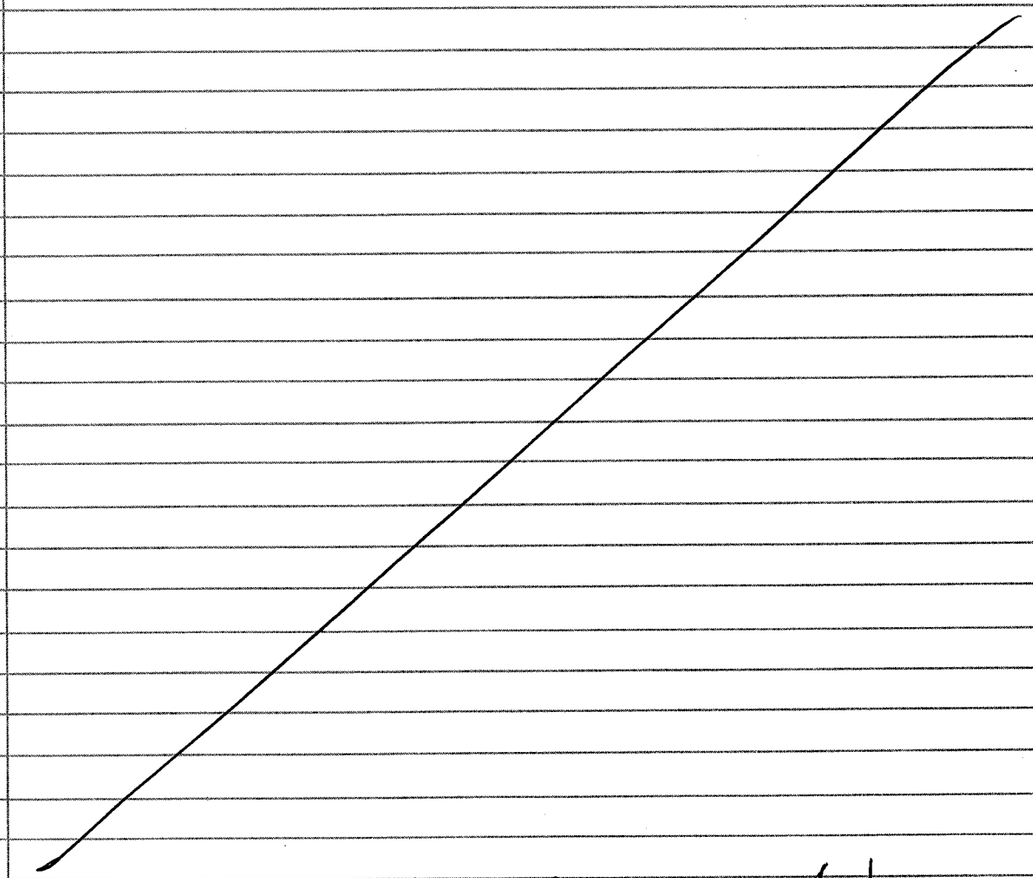
5M LiCl deaerated, crevice spec.

Grade 2 : tig2_001 – ptfe crevice

tig2_002 – ti g2 crevice

Grade 7 : tig7_001 – ptfe crevice

tig7_002 – ti g7 crevice



SB 8/11/00

Ti Grade 2:

tig2_3 — 1 M NaCl, ptfe crevice

tig2_4 — 1 M NaCl, tig2 crevice

Ti Grade 7

tig7_01b, tig7_02b } continuation from pg 145

SB 8/11/00

New long-term Expts w/ F^-

Ti Grade 2:

tig2_03b, tig2_04b } continuation of pg 146 expts in 1M NaCl

tig2F_01 — 1 M NaCl + 0.01 M NaF

~~TT~~ SB 9/15/00 tig2F_02 — 1 M NaCl + 0.1 M NaF

Ti Grade 7:

tig7_01c, tig7_02c } continuation of pg 145, 146 expts in 5M LiCl

tig7F_01 — 1M NaCl + 0.01M NaF

tig7F_02 — 1M NaCl + 0.01 M NaF

SB 9/15/00

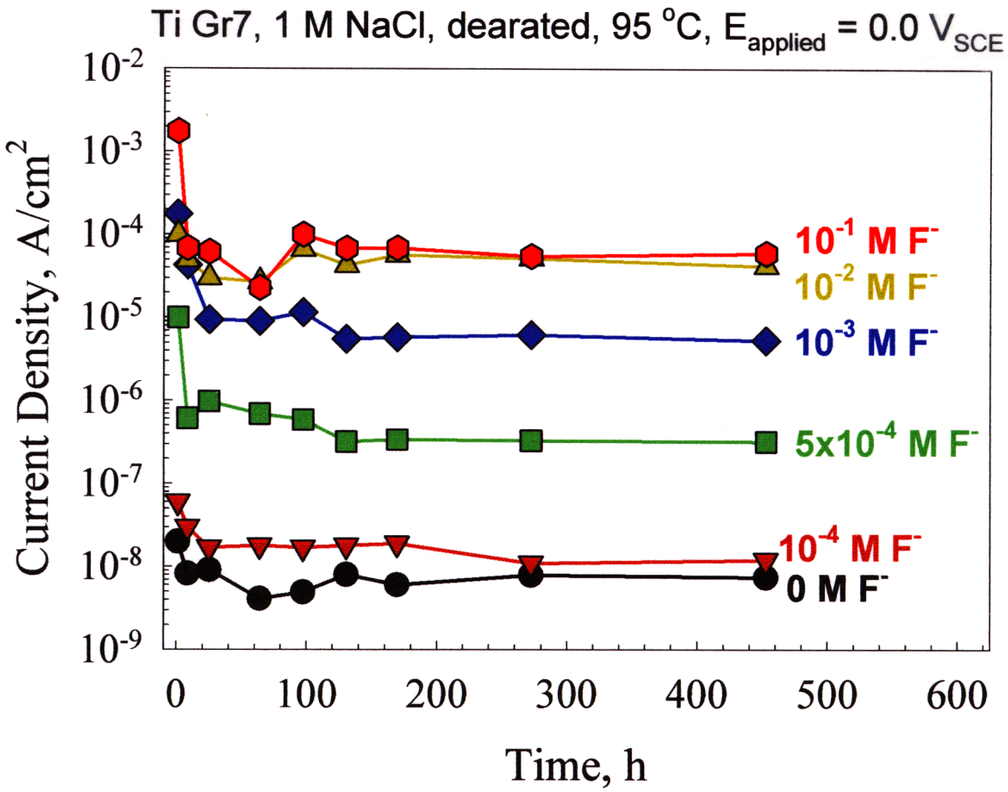
Ti grade 7 ocp in 1 M NaCl + 0.1 M NaF 95°C
aerated soln.
12/28/00 SRB

Testing still in progress SRB 3/22/01

Ti grade 7 long-term pstat hold at 0 V_{SCE}
in 1 M NaCl + 0.0001 M NaF 95°C
12/28/00 SRB

5×10^{-4} M NaF
10^{-3} M NaF
10^{-2} M NaF
10^{-1} M NaF
} same conditions as above w/ different NaF concentrations

SRB 3/22/01



SRB 3/22/01

TIMET

Titanium Metals Corporation
100 Titanium Way, Toronto, Ohio 43964
Telephone (614) 537-5694, FAX (614) 537-5759

APPROVED CERTIFICATE

PAGE 1 OF 1

MILL ORDER 18-45811-02
HEAT R5835
CUSTOMER Titanium Industries
GRADE TIMETAL'50A .15Pd
PURCHASE ORDER 27203
PRODUCT DESCRIPTION 1" PLATE

SPECIFICATIONS

ASME 265 GR 7_95; ASTM B 265 GR 7_95A

CHEMICAL ANALYSIS
(Weight Percent)

	C	Fe	N	O	Pd
R5835-AVG	0.009	0.115	0.007	0.140	0.155

	H2 (ppm)	LOCATION	METHOD
R5835-J2658-1	50	-	HOT EXT.

The Chemistry reported is the average of two results.
Balance titanium.

MECHANICAL PROPERTIES

ANNEAL 30 MIN @ 1550°F-AC
Room Temperature Tensile Results (YS @ .2% offset)

IDENTITY	TENSILE DIR	TS KSI	YS KSI	4D, % EL	RA, %
R5835-J2658-1	L	79	54	25	45
R5835-J2658-1	T	85	64	25	48

COMPLIANCE STATEMENTS

1 Material has received a .010" minimum pickle.
2 Surface free from contamination.
3 Grade Ti-PD to ASTM B 265-95 Grade 7 and ASME SB 265-92 Grade 7.

Results are from TIMET Quality Control records on file
Cert Master used: PLATE18

Date : 8-JAN-1998
Time : 13:14

TIMET 85 M.R. McC
Authorized Signature

This certification package contains the following checked items :

MANIFEST ____
CERTIFICATION ____
BILLET MAP ____
CUSTOMER WAIVER FORM ____

MAT'L. I.D. NO. P586 P.O. NO. 41573
SPEC. K52400 TIGR7 INITIAL MBB K.T.

ANSI-RAB American Quality Assessors
REGISTERED ISO 9002

NADCAP NDT & LAB

First in Titanium Worldwide

1/8/01 SB

AMERICAN FILLER METALS CO.

P.O. BOX 12748 • HOUSTON, TEXAS 77217-2748
PHONE: (713) 649-8785 • FAX: (713) 644-9628 • 1-800-394-4550

*** ACTUAL MATERIAL TEST REPORT ***

CUSTOMER ORDER # 164264 | DATE 09/10/98 | OUR ORDER # 38617

SOLD: HOLOX
SHIP: HOLOX

ITEMS

ITM	QTY	PRODUCT CODE	/ HEAT #	DESCRIPTION
1	20	A	/BN4591	ERTI-7 1/16 X 36 AWS A5.16

CHEMICAL PROPERTIES

ITM	HEAT #	C	FE	O	H	N	FE	PD	TI
	BN4591	.01	.038		.0014	.007	.03	.184	BAL

CHEMICAL PROPERTIES

ITM HEAT #

PHYSICAL PROPERTIES

ITM	YIELD STRENGTH	TENSILE STRENGTH	ELONG. REQ. % IN 2"	AREA	HARDNESS	CHARPY TEST	LAT. EXPAN.	SHEAR % FRAC.	TEST TEMP
1									

NOTES

MAT'L. I.D. NO. P150 P.O. NO. 40153
SPEC. ERTI-7 INITIAL MBB

This certification is provided by American Filler Metals Inc. with the understanding that if the product covered does not conform to the stated specifications, there shall be no personal liability of any kind by the undersigned. Furthermore, the obligation and liability (if such non-conformance) by American Filler Metals, Inc. will be limited to: a) furnishing the purchaser with a product conforming to the correct specifications, at no additional charge, or b) to refund the full purchase price paid for such non-conforming product. American Filler Metals, Inc. will not be liable for consequential damage.

Authorized Representative

1/8/01 SB

Copies made and sent to QA records
SBruce 3/22/01

TABLE 1 Chemical Requirements

Element	Composition, %									
	Grade									
	1	2	3	4	5	6	7	10	11	12
Nitrogen, max	0.03	0.03	0.05	0.05	0.05	0.05	0.03	0.05	0.03	0.03
Carbon, max	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.08
Hydrogen,[A] max	0.015	0.015†	0.015	0.015	0.015	0.020	0.015	0.020	0.015	0.015
Iron, max	0.20	0.30	0.30	0.50	0.40	0.50	0.30	0.35	0.20	0.30
Oxygen, max	0.18	0.25	0.35	0.40	0.20	0.20	0.25	0.18	0.18	0.25
Aluminum	...	...	...	...	5.5 to 6.75	4.0 to 6.0	...	...	...	...
Vanadium	...	...	...	...	3.5 to 4.5	...	...	...	...	...
Tin	...	...	...	...	...	2.0 to 3.0	...	3.75 to 5.25	...	...
Palladium	...	...	...	...	...	...	0.12 to 0.25	...	0.12 to 0.25	...
Molybdenum	...	...	...	...	...	...	...	10.0 to 13.0	...	0.2 to 0.4
Zirconium	...	...	...	...	...	...	...	4.50 to 7.50	...	...
Nickel	...	...	...	...	...	...	...	...	...	0.6 to 0.9
Residuals[B,C] (each), max	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Residuals[B,C] (total), max	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Titanium[D]	remainder	remainder	remainder	remainder	remainder	remainder	remainder	remainder	remainder	remainder

[A] Lower hydrogen may be obtained by negotiation with the manufacturer.
[B] Need not be reported.
[C] A residual is an element present in a metal or an alloy in small quantities inherent to the manufacturing process but not added intentionally.
[D] The percentage of titanium is determined by difference.
† Editorially corrected.

1/8/01 SB

Ti 7 Long-Term Potentiostatic Hold @ 0 VSCE
In Cl Solutions

Cell #1
Solution:
116.88 g NaCl Lot# 010166
8.40 g NaF Lot# 991559
92.80 g $NaNO_3$ Lot# 961772A
261.36 Na_2SO_4 Lot# 901213
+DI water To 2000 mls

Start wt = 6.445 g
End wt = 6.420 g 8-1-01 BKO
PH I = 8.604
PH F = 8.092 8-1-01 BKO
Reference: Fisher 13-620-52 SN# 005223
Temp: 95°C Hg Thermometer SN# 110858 cal 5/3/02

Cell #2
Solution
116.89 g NaCl Lot# 010166
0.842 g NaF Lot# 991559
92.83 g $NaNO_3$ Lot# 961772A
261.35 g Na_2SO_4 Lot# 901213
+DI water To 2000 mls

Start wt = 6.403 g
End wt = 6.402 g 8-1-01 BKO
PH I = 6.942
PH F = 7.780 8-1-01 BKO
Reference: Fisher 13-620-52 SN# 5210481
Temp = 95°C Hg Thermometer SN# H00-387 cal 11/15/01

Cell #3
Solution
108.73 g NaCl Lot# 010166
19.324 g NaF Lot# 991559
93.50 g $NaNO_3$ Lot# 9617724
159.04 g Na_2SO_4 Lot# 901213
+DI water To 2000 mls

Start wt = 6.405 g
End wt = 6.395 g 8-1-01 BKO
PH I = 5.358
PH F = 8.290 8-1-01 BKO
Reference = Fisher 13-620-52 SN# 8238341
Temp = 95°C Hg Thermometer SN# H98-162 cal 5/1/02

All weight measurements Taken with
OHaus Precision Standard Scale SN# 2883 Cal 7/2/01

All PH measurements Taken with
Fisher Accumet 950 meter SN# 3340 cal 7/20/00 - Cal 7/24/01
Probe # 13-620-296 SN# 1100208

6/12/01

Ti 7 Long-Term Potentiostatic Hold @ 0 VSCE
In Cl Solutions

Cell #4
Solution
448.83 g NaCl Lot# 010166
6.047 g NaF Lot# 991559
394.36 g $NaNO_3$ Lot# 961772A
42.32 g Na_2SO_4 Lot# 901213
+DI water To 2000 mls

Start wt = 6.431 g
End wt = 6.426 g 8-1-01 BKO
PH I = 6.847
PH F = 7.905 8-1-01 BKO
Reference = Fisher 13-620-52 SN# 8205244
Temp = 95°C Hg Thermometer SN# C98-132 cal 8/8/00

Cell #5
Solution
116.84 g NaCl Lot# 010166
5.413 g NaF Lot# 991559
102.00 g $NaNO_3$ Lot# 961772A
11.084 g Na_2SO_4 Lot# 901213
+DI water To 2000 mls

Start wt = 6.428 g
End wt = 6.427 g 8-1-01 BKO
PH I = 6.808
PH F = 8.572 8-1-01 BKO
Reference = Fisher 13-620-52 SN# 8238321
Temp = 95°C Hg Thermometer SN# C96-852 cal 11-1-00

Cell #6
Solution
116.89 g NaCl Lot# 010166 6/12/01
1.581 g NaF Lot# 991559
101.99 g $NaNO_3$ Lot# 961772A
11.089 g Na_2SO_4 Lot# 901213
+DI water To 2000 mls

Start wt = 6.441 g
End wt = 6.438 g 8-1-01 BKO
PH I = 6.328
PH F = 7.791 8-1-01 BKO
Reference = Fisher 13-620-52 SN# 7282317
Temp = 95°C Hg Thermometer SN# C96-816 cal 11-1-00

All weight measurements Taken with
OHaus Precision Standard Scale SN# 2883 Cal 3/2/01

All PH measurements Taken with
Fisher Accumet 950 meter SN# 3340 cal 7/20/00 - Cal 7/24/01
Probe # 13-620-296 SN# 1100208

* Test Stopped 7-31-01 *

6/12/01

Copies made & sent to QA records

[signature] 9/17/2001

Potentiostatic Test of Ti_2

objective: To measure Crevice Corrosion on Ti_2 specimen

Specimen: Ti_2 Polished To 600 Grit Finish - 2 PTFE Crevice washers Attached At 50 In-Oz Using [illegible] Proto 6104 SN# 314047 cal 6/4/01
Start wt: 15.87147g Sartorius Genius SN# 12809099 cal 6/23/01
End wt: Not Taken

Solution: 1 m Cl⁻
146.108g NaCl Lot# 015568
+ DI water To 2500mls

Start pH = 6.589 Fisher Accumet 950 meter SN# 3340 cal 7/24/01
End pH = Not Taken PH Probe 13-620-296 SN# 1100208

Temperature 95°C Hg Thermometer SN# C96-833 cal 6/26/01

Potentiostat - Gamry model # PC4/750

Reference - Fisher 13-620-52 SN# 8205245

Ecorr -640mv Keithley 614 SN# 467374 cal 10/4/01
Ept -169mv

Solution Deaerated with 99.999% N_2

Specimen Assembled wet In Test Solution - Also 1 PTFE Crevice washer was Inverted
Specimen Examination - will Repolish for further Testing

* Test Shutdown Results Inconclusive [signature] 12/3/01

[signature] 11/20/01

Galvanostatic Test of Ti_2

objective: To Measure Crevice Corrosion on Ti_2 Specimen

Specimen: Ti_2 Polished To 600 Coat Finish
2 PTFE Crevice Washers Attached At 50 In-Oz
Using Proto 6104 SN# 314047 Cal 6/4/01

Start wt 15.84510 g Sartorius Genius SN# 12809099 Cal 6 Dec 01
End wt 13.95473 g

Solution 1m Cl⁻
146.142 g NaCl Lot # 015568
+ DI water To 2500 mls

Start pH: 6.753 Fisher Accumet 950 meter SN# 3340 Cal 7/24/01
End pH: 4.203 pH Probe 13-620-296 SN# 1100208

Temperature: 95°C Hg Thermometer SN# C96-833 Cal 6/26/01

Potentiostat: Solartron 1287

Reference: Fisher 13-620-52 SN# 8205245

Econn: -530 mv Keithley 614 SN# 467374 Cal 10/4/01
Ept: +60 mv

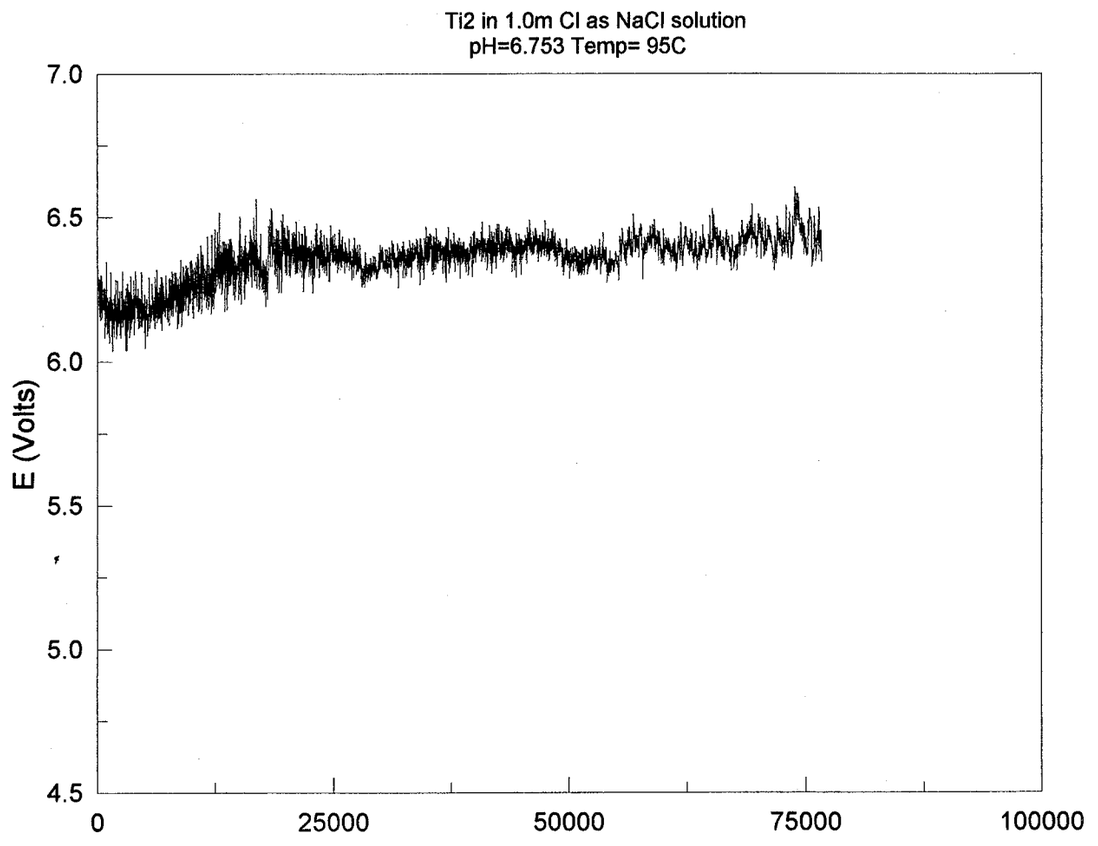
Solution Deaerated with 99.999% N_2

Specimen Assembled wet In Test Solution - with 1 PTFE Crevice washer Inverted

Specimen Examination - Crevice Corrosion Noticed on Specimen Also All Surfaces of Specimen Are Determined

Test Data Ti_2 galvastat1.con

12/5/01



12/6/01

12/6/01

Galvanostatic Test of ~~Ti7~~ 12/4/01 Ti 7

Objective: To measure Crevice Corrosion on Ti 7 Specimen

Specimen: Ti 7 Polished To 600 Grit Finish
2 PTFE Crevice washers Attached At 50 In-Oz
Using Proto 6104 SN# 314047 Cal 6/4/01

Start wt = 16.72151g Santorious Genius SN# 12809099 Cal 6/22/01
End wt = 14.83953g

Solution = 1m Cl^-
146.153g NaCl Lot# 015564
+ DI water To 2500mls

Start pH = 6.547 Fisher Accumet 950 meter SN# 3340 Cal 7/24/01
End pH = 6.055

Temperature = 95°C Hg Thermometer SN# C96-833 Cal 6/26/01

Potentiostat = Solartron 1287

Reference = Fisher 13-620-52 SN# 8205245

E_{conn} = +156 Keithley 614 SN# 467374 Cal 10/4/01
E_{pt} = -445

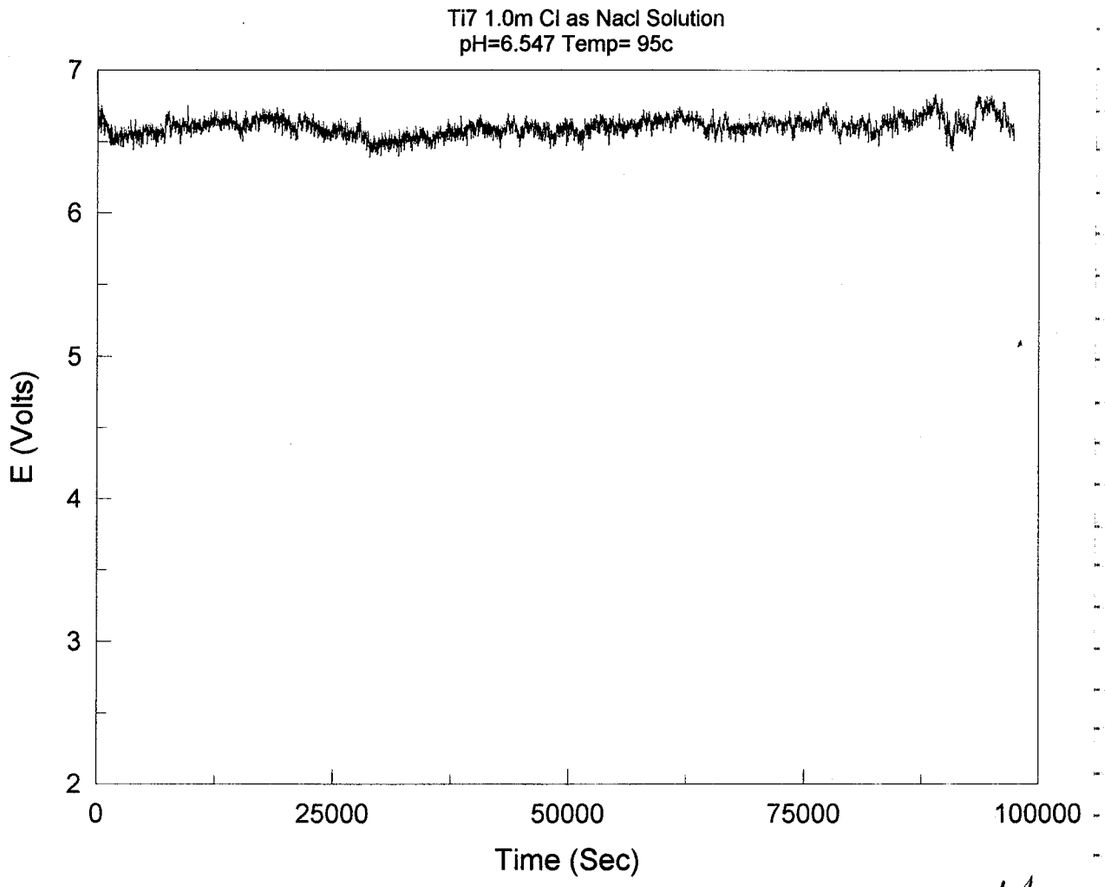
Solution Deaerated with 99.999% N_2

Specimen Assembled wet In Test Solution - with 1 PTFE Crevice washer Inverted

Specimen Examination: Crevice Corrosion Noticed on Specimen
All Surfaces of Specimen Are Deformed

Test Data Ti7 galvstat1.com

12/6/01



12/7/01

Copies to QA

3/12/02 SRB

9/5/02 SRB

I have reviewed this scientific notebook and find it in compliance with QAP-001. There is sufficient information regarding procedures used for conducting tests, acquiring and analyzing data so that another qualified individual could repeat the activity.

9/27/2004