Electrochemical Corrosion Testing of Tanks 241-AN-102, 241-AP-107, and 241-AP-108 in Support of Ultrasonic Testing

R. B. Wyrwas and J. B. Duncan
Washington River Protection Solutions LLC
Richland, WA 99352
mlb 11/20/08
08RV14800
U.S. Department of Energy Contract DE-AC27-~~99RL14047~~

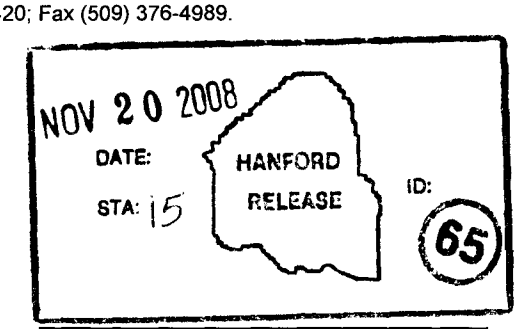
EDT/ECN: DRF UC:
Cost Center: 2EK00 Charge Code:
B&R Code: Total Pages: 35

Key Words: materials, methods, results, Tafel, scans, analytical chemistry data, cyclic potentiodynamic polarization, double-shell tank, corrosion potential, repassivation potential, open circuit potential, ultrasonic, electrochemical, formulations, composites, sample, tank AN-102, AP-107, AP-108, steel, ASTM, saltcake, Segment 21R1, Segment 21R2, Core 307, supernatant, sludge

Abstract: This report presents the results of the corrosion rates that were measured using electrochemical methods for tanks 241-AN-102 (AN-102), 241-AP-107 (AP 107), and 241-AP-108 (AP-108) performed under test plan RPP-PLAN-38215. The steel used as materials of construction for AN and AP tank farms was A537 Class 1. Test coupons of A537 Class 1 carbon steel were used for corrosion testing in the AN-107, AP-107, and AP-108 tank waste. Supernate will be tested from AN-102, AP-107, and AP-108. Saltcake testing was performed on AP-108 only.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: Document Control Services, P.O. Box 950, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.



L. T. Randal 11/20/08
Release Approval Date

Release Stamp

Approved For Public Release

RPP-RPT-39224
Revision 0

Electrochemical Corrosion Testing of Tanks 241-AN-102, 241-AP-107, and 241-AP-108 in Support of Ultrasonic Testing

R. B. Wyrwas
J. B. Duncan
Washington River Protection Solutions LLC

November 2008

Prepared for the U.S. Department of Energy
Office of River Protection

Contract No. DE-AC27-08RV14800

TABLE OF CONTENTS

1. INTRODUCTION 1
2. MATERIALS AND METHODS 3
3. RESULTS 4
4. DISCUSSION 8
5. REFERENCES 9
Appendix A Tafel Scans i
Appendix B Analytical Chemistry Data i

List of Figures

Figure 1. 241-AP-108 Core 330 Segment 24BR1 after Anaerobic Extrusion 6
Figure 2. 241-AP-108 Core 330 Segment 24BR2 after Anaerobic Extrusion 7
Figure 3. 241-AP-108 Core 330 Segment 24BR2 after Agitation 7
Figure 4. Electrochemical Cell Response to High and Low ASTM Reported Values. 8

List of Tables

Table 1. Tank Samples and Steel; X = Sample Run under this Test Plan; Done = Samples Run Under Separate Test Plans 2
Table 2. Sample Identification by Tank. 3
Table 3. AN-102 Composite Formulations 4
Table 4. Chemical Concentrations for Tank Waste Samples and Tank Waste Composites 4
Table 5. Electrochemical Constants and Corrosion Rates for Tank Waste Samples and Composite Samples. 5
Table 6. AP-107 Composite Formulation. 5

List of Terms

AN-102, 2AN	tank 241-AN-102
AP-107, 7AP	tank 241-AP-107
AP-108, 8AP	tank 241-AP-108
ASTM	American Society for Testing and Materials
AZ-102	tank 241-AZ-102
CPP	cyclic potentiodynamic polarization
DST	double-shell tank
E_{corr}	corrosion potential
E_{RP}	repassivation potential
OCP	open circuit potential
SY-101	tank 241-SY-101
UT	ultrasonic
WTP	Waste Treatment and Immobilization Plant

1. INTRODUCTION

The double-shell tanks (DST) are required to remain in service well beyond their design life to support the mission for treatment and disposal of the radioactive chemical wastes stored in the underground tank farms. The integrity of the DSTs must be protected to ensure the DSTs remain available for interim storage prior to Waste Treatment and Immobilization Plant (WTP) startup and during feed staging and transfer to support the WTP operations. Controlling aggressive forms of corrosion helps to protect the integrity of the tanks and extend their useful life. The primary means for determining the impact of corrosion on the DSTs is to periodically perform ultrasonic (UT) examinations of the primary tank carbon steel wall (RPP-7574, *Double-Shell Tank Integrity Program Plan*). The corrosion rates determined from this method require measurements over long time periods. Another independent method for determining corrosion rates of carbon steel exposed to an electrolyte is by using electrochemical methods, which have the advantage of measuring a corrosion rate in a single measurement and nearly instantaneously.

This report presents the results of the corrosion rates that were measured using electrochemical methods for tanks 241-AN-102 (AN-102), 241-AP-107 (AP-107), and 241-AP-108 (AP-108) performed under test plan RPP-PLAN-38215, *Electrochemical Corrosion Testing of Tanks 241-AN-102, 241-AP-107, and 241-AP-108 in Support of Ultrasonic Testing*. The steel used as materials of construction for AN and AP tank farms was A537 Class 1. Test coupons of A537 Class 1 carbon steel were used for corrosion testing in the AN-107, AP-107, and AP-108 tank waste. Supernate will be tested from AN-102, AP-107, and AP-108. Saltcake testing was performed on AP-108 only. A more detailed discussion of each tank follows:

a. **AN-102** Core 307, Segments 21R1 and 21R2, saltcake were previously subjected to electrochemical testing. AN-102 corrosion potential measurements were made on the saltcake from Core 307 in 2003 and corrosion rates calculated (interoffice memo 7S110-CMS-03-005, "Electrochemical Corrosion Testing of A537 Class 1 Carbon Steel in 241-AN-102 Sludge"). The data from this testing is presented for the AN-102 saltcake layer. The supernatant layer, which is higher in pH, has been tested for this report. Samples were taken during the May 2006 grab sampling event for process chemistry testing. One of the tests planned using these samples was corrosion potential testing. Samples were formulated for a supernatant composite to be used for Tafel and cyclic potentiodynamic polarization (CPP) testing. The composite used equal volumes of samples 2AN-06-01DUP, 2AN-06-02DUP, and 2AN-06-03DUP, which were taken for the top, middle, and bottom of the AN-102 supernatant. A subsample of the supernatant composite was analyzed.

b. **AP-107** was last sampled on December 30, 2003. Since then waste was transferred out of the tank in June 2004 and the tank backfilled with transfers from several sources, primarily AP-108 in March-June 2005 and tank 241-SY-101 (SY-101) in May 2006 [the tank received a recent transfer from tank 241-AZ-102 (AZ-102), but that occurred after completing the UT examination]. Any samples of AP-107 in archive will not be representative of the waste that was stored in the tank at the time of the FY 2008 UT examination. A supernatant composite was constructed from the samples taken from the

source tanks that made up the AP-107 waste supernatant at the time of the UT examination.

The composite was comprised of approximately

1. 18 vol% of the December 30, 2003, AP-107 supernatant grab sample event (7AP-03-01 surface sample).

2. 12 vol% of the January 8, 2006, AP-108 supernatant sample event (any of the samples 8AP-05-01, 8AP-05-02, or 8AP-05-03).

3. 70 vol% of the January 15, 2006, SY-101 supernatant grab sampling event (any of the samples 1SY-06-01, 1SY-06-02, 1SY-06-02DUP, 1SY-06-03, and 1SY-06-04).

A subsample of the supernatant composite was analyzed. Because the settled solids in the tank are minimal, only the supernatant was tested.

c. **AP-108** was core (330) sampled between February 14-March 17, 2008. Three supernatant segments and two saltcake retake segments from the tank bottom were obtained. Performing corrosion potential testing of the supernatant and saltcake was already planned in RPP-PLAN-37354, *Electrochemical Corrosion Testing for Tank 241-AP-108 Core 330, Supernatant and Segments 24BR1 and 24BR2*. The data generated from this testing can be used to support the UT examination program. RPP-PLAN-37354 requires instruction for preparing a supernatant composite for the testing. The supernatant composite would be comprised of approximately 18 vol% of Segment 330-1, 22 vol% of Segment 330-7, and 60 vol% of Segment 330-21. A subsample of the supernatant composite was analyzed.

The supernatant samples were composited as discussed in items a through c. The samples were tested under atmospheric condition and at room temperature. The sludge/saltcake samples testing were performed under anaerobic conditions.

Table 1 shows the tank waste sample tested by tank and class of steel. Table 2 gives the identification of the core (or grab sample) and segment numbers for each tank.

Table 1. Tank Samples and Steel; X = Sample Run under this Test Plan; Done = Samples Run under Separate Test Plans.

Tank/Material	AN-102	AP-107	AP-108
Supernatant	X (composite)	X (composite)	Done (composite)
Sludge/saltcake	Done	NA	Done
Steel	A537, Cl 1	A537, Cl 1	A537, Cl 1

Table 2. Sample Identification by Tank.

Tank	AN-102	AP-107	AP-108
Supernatant	Composite, equal volumes of AN-102-06-01DUP AN-102-06-02DUP AN-102-06-03DUP	Composite, 18% 7AP-03-01 12% 8AP-05-01, 8AP-05-02, 8AP-05-03* 70% 1SY-06-01, 1SY-06-02, 1SY-06-02DUP, 1SY-06-03, and 1SY-06-04*	Composite, 18% Segment 330-1 22% Segment 330-7 60% Segment 330-21
Sludge/saltcake	Done	NA	Core 330, Segments 24BR1 and 24BR2

* The selection of the sample will be based on availability.

A minimum of three tank steel coupons per tank waste sample were tested using an electrochemical cell design that allows interrogation of a different sample location for each coupon. All electrochemical scans were carried out at ambient hot cell temperature, which is approximately 25 °C (77 °F).

The electrochemical derived corrosion rate was calculated from the cathodic and anodic Tafel slopes using "The Shape of Electrochemical Polarization Curves" equation (Stern and Geary 1957). The software associated with the slope data selection and the corrosion rate calculation is PowerCORR®.[1] The third coupon was used to perform a CPP scan, reversing at 2.5 mA/cm^2 (ASTM G61-86, *Standard Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel-, or Cobalt-Based Alloys*).

2. MATERIALS AND METHODS

The coupons used in this study were obtained from Metal Samples®[2] and were A537 Class 1 EL410 (right cylinder configuration) with an area of approximately 5.64 cm^2. All coupons were prepared by a surface treatment of 600-grit wet sandpaper followed by sonication in acetone for 2 minutes and then fixing the coupon to a type 316 stainless steel electrode rod. A new sample coupon was used for each Tafel scan and each CPP scan.

As an instrument check, a scan using the ASTM G5-94, *Standard Reference Test Method for Making Potentiostatic and Potentiodynamic Anodic Polarization Measurements*, was carried out in a 500-mL I-CHEM®[3] jar used as the electrochemical cell before and after the corrosion potential scans.

[1] PowerCORR® is a registered trademark of Advanced Measurement Technologies, Inc., Oak Ridge, Tennessee.
[2] Metal Samples® is a division of Alabama Specialty Products, Inc., Munford, Alabama.
[3] I-CHEM® is a subsidiary of Nalge Nunc International Corporation, Rochester, New York.

The potentiostat used is a PARSTAT®[4] 2263 with data collection and analyses software, PARSTAT® PowerSuite, Advanced Electrochemistry Software, Version 2.33. The potentiostat has a 20-V compliance voltage and a maximum current of up to ±200 mA.

After surface preparations, the coupons were submerged in the sample and allowed to equilibrate at room temperature for 18 to 24 hours before a Tafel scan or CPP scan was initiated at the same temperature. Details of the Tafel scan, CPP scan, and electrochemical theory behind the technique are in RPP-PLAN-38215, *Electrochemical Corrosion Testing of Tanks 241-AN-102, 241-AP-107, and 241-AP-108 in Support of Ultrasonic Testing*.

3. RESULTS

3.1 AN-102

The composite of the AN-102 sample was a dark brown liquid, much like black coffee. The formulation of the composite is given in Table 3. The results of the chemical analysis performed on this composite sample are given in Table 4 for nitrate, nitrite, and hydroxide concentrations. The electrochemical constants and corrosion rates are given in Table 5. The Tafel scans and CPP scan performed on the tank waste composite are in Appendix A. The complete analytical sample results for the AN-102 composite are in Appendix B.

Table 3. AN-102 Composite Formulations.

Tank Waste Sample	Required Amount (mL)	Required Amount (mg)
2AN-06-01DUP	100.0	155.2
2AN-06-02DUP	100.0	158.1
2AN-06-03DUP	100.0	154.7
Totals	300.0	468.0

Table 4. Chemical Concentrations for Tank Waste Samples and Tank Waste Composites.

Sample	$[NO_3^-]$, M	$[NO_2^-]$, M	$[OH^-]$, M
8AP Core 330, Segment 24BR2*	-	-	-
8AP composite	2.9	1.7	2.4
7AP composite	2.4	0.6	1.1
2AN composite	3.0	1.8	0.4
2AN Core 307, Segment 21R1	3.3	1.9	0.3

* Data will be reported when available as a revision to this report and alternatively in RPP-RPT-39396, *Electrochemical Corrosion Testing for Tank 241-AP-108 Core 330, Supernatant and Segments 24BR1 and 24BR2.*

[4] PARSTAT ® PowerSuite is a registered trademark of Princeton Applied Research, Oak Ridge, Tennessee.

Table 5. Electrochemical Constants and Corrosion Rates for Tank Waste Samples and Composite Samples.

Tank Waste Sample	E_{corr} (mV)	I_{corr}(μA)	Corrosion Rate (mpy)	χ^2
8AP Core 330 24BR2 scan 1	-546	1.1	9.02 E-02	25
8AP Core 330 24BR2 scan 2	-531	6.1 E-01	4.93 E-02	53
8AP Core 330 24BR2 scan 3	-540	9.0 E-01	7.32 E-02	50
8AP Core 330 24BR2 scan 4	-523	1.0	8.41 E-02	69
8AP composition scan 1	-458	1.2 E-01	9.56 E-03	6.8
8AP composition scan 2	-503	1.7 E-01	1.38 E-02	19
8AP composition scan 3	-505	1.3 E-01	1.11 E-02	20
8AP composition scan 4	-466	8.9 E-02	6.96 E-03	58
7AP composition scan 1	-373	3.3 E-01	2.79 E-02	3.3
7AP composition scan 2	-377	1.7 E-01	1.34 E-02	4.7
7AP composition scan 3	-355	1.4 E-01	1.13 E-02	4.2
2AN composition scan 1	-411	5.8 E-01	5.48 E-02	26
2AN composition scan 2	-441	6.2 E-01	5.00 E-02	54
2AN composition scan 3	-459	8.1 E-01	6.55 E-02	9.5
2AN Core 307 21R2 scan 1*	-228	8.0 E-02	6.0 E-03	18
2AN Core 307 21R2 scan 2*	-177	2.4 E-01	2.0 E-02	9
2AN Core 307 21R2 scan 3*	-366	3.3 E-01	3.0 E-02	9

*Data obtained from 7S110-CMS-03-005, 2003, "Electrochemical Corrosion Testing of A537 Class 1 Carbon Steel in 241-AN-102 Sludge."

3.2 AP-107

The composite supernate samples from AP-107 were yellow in color and were not notably different than any other tank. The tank waste samples used for the composite formulation and the amount of each sample used are listed in Table 6. The results of the chemical analysis performed on this composite sample are in Table 4 for nitrate, nitrite, and hydroxide concentrations. The electrochemical constants and corrosion rates are in Table 5. The Tafel scans performed on this tank waste composite are in Appendix A. The complete sample analytical results for the AP-107 composite are in Appendix B.

Table 6. AP-107 Composite Formulation.

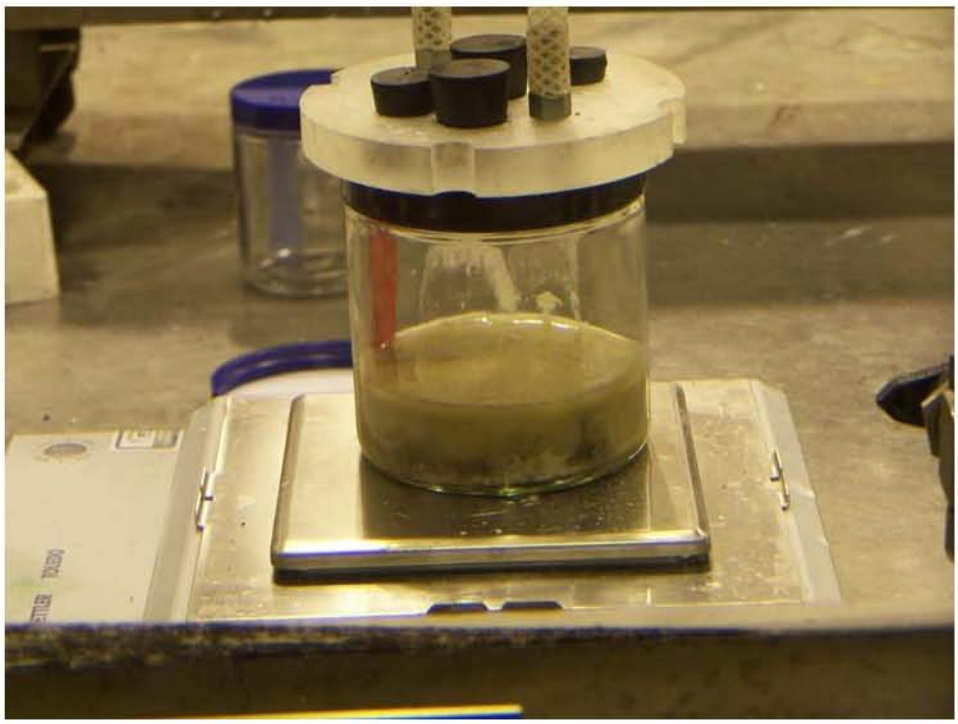
Tank Waste Sample	Required Amount (mL)	Required Amount (mg)
7AP-03-01	54.0	65.9
8AP-05-02	36.0	51.7
1SY-06-02DUP	140.0	179.1
1SY-06-04	70.0	89.2
Totals	300.0	385.8

3.3 AP-108

The grab samples from AP-108 were yellow in color and no different than any other tank. The tank waste sample extruded via anaerobic methods from Core 330, Segments 24BR1 and 24BR2, had a white interior and a brown exterior as in Figures 1 and 2. Segment 24BR1 contained a drainable liquid portion and a solid portion. Segment 24BR2 appeared to be very dry with no liquid. The segment was allowed to rest in the sealed electrochemical cell in argon for 24 hours. After the 24-hour period, the segment remained unchanged. Agitation of Segment 24BR2 caused the sample to physically break down and was found to contain liquid as seen in Figure 3. The homogenized waste was a brown in color. A more detailed description will be given in RPP-RPT-39396, *Electrochemical Corrosion Testing for Tank 241-AP-108 Core 330, Supernatant and Segments 24BR1 and 24BR2*. Tafel scans and CPP scan performed on the waste composite and core segments are in Appendix A. Since four scans were required under test plan RPP-PLAN-37354, an additional Tafel scan was available for this report; thus four scans are reported here for AP-108 composite and Core 330, Segment 24BR2.

The chemical concentrations of the AP-108 composite for nitrate, nitrite, and hydroxide are given in Table 4. The chemical analysis is not yet complete for Core 330, Segment 24BR2. The data will be included in a revised version of this report and alternatively included in RPP-RPT-39396. The complete results for the AP-108 composite are in Appendix B. Table 5 gives the corrosion potential (E_{corr}) in mV, the corrosion current in μA, and the corrosion rate in mils per year (mpy) for the tank waste samples studied. The associated chi-squared[5] (χ^2) is also provided.

Figure 1. 241-AP-108 Core 330 Segment 24BR1 after Anaerobic Extrusion.



[5] The chi-squared term is the goodness-of-fit measurement calculated by the fitting algorithm of the software package. A value less than 100 is considered acceptable.

Figure 2. 241-AP-108 Core 330 Segment 24BR2 after Anaerobic Extrusion.

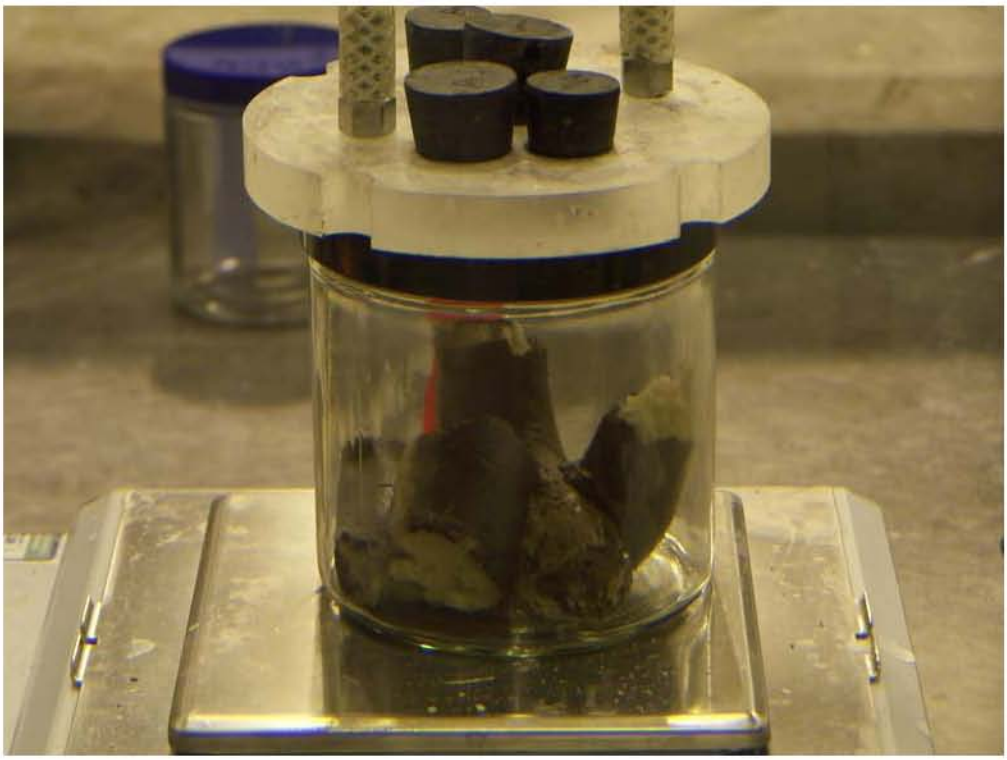


Figure 3. 241-AP-108 Core 330 Segment 24BR2 after Agitation.

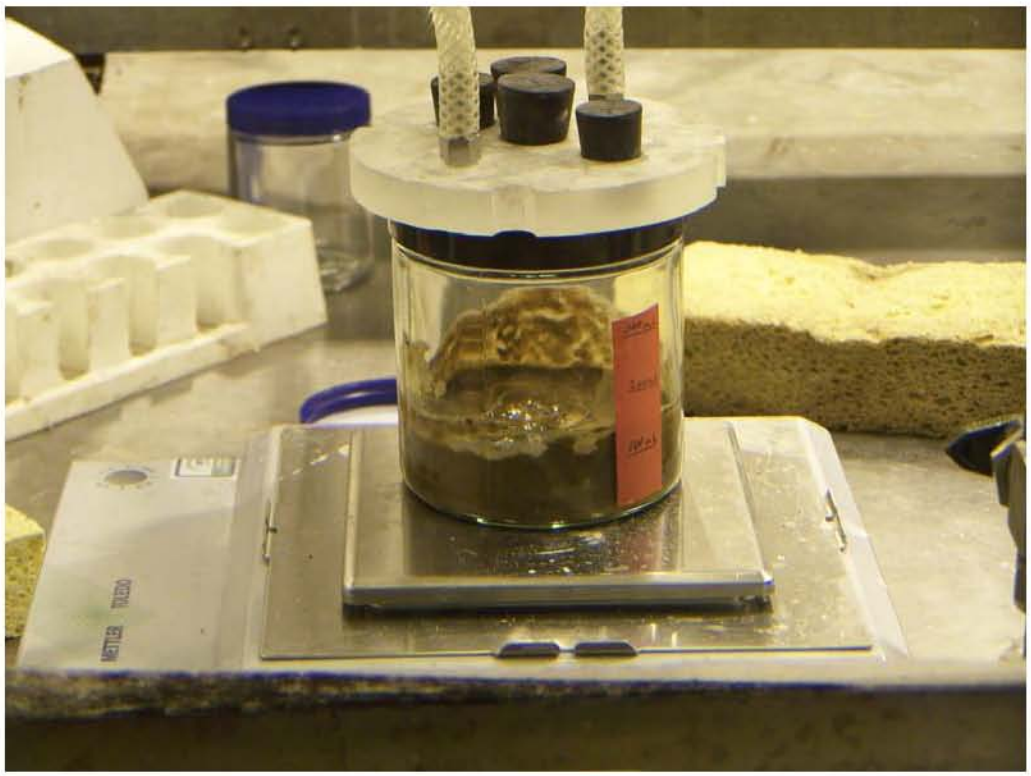
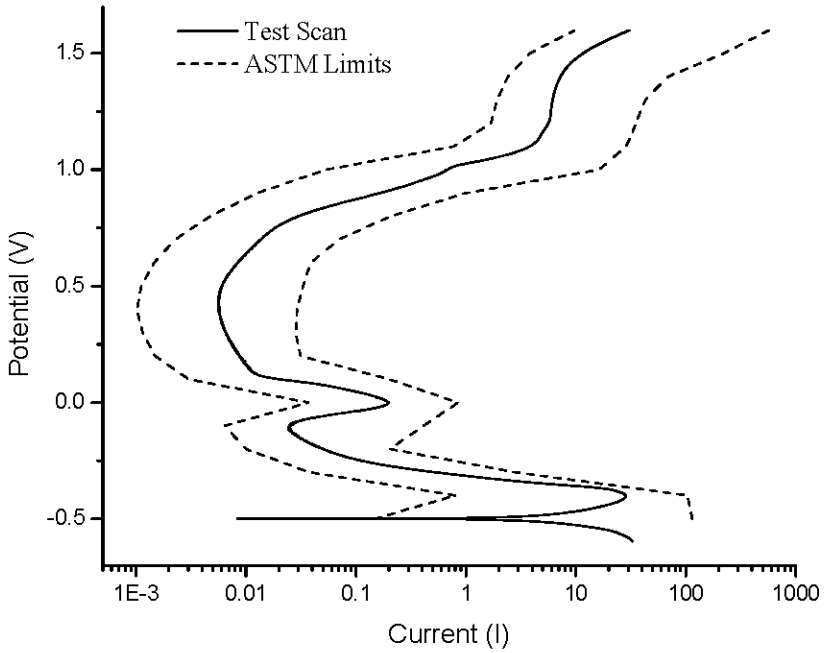


Figure 4 shows the electrochemical cell response to the ASTM G5-94 method. The cell response agrees well with the standard results demonstrating proper performance of the equipment and cell configuration. The acceptable ASTM high and low values are also displayed for reference.

Figure 4. Electrochemical Cell Response to High and Low ASTM Reported Values.



4. DISCUSSION

The corrosion rates for the tank waste samples and composite samples measured in this report were low with the highest rate being 9.02 E-02 mpy. With the exception of the AN-102 Core 307, the E_{corr} values are very low, which support a low generalized corrosion rate. The higher corrosion potentials alone cannot imply any specific corrosion behavior.

The CPP scans performed on the composite components of AN-102, AP-107, AP-108, and AP-108 Core 330, Segment 24BR2, show no indications of pitting by the observed negative hysteresis in the scan. The lower return current indicates pitting corrosion is not a concern for these waste samples. The CPP scans for the AP-107 and AP-108 composites give repassivation potentials (E_{RP}) that are 161 mV and 189 mV, respectively, above the corrosion potential (E_{corr}). The repassivation potential is the potential at which zero current is measured during the reverse scan of the CPP scan. The difference between E_{corr} and E_{RP} can be used as a measure of the corrosion resistance of a particular material [*Corrosion Tests and Standards: Application and Interpretation* (Sculley 2005)]. A greater difference between the two potentials will amount to a higher resistance to corrosion. Currently there are no guidelines set at the Hanford Site that would dictate action levels based on the difference between the E_{corr} and E_{RP}.

5. REFERENCES

7S110-CMS-03-005, 2003, "Electrochemical Corrosion Testing of A537 Class 1 Carbon Steel in 241-AN-102 Sludge" (interoffice memo from C. M. Seidel to K. G. Carothers, October 9), CH2M HILL Hanford Group, Inc., Richland, Washington.

ASTM G5-94, 2004 (Reapproved 2004), *Standard Reference Test Method for Making Potentiostatic and Potentiodynamic Anodic Polarization Measurements*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

ASTM G61-86, 2003 (Reapproved 2003), *Standard Test Method for Conducting Cyclic Potentiodynamic Polarization Measurements for Localized Corrosion Susceptibility of Iron-, Nickel-, or Cobalt-Based Alloys*, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

RPP-7574, 2007. *Double-Shell Tank Integrity Program Plan*, Rev. 2, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-PLAN-37354, 2008, *Electrochemical Corrosion Testing for Tank 241-AP-108 Core 330, Supernatant and Segments 24BR1 and 24BR2*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

RPP-PLAN-38215, 2008, *Electrochemical Corrosion Testing of Tanks 241-AN-102, 241-AP-107, and 241-AP-108 in Support of Ultrasonic Testing*, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

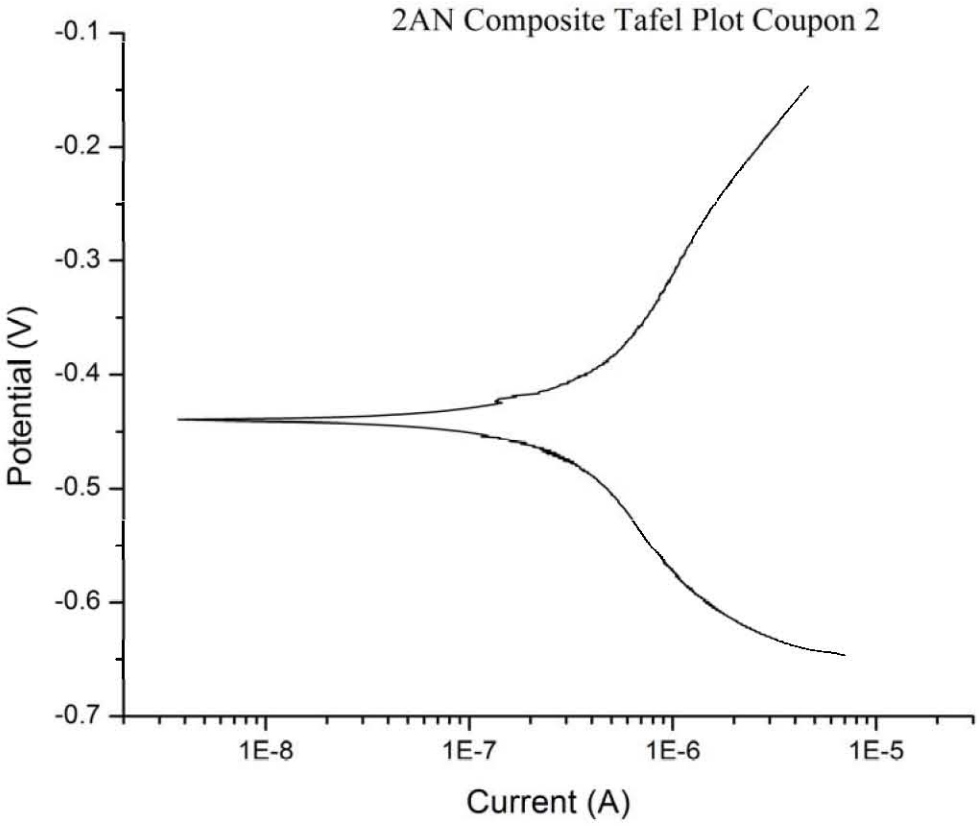
RPP-RPT-39396, 2008, *Electrochemical Corrosion Testing for Tank 241-AP-108 Core 330, Supernatant and Segments 24BR1 and 24BR2*, Draft, Washington River Protection Solutions LLC, Richland, Washington.

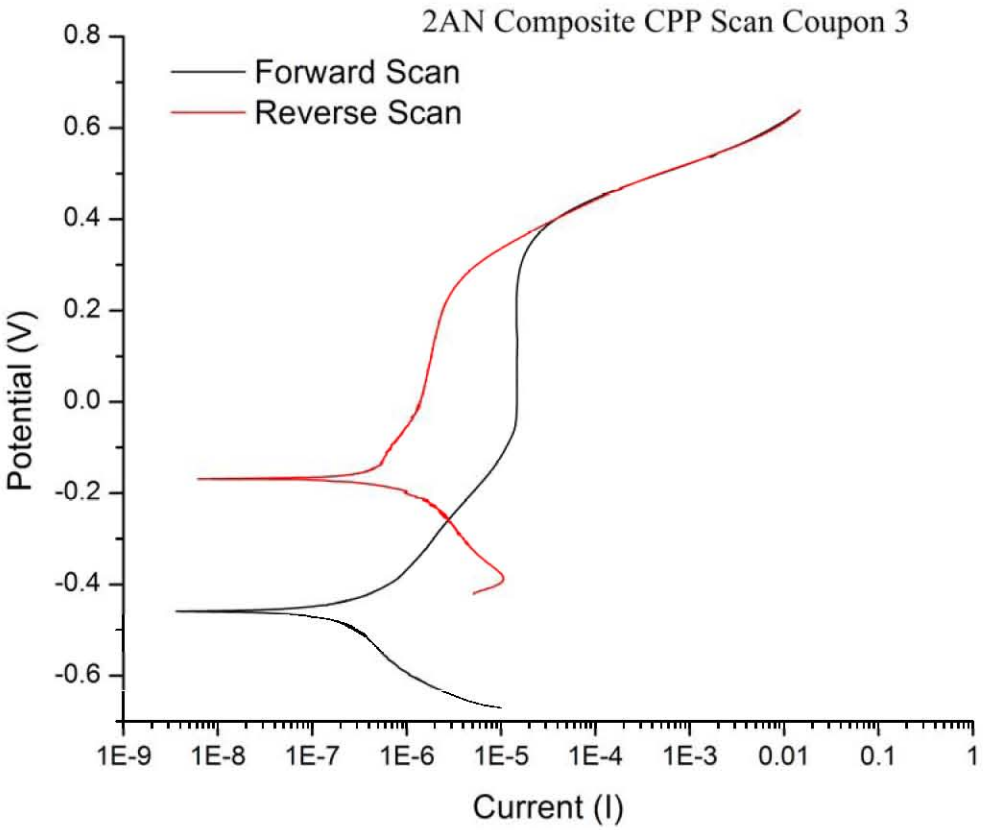
Sculley, J. R., 2005, Chapter 7, "Electrochemical Tests," in *Corrosion Tests and Standards: Application and Interpretation*, 2nd Edition, pp. 107-130, ASTM International, West Conshohocken, Pennsylvania.

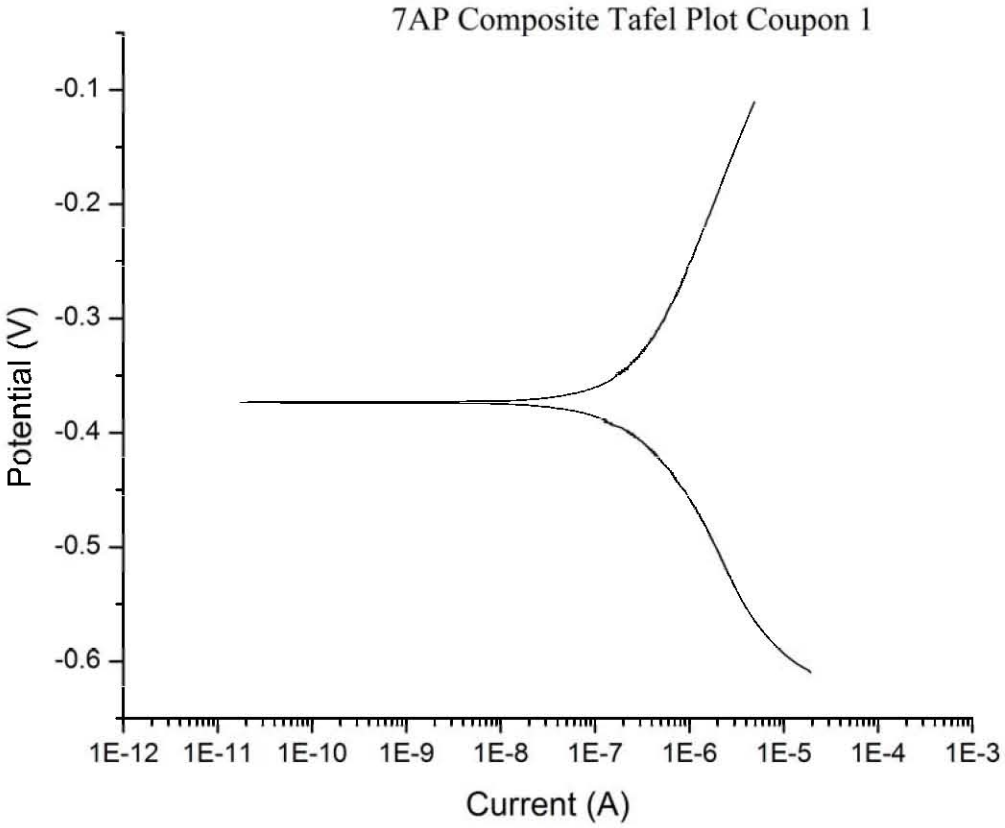
Stern, M., and A. L. Geary, 1957, "The Shape of Electrochemical Polarization Curves," *J. Electrochem. Soc.*, 104, 56.

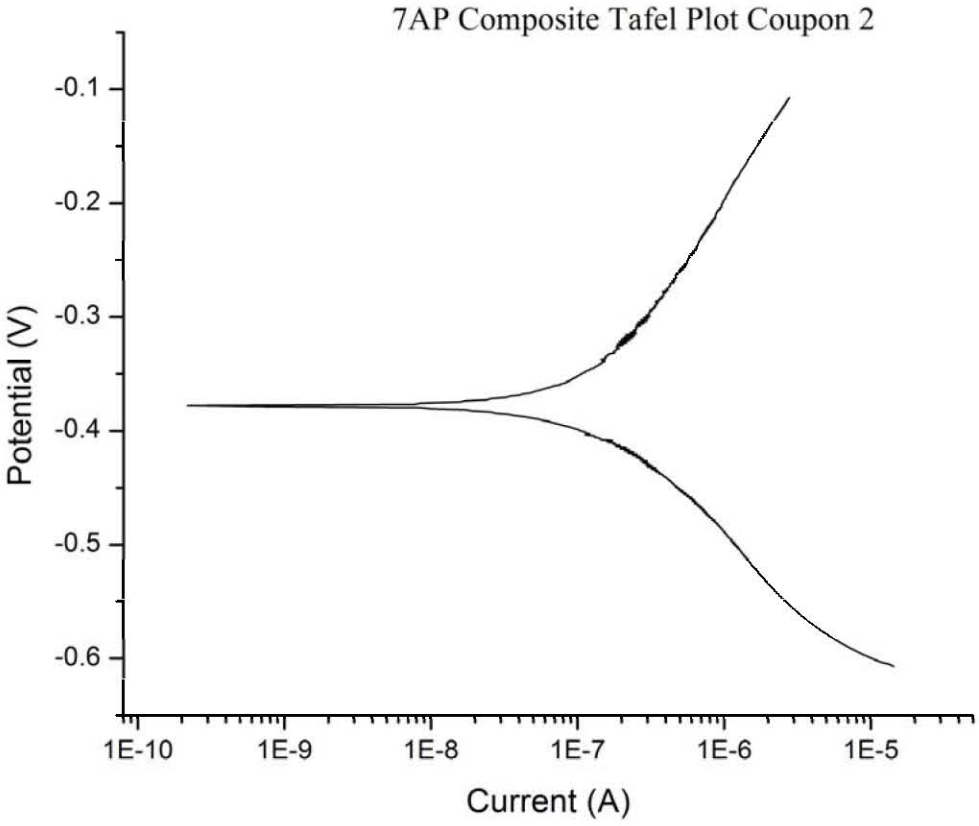
Appendix A

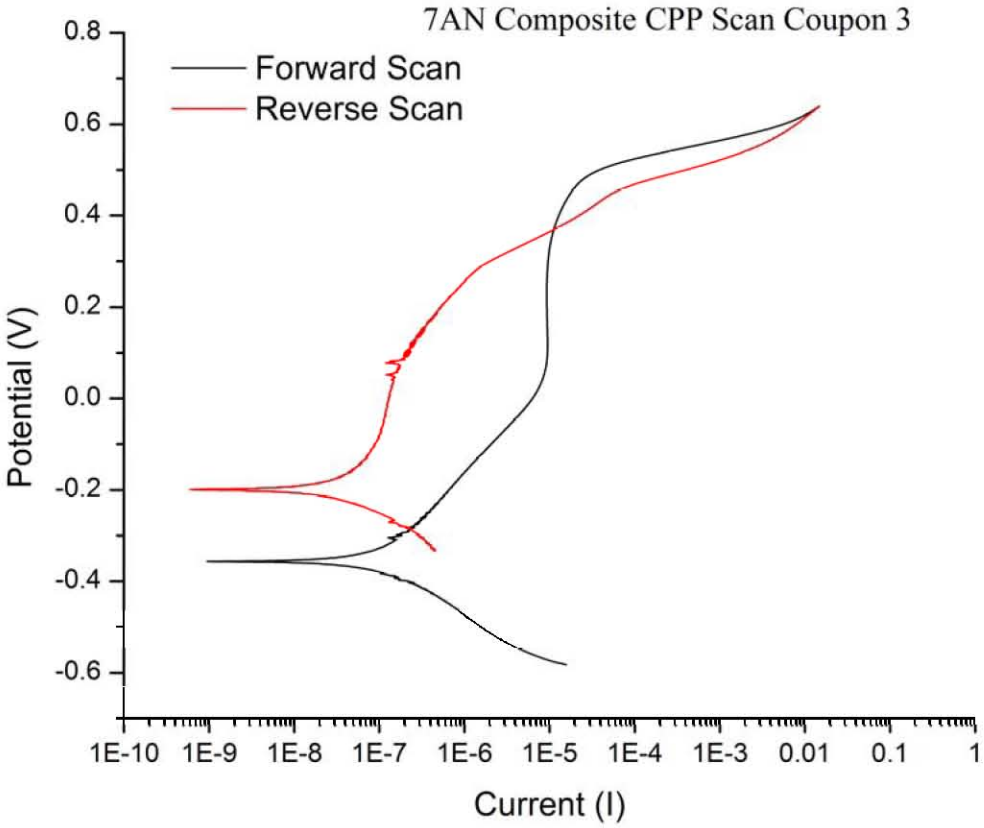
Tafel Scans

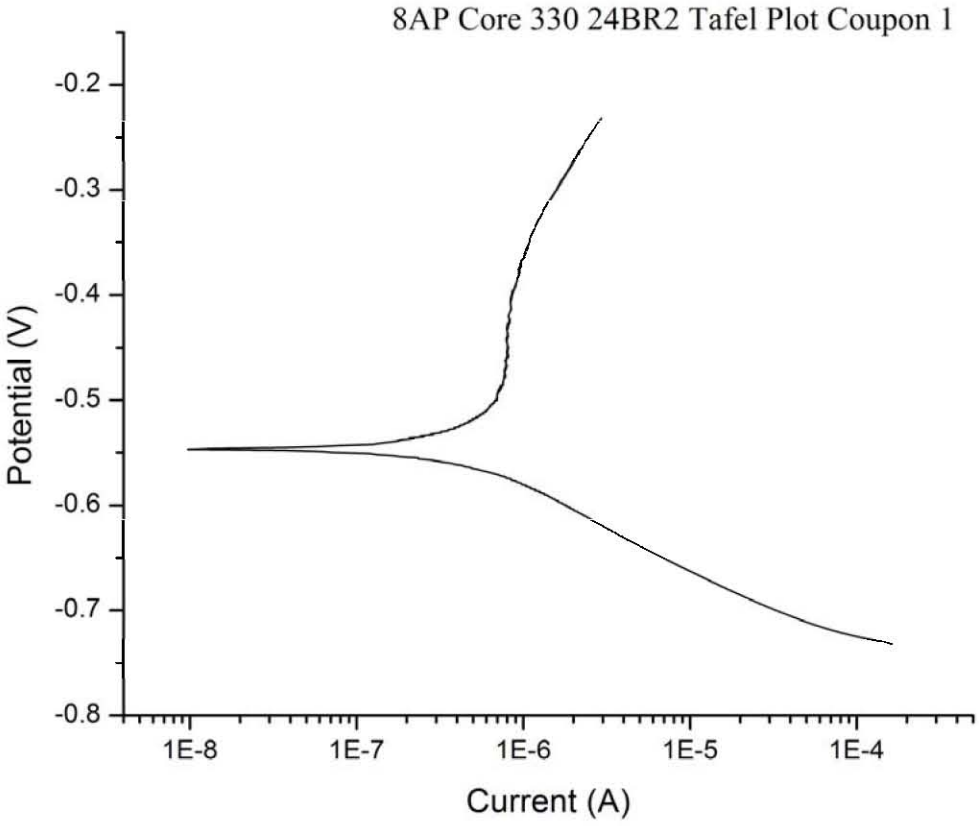

2AN Composite Tafel Plot Coupon 2
Potential (V)
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
1E-8
1E-7
1E-6
1E-5
Current (A)

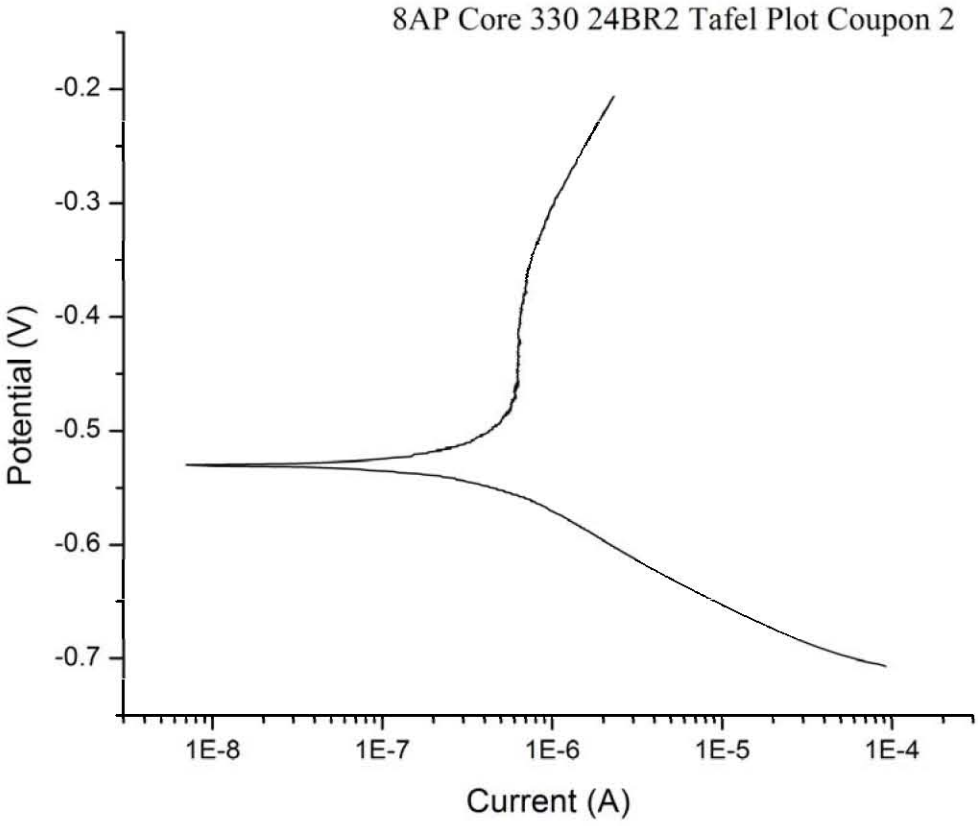

2AN Composite CPP Scan Coupon 3
Forward Scan
Reverse Scan
Potential (V)
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
1E-9
1E-8
1E-7
1E-6
1E-5
1E-4
1E-3
0.01
0.1
1
Current (I)

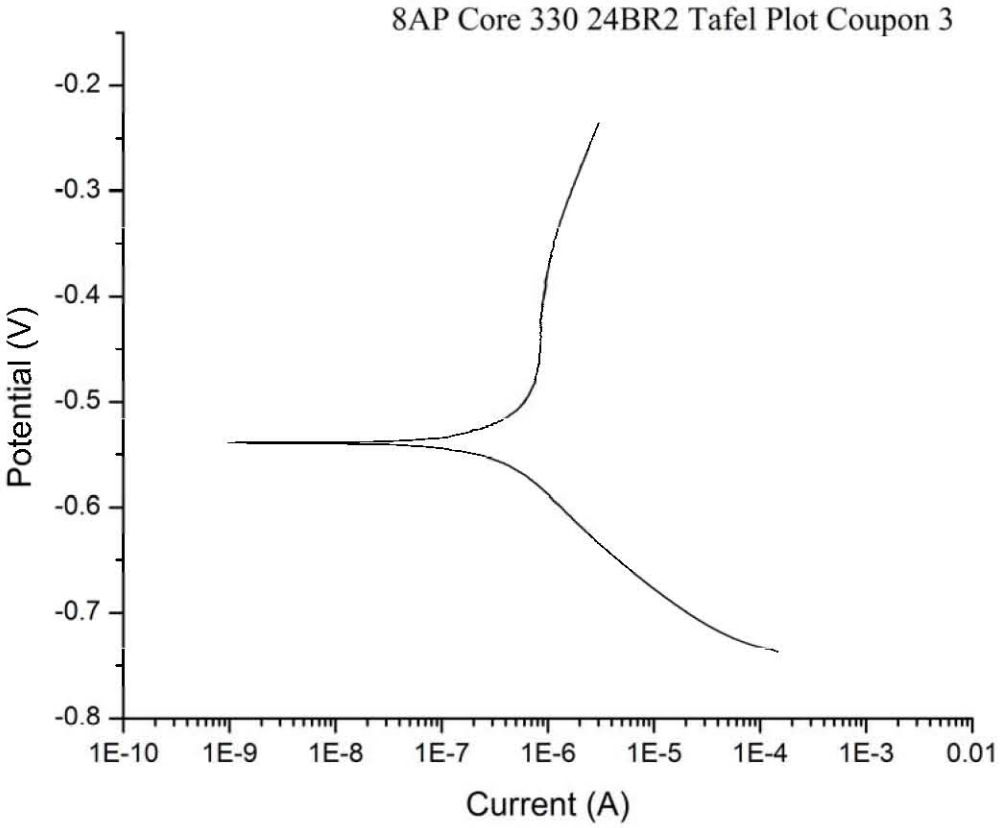

7AP Composite Tafel Plot Coupon 1
Potential (V)
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
1E-12
1E-11
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
1E-4
1E-3
Current (A)

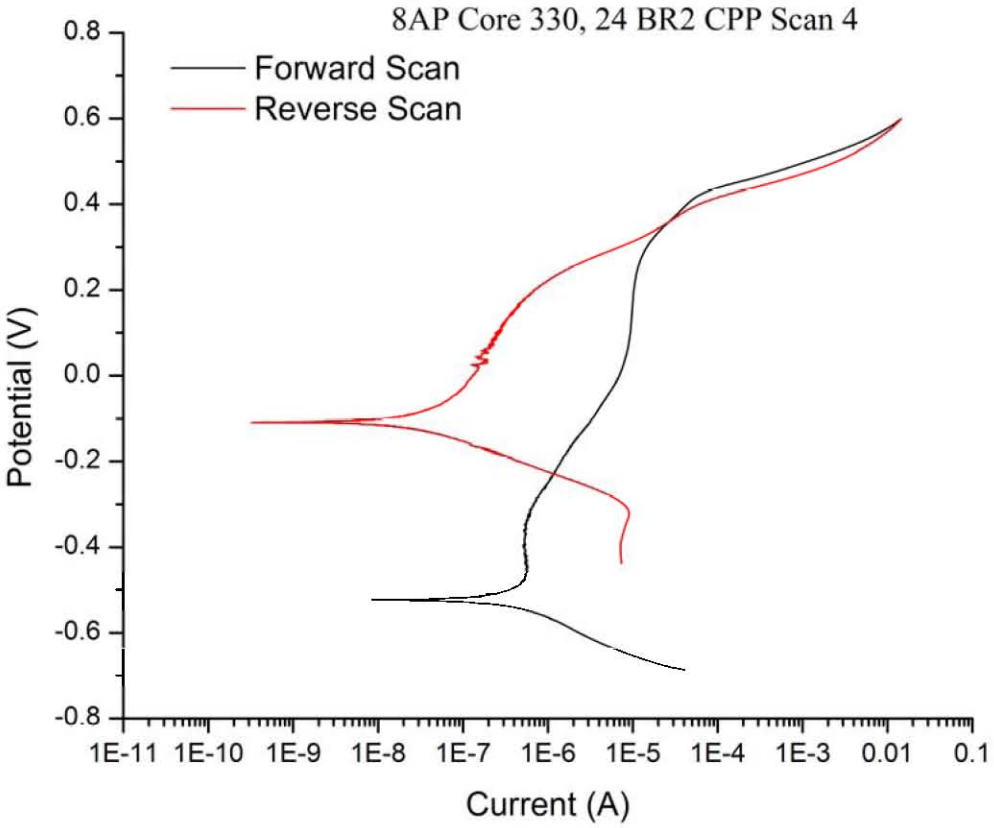

7AP Composite Tafel Plot Coupon 2
Potential (V)
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
Current (A)

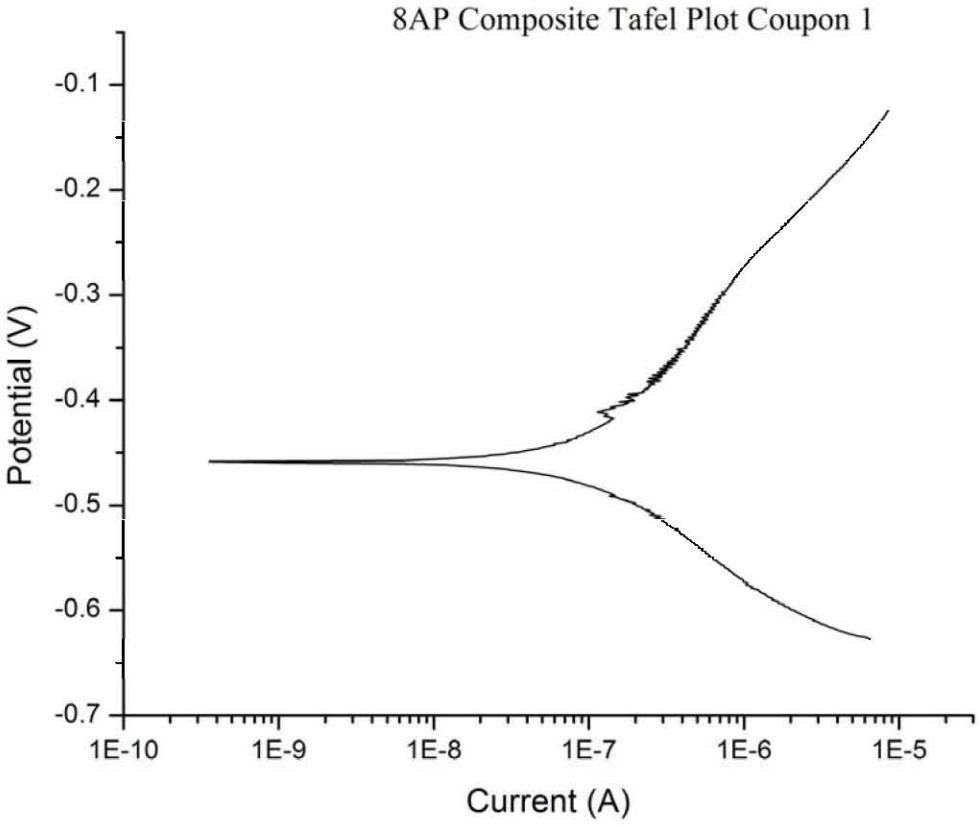

7AN Composite CPP Scan Coupon 3
Forward Scan
Reverse Scan
Potential (V)
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
1E-4
1E-3
0.01
0.1
1
Current (I)

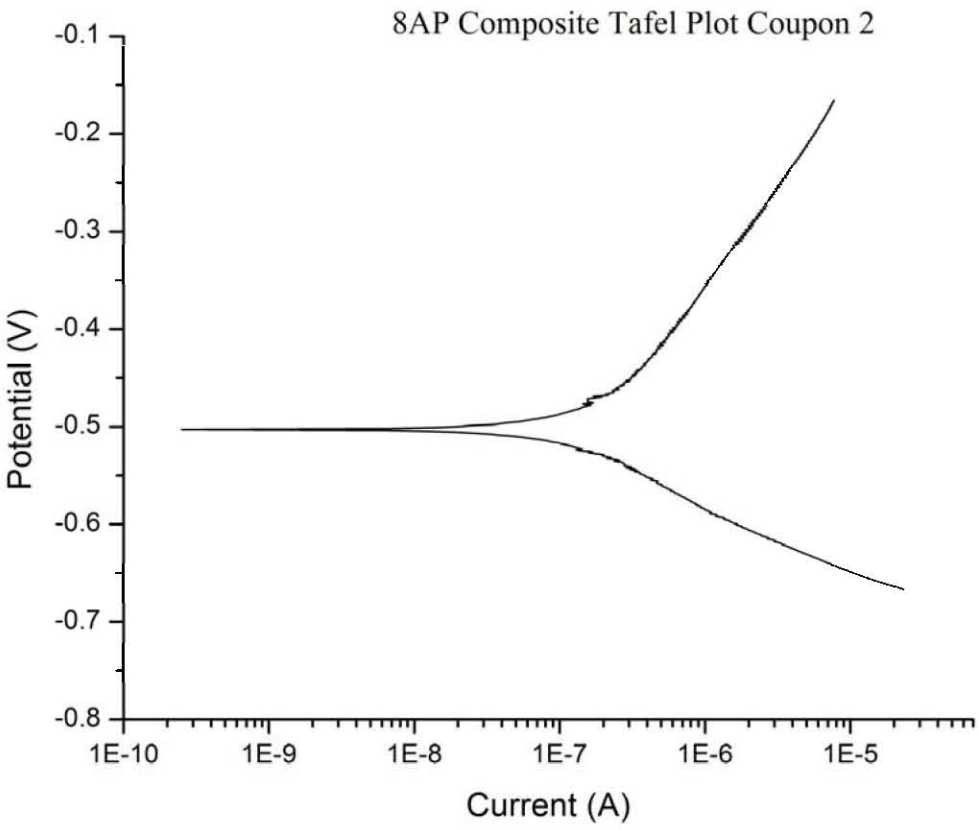

8AP Core 330 24BR2 Tafel Plot Coupon 1
Potential (V)
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
1E-8
1E-7
1E-6
1E-5
1E-4
Current (A)

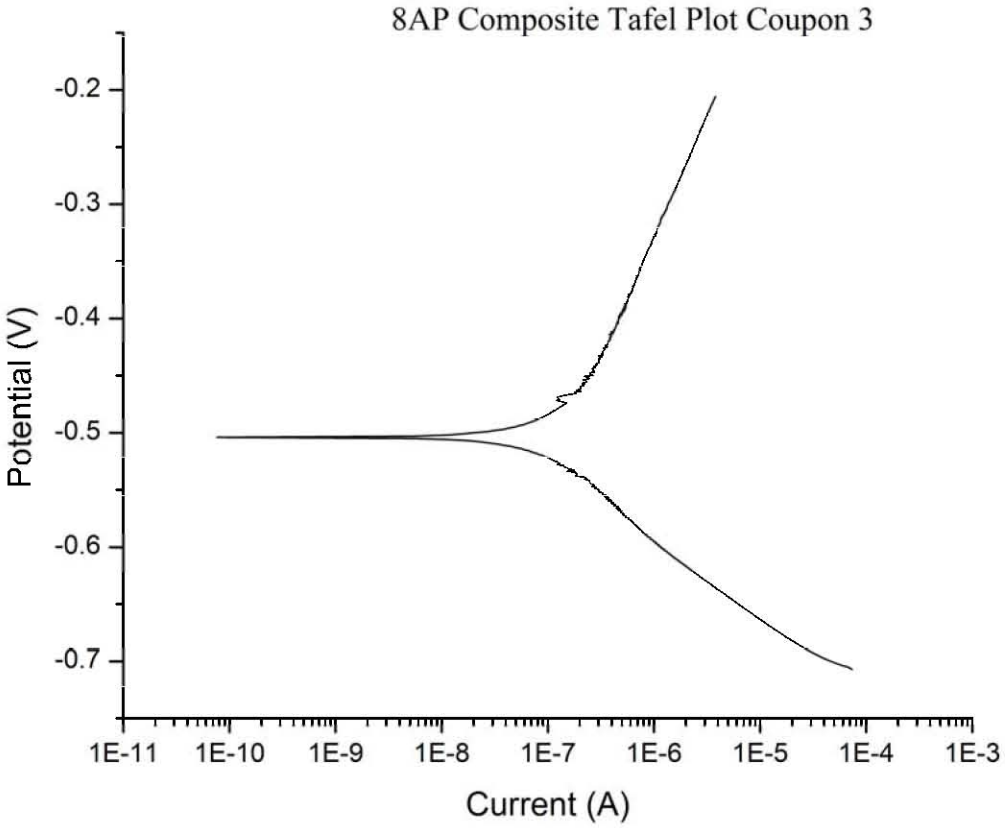

8AP Core 330 24BR2 Tafel Plot Coupon 2
Potential (V)
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
1E-8
1E-7
1E-6
1E-5
1E-4
Current (A)

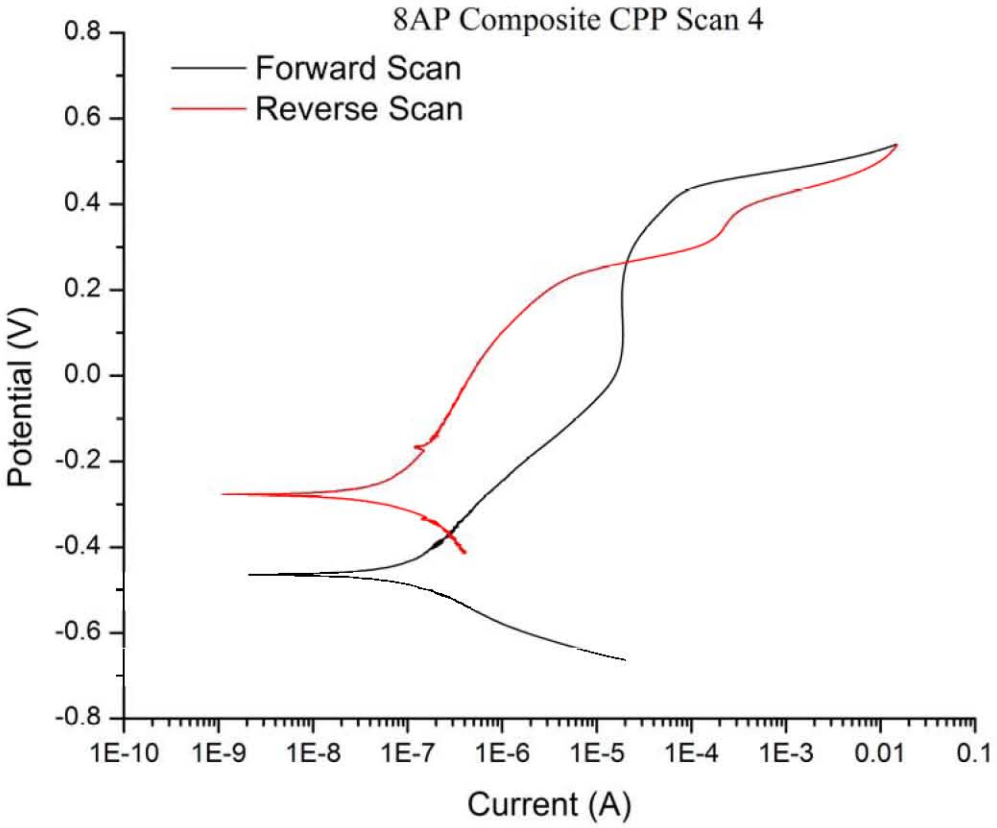

8AP Core 330 24BR2 Tafel Plot Coupon 3
Potential (V)
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
1E-4
1E-3
0.01
Current (A)


8AP Core 330, 24 BR2 CPP Scan 4
Forward Scan
Reverse Scan
Potential (V)
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
1E-11
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
1E-4
1E-3
0.01
0.1
Current (A)


8AP Composite Tafel Plot Coupon 1
Potential (V)
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
Current (A)


8AP Composite Tafel Plot Coupon 2
Potential (V)
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
Current (A)


8AP Composite Tafel Plot Coupon 3
Potential (V)
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
1E-11
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
1E-4
1E-3
Current (A)


8AP Composite CPP Scan 4
Forward Scan
Reverse Scan
Potential (V)
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
1E-10
1E-9
1E-8
1E-7
1E-6
1E-5
1E-4
1E-3
0.01
0.1
Current (A)

Appendix B

Analytical Chemistry Data

AN-102 Composite, Chemical Composition Data
(3 sheets)

Constituent	Result	Unit
%WATER	47.270	PCT
Acetate	<6.1614E+01	µg/mL
Acetate	<6.7104E+00	µg/mL
Aluminum	1.3495E+04	µg/mL
Amount of sample present	30.3	g
Antimony	<4.0000E+01	µg/mL
Arsenic	<4.0000E+01	µg/mL
Barium	<2.4000E+00	µg/mL
Beryllium	<8.0000E-01	µg/mL
Bismuth	<8.0000E+01	µg/mL
Boron	4.7686E+01	µg/mL
Bromide	<5.9166E+02	µg/mL
Bromide	<6.4438E+01	µg/mL
Cadmium	6.1119E+01	µg/mL
Calcium	4.2276E+02	µg/mL
Cerium	<2.4000E+01	µg/mL
Chloride	2.9876E+03	µg/mL
Chloride	3.6754E+03	µg/mL
Chromium	2.3529E+02	µg/mL
Cobalt	<8.0000E+00	µg/mL
Copper	2.3331E+01	µg/mL
Dose rate	400	MRH
Europium	<4.0000E+00	µg/mL
Fluoride	<1.6424E+01	µg/mL
Fluoride	<1.7887E+00	µg/mL
Formate	1.0236E+04	µg/mL
Formate	8.2934E+03	µg/mL
Glycolate	1.5230E+04	µg/mL
Glycolate	9.6909E+03	µg/mL
Hydroxide	7.1000E+03	µg/mL
Total inorganic carbon	1.3800E+04	µg/mL
Iron	2.9681E+01	µg/mL
Lanthanum	1.2352E+01	µg/mL
Lead	1.7645E+02	µg/mL
Lithium	<2.4000E+00	µg/mL
Magnesium	<4.0000E+01	µg/mL

AN-102 Composite, Chemical Composition Data
(3 sheets)

Constituent	Result	Unit
Manganese	1.4966E+01	µg/mL
Molybdenum	5.2725E+01	µg/mL
Neodymium	1.8118E+01	µg/mL
Nickel	4.0067E+02	µg/mL
Niobium	<2.4000E+01	µg/mL
Nitrate	1.8572E+05	µg/mL
Nitrite	8.3085E+04	µg/mL
Nitrite	8.5561E+04	µg/mL
Total organic carbon	2.5000E+04	µg/mL
Oxalate	<2.3564E+02	µg/mL
Oxalate	<2.5664E+01	µg/mL
Palladium	<8.0000E+01	µg/mL
Phosphate	1.1954E+03	µg/mL
Phosphate	5.1981E+03	µg/mL
Phosphorus	1.7588E+03	µg/mL
Potassium	2.0151E+03	µg/mL
Praseodymium	<8.0000E+00	µg/mL
Rhodium	<4.0000E+01	µg/mL
Rubidium	<8.0000E+02	µg/mL
Ruthenium	<2.4000E+01	µg/mL
Samarium	<1.6000E+01	µg/mL
Sample amount	30.300	µg/mL
Selenium	<8.0000E+01	µg/mL
Silicon	2.4062E+01	µg/mL
Silver	<4.0000E+00	µg/mL
Sodium	1.9249E+05	µg/mL
Strontium	<2.4000E+00	µg/mL
Sulfate	1.5260E+04	µg/mL
Sulfate	9.2510E+03	µg/mL
Sulfur	4.7845E+03	µg/mL
Tantalum	<4.0000E+01	µg/mL
Tellurium	<8.0000E+01	µg/mL
Thallium	<8.0000E+01	µg/mL
Thorium	<4.0000E+01	µg/mL
Tin	<2.4000E+01	µg/mL
Titanium	<4.0000E+00	µg/mL

AN-102 Composite, Chemical Composition Data
(3 sheets)

Constituent	Result	Unit
Tungsten	<1.6000E+02	µg/mL
Uranium	<8.0000E+01	µg/mL
Vanadium	<4.0000E+00	µg/mL
Yttrium	<1.6000E+00	µg/mL
Zinc	5.4370E+00	µg/mL
Zirconium	8.4756E+00	µg/mL
pH	>13.500	pH

AP-107 Composite, Chemical Composition Data
(2 sheets)

Constituent	Result	Unit
%WATER	66.450	PCT
Acetate	3.4160E+02	µg/mL
Acetate	<6.1614E+01	µg/mL
Aluminum	8.8500E+03	µg/mL
Amount of sample present	27.7	g
Antimony	<4.0000E+01	µg/mL
Arsenic	<4.0000E+01	µg/mL
Barium	<2.4000E+00	µg/mL
Beryllium	<8.0000E-01	µg/mL
Bismuth	<8.0000E+01	µg/mL
Boron	4.4252E+01	µg/mL
Bromide	<5.9166E+02	µg/mL
Bromide	<6.4438E+01	µg/mL
Cadmium	<4.0000E+00	µg/mL
Calcium	<4.0000E+01	µg/mL
Cerium	<2.4000E+01	µg/mL
Chloride	1.0521E+03	µg/mL
Chloride	2.5955E+03	µg/mL
Chromium	5.3740E+02	µg/mL
Cobalt	<8.0000E+00	µg/mL
Copper	<4.0000E+00	µg/mL
Dose rate	70	MRH
Europium	<4.0000E+00	µg/mL
Fluoride	1.2559E+02	µg/mL
Fluoride	8.0869E+01	µg/mL
Formate	1.1122E+03	µg/mL
Formate	5.5789E+02	µg/mL
Glycolate	3.3819E+02	µg/mL
Glycolate	<9.5583E+01	µg/mL
Hydroxide	1.9100E+04	µg/mL
Total inorganic carbon	4.0200E+03	µg/mL
Iron	5.5870E+00	µg/mL
Lanthanum	<2.4000E+00	µg/mL
Lead	<4.0000E+01	µg/mL
Lithium	<2.4000E+00	µg/mL
Magnesium	<4.0000E+01	µg/mL
Manganese	<2.4000E+00	µg/mL
Molybdenum	3.0471E+01	µg/mL
Neodymium	<8.0000E+00	µg/mL

AP-107 Composite, Chemical Composition Data
(2 sheets)

Constituent	Result	Unit
Nickel	<1.6000E+01	µg/mL
Niobium	<2.4000E+01	µg/mL
Nitrate	1.4793E+05	µg/mL
Nitrite	2.9510E+04	µg/mL
Nitrite	3.3939E+04	µg/mL
Total organic carbon	1.4100E+03	µg/mL
Oxalate	<2.3564E+02	µg/mL
Oxalate	<2.5664E+01	µg/mL
Palladium	<8.0000E+01	µg/mL
Phosphate	3.0665E+03	µg/mL
Phosphate	<1.7036E+02	µg/mL
Phosphorus	1.2780E+03	µg/mL
Potassium	2.3701E+03	µg/mL
Praseodymium	<8.0000E+00	µg/mL
Rhodium	<4.0000E+01	µg/mL
Rubidium	<8.0000E+02	µg/mL
Ruthenium	<2.4000E+01	µg/mL
Samarium	<1.6000E+01	µg/mL
Sample amount	27.700	µg/mL
Selenium	<8.0000E+01	µg/mL
Silicon	1.2287E+02	µg/mL
Silver	<4.0000E+00	µg/mL
Sodium	1.3648E+05	µg/mL
Strontium	<2.4000E+00	µg/mL
Sulfate	1.8011E+03	µg/mL
Sulfate	3.6478E+03	µg/mL
Sulfur	1.6181E+03	µg/mL
Tantalum	<4.0000E+01	µg/mL
Tellurium	<8.0000E+01	µg/mL
Thallium	<8.0000E+01	µg/mL
Thorium	<4.0000E+01	µg/mL
Tin	3.5653E+01	µg/mL
Titanium	<4.0000E+00	µg/mL
Tungsten	<1.6000E+02	µg/mL
Uranium	<8.0000E+01	µg/mL
Vanadium	<4.0000E+00	µg/mL
Yttrium	<1.6000E+00	µg/mL
Zinc	<4.0000E+00	µg/mL
Zirconium	<4.0000E+00	µg/mL
pH	>13.500	pH

AP-108 Composite, Chemical Composition Data
(2 sheets)

Constituent	Result	Unit
%WATER	51.910	PCT
Acetate	2.0978E+02	µg/mL
Acetate	7.5267E+02	µg/mL
Aluminum	2.3593E+04	µg/mL
Amount of sample present	30.3	g
Antimony	<2.8000E+01	µg/mL
Arsenic	<2.8000E+01	µg/mL
Barium	<1.6800E+00	µg/mL
Beryllium	<5.6000E-01	µg/mL
Bismuth	<5.6000E+01	µg/mL
Boron	3.4480E+01	µg/mL
Bromide	<1.2302E+02	µg/mL
Bromide	<5.9166E+02	µg/mL
Cadmium	5.6314E+00	µg/mL
Calcium	4.6436E+01	µg/mL
Cerium	<1.6800E+01	µg/mL
Chloride	4.7921E+03	µg/mL
Chloride	5.0406E+03	µg/mL
Chromium	7.7168E+02	µg/mL
Cobalt	<5.6000E+00	µg/mL
Copper	5.2020E+00	µg/mL
Dose rate	250	MRH
Europium	<2.8000E+00	µg/mL
Fluoride	1.2325E+02	µg/mL
Fluoride	1.7952E+02	µg/mL
Formate	1.2287E+03	µg/mL
Formate	1.7553E+03	µg/mL
Glycolate	2.4278E+02	µg/mL
Glycolate	4.4974E+02	µg/mL
Hydroxide	3.9400E+04	µg/mL
Total inorganic carbon	7.0800E+03	µg/mL
Iron	7.7523E+00	µg/mL
Lanthanum	<1.6800E+00	µg/mL
Lead	3.3724E+01	µg/mL
Lithium	<1.6800E+00	µg/mL
Magnesium	<2.8000E+01	µg/mL
Manganese	<1.6800E+00	µg/mL
Molybdenum	6.1988E+01	µg/mL
Neodymium	<5.6000E+00	µg/mL
Nickel	3.0265E+01	µg/mL

AP-108 Composite, Chemical Composition Data
(2 sheets)

Constituent	Result	Unit
Nitrate	1.8044E+05	µg/mL
Nitrate	<4.4117E+01	µg/mL
Nitrite	7.2865E+04	µg/mL
Nitrite	7.9837E+04	µg/mL
Total organic carbon	2.9200E+03	µg/mL
Oxalate	<2.3564E+02	µg/mL
Oxalate	<4.8995E+01	µg/mL
Phosphate	<1.7036E+02	µg/mL
Phosphate	<3.5421E+01	µg/mL
Phosphorus	4.8191E+02	µg/mL
Potassium	1.0141E+04	µg/mL
Samarium	<2.8000E+01	µg/mL
Selenium	<5.6000E+01	µg/mL
Silicon	2.3432E+02	µg/mL
Silver	<2.8000E+00	µg/mL
Sodium	1.8941E+05	µg/mL
Specific gravity	1.4158	SpG
Strontium	<1.6800E+00	µg/mL
Sulfate	1.8291E+03	µg/mL
Sulfate	2.3653E+03	µg/mL
Sulfur	1.3193E+03	µg/mL
Thallium	<5.6000E+01	µg/mL
Thorium	<2.8000E+01	µg/mL
Titanium	<2.8000E+00	µg/mL
Uranium	<5.6000E+01	µg/mL
Vanadium	<2.8000E+00	µg/mL
Yttrium	<1.1200E+00	µg/mL
Zinc	3.5960E+00	µg/mL
Zirconium	<2.8000E+00	µg/mL
pH	>13.500	pH