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HANFORD DOUBLE SHELL WASTE TANK CORROSION STUDIES – FINAL REPORT FY2014

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EXECUTIVE SUMMARY

SRNL tasks for FY14 included studies to evaluate the susceptibility of carbon steel to vapor space corrosion (VSC), liquid-air interface (LAI) corrosion, and pitting corrosion. Additionally, SRNL evaluated the susceptibility of carbon steel to pitting corrosion under buffered waste conditions, with the objective of determining the adequate amount of inhibitor (e.g., nitrite) necessary to mitigate pitting corrosion. Other CPP experiments were performed in historical waste simulants and the results were compared to previously gathered results. The results of these activities were utilized to assess the robustness of the standardized CPP protocol.

For FY2014, four task activities were performed and the results were arranged in five parts and discussed in section 5. Below is a summary and conclusions for every part:

1. Secondary Wall of AY-102 Tank Corrosion Studies

Liquid air interface (LAI) and vapor space (VS) corrosion tests were performed using Leak Detection Pit (LDP) residue (Solutions 12 and 13) and Groundwater (GW) simulants (Solutions 14 and 15). For LAI samples after two months, aggressive corrosion was sustained for all samples. For the partially immersed samples after two months of exposure, the corrosion occurred at the water line and below. By the fourth month, the corrosion increased above the water line of the coupon as well. The corrosion rate was steady for the 4 month test at approximately 10 mpy. A similar corrosion rate was observed for samples that were totally immersed in the LDP and GW simulants. For VS samples, corrosion was more prominent for the coupons exposed to GW simulant (Solution 8) than the coupons exposed to LDP residue (Solution 7). More aggressive attack was observed on the samples closest to the liquid level (Level 1 > Level 2 > Level 3) for the coupons from GW simulant.

2. Testing in Waste Buffering Simulant from DST AN-102

Electrochemical testing using waste buffering simulants based on waste from tank AN-102 at different hydroxide, nitrate and nitrite concentrations was performed. The results demonstrated that hydroxide concentrations as low as 0.032 M can still offer inhibition for corrosion in carbon steel provided sufficient nitrite is present. The four month LAI tests showed no significant corrosion. These results concur with electrochemical testing in that the solutions studied inhibited the development of pits when carbon steel is immersed and creates very small pits that do not seem to grow or increase in quantity over time.

3. Vapor Space Corrosion tests at new SCC limits with different concentrations of Ammonia gas in Air

VSC tests were executed with three simulants based on the new SCC corrosion control guideline. The simulants contained the minimum nitrite/nitrate ratio of 0.15 and nitrate concentrations of 0.4, 2 and 4.5 M. The vapor space above each simulant had either 50 or 550 ppm ammonia. The samples after four-months of exposure showed no indications of VSC at levels 3 and 2 with minor corrosion areas at Level 1 for the 550 ppm ammonia in each of the three simulants. The same was true at 50 ppm, as there was no significant VSC. When the cold mount was removed from the coupons, some crevice attack had occurred in some instances. Although crevice attack did occur on several of the samples, the results tend to indicate that even at 50 ppm ammonia with solutions comprised of the new SCC control limits, VSC can be inhibited.

4. Liquid Air Interface tests at new SCC limits

Eight different solutions were prepared with compositions that were at or near the new SCC control limits. After two and fourth months of exposure none of the samples exhibited LAI corrosion or any attack in the immersed area. Typically any corrosion seemed to initiate at the top of the coupon and develop an area of general corrosion and that continues to spread above the LAI. The smallest ratio of nitrite to nitrite (0.12) was solution 8 and during the contact with the carbon steel coupon it developed a film that completely covered the coupon and protected it from corrosion attack even though the ratio is less than the new minimum SCC control limits. The corrosion appeared to be more severe for the more dilute solutions at a given nitrite/nitrate ratio.

5. Pitting Corrosion studies using the standardized CPP protocol

CPP tests were conducted to compare historical data with data that was collected using the new standardized CPP protocol. The purpose was to determine the effect of the CPP parameters on the results and also compare the results from the new CPP test protocol with long-term coupon tests. Forty test conditions were selected for testing during FY2014 from the more than 900 historical test conditions. In cases where either a clear-cut pitting or no pitting case, there was 100% agreement between the historical CPP results and the present testing. On the other hand if the environment was a borderline condition (i.e., transition from pitting to not pitting) agreement was not as good. Both the CPP test parameters and the microstructure of the material may have had a role in these contrary results. The historical data and new CPP protocol still remain useful as in both cases the behavior at the borderline condition was consistent. Both the historical data and the new CPP test protocol were consistent with coupon results that indicated either clear-cut pitting or no pitting results and borderline conditions.

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
CPP	Cyclic Potentiodynamic Polarization
DNV-GL	Det Norske Veritas-Germanisher Lloyd
DST	Double-Shell Tank
DWPF	Defense Waste Processing Facility
EPOC	External Panel Oversight Committee
GW	Ground Water
LAI	Liquid-Air Interface
LDP	Leak Detection Pit
LPR	Linear Polarization Resistance
OCP	Open Circuit Potential
PNNL	Pacific Northwest National Laboratory
SCC	Stress Corrosion Cracking
SCE	Saturated Calomel Electrode
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
SST	Single-Shell Tank
TI	Total Immersion
VS	Vapor Space
VSC	Vapor Space Corrosion
WRPS	Washington River Protection Solutions

1.0 Introduction

Radioactive waste at the Hanford Site is being retrieved from the single-shell tanks (SSTs) and transferred to newer double-shell tanks (DSTs) for storage prior to pretreatment and eventual vitrification at the Waste Treatment Plant (WTP). The DSTs have a detailed corrosion control program developed over the years. The program includes special construction requirements; waste chemistry controls and systematic non-destructive (NDE) tank wall inspections. On the other hand, the composition of the wastes in SSTs was never controlled to the chemistry standards required for the DSTs, and generally does not meet the DST waste specifications. Thus, it is likely that some of the wastes transferred to the DSTs will not comply with DST waste specifications and hence would be vulnerable to corrosion attack.

Since 2004, the Expert Panel for Hanford Double-Shell Tank Waste Chemistry Optimization Oversight Committee (EPOC) has advised the Hanford site on matters regarding laboratory testing that support corrosion control for the DSTs as the waste is being transitioned between the SSTs and the vitrification facility [1]. Three laboratories have been involved in the corrosion testing: Det Norske Veritas-Germanischer Lloyd (DNV-GL), Savannah River National Laboratory (SRNL), and the 222-S facility at Hanford currently operated by Washington River Protection Solutions (WRPS). SRNL has primarily been focused on laboratory studies related to vapor space corrosion (VSC), liquid-air interface (LAI) corrosion, and pitting corrosion, particularly for waste supernates that have a relatively dilute chemistry. SRNL also recently participated in a round robin test program with the other two laboratories that established a standardized test protocol for the performance of cyclic potentiodynamic polarization (CPP) tests [2]. This accelerated test is utilized to determine the susceptibility of a material (e.g., carbon steel) to a given environment (e.g., waste supernate, interstitial liquid, etc.).

The SRNL tasks for FY14 were also aligned within these general categories. Laboratory tests were conducted to evaluate the susceptibility of carbon steel to VS and LAI corrosion in supernate chemistries that are at the recently recommended requirements for inhibition of stress corrosion cracking [3]. Additionally, SRNL evaluated the susceptibility of carbon steel to pitting corrosion under buffered waste conditions, with the objective of determining the adequate amount of inhibitor (e.g., nitrite) necessary to mitigate corrosion. As a secondary objective, the results of these activities were utilized to assess the robustness of the standardized CPP protocol.

2.0 Background

The SRNL Task Plan included five testing programs [4]. A brief description of the previous investigations for each is given in the sections that follow.

2.1 Vapor space corrosion testing at SRNL

Vapor space corrosion tests were performed to investigate the likelihood of this type of attack in the Hanford DSTs. Until now, there have been no consequential incidents of uniform or localized corrosion in the DSTs, but there have been instances of unexplained corrosion in equipment that were suspended above the waste. In the vapor space, the chemistry of condensate that can form on the tank walls is complex and is constantly evolving. As the condensate evaporates from the tank wall, it influences the formation of corrosion products and the corrosion of the carbon steel. Previous explorations of the mechanism of VSC involved: the chemical composition of the liquid that condensed on the carbon steel in the vapor space [5] and corrosion above simulated waste environments [6],[7].

Six Hanford DST supernates were selected for testing in order to evaluate the impact of vapor space corrosion. These were: AY-101 (Segment 3), AY-101 (Segment 8), AN-102, AY-102, SY-102 (high nitrate) and SY-102 (high chloride). Thermodynamic studies by Pacific Northwest National Laboratory (PNNL) were done to be able to predict the chemistry of adsorbed surface condensates based on equilibrium of major vapor space constituents and condensate and it was verified with experimental results [4]. Ammonia and carbon dioxide were determined to be the dominant species in vapor space that are most likely to impact tank corrosion.

Ammonia is produced predominantly in the supernate through thermal and radiolytically induced reactions between organic waste components and nitrate and nitrite ions. The concentration in the vapor space varies but it can be as high as 550 ppm obtained in Tank SY-102. Through limited laboratory testing, VSC has been observed to be inhibited by ammonia [8],[9].

Corrosion chemistry limits were recommended to minimize SCC in the DST [3]. Table 2-1 lists the different specifications and the maximum or minimum requirements needed for SCC control. The specific limit of interest for current testing is the minimum nitrate/nitrate ion ratio of 0.15 with minimum nitrate concentration of 0.05M. For nitrate concentrations of 0.4, 2 and 4.5 M the minimum ratio of 0.15 was not able to prevent pitting corrosion in the VS [7].

Table 2-1 Proposed Specifications for the Control of SCC in Nitrate Ion Wastes in DSTs.

Maximum Temperature	50 °C
Maximum Concentration of Nitrate Ion	6.0 M
Maximum Concentration of Hydroxide Ion	6.0 M
Minimum pH	11
Minimum Concentration of Nitrite Ion	0.05 M
Minimum Nitrite Ion/Nitrate Ion Ratio	0.15

2.2 Liquid-Air Interface Corrosion testing at SRNL

LAI corrosion can occur when the liquid level remains stagnant for a long period of time and develops as pits or a localized general corrosion that initiates at the interface. At Hanford, only tank AY-101 has shown evidence of this type of corrosion [10]. During laboratory testing, DNV-GL also observed LAI corrosion from a simulant of waste in Hanford DST AP-105 [11]. Several experimental approaches have been attempted during previous years to understand the phenomenon [11]-[13]. However, a clear understanding of the mechanism has not being achieved. Several findings of the results of LAI test were able to identify that LAI corrosion cannot be fully simulated and can be challenging to develop a test that can be reliable.

SRNL studied the effects of LAI corrosion in solutions at the boundary of the new corrosion control limits for SCC during long term testing for four months [14]. The tests demonstrated that the minimum ratio of nitrate to nitrate of 0.15 was insufficient to prevent corrosion at LAI. Results from these tests also indicated that both the ratio of nitrite to nitrate and the amount of nitrite influence the corrosion susceptibility at the LAI [14]. Long-term (i.e., 4 months) partial immersion coupon tests will once again be employed for this activity. These tests will cover compositions at the boundary of the new corrosion chemistry limits that will prevent SCC in the DST [3].

2.3 AY-102 Leak Detection Pit and Secondary Tank Corrosion Studies

Waste from Tank AY-102 has leaked into the annulus region of the tank [15]-[17]. The secondary liner of the tank provides the barrier between the waste and the environment. The Leak Detection Pit (LDP) provides a means of detecting a leak in the secondary liner. The exterior of the secondary wall for Tank AY-102 is potentially exposed to liquid and/or vapors from the solutions contained in the LDP or the drain line to the pit that is beneath the tank. The rate of corrosion of the steel due to this exposure is unknown. LAI corrosion and VS corrosion testing for carbon steel exposed to very dilute solutions was needed to quantify this attack. It is also possible that the underliner is completely immersed in the liquid. Therefore, coupons that are fully immersed in anticipated LDP liquid were tested as well. These tests were merged within the VSC and LAI corrosion activities.

2.4 Waste Buffering Corrosion Studies

Grab samples of actual waste from double shell tank 241-AN-102 (AN-102) were obtained in 2012 to determine if the waste was within the corrosion control chemistry requirements [18],[19]. The corrosion chemistry for supernate samples were taken at six different levels beneath the surface. While sufficient nitrite inhibitor was present, the hydroxide concentration was near or below the minimum requirement.

Electrochemical testing was performed by WRPS at the 222-S laboratory to determine if these solutions were corrosive towards carbon steel [18]. Testing was performed in four of the actual wastes at temperatures between 30 and 50 °C. The Cyclic Potentiodynamic Polarization (CPP) test results indicated that carbon steel was not susceptible to pitting corrosion in the actual waste environment.

In parallel with the WRPS tests, CPP tests were performed at DNV-GL on carbon steel exposed to AN-102 waste simulants [20]. Tests were conducted with simulant chemistries that were adjusted such that the hydroxide concentrations were significantly less than that for the actual waste and the corrosion chemistry requirements (i.e., pH 10.3-13.6). The composition of the minor constituents for the waste simulant also differed from that of the actual waste. The CPP test results indicated that carbon steel was mildly susceptible to pitting corrosion in these environments. The minimum nitrite/nitrate ratio and or minimum nitrite concentration necessary to mitigate pitting at these lower pH values was not determined.

Both of these test programs were conducted prior to the round robin testing that was performed to develop a standardized CPP test protocol [2]. Therefore, these tests were repeated with the new standardized test protocol.

2.5 Pitting Corrosion Studies

Electrochemical techniques have been utilized as an accelerated means for assessment of the pitting susceptibility of waste tank materials in simulated supernates for several years. Variations on the CPP technique, coupled with long term immersion tests, have been performed to provide a basis for corrosion chemistry control.

The three laboratories (SRNL, DNV-GL and WRPS) that have supported Hanford corrosion testing, recently conducted a round robin test program to establish a standardized test protocol for the performance of CPP tests [2]. Table 2-2 compares the test parameters used recently by each laboratory to the new standardized pitting protocol. The major changes to the protocol were the establishing of a potential stabilization to be limited to 2 hours, the surface preparation prior to testing of a 600-grit finish and the use of the bullet geometry. This protocol will be used for all subsequent testing related to Hanford DST wastes.

Table 2-2 CPP protocol with the parameters utilized for testing

Parameters	SRNL	WRPS	DNV	Standardized CPP Protocol
Potential Stabilization (hrs.)	2	18*	2	2
Start Potential (V vs. OCP)	-0.05	-0.2	-0.1	-0.05
Scan Rate (mV/s)	0.5	0.167	0.167	0.167
Vertex Threshold (mA/cm^2)	1	5	1	1
Finish Potential (V vs. OCP)	0	0	-0.1	0
Sample geometry	Disk	cylinder	bullet	bullet
Surface Preparation	600 grit	None	None	600 grit

* potential was stabilized for 18 hours and then LPR was performed; Electrode was allowed to rest for 1 hour after LPR and then CPP scan was performed.

3.0 Task Description and Activities

The tasks are described in the sections below with the activities performed during FY14.

3.1 Task 1: Vapor space Corrosion Studies for Hanford Double Shell Tanks

Long-term exposure experiments were conducted for four months to investigate ammonia inhibition of vapor space corrosion at the new SCC control limits. The tests were also conducted above simulated LDP water and above zone groundwater [21],[22]. In general, Hanford groundwater is calcium bicarbonate dominated water with a pH that typically ranges from 7.5 to 8.5. Other prominent major ions are sodium, chloride, sulfate and magnesium. The LDP water has the same components although at more dilute concentrations. The dilution likely occurs to condensation of water vapor within the LDP system. Coupons of carbon steel were located at three different levels above the simulant to mimic different conditions inside the DST. These conditions were (1) the carbon steel is exposed to a wet/dry cycle with the waste; (2) the carbon steel was wetted at some point but now is only exposed to humid air and (3) carbon steel that was never wetted by the waste and therefore only exposed to humid air. The results for this task are presented in subsection 5.1.2 for the conditions near the secondary liner of Tank AY-102 and section 5.3 for the simulants with the new control limits for SCC with ammonia in the vapor phase.

3.2 Task 2: Liquid Air Interface Corrosion Testing

Carbon steel at the LAI was examined to determine the susceptibility for corrosion at simulants with the new SCC control limits and in the environment at the exterior of the secondary wall of AY-102. The coupons in rectangular form were immersed at approximately 50% into solution. Complete immersion was also performed in several coupons to study corrosive conditions at this environment beneath the secondary wall of AY-102. The results obtained for this Task are shown in subsections 5.1.1, 5.2.2 and section 5.4.

3.3 Task 3: Waste Buffering

Simulants based on samples of actual waste from Tank AN-102 were utilized to perform electrochemical tests. The tests were used to determine minimum hydroxide concentration necessary to prevent pitting in high nitrate solutions that also have a high nitrite concentration. These results, which were gathered with the new standardized CPP protocol, were compared with data gathered previously at DNV-GL and 222-S. The results and discussion are presented in section 5.4.

3.4 Task 4: Pitting Corrosion

CPP experiments were performed in historical waste simulants with the standardized CPP protocol and the results were compared to the previously gathered. This activity was designed to understand the test parameters that may have an influence in the results and to assess the applicability of the previous tests. The results are organized in section 5.5.

4.0 Experimental Procedure

Carbon steel coupons were used for corrosion testing and analysis. They were fabricated from AART128 Rail Car Steel. This steel was selected for testing since it approximates the chemistry and microstructure of American Society for Testing and Materials (ASTM) A515 Grade, Grade 60 carbon steel, the steel from which the tanks were fabricated [23]. The rail car steel was also chosen because it was of the same vintage as the tank steel. The chemical composition of the steel is shown in Table 2.

Table 4-1 Chemical Composition of AART128 Rail Car Steel.

	C	Mn	P	S	Si	Fe
Specification (wt%)	0.24 (max.)	0.9 (max.)	0.035 (max.)	0.04 (max.)	0.13 to 0.33	Balance
Measured (wt%)	0.212	1.029	0.012	0.013	0.061	Balance

Below are the experimental details and conditions in which the carbon steel was used and prepared for VS corrosion, LAI corrosion and electrochemical corrosion testing.

4.1 Vapor Space Corrosion Testing

4.1.1 *Material sample*

Circular coupons that are 5/8 inch diameter and 1/8 inch thick carbon steel (Metal samples) were mounted using a two part acrylic solution (Buehler) so that one face of the coupon was exposed. While mounting, a wire was placed in a lateral position to be able to hang the coupons. After cold mounting the coupons, they were polished to a 600 grit finish and rinsed with distilled water and ethanol. Clear nail polish was utilized around the edges of the disk to minimize crevice corrosion. A sample of the coupon can be seen in Figure 4-1.

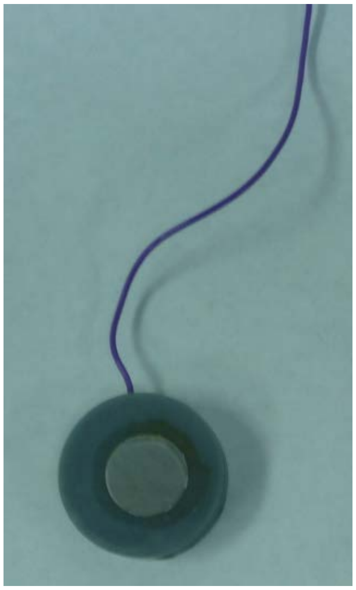


Figure 4-1 Coupon mounted in cold mount with wire

Twelve coupons were suspended in rings attached to stainless steel rods (four at each level) as shown in Figure 4-2. As shown in the figure, three rings at different locations were welded onto the rod.

Figure 4-2 Picture of the rod with four coupons hanged at each level.

4.1.2 *Simulants*

VSC tests were conducted at conditions described in Table 4-2. Chemical compositions for each vessel are presented in Appendix A. Six vessels contained simulants that had a composition representing the new SCC control limits which is a nitrite/nitrate ratio of 0.15. Nitrate concentrations were selected from possible supernate concentrations and nitrite was calculated using this ratio. The pH of the simulants was selected as 12 to be slightly above the minimum requirement of 11. The composition of the minor constituents in the simulant is consistent with values from samples of the waste supernates that were utilized during previous testing [7]. The tests were conducted at VS ammonia levels of 50 ppm for three vessels and 550 ppm for three vessels. The remaining two vessels had a chemical composition representing the LDP residue and GW found close to the secondary liner in the tank, respectively. These tests were conducted with humid air passing through the glass column.

During the test, it was desired to establish equilibrium between the ammonia gas and the dissolved ammonia in the liquid. By relating the concentrations to Henry's Law [24], the concentrations of dissolved ammonia were calculated in the liquid and were added in the simulants using ammonium nitrate to achieve equilibrium. The ammonium ion from ammonium nitrate and ammonia achieve this equilibrium by the following equation [25] :

$$NH_4^+ + OH^- + (n-1)H_2O_{(l)} \leftrightarrow NH_3.nH_2O_{(aq)} \quad [1]$$

where n is stoichiometric number. A previous report explains in detail more about the ammonia addition to the solution [7].

Table 4-2 Test conditions for VSC testing

Vessel	Initial pH	Ammonia gas concentration in Air (ppm)	Temperature (°C)
1	12	50	40
2	12	50	40
3	12	50	40
4	12	550	40
5	12	550	40
6	12	550	40
7	7.6	0	45
8	7.6	0	45

4.1.3 *Testing Apparatus*

The VSC apparatus is shown in Figure 4-3. Eight glass columns prepared by the SRNL glass shop were placed inside a walk-in hood and mounted in an aluminum frame. The columns have dimensions of 1 m by 15 cm and consisted of a jacketed glass vessel connected to a glass tube and closed at the top with a glass cap. 1 Liter of simulant was added to each vessel and the temperature was monitored with a temperature reader (Omega). The gas cylinders provided ammonia (50 and 550 ppm) and were located at the right side of the configuration. The cylinders were connected to a mass flow controller at each gas concentration to maintain a flow of 15 sccm. The mass flow was diverted for each vessel by means of a flow meter. Three flowmeters at each concentration of ammonia in air maintained flow to each vessel at 5 sccm. The first six vessels (from right to left) were connected in parallel to a water circulator that maintained the simulant temperature at 40 °C. The last two vessels (from right to left) were connected to a water circulator in parallel to maintain a simulant temperature of 45°C. The ammonia gas was bubbled through a bottle filled with the corresponding simulant to humidify the gas before it entered the column.

The rods containing the coupons were placed inside the vessels. They represent different levels above the simulant. These levels are described below.

Level 3: This set of coupons was not exposed to the solution prior to testing. The coupons were suspended approximately 36 inches above the simulant. This level is representative of a vapor space region that is only exposed to the humidified air, the ammonia, and any volatile species from the solution.

Level 2: The coupons were dipped in simulant for five minutes prior to test. The coupons were hung at the middle fixed ring. These coupons were approximately 18 inches above the liquid. This level is representative of a vapor space region of the tank that at one time was exposed to waste, but now has infrequent or no contact with the waste. However, this region is exposed to the humidified air and the ammonia gas.

Level 1: The coupons were dipped in simulant for five minutes prior to test. The coupons were hung at the bottom fixed ring. These coupons were suspended approximately 1 inch above the liquid level of the simulant. Once every two weeks the coupons were lowered to the solution to be dipped in the simulant for 5 minutes. This level is representative of a vapor space region of the tank that experiences periodic wetting/drying. This sequence could occur due to: a) waste transfers into and out of the tank, b) splashing due to flushing operations, and/or c) solution "creep" above the liquid air interface.

Testing of the coupons in vapor space environment was performed for four months with monthly specimens taken at each level for each vessel (i.e., 3 coupons each month for each vessel). Coupons were cleaned using ASTM G1 Clark's solution [26] and weight losses were recorded.

Figure 4-3 Picture of the Vapor Space Corrosion setup inside the walk-in hood.

4.2 <u>Liquid Air Interface Corrosion Testing</u>

4.2.1 *Material sample*

Rectangular carbon steel coupons, that were 1 inch by 2 inches and ¼ inch thick, were positioned in solution so that approximately 50% of the coupon was immersed. Prior to the test, the surface was polished on 600 grit paper and rinsed with distilled water and acetone. Figure 4-4 shows an example of the coupon. A stainless steel rod was used to connect to the coupon and fixed it in place for long term testing. The stainless steel rod was insulated with Teflon tape to minimize contact with the coupon.

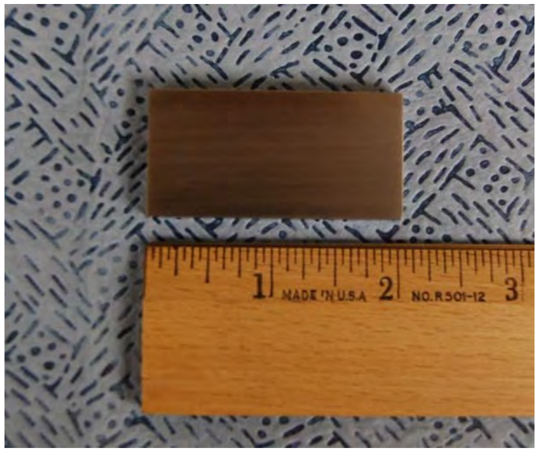


Figure 4-4 Rectangular coupon for LAI test.

4.2.2 *Simulants*

LAI corrosion tests were conducted using simulants with different chemical compositions. A total of 15 containers were utilized consisting of 13 different formulations of simulants. The first 8 containers have simulant compositions shown in Table 4-3. At the comments section a basis for the selection of each composition is explained. The initial pH for these simulants was 12. A detailed chemical composition for all containers can be found in Appendix C.

Table 4-3 Nitrate and nitrite concentrations for LAI corrosion test simulants.

Container	Nitrate (M)	Nitrite (M)	Nitrite/Nitrate Ratio	Comments
1	0.1	0.05	0.5	Dilute solution; Minimum nitrite allowed by new SCC requirement; Ratio is greater than that required by new SCC limits, but less than that required by Zapp's law [27]
2	0.1	0.166	1.66	Dilute solution; Zapp's law minimum required nitrite/nitrate ratio.
3	0.5	0.075	0.15	At approximately this concentration of nitrate, Hoffman observed that the addition of more nitrite was not necessarily beneficial [28]; Minimum nitrite/nitrate ratio for new SCC limit.
4	0.5	0.83	1.66	Zapp's law minimum required nitrite to nitrate ratio.
5	1	0.15	0.15	Minimum nitrite to nitrate ratio for new SCC limits
6	1	0.6	0.6	Hoffman results suggest that this amount of nitrite is sufficient to prevent pitting.
7	1	1.66	1.66	Zapp's law minimum required nitrite to nitrate ratio.
8	5	0.6	0.12	FY13 tests indicated that the new SCC ratio was sufficient to mitigate LAI attack [14]. The ratio is slightly less than the new minimum requirement, but in-line with the minimum amount of nitrite required by the Hoffman results.

Three additional containers were added from the waste buffering activity (Task 3) for LAI corrosion testing. They were performed to asses a relationship between the results of electrochemical test and an alternate approach for testing pitting corrosion. Table 4-4 describes the nitrate, nitrite and hydroxide concentration for each test.

Table 4-4 Nitrate, nitrite and hydroxide concentrations for LAI corrosion test simulants from Waste buffering activity

Container	Nitrate (M)	Nitrite (M)	Hydroxide (M)
9	3.11	1.95	0.26
10	3.06	1.91	0.07
11	3	1	0.03

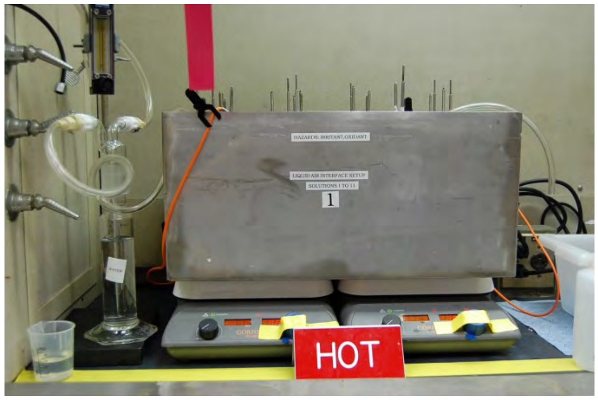
LAI corrosion tests were performed in the LDP and GW simulants, which simulated the environment on the exterior of the AY-102 secondary liner. Two LAI corrosion tests (containers 12 and 14) were performed with a partially immersed coupon and the other two tests (containers 13 and 15) were performed with a totally immersed coupon.

4.2.3 *Testing Apparatus*

The tests were performed in 1 Liter polycarbonate bottles. The black cap was modified as shown in Figure 4-5. Orange rubber stoppers were placed in four of the holes. Two connectors were attached to flexible Tygon tubing to provide an inlet and outlet flow of air and the other two stabilized the stainless steel rods that held the rectangular coupons in position (white Teflon tape covered rods). The stoppers were sealed with silicone to prevent air leakage. A hole in the middle was used to provide access to a pH probe, a thermocouple, and a reference electrode. In the picture this hole has a black rubber stopper.

Figure 4-5 Modified cap of containers for LAI corrosion studies

Eleven containers (containers 1 to 11) were placed in a water bath at 40 °C and four containers (containers 12 to 15) were placed in another water bath at 45 °C. A picture of the bath is shown in Figure 4-6. The water bath consists of a stainless steel box on top of two hotplates. The temperature of the bath was controlled by placing each individual thermocouples from the hotplate into the water surrounding the plastic containers. These containers were connected in series with Tygon tubing to provide the flow of air from a gas humidifier that was connected to a flowmeter for a flow rate of 5 sccm. The evaporation of water from the bath was minimized by placing packaging styrofoam pellets above the water.



(a)

(b)

Figure 4-6 LAI corrosion setup in hood showing (a) the bath on top of hot plates and (b) showing the contents of the bath.

To each container 500 mL of the specified simulant was added. The rods that hold the coupons were lowered to reach the desired position within the liquid. The containers were placed in the bath and water was added to reach similar level as the liquid inside the container. This level inside was marked outside the container to account for losses during testing. Water was added periodically to the bath to maintain the same level. Make-up distilled water was added in some instances to the containers to also maintain the LAI level, although on a less frequent basis.

At the beginning of testing pH, temperature and OCP was measured. The temperature of the solution in each container and pH was continued to be taken daily and OCP was measured two times per day when possible during working days. The coupons were maintained at these conditions for four months. One coupon was removed from each container after a two month interval.

At the end of testing the coupons were removed and cleaned using ASTM G1 Clark's solution [26] and weight losses were recorded.

4.3 Electrochemical Testing of Simulants

4.3.1 *Material sample*

For electrochemical testing, carbon steel in the form of “bullets” with dimensions 0.188 inch diameter and 1.25 inches long (Metal Samples) were used. Before testing, a drill was used to polish the sample to a 600-grit finish. The electrodes were examined with a stereomicroscope for any defect and to ensure that the sample had a homogeneous surface. Then they were rinsed with distilled water and acetone. Figure 4-7 shows a picture of the sample after being polished and rinsed. It shows the surface of the shank and nose of the bullet. The bullet was attached to a stainless steel rod protected by a glass holder. A Teflon fixture was used to prevent liquid contact with the stainless steel rod and ensure electrical isolation.

Figure 4-7 Side picture of the bullet (left) and frontal picture of the bullet (right).

4.3.2 *Simulants*

Simulants were prepared for two tasks (Task 3 and Task 4) from the task activities. For Task 3 simulants were made based on waste buffering from actual waste of tank AN-102. Task 4 simulants were obtained by performing a statistical test matrix covering data of corrosion activities from several years. Additional details of this assessment will be covered in section 5.5. A detailed chemical composition of each simulant is found in Appendix F for Task 3 and Appendix G for Task 4 as well as the corresponding results.

4.3.3 *Testing Apparatus*

Approximately 700 mL of simulant was added to a cell made by the SRNL glass shop that is similar to the cell for corrosion studies designed by Princeton Applied Research. At temperatures of testing greater than 50 °C, a condenser was used to minimize evaporation. Two carbon graphite rods served as the counter electrode. A saturated calomel electrode (SCE) was used as the reference electrode. Prior to each test, the electrode was checked against a standard before testing (a SCE in 1M KCl solution not used for testing). The SCE was placed in a bridge containing 0.1 $NaNO_3$ solution. The cell was placed on top of a hotplate with temperature control. REF 600 (Gamry) and VERSASTAT 3 (Ametek) potentiostats were used in this study and prior of using them ASTM G5 [29] was performed for quality assurance. The standardized pitting protocol was used to gather the data. The open circuit potential (OCP) was measured during the sample stabilization for two hours. The cyclic potentiodynamic polarization (CPP) test was conducted by applying a cyclic potential ramp from -50 mV vs. OCP up to a vertex threshold current of 1 mA/cm^2 at a scan rate of 0.167 mV/s. The potential was finally returned back to the OCP to complete the test.

5.0 Results and Discussion

Pictures of the samples after exposure of the different conditions are presented in Appendix B and D for task activity 1 and 2. For Task activity 3 and 4 electrochemical results and pictures obtained after testing are shown in Appendix F and G, respectively. The discussion of results for the task activities are organized in sections to correlate all data obtained with the particular study.

5.1 Secondary Wall of Tank AY-102 Corrosion Studies

Corrosion studies were undertaken to assess the likelihood of a breach to the secondary liner of Tank AY-102. This testing will assess the susceptibility of this secondary liner to degradation by the leaked waste inside the primary containment and on the exterior of the secondary due to interactions with humid air or ground water.

The simulants for the LDP residue and the GW were recommended by the EPOC. LAI, Total Immersion (TI) and VS corrosion were performed and results are presented in the following subsections.

5.1.1 *Liquid Air Interface and Total Immersion tests*

LAI and TI tests were performed to determine the susceptibility of carbon steel to corrode in simulants corresponding to LDP and GW. Photographs of the coupons after two months and four months of exposures are presented in Figure 5-1 for LDP and in Figure 5-2 for GW for 50% and 100% immersion.

Aggressive corrosion behavior was observed on the carbon steel exposed to LDP and GW. At 50% immersion, the corrosion attack concentrated at the water line and below for the two simulants. A clear distinction in the degree of corrosion that occurred in each simulant could not be seen visually. It did appear however, that during the first two months of exposure the majority of the coupon above the LAI did not corrode. Table 5-1 shows the weight losses of the coupons. For the LDP simulant, LAI coupon experienced approximately half the weight loss of TI coupon for the two month period. However, very similar weight losses were observed with this simulant after four months of exposure. Observing the pictures for LDP 50% immersion at four months, general attack in the vapor space above the LAI results in a weight loss that was similar to the sample that was 100% immersed. This result indicates that corrosion during the first two months was focused at the waterline and below but after longer time exposure, the corrosion increased to the vapor space area of the coupon. The results for coupon completely immersed in LDP simulant (solution 13) were similar to 50% immersion and TI in GW simulant (Solution 14 and 15, respectively). The general corrosion rate remained fairly constant at approximately 10 mils/yr during the 4 month test.

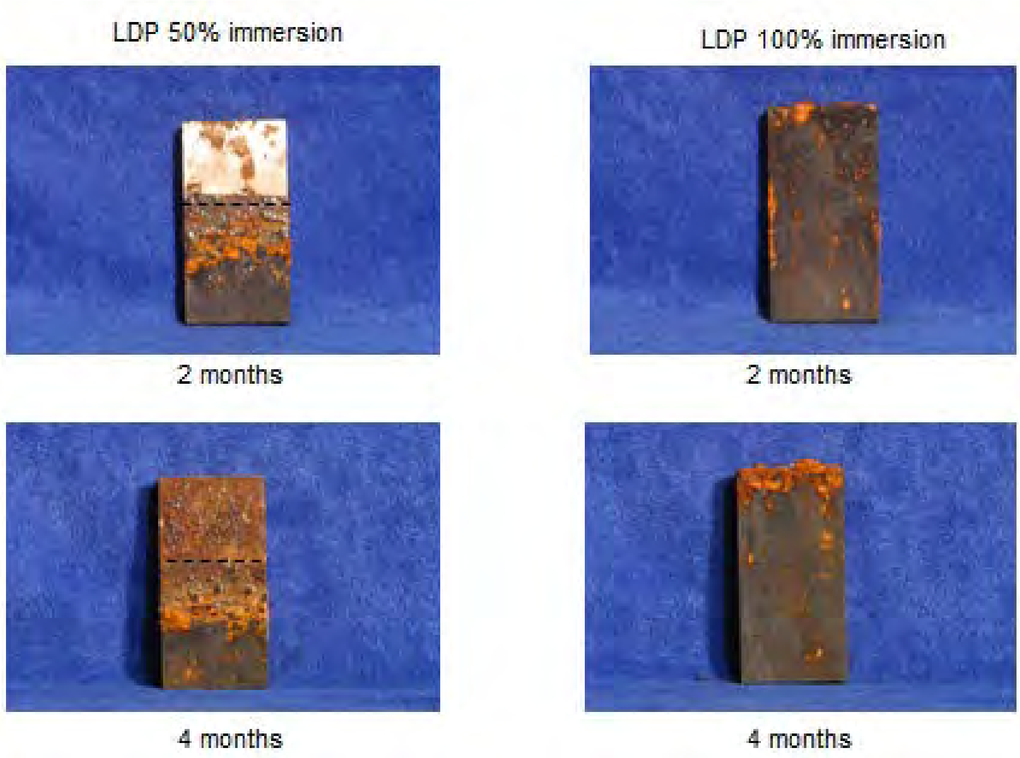


Figure 5-1 Coupons from LAI and TI corrosion test using LDP simulant

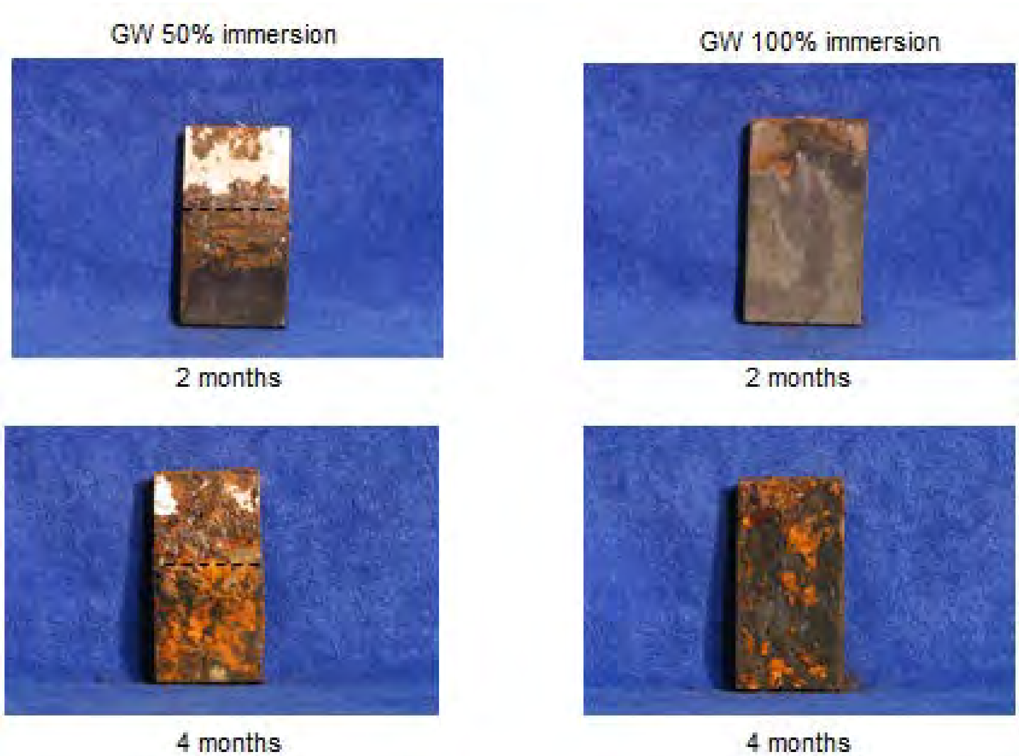


Figure 5-2 Coupons from LAI and TI corrosion test using GW simulant

Table 5-1 Weight losses and corrosion rates for carbon steel coupons exposed to LDP and GW simulants

Simulants	Months Exposure			
	Two months		Four months	
	weight loss (g)	Corrosion rate (mpy)	weight loss (g)	Corrosion rate (mpy)
Solution 12 LDP simulant 50% immersion	0.5797	5.34	2.2387	10.3
Solution 13 LDP simulant 100% immersion	0.9999	9.2	2.3817	10.96
Solution 14 GW simulant 50% immersion	1.0397	9.57	2.3651	10.88
Solution 15 GW simulant 100% immersion	1.0780	9.92	2.5246	11.62

Figure 5-3 shows the OCP transients that were measured during the course of the long term test of the coupons immersed at 50% and 100% in LDP and GW simulants. For all the cases the OCP started at a potential of -630 to -675 mV vs. Ag/AgCl and increased to more noble values over time. Furthermore, there was no significant difference in OCP for the partially immersed and totally immersed coupons since for both simulants the OCP are comparable during the 4 months for the coupons in GW simulant; and after 1000 hours for the coupons in LDP simulant. During the first 24 hours the OCP stabilized and reached similar values for the four coupons. Shortly thereafter the OCP for the coupons exposed in LDP increased rapidly which may indicate the formation of corrosion products on the surface. The OCP started to stabilize around 560 hours for the coupon 50% immersed and around 1100 hours for the coupon 100% immersed in which reached a range of -130 to -230 mV vs. Ag/AgCl. The coupons immersed in GW continued gradually to increase OCP during the 4 month period and it appears that the voltage started to stabilize after 2600 hours close to -350 mV vs. Ag/AgCl on average.

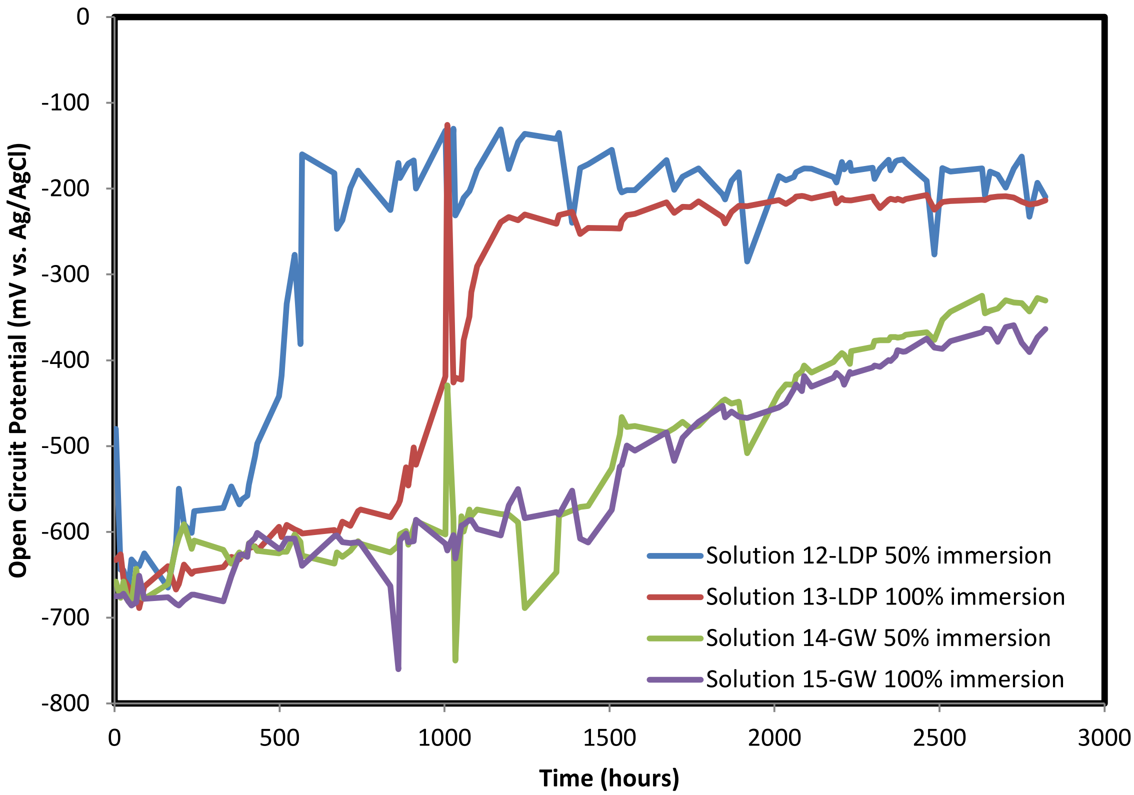


Figure 5-3 OCP vs. time of carbon steel coupons exposed to LDP and GW simulants for four months

Pits sizes were measured utilizing an optical microscope and the results are displayed in Table 5-2 along with qualitative assessments of the surface. The pits tended to be broad, shallow depressions within an area of general attack. For the samples immersed at 50% in LDP and GW simulant the pits sizes were the largest at the water line and below with pits increasing in size. Pits were most uniform and with depths ranging from 1 to 2 mils above LAI after 2 months, but increased in size after 4 months of exposure to sizes similar to the pits at the waterline and below. However the attack was not as strong as observed at the waterline and below. For the totally immersed samples general corrosion with broad shallow depressions were observed.

Table 5-2 Pitting diameter and depth range of solutions from LDP and GW simulants

Solution	Time exposed (months)	diameter range (mils)	depth range (mils)	Remarks
12 (LDP)	2	1.1-24.2	0.1-3.1	Strong GA at waterline and below. Some areas with weak GA above the waterline. Large pits found at water line and decreasing in size from waterline to below.
	4	1.8-37.8	1.1-5.0	Strong GA in the entire sample with large pits found around the waterline and decreasing in size from waterline to below.
13 (LDP)	2	1.6-6.7	0.6-2.6	GA with broad, shallow depressions were observed in all sample.
	4	0.9-25.9	0.9-8.6	GA with large pits observed in the entire sample with very strong attack at the top area.
14 (GW)	2	1.9-21.7	0.6-3.6	Strong GA at waterline and below. Some areas with weak GA above waterline. Large depressions found at waterline and below
	4	0.6-19.7	0.5-7.8	Strong GA in 95% of sample with large pits found around waterline and below
15 (GW)	2	1.2-4.1	1.1-1.8	GA with broad, shallow depressions observed in the entire sample.
	4	0.6-12.5	0.6-6.0	GA with broad, shallow depressions observed in the entire sample.

GA – General Attack

5.1.2 *Vapor space corrosion tests*

Vapor space corrosion testing with the LDP and GW simulants was conducted for four months at the three different levels. A coupon was removed each month from each level. Figure 5-4 and 5-5 shows pictures of the coupons after exposure for Vessel 7 and Vessel 8, respectively. Pictures of the coupons before and after cleaning are presented in Appendix B.

Generally, VS corrosion was more prevalent on the coupons above the GW simulant (Solution 8), than LDP residue simulant (Solution 7). Not surprising, VSC was greater for the samples that experienced the wet/dry cycle. As seen in Figure 5-5, the surface corroded more for the coupons located in Level 1, followed by the coupons located at Level 2 and finally little to no surface corrosion at Level 3. The coupons from LDP did not reflect the same tendency as a similar degree of corrosion was observed at every level (Figure 5-4). Additionally, the degree of attack on the coupons above the LDP simulant did not appear to increase with exposure time. For example, at each level the coupons do not identify a pattern of more VSC as the time progresses from 1 month to 4 months. These results likely reflect the higher concentrations of aggressive species (chloride and sulfate) present in the GW simulant.

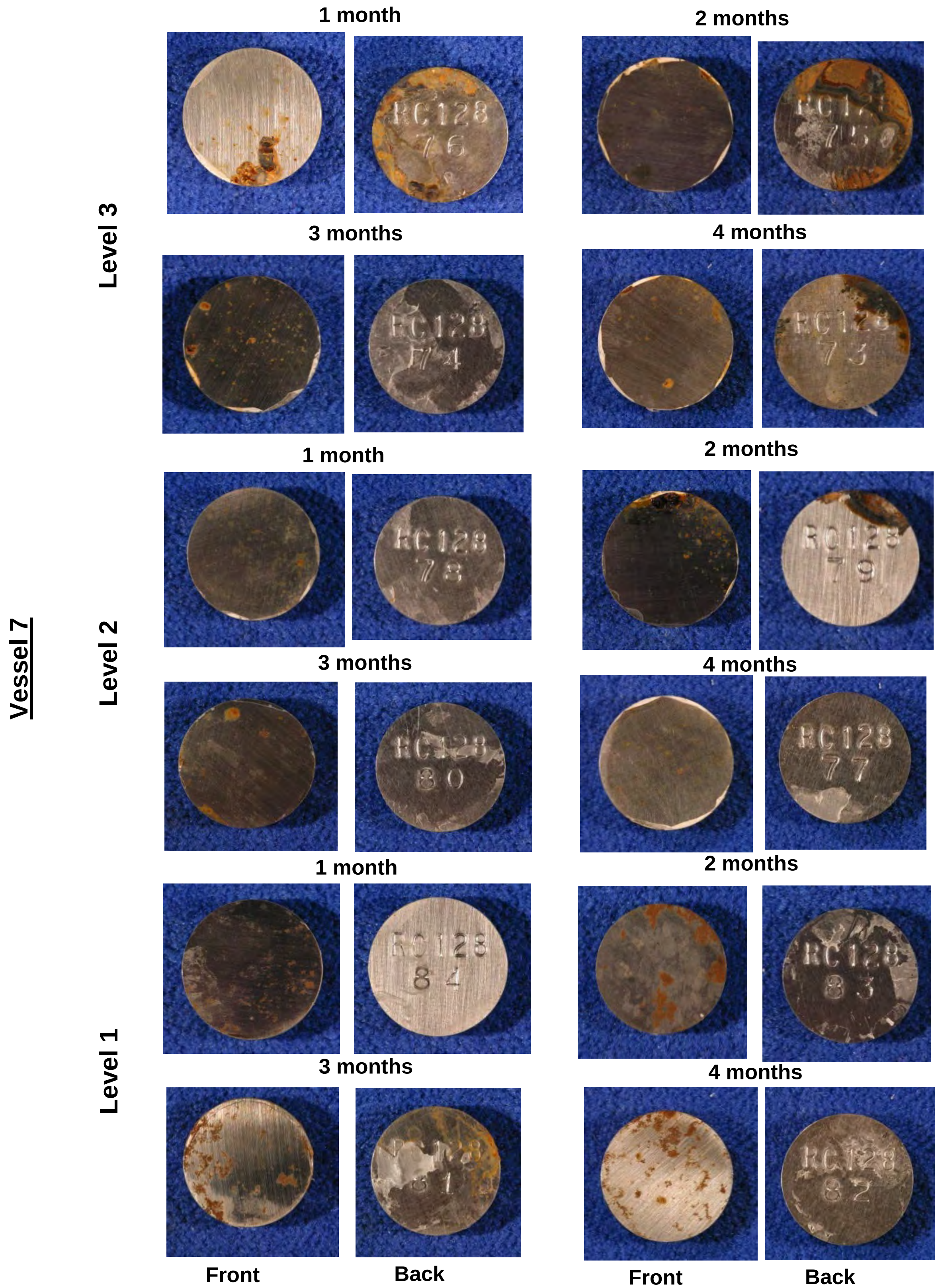


Figure 5-4 Pictures after VS exposure in simulant 7 at three different levels

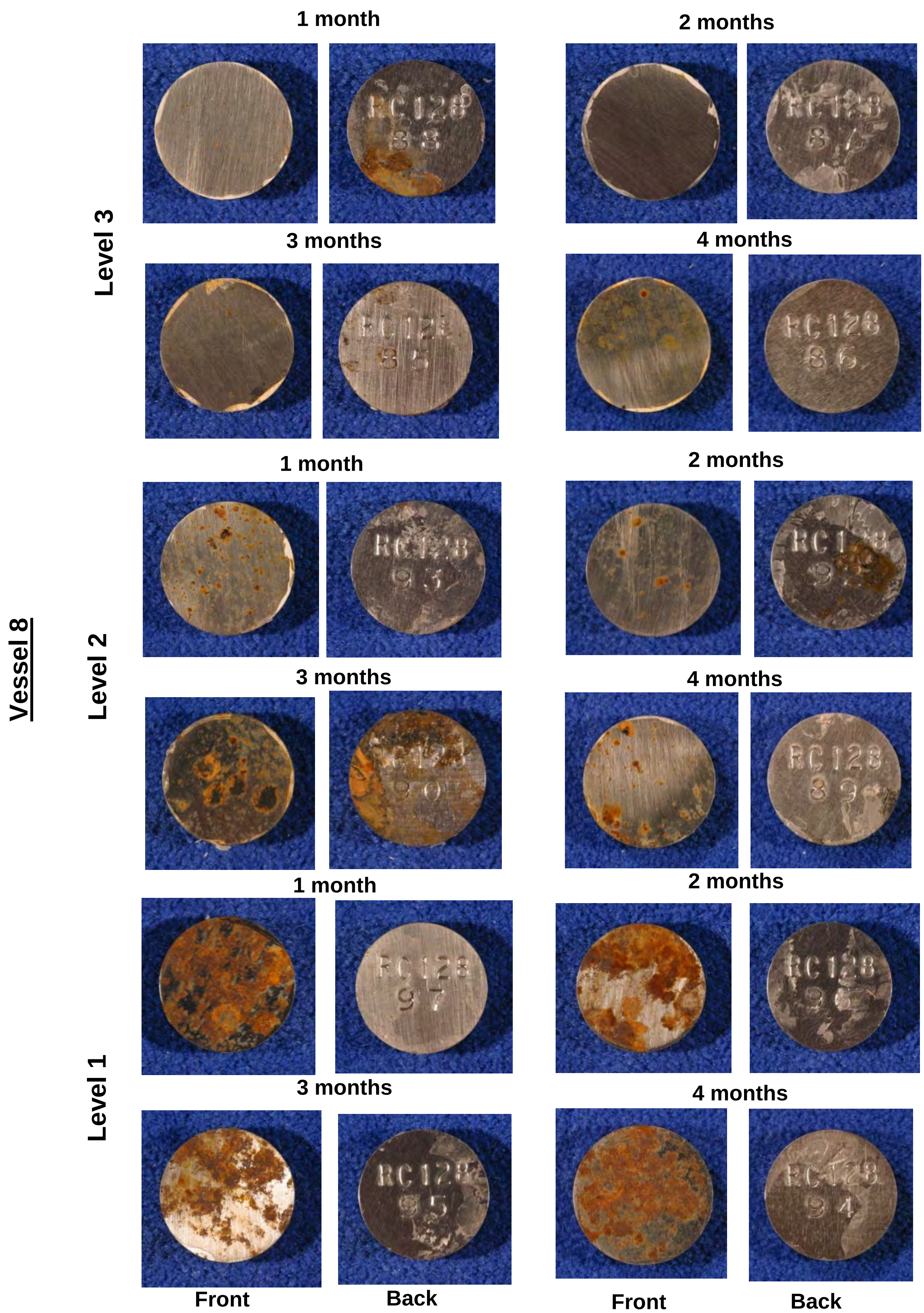


Figure 5-5 Pictures after VS exposure in simulant 8 at three different levels

An issue encountered after removing the coupons from the cold mount was crevice corrosion. The occurrence of the attack varied as it occurred in some samples more than in others, and was independent of the time that the coupon was subjected to corrosive conditions. It is evident that the nail polish was not as effective as in previous studies. Other techniques for the prevention of crevice corrosion, such as other stronger and more durable coatings, that can withstand humid environments, if cold mounted samples are being used.

Weight losses for the coupons were obtained for each sample and are presented in Table 5-3. As seen the weight losses were not representative of the amount of corrosion seen in each sample. For example, coupons from level 1 of Vessel 8 were observed to have a great amount of corrosion so it is expected high weight losses but after comparing to coupons at level 3 for this vessel that they appear to have minimal corrosion, however, the weight losses are higher. The weight losses to determine the VS corrosion rate were confounded somewhat due to the degree of attack in the crevices that do not reflect VSC. It is recommended than methods to prevent crevice corrosion can be developed and cold mounted preparation to maintain accuracy in weight loss from VSC. However, the visual evidence suggests that vapor space attack would be most significant if the surface of the steel was periodically wetted.

Table 5-3 Weight losses of coupons at different levels in solutions 7 and 8.

Vessel number	Level in vessel	Time exposure (month)	Weight loss (g)
7	High (Level 3)	1	0.0174
	High (Level 3)	2	0.0111
	High (Level 3)	3	0.0110
	High (Level 3)	4	0.0286
	Middle (Level 2)	1	0.0109
	Middle (Level 2)	2	0.0062
	Middle (Level 2)	3	0.0061
	Middle (Level 2)	4	0.0020
	Low (Level 1)	1	0.0341
	Low (Level 1)	2	0.0477
	Low (Level 1)	3	0.0045
	Low (Level 1)	4	0.0090
8	High (Level 3)	1	0.0155
	High (Level 3)	2	0.0147
	High (Level 3)	3	0.0439
	High (Level 3)	4	0.0282
	Middle (Level 2)	1	0.0311
	Middle (Level 2)	2	0.0147
	Middle (Level 2)	3	0.0137
	Middle (Level 2)	4	0.0077
	Low (Level 1)	1	0.0101
	Low (Level 1)	2	0.0121
	Low (Level 1)	3	0.0065
	Low (Level 1)	4	0.0049

5.2 Waste Buffering of simulant from DST AN-102

Previous electrochemical testing in actual waste from tank 241-AN-102 was performed to determine the susceptibility of carbon steel to corrode [18]. The test results indicated that the carbon steel was not vulnerable to pitting corrosion in the actual waste. The electrochemical testing and LAI long term testing of carbon steel in waste buffering simulants of Hanford DST AN-102 supernate is discussed below.

5.2.1 Electrochemical Testing

Using a full simulant based in an actual waste for tank AN-102 with different concentrations of nitrate, nitrite and hydroxide, electrochemical experiments were performed. Table 5-4 shows the tests with molar concentration of nitrate, nitrite and hydroxide. The tests were ordered from the highest hydroxide concentration to the lowest. Tests 1, 2 and 3 have similar hydroxide concentration to the actual waste from tank AN-102 (0.30 M). The temperatures of the tests varied from 30 to 50 °C.

Table 5-4 Electrochemical test conditions for waste buffering simulants based from actual waste from tank AN-102

Test	Temperature (°C)	Hydroxide (M)	Nitrite (M)	Nitrate (M)	Hysteresis	Pitting on Sample?
1	40	0.262	1.00	3.00	Negative	None
2	50	0.262	2.00	3.00	Negative	None
3	50	0.262	2.50	3.00	Negative	None
4	50	0.162	1.00	3.00	Negative	None
5	30	0.072	1.95	3.11	Negative	None
6	40	0.072	1.95	3.11	Negative	None
7	50	0.072	1.95	3.11	Negative	None
8	50	0.062	1.94	2.90	Negative	None
9	30	0.052	2.24	3.77	Negative	None
10	40	0.052	2.24	3.77	Negative	None
11	50	0.052	2.24	3.77	Negative	None
12	30	0.032	1.91	3.06	Negative	None
13	30	0.032	2.13	3.40	Negative	None
14	40	0.032	1.91	3.06	Negative	None
15	40	0.032	2.13	3.40	Negative	None
16	50	0.032	1.91	3.06	Negative	None
17	50	0.032	2.13	3.40	Negative	None

*Conditions for LAI corrosion testing are highlighted in yellow.

Table 5-4 contains a summary of the behavior of the CPP curve and a description of the post-test condition of the sample. All the tests in the matrix indicated negative hysteresis and no pitting on the sample. Appendix F shows each of the simulant compositions followed by the CPP curves for the sample and a duplicate test. Post-test pictures of nose and shank at 10X and 20X magnification, respectively, are also exhibited. Figure 5-6 shows CPP curves of sample and duplicate of carbon steel for tests 1, 2 and 3. These tests had the maximum hydroxide concentration with a variation in nitrite concentration. Similar curve patterns were observed for Tests 1 and 2 (also shown in Appendix F). The open circuit potential was approximately -0.600 V vs. SCE in both cases. This was followed by was an extended passive region for approximately 1 V before transpassive behavior was observed. Negative hysteresis was observed on the return scan. Almost all of the tests showed a CPP curve as described, except the duplicate of test 16 in which the open circuit was obtained close to -0.800 V vs. SCE so the transpassive region started at a lower potential. Tests at lower nitrite and hydroxide concentrations produced CPP curves similar to that shown in Figure 5-7. No significant change in the corrosion behavior was observed.

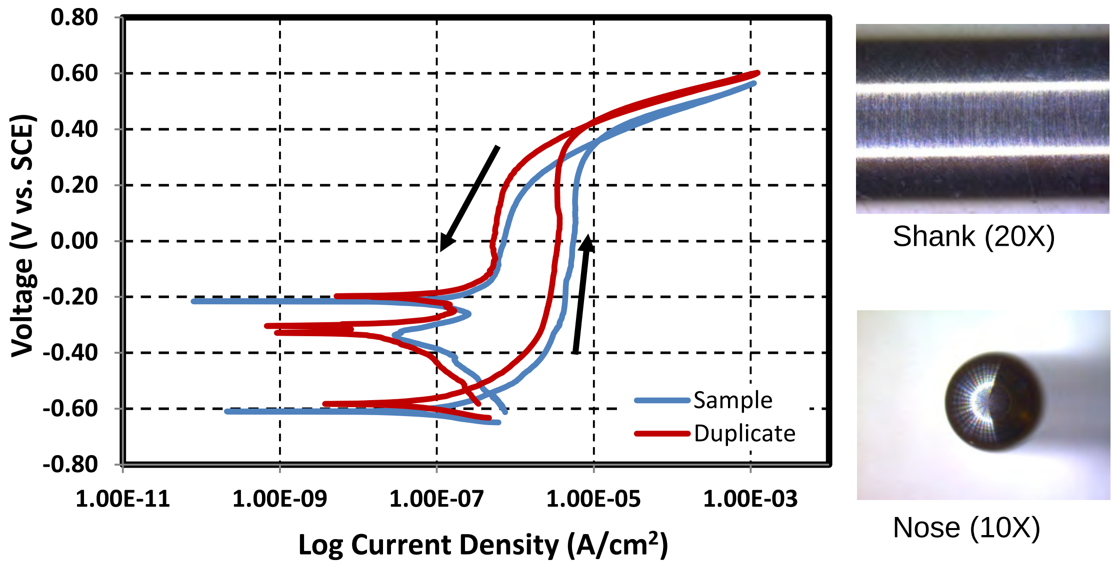


Figure 5-6 Cyclic potentiodynamic polarization scans for sample and duplicate using conditions described in Test 1

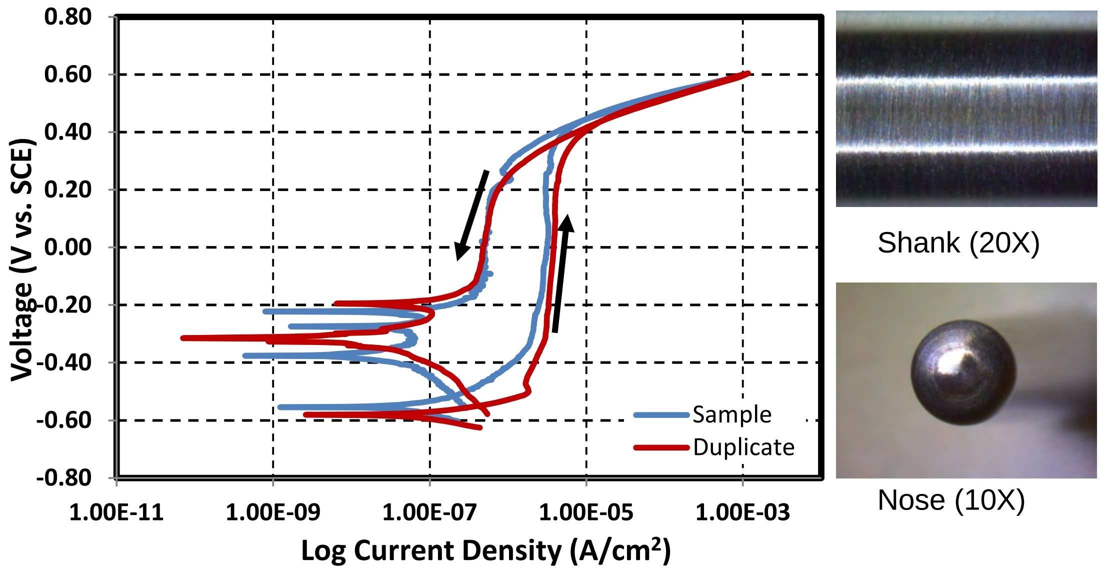


Figure 5-7 Cyclic potentiodynamic polarization scans for sample and duplicate using conditions described in Test 4

Tests 5, 6, and 7 had similar nitrate, nitrite and hydroxide concentrations with temperature as the only variable. The CPP results for the highest temperature at 50 °C (Test 7) are presented in Figure 5-8. The open circuit potential was again approximately -0.600 V vs. SCE and the passive region again extended for approximately 1.0 V. The electrode surfaces were again free of attack. Similar curves were obtained for tests 5 and 6 indicating no strong temperature dependence within this range of temperatures.

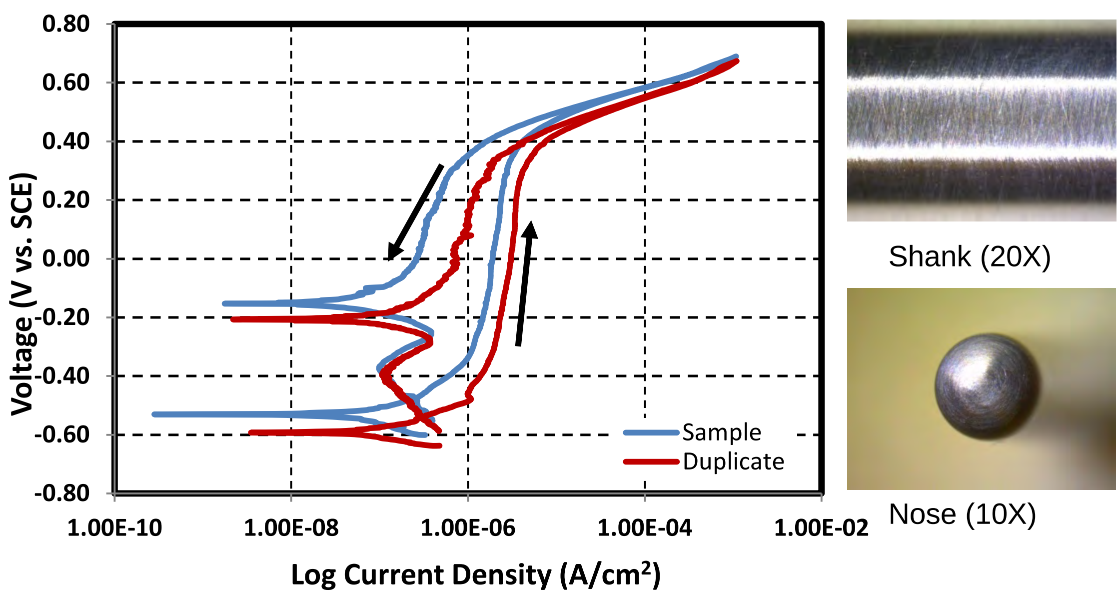


Figure 5-8 Cyclic potentiodynamic polarization scans for sample and duplicate using conditions described in Test 7

At very low hydroxide concentrations (0.032 M) no evidence of pitting was observed on the electrode as shown in the pictures in Figure 13 for test 17. The CPP curve was similar to the previous cases, but the degree of negative hysteresis was less.

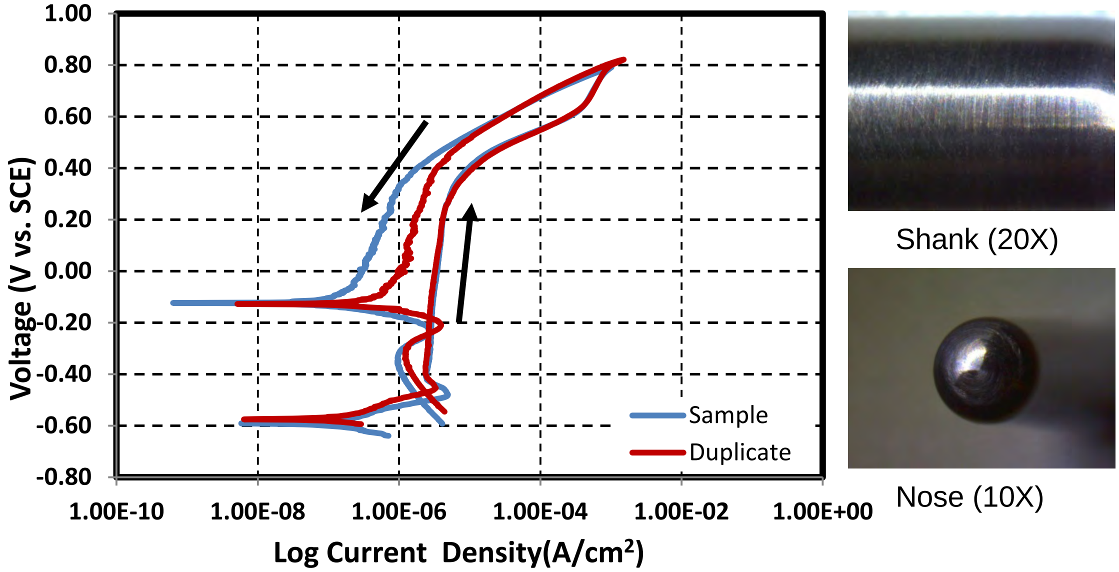


Figure 5-9 Cyclic potentiodynamic polarization scans for sample and duplicate using conditions described in Test 17

The results demonstrated that hydroxide concentrations as low as 0.032 M can still offer inhibition at these high nitrate concentrations provided sufficient nitrite is also present.

5.2.2 Liquid air interface testing

LAI corrosion testing was performed for four months for tests 1, 6 and 14 from Table 5-4, which corresponds to solutions 9, 10, and 11, respectively. Figure 5-10 shows the pictures of the carbon steel coupons after two and four months of exposure. As seen in the pictures no general corrosion developed on any of the specimens and coupons appeared visually to be independent of the amount of time exposed to the simulant. A salt film developed above the LAI (white residue at the top of coupon) during condensation in this area. The salt film appeared to be thicker for Solutions 9 and 10 than for solution 11. Close to the LAI and below the carbon steel in solution showed no signs of localized corrosion or any corrosion attack. Weight loss results for all the samples showed negligible weight loss indicating no dissolution of the metal during exposure.

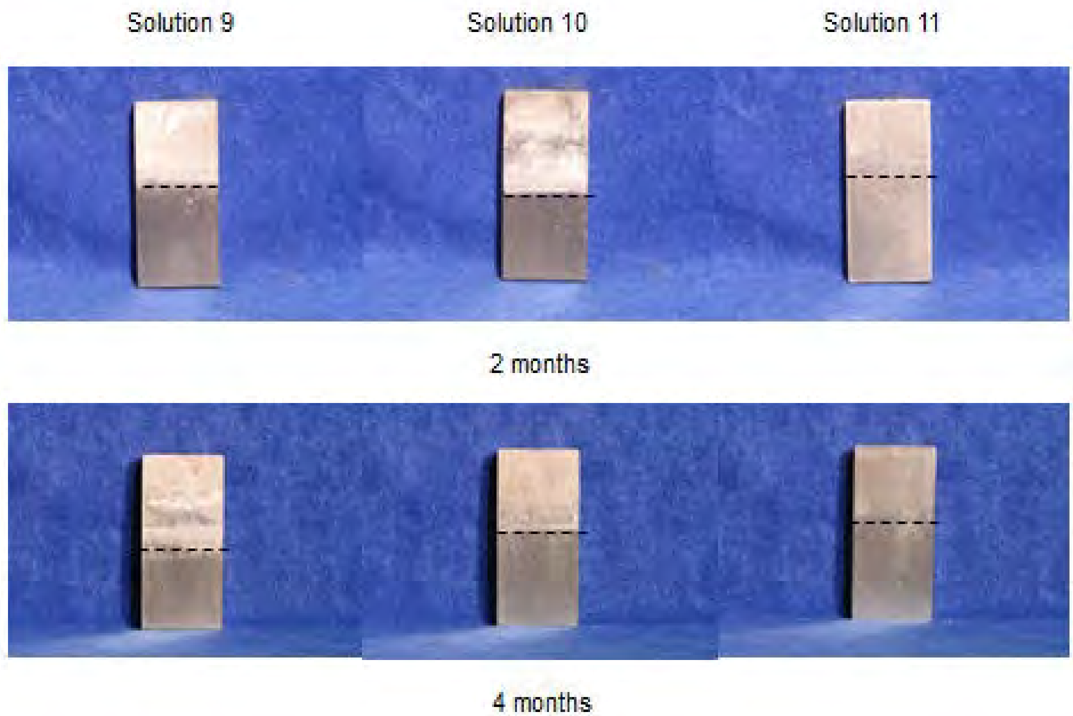


Figure 5-10 LAI coupons immersed in simulants developed for waste buffering from actual AN-102 waste (Sols. 9-11) for 2 and 4 months

Analyzing the samples under a measuring microscope minor pitting was observed. The ranges of pits are tabulated in Table 5-5. The pits located ranged from 0.5 to 1.3 mils in depth and 0.5 to 4.3 mils in diameter for all samples. The pit density was also low. For solutions 9 and 10 the pits were found mostly at the LAI while for solution 11, pits were also found above LAI. It appears that at lower hydroxide concentrations the salt film was thinner and it makes it susceptible for more localized corrosion attack. After four months of exposure a small increase in pit diameter was observed, however there was no significant increase in depth. Compared to pit sizes in uninhibited wastes (e.g., 60 mils deep after 2 months [30], these pits are of little consequence. Below the LAI, where the carbon steel was immersed in the simulant, there were no indications of pitting, which means that these conditions are relatively benign.

Table 5-5 Pitting diameter and depth range of solutions simulating AN-102 waste

Solution	Time exposed (months)	diameter range (mils)	depth range (mils)	Remarks
9	2	0.6-1.0	0.7-0.9	Salt deposition above LAI with small shallow pics observed at LAI.
	4	1.1-4.3	0.6-1.3	Salt deposition above LAI with small shallow pics observed at LAI.
10	2	0.5-1.6	0.6-0.7	Salt deposition above LAI with small shallow pics observed at LAI
	4	0.7-3.4	0.7-1.1	Salt deposition above LAI with small shallow pics observed at LAI.
11	2	0.6-1.1	0.5-0.7	Salt deposition above LAI with minor deposition below LAI. Small shallow pics observed above and at LAI.
	4	0.6-2.1	0.3-0.8	Salt deposition above LAI with minor deposition below LAI. Small shallow pics observed above and at LAI.

The OCP was measured during the LAI testing to examine trends in open circuit potential that can identify periods of active corrosion and passivation. Figure 5-11 shows an OCP vs. time curve for Solutions 9, 10 and 11. The general trend shows that below 100 hours the OCP increases as the oxide film grows and become stable. The long term stability of the OCP suggests that the steel surface is passive and minimal corrosion is occurring.

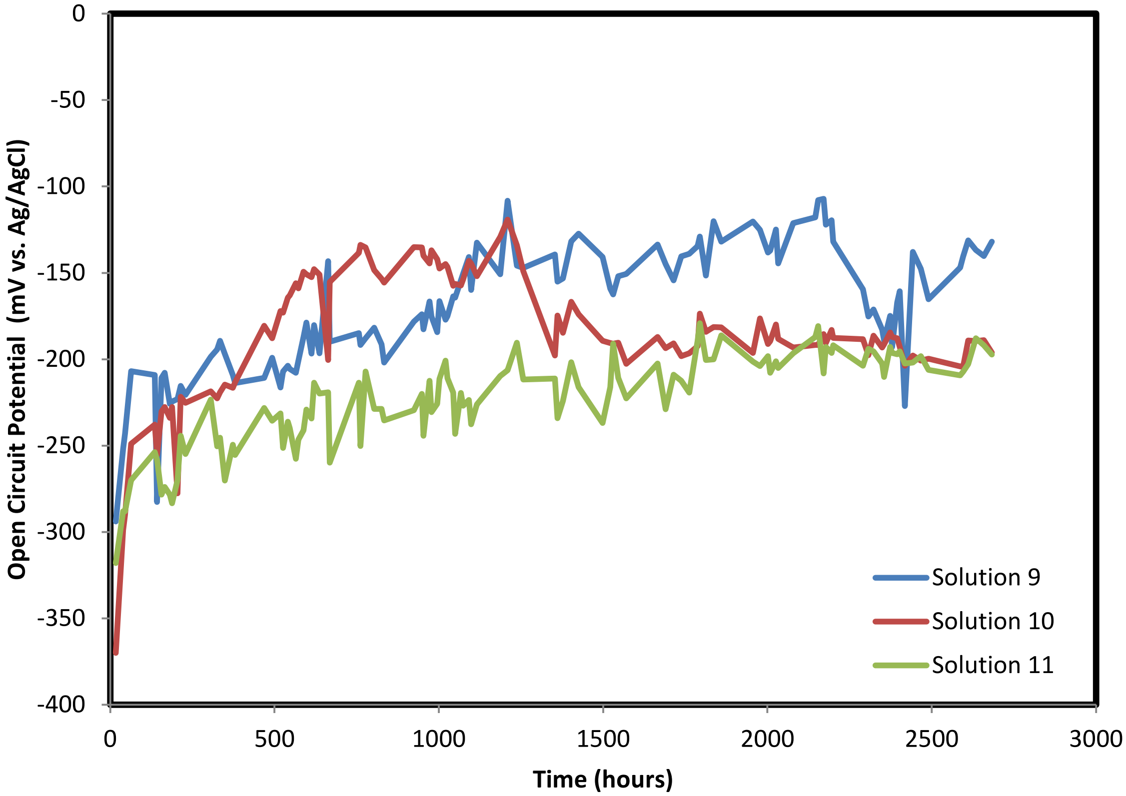


Figure 5-11 OCP measurements at different periods during four month testing of LAI for Solutions 9, 10, 11.

5.3 <u>Vapor Space Corrosion tests at new SCC limits at different ammonia concentrations</u>

Three different simulants, at the borderline of the new SCC corrosion limits were utilized for VSC tests. The specific limit of testing is the minimum nitrite/nitrate ratio of 0.15 and the nitrate concentrations that were tested were 0.4, 2 and 4.5 M. Previously, it was found that these concentrations of nitrate were insufficient to prevent pitting in the vapor space [7]. Ammonia gas at two concentrations (50 and 550ppm) was selected based on previous results that indicated that 550 ppm mitigates vapor space corrosion for a simulant with a high nitrate concentration [7].

Coupon tests were conducted for four months in each environment with coupons being removed on monthly intervals. Figures 5-12 and 5-13 correspond to fourth month testing at 50 ppm ammonia (Vessels 1, 2 and 3) and 550ppm ammonia (Vessels 4, 5 and 6), respectively. The complete arrays of images for all coupons are shown in Appendix B. At 550 ppm of ammonia in the VS (Figure 5-12), the front surface for all of the simulants indicated no sign of VSC at Levels 3 and 2 with very minor general corrosion regions at Level 1. Even at 50 ppm (Figure 5-13), there was no appararent VSC at the surface for Levels 3 and 2. Al Level 1 for the samples exposed at 50 ppm Ammonia, minor corrosion can be observed around the edges of the circular coupon. However, is still falls below of what was previously seen in previous experiments [7]. This confirms that as little as 50 ppm of ammonia can be effective to inhibit VSC of carbon steel at wastes covered by the new SCC control specifications.

When the back of the coupons were examined, evidence of crevice corrosion was observed. As explained in section 5.1.2, the occurrence of crevice attack was variable and did not depend on the exposure time or the height above the liquid level. The nail polish, utilized to prevent crevice attack, appeared to degrade as it turned from clear to white in most cases. Other prevention methods for crevice corrosion should be utilized in the future. An interesting observation of the corrosion on the back of the coupons is that it appears that this type of corrosion affected more coupons subjected at 550 ppm than 50 ppm of ammonia.

The weight losses for coupons were not shown in the report because they were not representative of the VSC on each sample due to the crevice attack. Moreover, the weight losses for VSC in this case are essentially not needed since very minor or almost no corrosion was observed on the exposed surface of the coupon.

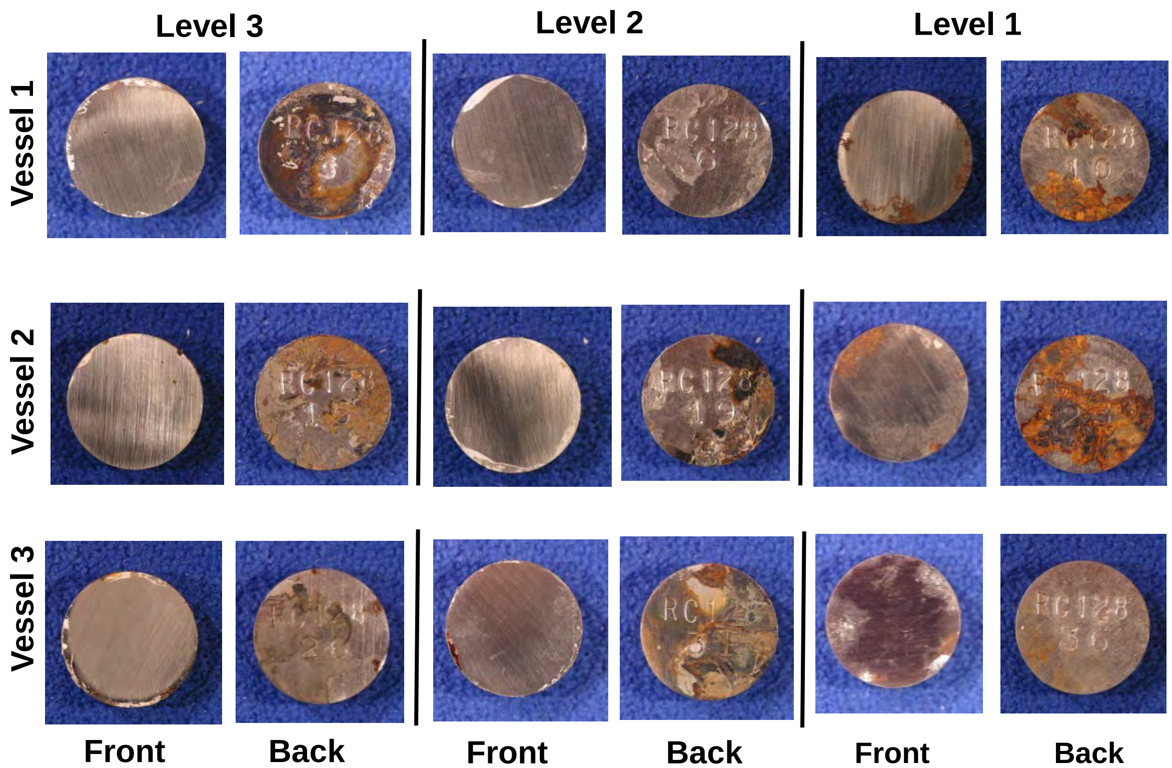


Figure 5-12 Fourth-month exposure at VS conditions of carbon steel in Vessels 1, 2 and 3 at 50 ppm Ammonia

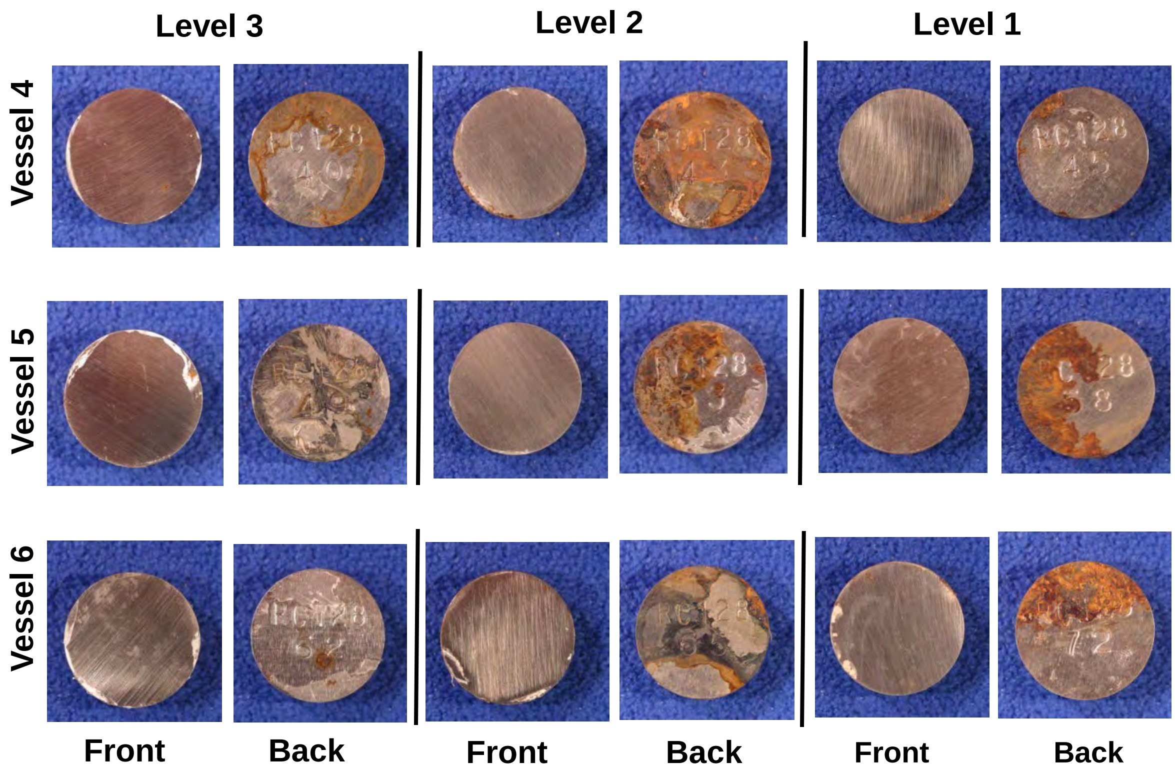


Figure 5-13 Fourth-month exposure at VS conditions of carbon steel in Vessels 4, 5 and 6 at 550 ppm Ammonia

5.4 Liquid Air Interface tests at new SCC limits

For these tests, the ratio of nitrite to nitrate was varied shown in Table 4-3. The solution chemistries for the eight tests are shown in Appendix C. Coupons were exposed for two months and four months using the LAI setup.

Figure 5-14 and 5-15 shows the pictures for carbon steel coupons in solutions 1-4 and 5-8, respectively. None of these coupons exhibited significant corrosion attack at LAI or below. This confirms previous results obtained from Zapp [27] and Hoffman [28] that observed no pitting corrosion at the conditions outline in Table 4-3. Varying degrees of attack were observed in the VS above the liquid level, with the worst case being solution 3. This condition was at a relatively low nitrate concentration (0.5 M) and at the minimum nitrite/nitrate ratio for the new SCC limits (0.15). The coupons exposed to solution 7 appeared almost exactly as they did prior to test. This solution had a higher nitrate concentration and the highest nitrite/nitrate ratio (1.66).

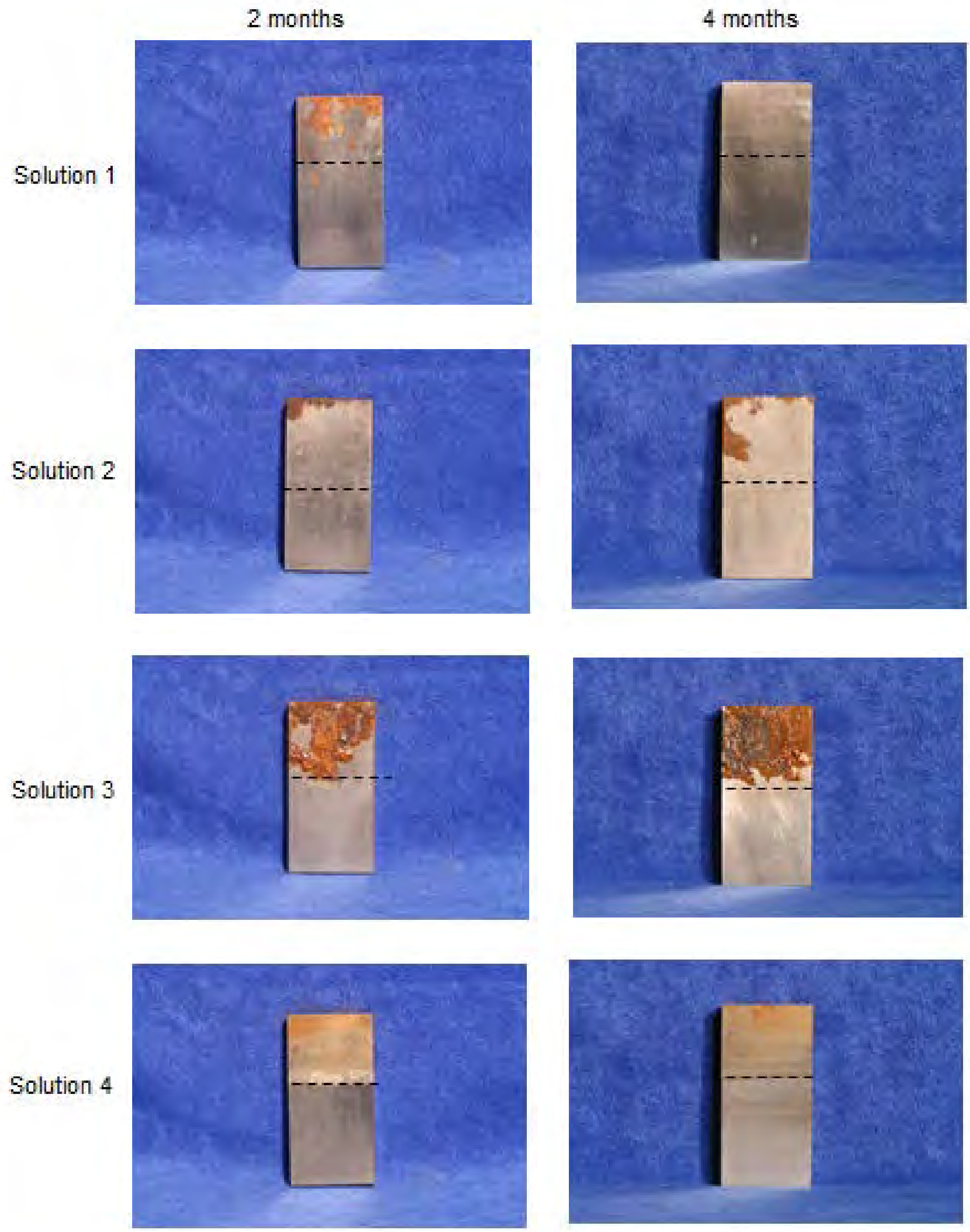


Figure 5-14 Pictures of coupons after two months and four months exposure during LAI testing for solutions 1, 2, 3 and 4. The dash line represents the interface.

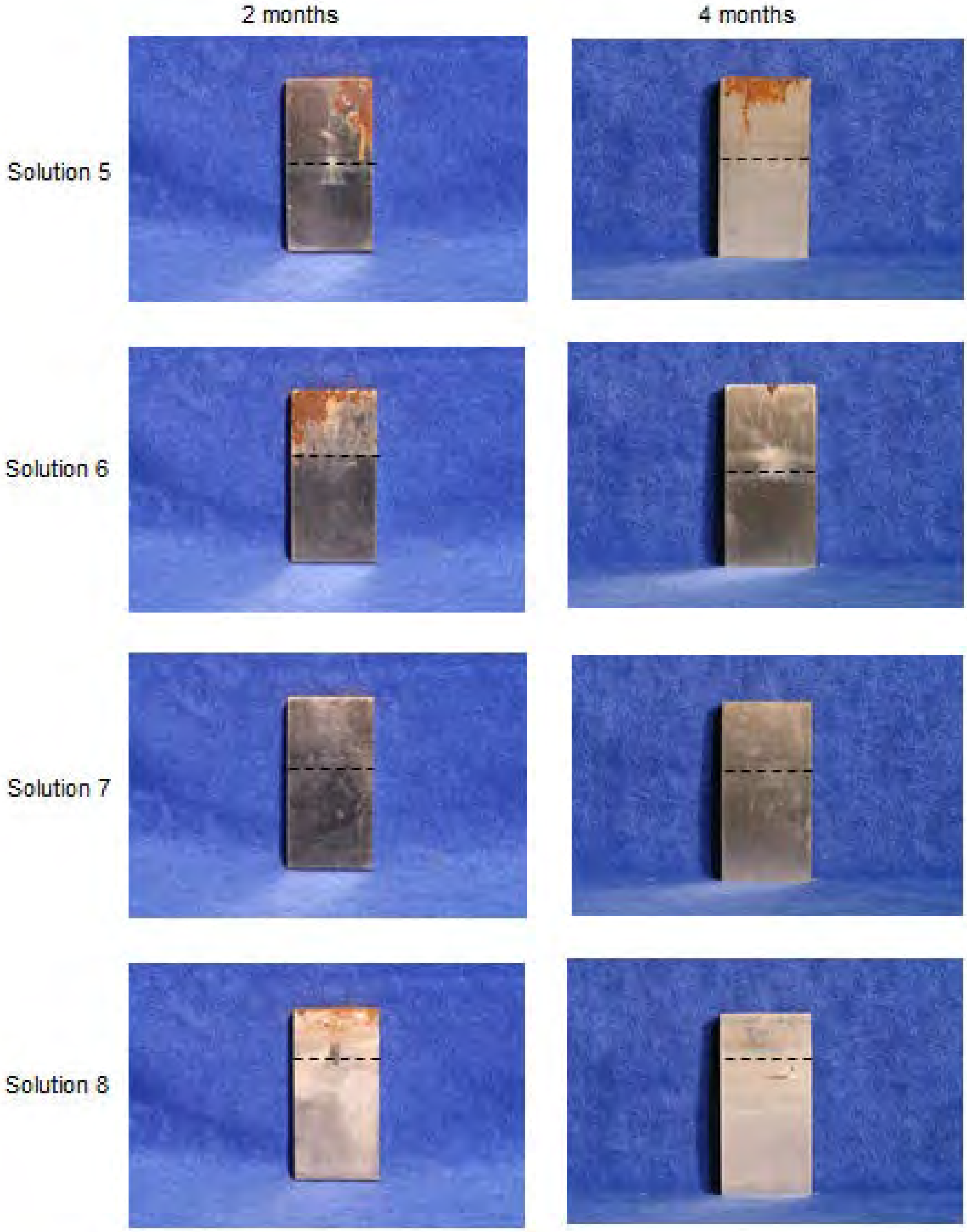


Figure 5-15 Pictures of coupons after two months and four months exposure during LAI testing for solutions 5, 6, 7 and 8. The dash line represents the interface.

Table 5-6 Weight losses and corrosion rates for carbon steel coupons exposed to Solutions 1 to 8 for 2 and 4 months

Solutions	Months Exposure			
	Two months		Four months	
	weight loss (g)	Corrosion rate (mpy)	weight loss (g)	Corrosion rate (mpy)
1	0.0329	0.30	0.0000	0.00
2	0.0386	0.36	0.0180	0.08
3	0.0988	0.91	0.1723	0.79
4	0.0166	0.15	0.0003	0.00
5	0.0282	0.26	0.0041	0.02
6	0.0097	0.09	0.0022	0.01
7	0.0028	0.03	0.0002	0.00
8	0.0000	0.00	0.0002	0.00

Weight losses after two months and four months are presented in Table 5-6 and confirm corrosion rates are less than 1 mpy and in some cases close to 0 mpy. The highest corrosion rate occurred in carbon steel coupons exposed to solution 3. All the corrosion on this sample occurred in the VS. Typically any corrosion seemed to initiate at the top of the coupon and develop an area of general corrosion and that continues to spread above the LAI. The smallest ratio of nitrite to nitrite (0.12) was solution 8 and during the contact with the carbon steel coupon it developed a film that completely covered the coupon and protected it from corrosion attack even though the ratio is less than the new minimum SCC control limits. The corrosion appeared to be more severe for the more dilute solutions at a given nitrite/nitrate ratio.

OCP measurements for solutions 1 to 8 are presented in Figure 5-16. The OCP for the solutions in general gradually increased from an initial value to a relatively constant value after 2-3 days. The potential transient does oscillate slightly, which indicates some changes in the oxide film. For most of the tests, there was a period of OCP instability during four months indicated active corrosion for short periods of time. The most negative OCP was for carbon steel in contact with solution 3 and 4. Solutions 3, and 5 exhibited the most activity (i.e., the largest variance in OCP values) during the course of the test. For the carbon steel exposed in solution 7 the OCP was the most stable during the fourth month period and indicates a stable oxide condition in that particular solution.

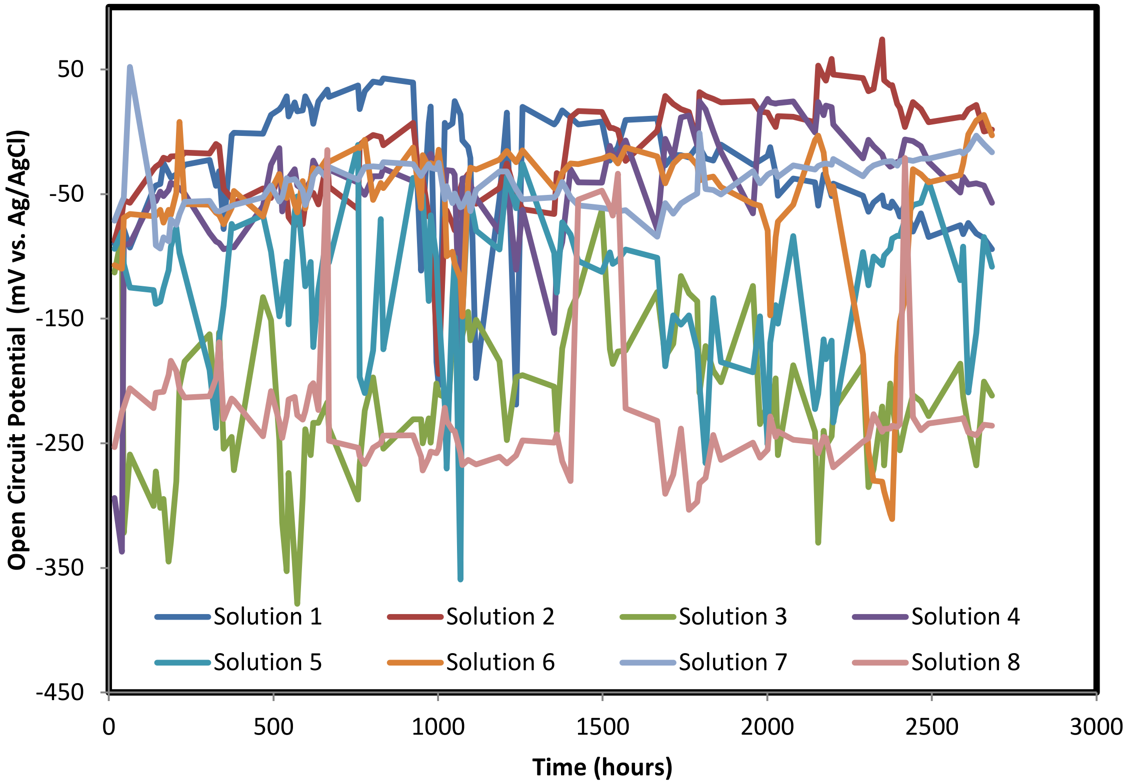


Figure 5-16 OCP measurements at different periods during four month testing of LAI for Solutions 1 to 8.

The pit diameter and depth for each of the coupons are summarized in Table 5-7. The qualitative assessments of the sample are also listed in the table. Small, broad, shallow pits were observed on most of the coupons and were located inside the areas of general attack. The largest and deepest pits were observed on coupons exposed to solution 3. The range of the pit diameter was 0.5-12.3 mils, while the range for the pit depths was 0.4-4.5 mils. As in other cases, it appears that the pits do not get deeper during time but spread and increase the general attack area. There were some special cases that less general corrosion was observed for the four month exposure than the two month exposure (Solution 1 and 6) which tends to indicate a borderline condition. Weak LAI corrosion attack was observed on coupons exposed to solutions 4 and 8. Pits were present in this area, but were no larger than the pit sizes found above the interface. The ranking observed for corrosion of these samples based on the degree and amount of corrosion attack from higher to lower was 3, 2, 1, 5, 6, 4, 8 and 7.

Table 5-7 Pitting diameter and depth range of solutions using the new SCC limits. Percentages were obtained by a qualitative assesment.

Solution	Time exposed (months)	diameter range (mils)	depth range (mils)	Remarks
1	2	0.6-8.1	0.7-2.7	GA with small pits observed above LAI on top area. Less than 20% corrosion. No LAI corrosion observed.
	4	0.8-3.4	0.2-1.6	GA observed in less than 2% of coupon. Very small pits observed above LAI. No LAI corrosion observed.
2	2	0.5-3.8	1.2-2.7	GA with small pits observed on top area of coupon. Less than 10% corrosion. No LAI corrosion observed.
	4	0.3-1.9	0.4-0.9	GA with small pits observed above LAI on top area. Less than 20% corrosion. No LAI corrosion observed.
3	2	1.0-11.7	0.4-3.9	Large GA with pits observed above LAI on top area. Around 30% to 40% corrosion. No distinctive LAI corrosion observed.
	4	0.5-12.3	0.6-4.5	Large GA with pits observed above LAI on top area. Around 40% corrosion. No distinctive LAI corrosion observed.
4	2	0.7-7.3	0.8-1.1	GA with shallow pits above LAI. Weak LAI corrosion attack.
	4	0.8-5.3	0.5-0.9	GA with shallow pits above LAI. Weak LAI corrosion attack.
5	2	0.1-3.6	0.7-1.8	GA with small pits observed above LAI on top area. Less than 10% corrosion. No LAI corrosion observed.
	4	0.7-7.6	0.7-1.5	GA with small pits observed above LAI on top area. Less than 10% corrosion. No LAI corrosion observed. GA small area below LAI.
6	2	0.7-3.7	0.9-1.8	GA with shallow pits observed on top area of coupon. Less than 20% corrosion. No LAI corrosion observed.
	4	1.2-5.6	1.1-1.8	GA with small pits observed above LAI on top area. Less than 4% corrosion. No LAI corrosion observed.
7	4	0.9-2.2	0.5-1.0	Very small pits were observed above LAI. No LAI corrosion observed.
	2	0.9-2.9	1.0-1.5	Very small pits were observed above LAI. No LAI corrosion observed.
8	2	0.8-1.4	0.6-1.1	GA with shallow pits observed above LAI on top area. Salt deposition below and above LAI. Weak LAI corrosion observed.
	4	0.4-5.2	0.5-1.4	GA with shallow pits observed above LAI on top area. Salt deposition below and above LAI. Weak LAI corrosion observed.

5.5 Pitting Corrosion studies using the standardized CPP protocol

The CPP technique has been utilized for over 30 years in the DOE weapons complex as a means for evaluating the pitting susceptibility of waste tank materials (i.e., carbon steel) exposed to the waste environments. The results of these tests, coupled with long-term (i.e., 4 month) coupon immersion testing, have provided a basis for corrosion control requirements for pitting corrosion at both the SRS and the Hanford site (Corrosion Control Program). These tests were performed over a wide range of environmental conditions (i.e., composition and temperature) and at several different laboratories (e.g., SRNL, DNV-GL, WRPS, etc.).

During FY13, DOE requested that WRPS demonstrate that the outcome of the tests were reproducible irrespective of the laboratory that performed the test. As a result, a round robin test program between three laboratories was conducted [2]. Prior to initiating the round robin, a review of the CPP techniques at each of the laboratories was performed. Differences between the laboratories were noted for test set-up and CPP parameters (e.g., sample geometry, sample preparation, pre-test exposure, threshold current, etc.). The outcomes although similar were different, particularly at environmental conditions where the response transitions from “pitting” to “no-pitting”. The round robin program eventually led to the development of a standardized CPP protocol [2]. This standardized CPP protocol was utilized will be utilized for all future testing related to the Hanford DST.

A correlation between previous CPP test data (i.e., prior to the standardized CPP protocol development), and data gathered utilizing the standardized CPP protocol was performed.

5.5.1 *Interpretation of CPP Test Results*

During 2014, the EPOC also standardized an approach for interpreting the results of the CPP tests [31]. Important aspects of this approach are summarized as a reference here since they will be utilized in the discussion of the results. Figure 5-17 shows a schematic of an idealized CPP curve along with experimental parameters that are measured from the curve.

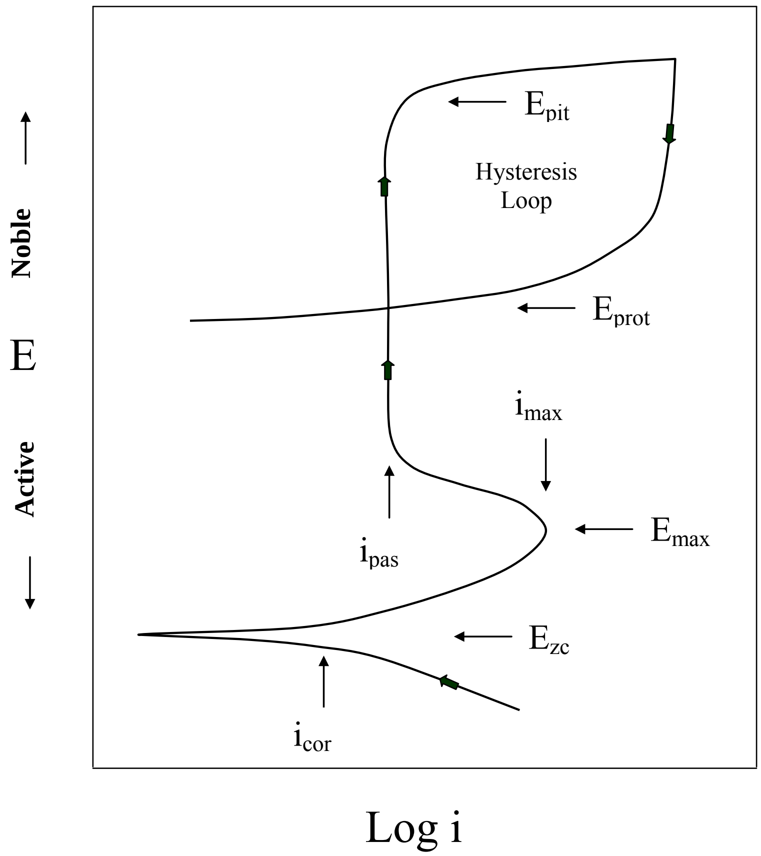


Figure 5-17 Schematic of an idealized (CPP) Curve.

Definitions for these polarization parameters:

E_{zc} = Zero Current Potential:	The potential at zero current, measured on the forward scan.
E_{max} = Peak Current Potential:	The potential at the active peak prior to passivation.
E_{pit} = Pitting Potential:	The potential at which stable pits initiate on the forward scan. The increase in current at this potential may not be associated with pitting. The potential may be the result of other anodic reactions (e.g., oxygen evolution). In that case the potential may be referred to as the transpassive potential (E_{trans}). A transpassive potential is often observed for samples that have negative hysteresis.
E_{prot} = Protection Potential:	The potential at which pits (if they occur) passivate and stop growing on the reverse scan.
i_{cor} = Corrosion Current Density:	The corrosion current density, which is related to the corrosion rate by Faraday's law.
i_{max} = Peak Current Density:	The current density at the active peak prior to passivation.
i_{pas} = Passive Current Density:	The current density in the passive range.

The zero current potential, E_{zc}, taken from CPP curves is the potential at which the current changes polarity from negative to positive on the forward scan. The corrosion potential, E_{cor}, also sometimes referred to as the open circuit potential, is the potential of a specimen measured under open circuit conditions where the specimen is connected solely to a high impedance voltmeter. In a CPP test, E_{cor} is measured for a short time period (e.g., 2 hours) prior to starting the scan and the scan is started at a fixed voltage (e.g, 100 mV) below the measured E_{cor} The E_{zc} may not be the same potential as E_{cor} measured before starting the scan. E_{cor} typically moves in the noble direction with exposure time for passive alloys. Therefore, the E_{cor} value measured prior to starting a CPP scan and E_{zc} typically are more negative than E_{cor} values measured after longer exposure times.

If the sample is corroding actively at E_{zc}, the current will increase exponentially as the potential is scanned upwards from E_{zc}, exhibiting a straight line in the semi-log plot. Samples susceptible to pitting must be passive, so an active/passive transition resulting in a peak current density, i_{max}, will be observed for such samples. Under conditions where the alloy is spontaneously passive, the current reaches a relatively constant value just above E_{zc}, so that i_{max} is not observed. In the passive region, the current, i_{pas}, is usually almost constant, with little dependence on potential.

The pitting potential is the value at which the current increases rapidly owing to the onset of stable pitting. In most instances, pitting potentials are reasonably easy to define by a change in slope and a sharp increase in the corrosion current. The occurrence of positive hysteresis, where the current on the reverse (downward) scan is higher than during the forward scan, is usually indicative of the occurrence of localized corrosion such as pitting or crevice corrosion. For steel samples that do not exhibit localized corrosion, the current will eventually increase above i_{pas} at high applied potentials owing to oxygen evolution by water oxidation. In such a case, during the reverse scan, the current will trace back along the increasing part of the forward scan with no evidence of hysteresis. Often, a negative hysteresis is observed where the passive current on the reverse scan is lower than that on the forward scan. Pitting and crevice corrosion are almost never found in association with such a CPP curve. The potential in this case is referred to as a transpassive potential (E_{trans}) rather than the pitting potential.

For a sample exhibiting pitting and a positive hysteresis, the pits will eventually repassivate during the reverse scan as the potential is lowered. The potential at which this happens is called the protection or repassivation potential (E_{prot}). This is a critical parameter in the assessment of localized corrosion susceptibility because a conservative approach for designing against localized corrosion would be to determine that the corrosion potential would remain well below this value. E_{prot} is often defined as the potential at which the current on the reverse scan falls below that observed on the forward scan. In other words, it is the potential at which the reverse scan crosses the forward scan as shown in Figure 5-17. However, in some cases, the passive current on the reverse scan is higher than that on the forward scan. In that case, the protection potential is taken as the point at which the current exhibits a sharp decrease. In other cases, the protection potential is below the E_{zc} observed on the forward scan. If the original E_{zc} was used as the final limit for the reverse scan, then the protection potential cannot be definitively determined in this situation.

The severity of pitting corrosion can be ranked based on the shape of the CPP curve according to five categories:

Category 1: Negative hysteresis and no evidence of pitting.

Category 2: Positive hysteresis, but with pitting and protection potentials well above the zero current potential ($E_{prot} \gg E_{zc}$).

Category 3: Positive hysteresis with a noble pitting potential, but with the protection potential relatively near the zero current potential (E_{prot} near E_{zc}).

Category 4: Positive hysteresis with the protection potential lower than the zero current potential ($E_{prot} < E_{zc}$).

Category 5: Spontaneous pitting at the zero current potential so that the current increases rapidly upon polarization to potentials above the zero current potential.

These categories are shown graphically in Figures 5-18 to 5-22. For these figures, the metal is assumed to be passive at the free corrosion potential so no active-passive transition is shown.

The Category 1 ranking (Figure 5-18) is the most desirable because it indicates that the environment is not capable of promoting pitting of the alloy. This should be confirmed by a post-test examination of the specimen. Note that the potential associated with the significant increase in current on the forward scan is not called a pitting potential (E_{pit}) for Category 1 because it is not associated with pitting corrosion. The increase in current is associated with water breakdown or transpassive behavior and the potential is referred to as the transpassive potential (E_{trans}) in Figure 5-18. This case is defined as a "pass" condition and no additional testing is required; the environment is considered to be benign with respect to pitting.

For Categories 3 through 5 (Figures 5-19 through 5-22) localized corrosion is likely to occur in service. In the presence of pitting on the sample, these categories are considered a "fail" condition; the environment is considered to be aggressive with regard to pitting.

All other outcomes require additional testing. Examples of other outcomes include:

- Category 1 behavior with pitting on the sample;
- Category 2 behavior (Figure 5-19) with or without pitting;
- Category 3 through 5 with no pitting;
- Undefined hysteresis with or without pitting; this type of behavior is typified by the reverse scan following close to the forward scan or crossing it several times.

Additional tests include ASTM G192 [32] long-term coupon immersion testing, and in-tank reference electrode measurements to determine E_{cor}. The ASTM G192 protocol is being modified for carbon steels in waste simulants by DNV-GL[33].

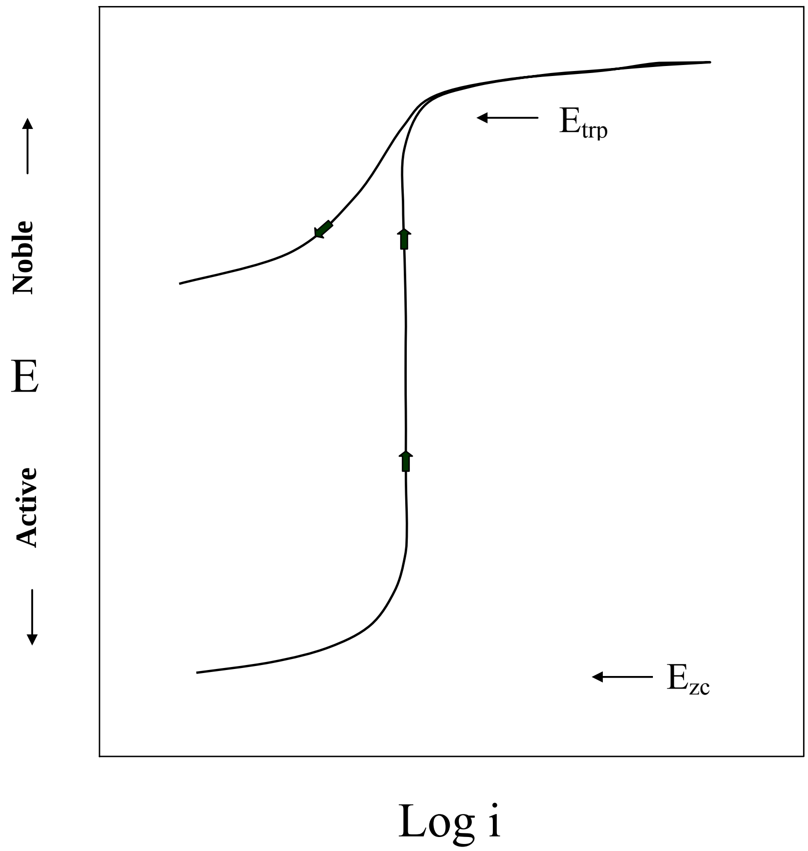


Figure 5-18 Schematic of Category 1 CPP Curve.

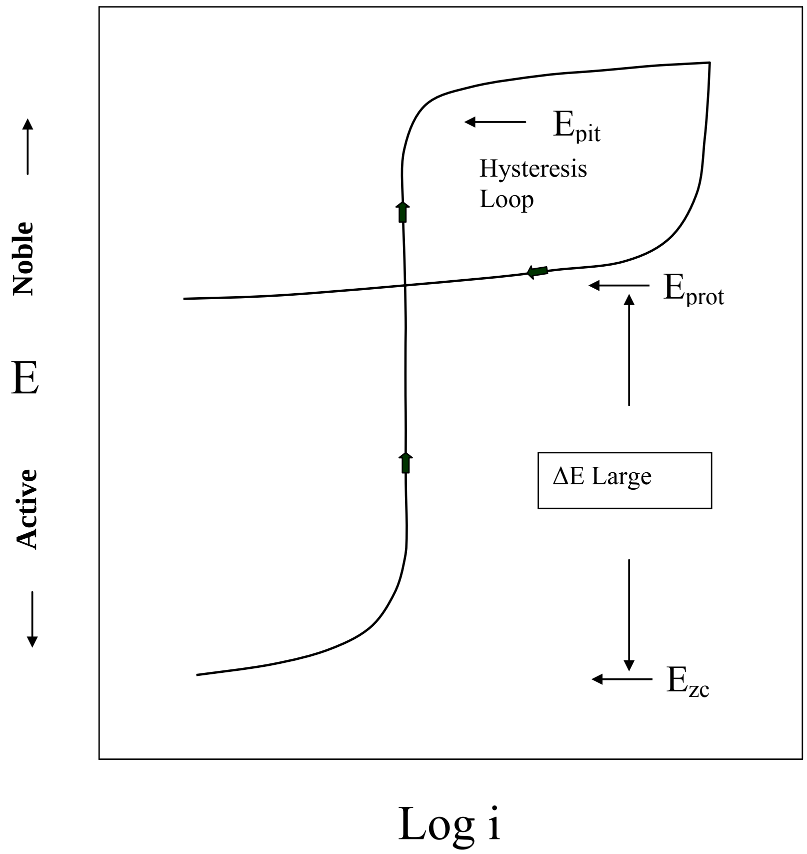


Figure 5-19 Schematic of Category 2 CPP Curve.

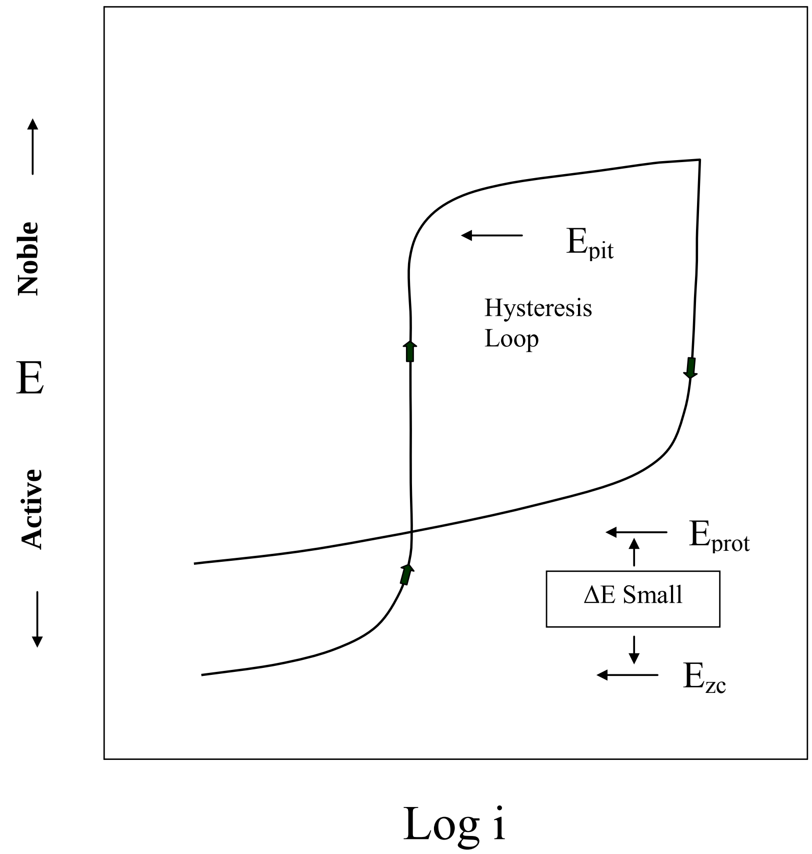


Figure 5-20 Schematic of Category 3 CPP Curve.

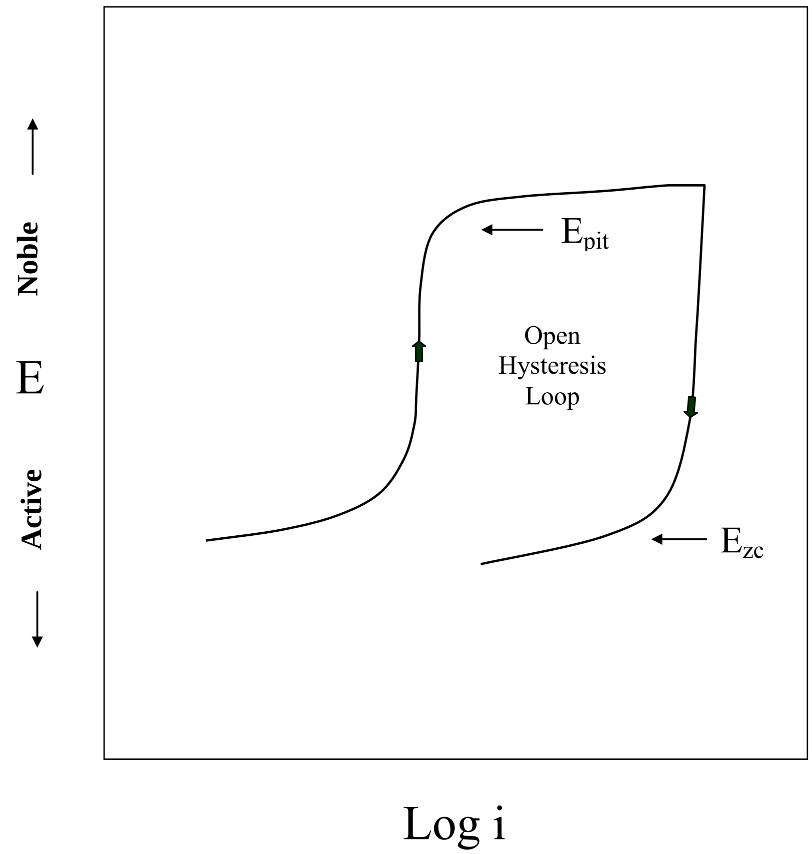


Figure 5-21 Schematic of Category 4 CPP Curve.

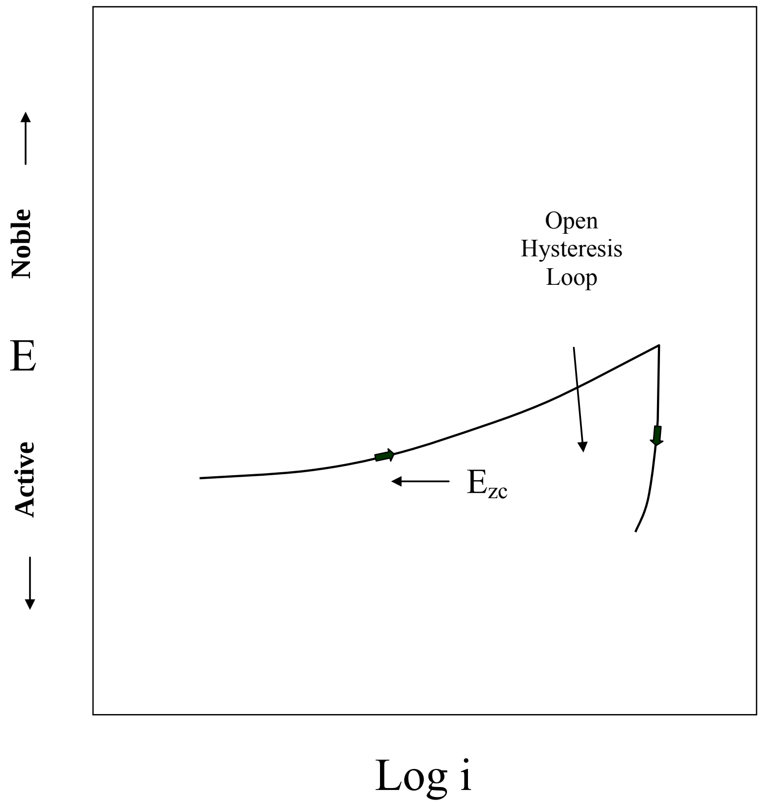


Figure 5-22 Schematic of Category 5 CPP curve.

5.5.2 *Literature Review of Historical Data*

Data from 22 literature sources were compiled for this activity [28],[33]-**Error! Reference source not found.**. More than 1800 CPP data points, which represents 920 test conditions, were catalogued and classified (See Appendix H). Of these test conditions, 814 tests were performed in SRS waste simulants and 106 tests were performed in Hanford simulants. Pitting was observed in 479 (52%) of the tests. Further observations of the data indicated that it could be classified based on when the test was performed, that is, pre-1993 and post-1993. CPP tests were performed on 518 test conditions (56%) pre-1993. Pitting was observed on 242 (47%) of these CPP tests. On the other hand, of the 402 CPP test conditions examined post-1993, 237 (59%) indicated pitting susceptibility.

There were three major differences in how test matrices were selected for the two data classifications. First, all the pre-1993 data focused on anticipated feed preparation streams for the Defense Waste Processing Facility (DWPF) at SRS. These were low sodium dilute waste streams (i.e., less than 1 M nitrate) typically at temperatures lower than 40 °C. Secondly, the test conditions (i.e., compositions with various inhibitor anion/aggressive anion ratios) were selected by a “best guess” process based on the previous test results rather than using a pre-determined test matrix of compositions [36]. This selection process minimized the number of scans required, yet still resulted in a very exact determination of the pit-no pit boundary. Finally, records of the pre-1993 CPP data are sparse. A few examples of CPP curves exist in reports, however, a majority of the data in the reports is shown in log-log plots of the aggressive species vs. the inhibitor species.

These plots show qualitative assessments of the CPP results such as, “no pits”, “occasional pitting”, or “pits”.

In contrast, the post-1993 data has focused on compositions related to present waste storage or waste retrieval conditions. As such, there is typically a greater range in composition (e.g., up to 7 M nitrate) and temperature (e.g., up to 77 °C) and waste simulants from both the Hanford site and SRS have been considered. Also, rather than a “best-guess” approach, typically the test compositions were based on either a statistical matrix that covered a broad envelope of anticipated compositions or on waste samples taken from the tank. As a result, there is a more even distribution of data for these tests. Finally, records for the CPP data are more readily available and can be compared.

Due to the lack of pre-1993 records, the definition of a borderline or marginal test condition is also different for the two data classifications. Figure 5-23 shows an example of a log-log plot taken from a report. In this case, the nitrate is the aggressive species and nitrite is the inhibitor species. The line that is drawn represents the minimum nitrite that prevented the initiation of pitting. Open squares above the line were conditions that no pits were observed, while partially filled and filled squares represented conditions where occasional pitting and pits were observed, respectively. The borderline condition was drawn at the transition between occasional pitting and no pits. As a result of the “best-guess” approach, a majority of the test conditions are located at the boundary between the pit-no pit regime. Therefore, in analyzing the present CPP tests, the location (i.e., borderline condition) of the historical data will be taken into account.

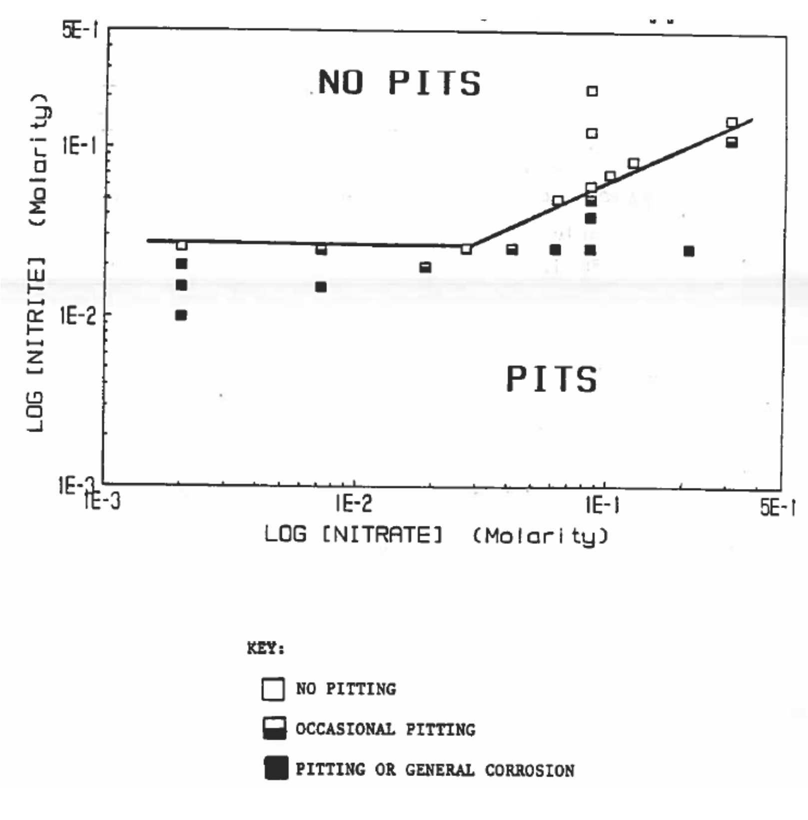
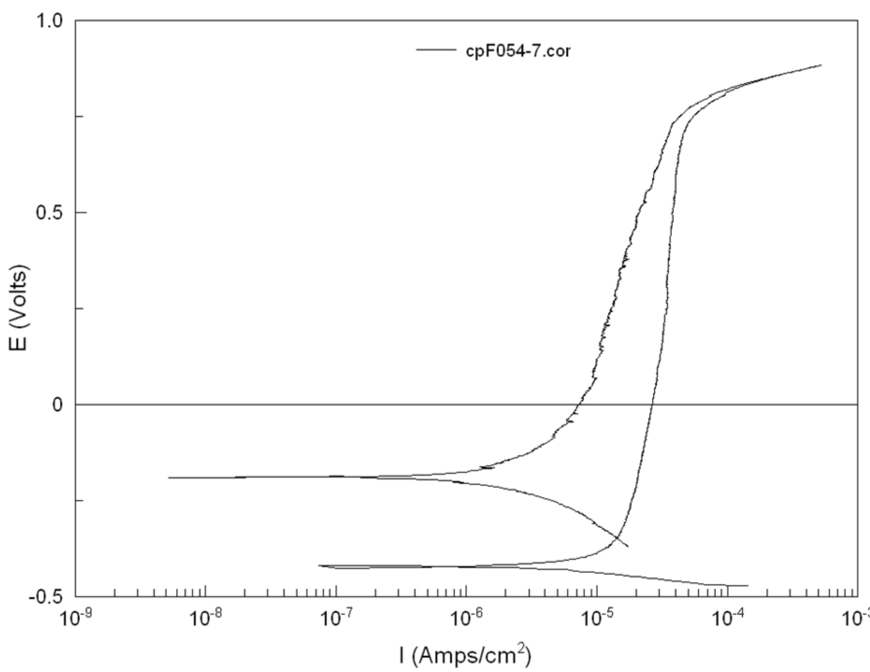


Figure 5-23 Log-log plot for SRS dilute waste simulant that shows the minimum nitrite required to prevent pit initiation as a function of nitrate concentration [36].

Although no CPP curves were shown, one pre-1993 report suggests that borderline of marginal results were observed during tests [55]. The author noted, "The scans…almost always corroborated the specimen appearance when the hysteresis, either positive or negative, was of the order of an order of magnitude in current density…With hysteresis less than an order of magnitude, the scans did not correlate as well with the specimen appearance." In a separate report [45] another author observed, "Samples were run in duplicate and in cases where the results differed the more aggressive corrosion behavior was reported." It is not known whether either of these cases are associated with all the occasional pitting data, but this may be a reasonable assumption.

In contrast, the CPP curves can be utilized to define borderline behavior for the post-1993 tests. Figure 5-24 shows an example of borderline behavior for a dilute, SRS waste simulant. For this test, the nitrate concentration was 0.85 M, the nitrite concentration was 0.43 M, the pH was 10 and the temperature was 40 °C. Negative hysteresis was observed for the CPP curve, however, small pits were observed on the electrode. Given the priority placed on the post-test condition of the sample, this result was considered to be a fail. Based on the pre-1993 log-log plots, this test condition would fall slightly below the line de-lineating the pit regime from the no-pit regime. In this region, "occasional pitting" data might be expected.



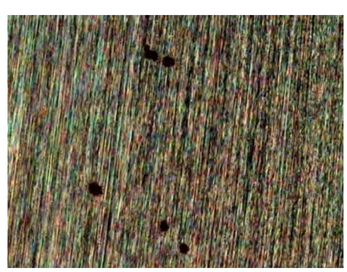


Figure 5-24 Borderline behavior in a dilute, SRS waste simulant [28]. The CPP scan exhibited negative hysteresis, however, small pits were detected on the electrode surface. Magnification was approximately 10X.

The third difference between the two data set classifications lies in the manner in which the tests were conducted. A full catalog of the protocol that was used for each of the 21 tests programs is shown in Appendix H. There were primarily 2 differences between the pre-1993 test protocol and the post-1993 test protocol: 1) the potential stabilization time and 2) the scan vertex threshold. For the pre-1993 tests, potential stabilization time was typically 30 minutes, whereas for the post-1993 tests the potential stabilization time was typically 2 hours or more. The longer stabilization time likely ensured a stable E_{corr} value at the initiation of the test, which is indicative of an equilibrated system.

The vertex threshold (i.e., the potential or current at which the CPP scan is reversed) for the pre-1993 tests was based on a threshold potential, typically around 1.0 V. Figure 5-25 shows an example of a pre-1993 CPP curve in a dilute SRS waste simulant that exhibited positive hysteresis and pitting [45]. Given that the sample was approximately 2 cm^2, the current density at the vertex potential was greater than 15 mA/cm^2. There are no pictures of the sample from the pre-1993 test, therefore the size and density of the pitting is unknown, however, relatively low current density and small degree of hysteresis suggests that pitting was minimal. In the case of the post-1993, a threshold current of approximately 1 to 5 mA/cm^2 was utilized.

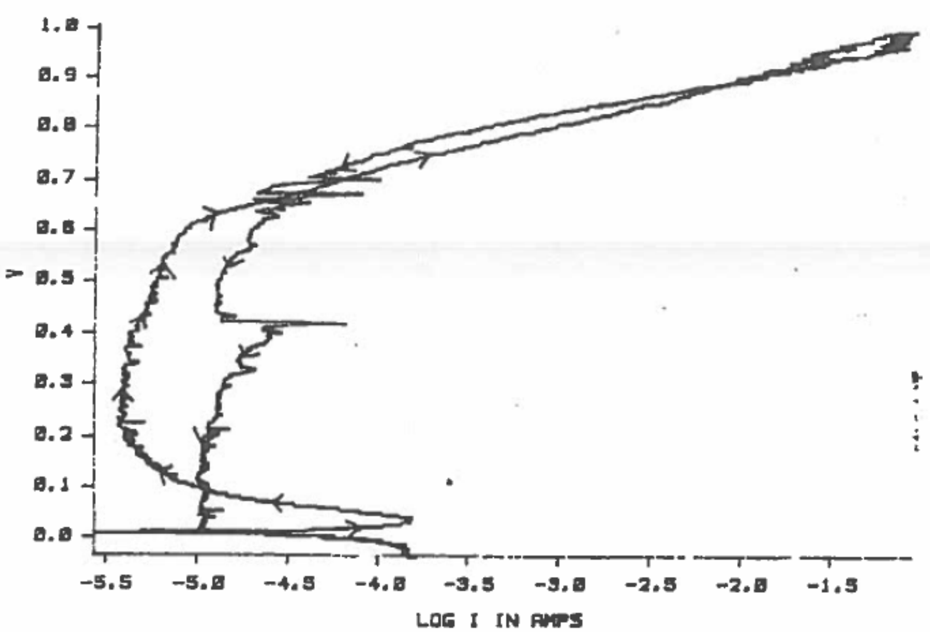


Figure 5-25 CPP curve in dilute SRS waste simulant that illustrates the vertex threshold potential of 1.0 V [45].

Figure 5-26 shows an example of a CPP curve taken from the FY2014 tests with a threshold current of 1 mA/cm^2. The CPP curve exhibited negative hysteresis and the electrode did not pit. The difference between the simulants is that the pH of the pre-1993 test solution was 10.07, while for the post-1993 test the pH was 10.18. It cannot be stated for certain, but it is possible that by scanning to a higher threshold current, that small pits were initiated at an overly conservative condition. At a borderline condition, this could be the difference between interpreting the CPP test as pass or fail. (Note: The post-1993 test is a repeat of a pre-1993 test. The result of the test in 1988 was a pass as no pitting was observed. Thus, the test shown in Figure 5-19 would have been considered a borderline condition.)

Coupon tests were used in the past to confirm the results of CPP tests, particularly near the borderline conditions. A review of this data indicates that coupon testing was more common pre-1993. The tests were set-up so that the coupon was partially immersed, enabling the evaluation of LAI and VSC as well as corrosion of the immersed portion of the sample. The tests were typically performed for four months. The tests typically corroborated the results of the CPP tests. Conditions that resulted in pitting during a CPP test would produce pitting during a coupon test. Of interest was the observation that borderline CPP results oftentimes produced mixed results for the coupon tests. That is, a coupon test may indicate pitting on one sample, but not on a duplicate sample. Thus, the results of the coupon tests increased the confidence in the results observed for the CPP tests.

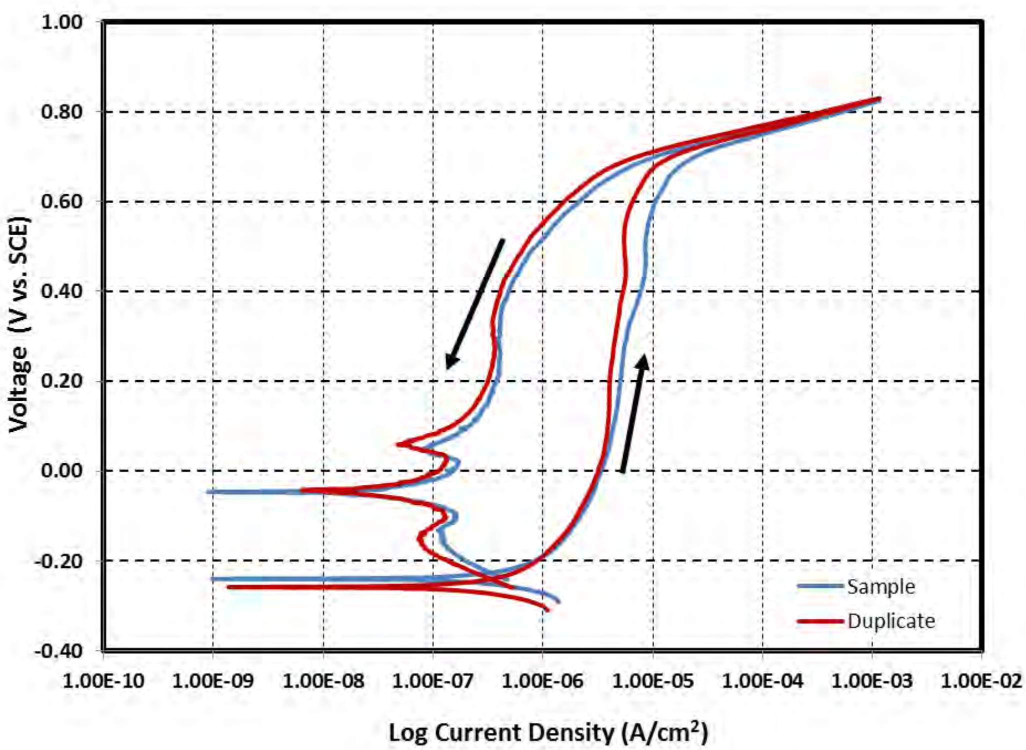


Figure 5-26 CPP curve in dilute SRS waste simulant that illustrates the vertex threshold current of 1 mA/cm^2.

5.5.3 *Test Selection*

A random sample of 40 tests was selected from the historical database for testing by the new CPP protocol. The sample was not completely random as the EPOC requested that additional tests be performed at higher pH [4] in order to ensure that the Hanford site waste chemistry was adequately addressed. The 40 tests that were selected are shown in Table 5-8 and 5-9. The composition and temperature for each test is listed. Characteristics of the test matrix included:

- 35 of the 40 CPP tests (87.5%) were performed in SRS waste simulants, which leaves only 5 tests performed in Hanford waste simulants. This proportion is slightly less than the proportion for the total database (88.5%).
- 26 of the 40 CPP tests (65%) indicated pitting susceptibility. This proportion is higher than what was observed for the total database (52%).
- 21 of the 40 CPP tests were replicates of pre-1993 tests. This proportion is slightly less than the proportion for the total database (53% vs. 56%). The proportion is likely less because the distribution was skewed slightly to include more tests at a higher pH [4]. Since the post-1993 tests contained the higher pH tests, there would be an increase in the proportion of these CPP tests.
- 12 of the 21 (57%) pre-1993 tests indicated pitting susceptibility. This proportion is slightly higher than that observed for the total distribution of pre-1993 tests.
- 16 of the 21 pre-1993 tests were considered borderline conditions. This proportion seems a high given that Figure 5-23 suggests that a little over half of the data would be expected to be borderline conditions. However, as mentioned before, the “best-guess” approach would tend to cluster more of the data near the borderline defined by the minimum inhibitor concentration.
- 14 of the 19 post-1993 (74%) tests indicated pitting susceptibility. This proportion is slightly higher than that observed for the total distribution of pre-1993 tests.
- 4 of the 19 post-1993 tests were considered borderline conditions. This lower proportion is not as surprising given that the selection process produced a test matrix that was more evenly distributed across the envelope.

The quasi-random sample appears to have adequately represented the tested conditions in the total database as well as the test conditions for the two classifications. The next section will review the distributions for the variables that were tested.

Table 5-8 CPP Test Solution Composition and Temperature

Reference	Test	Temperature (°C)	Concentration of Species (M)									pH
			$CO_3^{=}$	$HCO_3^{=}$	Citrate	PO_4^{3-}	Cl^-	F^-	SO_4^{2-}	NO_3^-	NO_2^-	
42	1	40	0.0015	NA	NA	0.000084	0.00032	0.000153	0.0014	0.04	0.015	12.5
50	2	50	1.118	NA	NA	0.009	0.046	0.084	0.028	1.635	1.27	14.5
48	3	50	0.1	NA	NA	0.05	0.1	NA	0.1	7	0.1	13
48	4	50	0.1	NA	NA	0.05	0.1	NA	0.1	5.5	0.2	13.8
42	5	40	0.0015	NA	NA	0.000084	0.01	0.000153	0.0014	0.04	0.325	12.5
42	6	40	0.0015	NA	NA	0.000084	0.025	0.000153	0.0014	0.04	0.9	12.5
48	7	25	0.1	NA	NA	0.05	0.1	NA	0.1	7	0.01	12
42	8	40	0.0015	NA	NA	0.000084	0.00032	0.000153	0.1	0.04	0.12	12.5
49	9	40	0.02	NA	0.6	0.0005	0.4	0.05	0.005	0.1	0.5	12.12
42	10	40	0.0015	NA	NA	0.000084	0.00032	0.000153	0.1	0.04	0.18	12.5
42	11	40	0.0015	NA	NA	0.000084	0.00032	0.000153	0.02	0.04	0.04	12.5
49	12	40	0.2	NA	0.04	0.05	0.06	0.02	0.1	0.7	0.02	11.7
36	13	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.002	0.0008	0.01	9.6
33, 34	14	23	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.015	9.73
33, 34	15	40	0.026	0.056	NA	0.00031	0.0012	0.00057	0.005	0.076	0.058	9.79
46	16	40	0.0526	0.098	NA	NA	0.0037	NA	0.0451	0.2	0.15	10
45	17	40	0.236	0.438	NA	NA	0.0115	NA	0.186	0.9	0.675	10
35	18	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.06	0.04	9.6
46	19	40	0.0789	0.147	NA	NA	0.0051	NA	0.0731	0.45	0.225	10
36	20	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.13	0.0284	0.2	9.6

Table 5-9 CPP Test Solution Composition and Temperature (continued)

Reference	Test	Temperature (°C)	Concentration of Species (M)									pH
			$CO_3^{=}$	$HCO_3^{=}$	Citrate	PO_4^{3-}	Cl^-	F^-	SO_4^{2-}	NO_3^-	NO_2^-	
35	21	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.05	0.025	9.6
35	22	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0085	0.085	0.1	9.6
46	23	40	0.3158	0.586	NA	NA	0.0142	NA	0.3806	0.9	0.9	10
28	24	40	0.1491	0.277	NA	NA	0.010625	NA	0.0425	0.85	0.425	10
33, 34	25	40	0.011	0.035	NA	0.00016	0.0006	0.0003	0.0026	0.039	0.022	9.66
33, 34	26	50	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.7	10.06
46	27	40	0.0395	0.073	NA	NA	0.003	NA	0.032	0.45	0.113	10
28	28	40	0.193	0.358	NA	NA	0.006875	NA	0.0275	0.55	0.55	10
36	29	40	0.0042	0.019	NA	0.00013	0.004	0.00024	0.002	0.028	0.07	9.6
28	30	40	0.6316	1.173	NA	NA	0.0175	NA	0.0375	0.25	1.8	10
36	31	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.06	0.06	9.6
44	32	80	0.337	0.243	NA	NA	0.0009	0.00267	0.00264	0.0098	0.022	10.18
46	33	40	0.0702	0.13	NA	NA	0.0046	NA	0.0635	0.8	0.2	10
50	34	77	0	NA	NA	0.012	0.004	0.003	0.018	0.002	0.001	11
46	35	40	0.0351	0.065	NA	NA	0.0028	NA	0.0278	0.2	0.1	10
47	36	40	0.1754	0.326	NA	NA	0.032	NA	0.121	0.8	0.5	10
35	37	40	0.013	0.058	NA	0.00039	0.0015	0.00073	0.0059	0.085	0.04	9.6
50	38	77	1.028	NA	NA	0.012	0.004	0.003	0.018	0.002	0	11
35	39	40	0.013	0.058	NA	0.00039	0.0011	0.0011	0.0059	0.085	0.06	9.6
36	40	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.03	0.0284	0.02	9.6

5.5.4 *Distributions of Variables for the 40 Tests*

The distribution of pH, temperature, nitrate concentration, nitrite concentration, and the nitrite/nitrate ratio associated with the total distribution and the proposed test matrix were examined. In general, the proposed test matrix appears to represent the total distribution of these key corrosion variables well.

5.5.4.1 pH

Figure 5-27 shows the distribution for the pH that was observed for the total database (blue diamonds) and the proposed test matrix (red squares). Nearly 80% of the tests from the total database were at a pH of ~10 or slightly less. This is the equilibrium pH that is established due to the reaction of carbon dioxide from the air with the hydroxide in the waste [56]. Most of the SRS tests were performed at this condition. The proposed test distribution deviates slightly from the total database distribution. As mentioned previously, the EPOC requested that the matrix include a representative number of tests that were performed at a higher pH. Thus, a higher proportion of the 40 tests were performed at a pH greater than 10 than would have been dictated by a random selection from the total distribution.

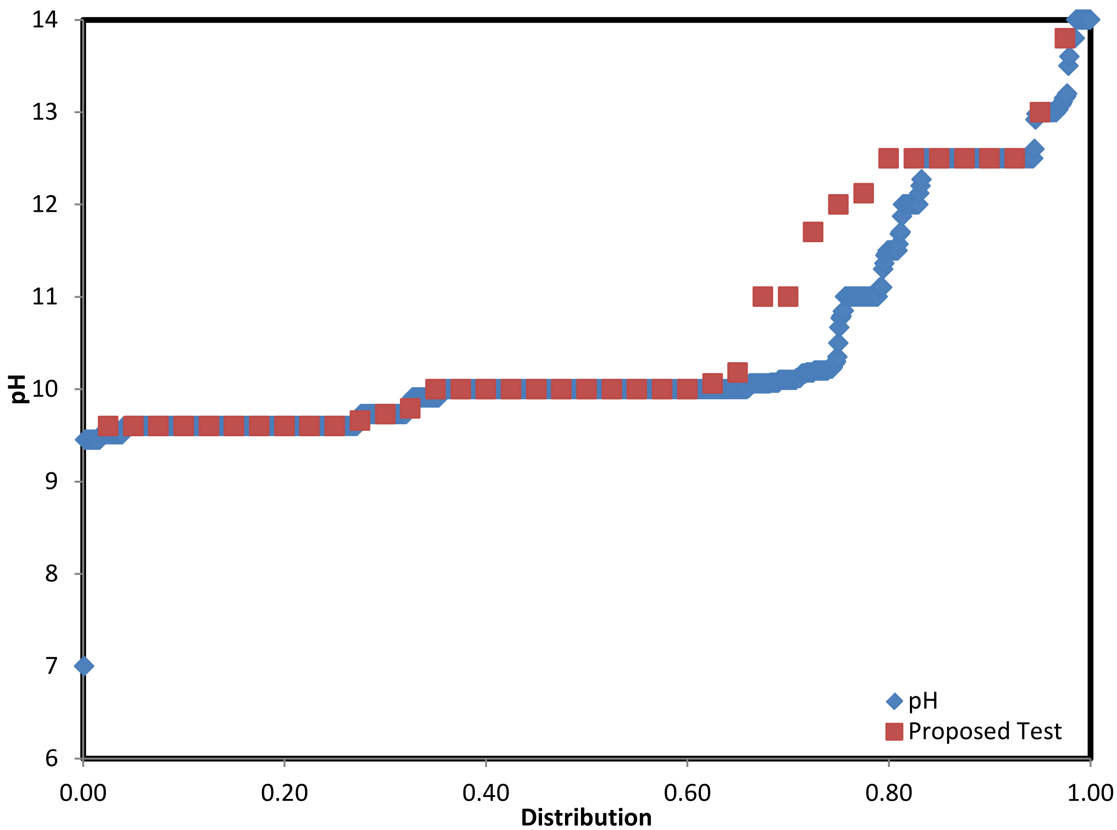


Figure 5-27 pH distribution for total distribution and 40 test matrix.

5.5.4.2 Temperature

Figure 5-28 shows the distribution for the temperature that was observed for the total data base (blue diamonds) and the proposed test matrix (red squares). Approximately 80% of the tests from the total database were at a temperature of 40 °C or less. This temperature is the maximum expected value during feed preparation for the DWPF at SRS. Seven tests were performed at temperatures of 50 °C or higher. Three of these were performed in Hanford waste simulants, most notably the present interstitial liquid simulant for Tank AY-102.

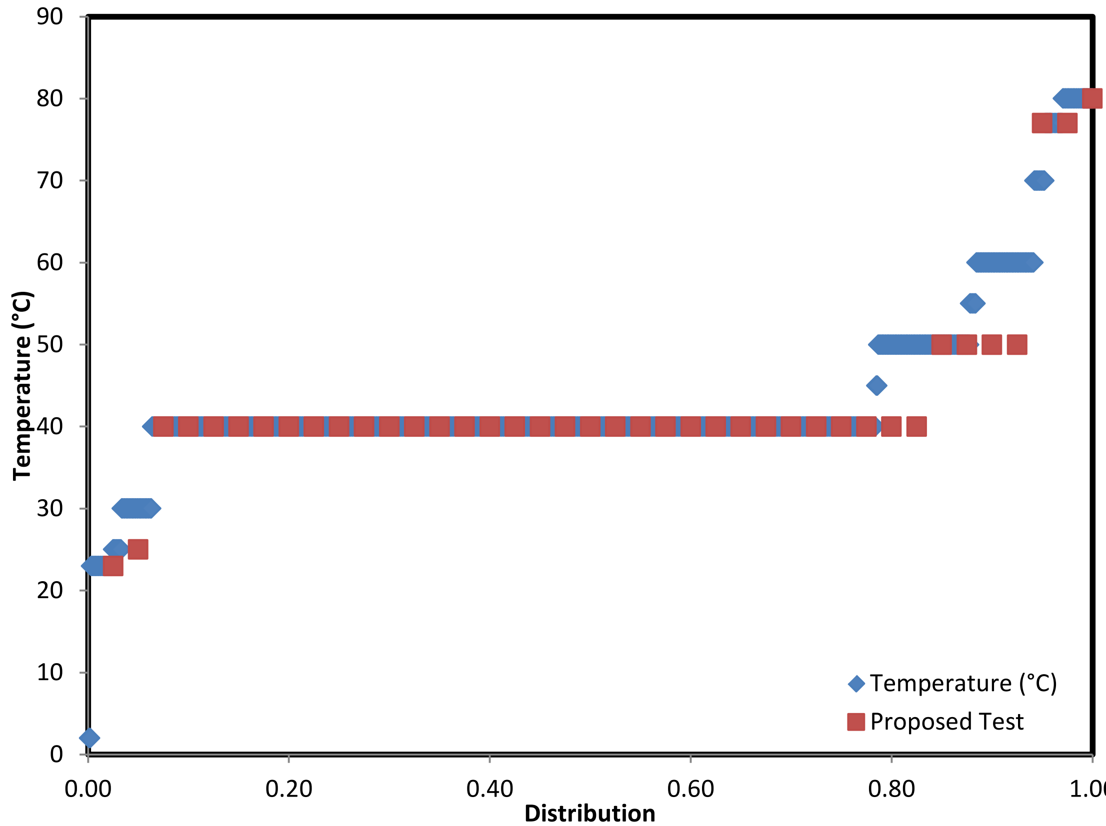


Figure 5-28 Temperature distribution for total distribution and 40 test matrix.

5.5.4.3 Nitrate Concentration

Figure 5-29 shows the distribution for the nitrate concentration that was observed for the total data base (blue diamonds) and the proposed test matrix (red squares). Approximately 90% of the tests from the total database were at a nitrate concentration of 1 M or less. These nitrate concentrations occur during the washing process for feed preparation to the DWPF at SRS. The large source of data may enable the Hanford site to investigate the possibility of nitrite inhibition in dilute wastes. A limited amount of data exists at nitrate concentrations greater than 1 M. Most of this data is related to either Hanford simulants or SRS dissolved salt solutions.

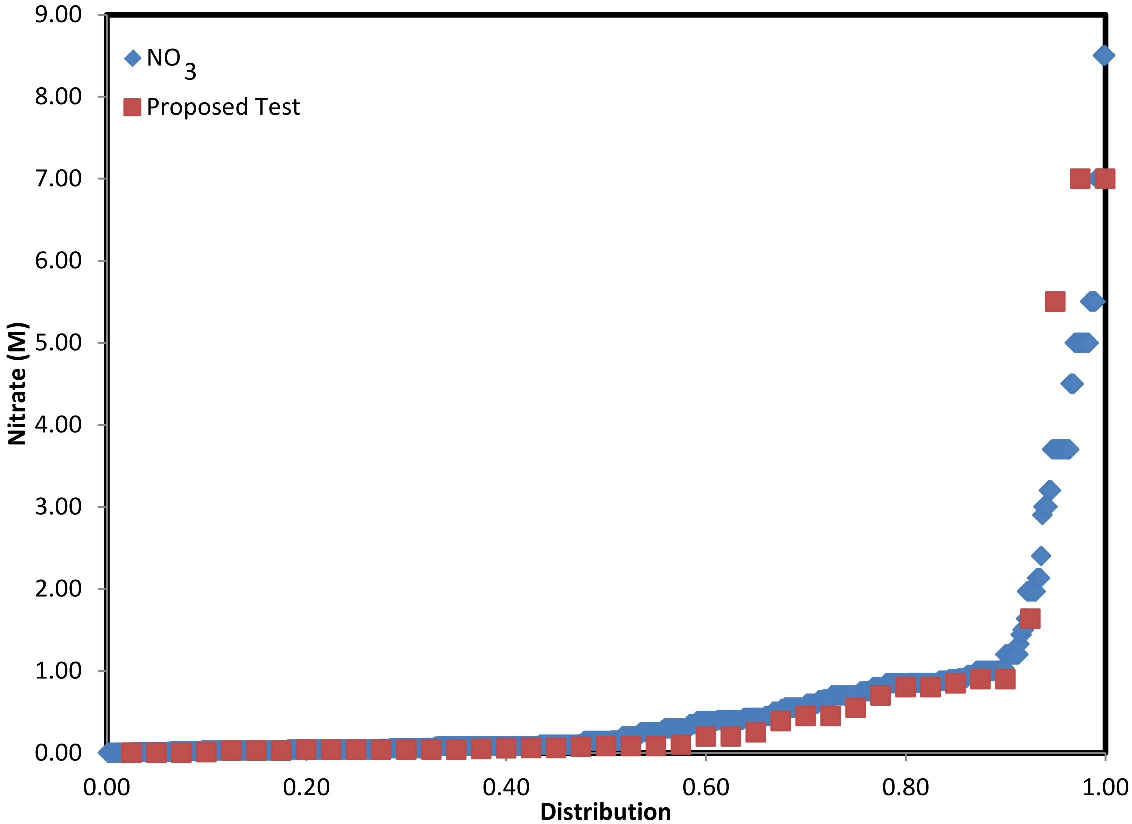


Figure 5-29 Temperature distribution for total distribution and 40 test matrix.

5.5.4.4 Nitrite Concentration

Figure 5-30 shows the distribution for the nitrite concentration that was observed for the total data base (blue diamonds) and the proposed test matrix (red squares). Again approximately 90% of the tests from the total database were at a nitrite concentration of 1 M or less. These nitrite concentrations occur during the washing process for feed preparation to the DWPF at SRS. A limited amount of data exists at nitrite concentrations greater than 1 M. Most of this data is related to Hanford waste simulants.

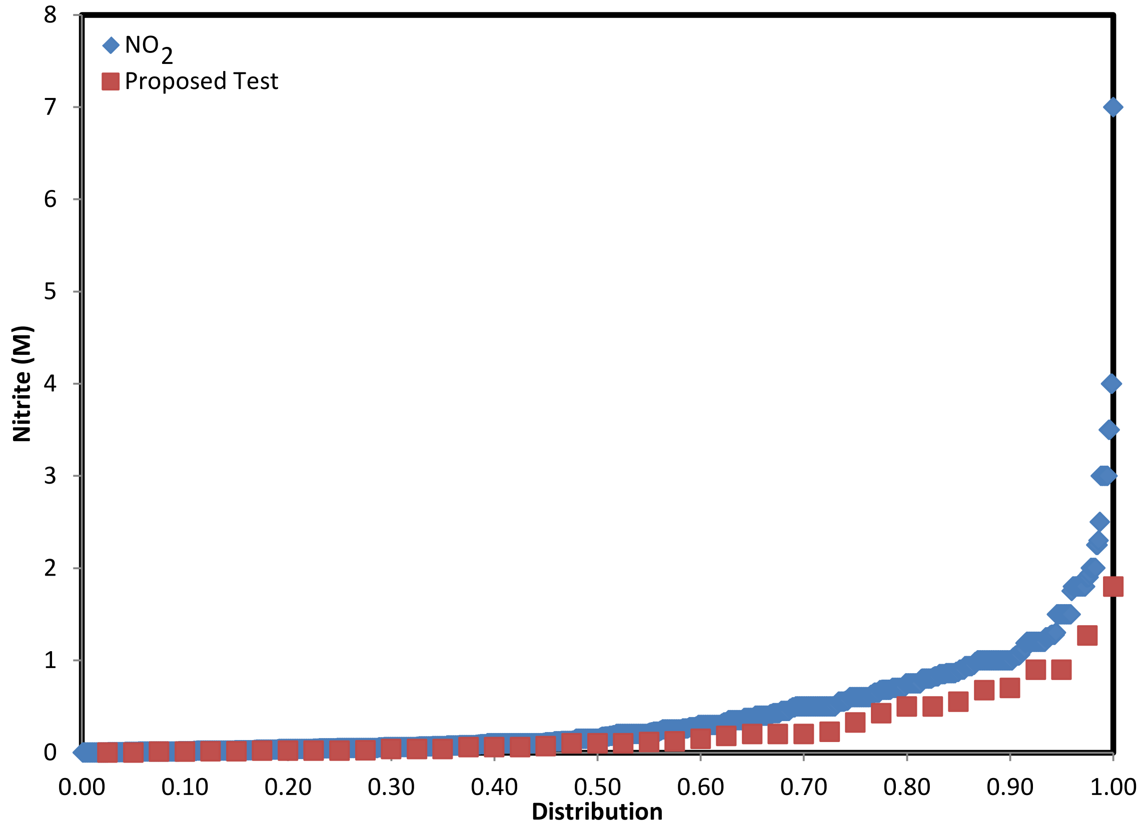


Figure 5-30 Nitrite concentration distribution for total distribution and 40 test matrix.

5.5.4.5 Nitrite/Nitrate Ratio

Figure 5-31 shows the distribution for the nitrite/nitrate ratio that was observed for the total data base (blue diamonds) and the proposed test matrix (red squares). Again approximately 80% of the tests from the total database were at a nitrite/nitrate ratio less than 1. Of particular interest to Hanford is the observation that 20% of the data was obtained at nitrite/nitrate ratios less than 0.15. This nitrite/nitrate is the minimum required by the new SCC limits that are being established at Hanford [3].

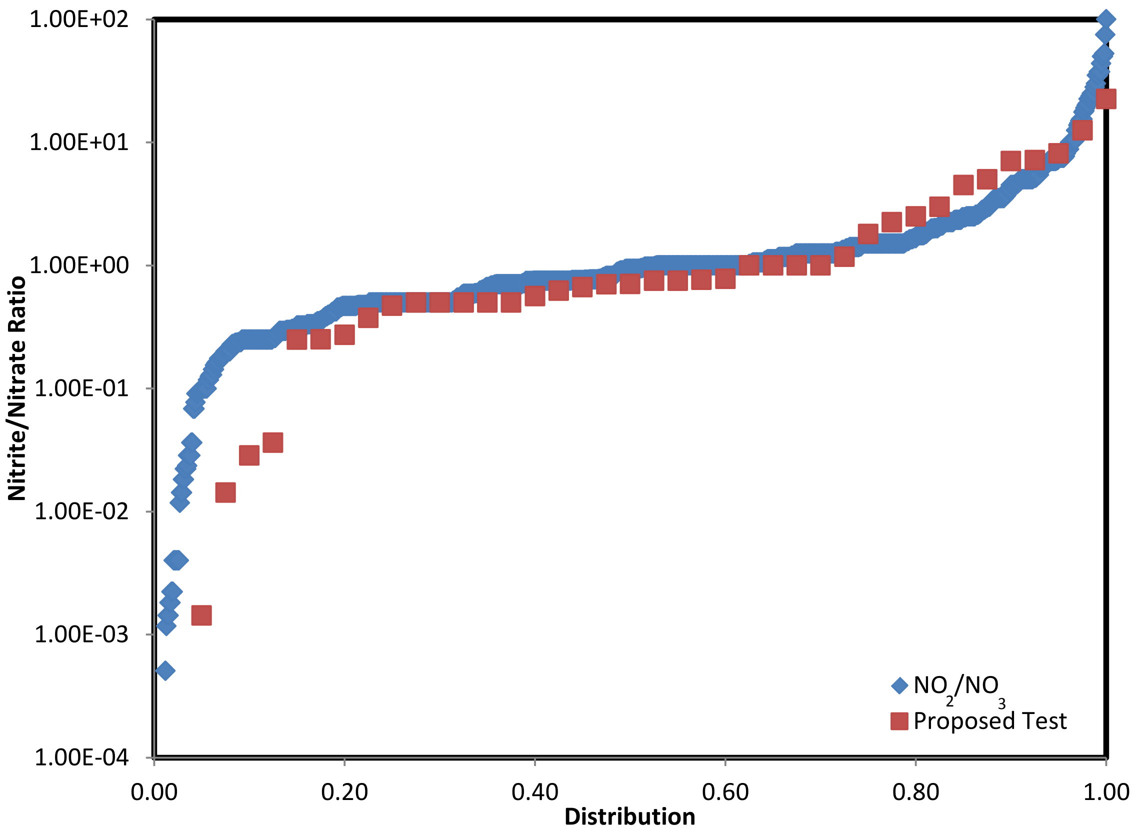


Figure 5-31 Nitrite/Nitrate ratio distribution for total distribution and 40 test matrix.

5.5.5 *CPP Results*

Results from historical CPP curves, where available, and the FY2014 testing were compared to determine how well test conditions were reproduced. No results from historical tests that line-up exactly with the FY2014 test conditions have not been located yet. However, an historical case with a similar waste composition to one of the FY2014 conditions was located in a paper [35]. The simulant compositions are shown in Table 5-10. The simulants are the same, except that the nitrite concentration for the historical case is slightly higher. The nitrite to nitrate ratio for the historical test was approximately 1, while for the FY2014 test the ratio was 0.76.

Table 5-10 Comparison of Chemistry for FY2014 Test Condition #15 and Historical Test Condition

Simulant Source	FY2014 Concentration (M)	Historical Concentration
Sodium carbonate	0.0263	0.0263
Sodium bicarbonate	0.0564	0.0564
Sodium oxalate	0.000268	0.000268
Sodium molybdate, dihydrate	0.0000143	0.0000143
Sodium metasilicate, 5-hydrate	0.000109	0.000109
Sodium phosphate, 12-hydrate	0.000309	0.000309
Sodium chloride	0.0011875	0.0011875
Sodium fluoride	0.000573	0.000573
Sodium sulfate	0.00503	0.00503
Sodium nitrate	0.0758	0.0758
Sodium nitrite	0.058	0.076
Sodium aluminate	0.00045	0.00045
Cobalt nitrate, 6-hydrate	0.00003	0.00003
Nickel nitrate, 6-hydrate	0.0015	0.0015
Ferric nitrate, 9-hydrate	0.000248	0.000248
Mercury (II) nitrate	0.00025	0.00025
Cupric nitrate, 2.5 hydrate	0.000043	0.000043
Manganese dioxide	0.00575	0.00575

The historical CPP curve is shown in Figure 5-32. No pitting was observed on the surface of the sample. The FY2014 Test 15 curve is shown in Figure 5-33. Negative hysteresis was observed, however, minor pitting was observed (i.e., Category 1 with additional testing recommended). The historical results at the Test 15 conditions concurred that this would potentially be a borderline test condition. Despite this difference, the curves illustrate similar polarization characteristics.

- The E_{zc} is approximately the same, 0.1 V vs. SCE.
- Both curves exhibit an active/passive transition (i.e., I_{max}, E_{max}).
- The passive current density is slightly higher for Test 15, however, they are of the same order of magnitude.

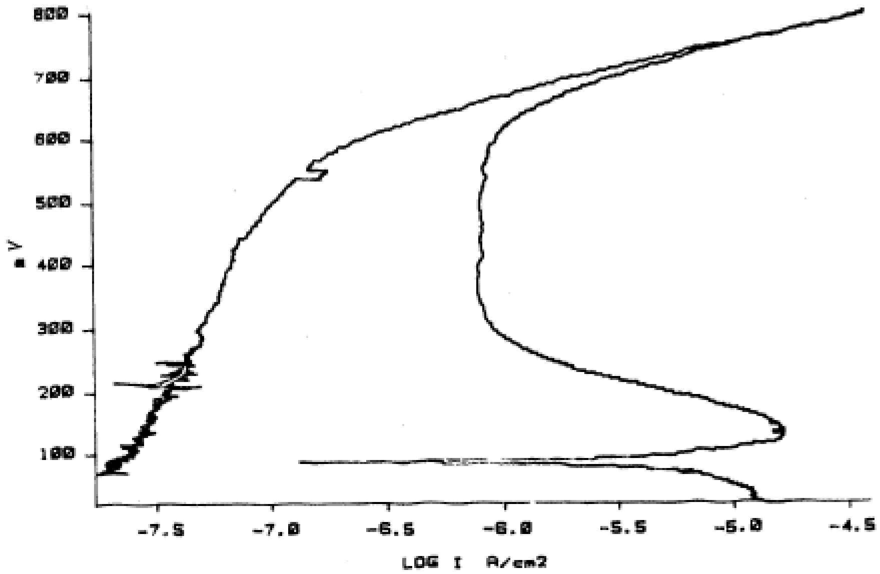


Figure 5-32 CPP curve from historical test data [35]. Note potential is with respect to SCE reference electrode.

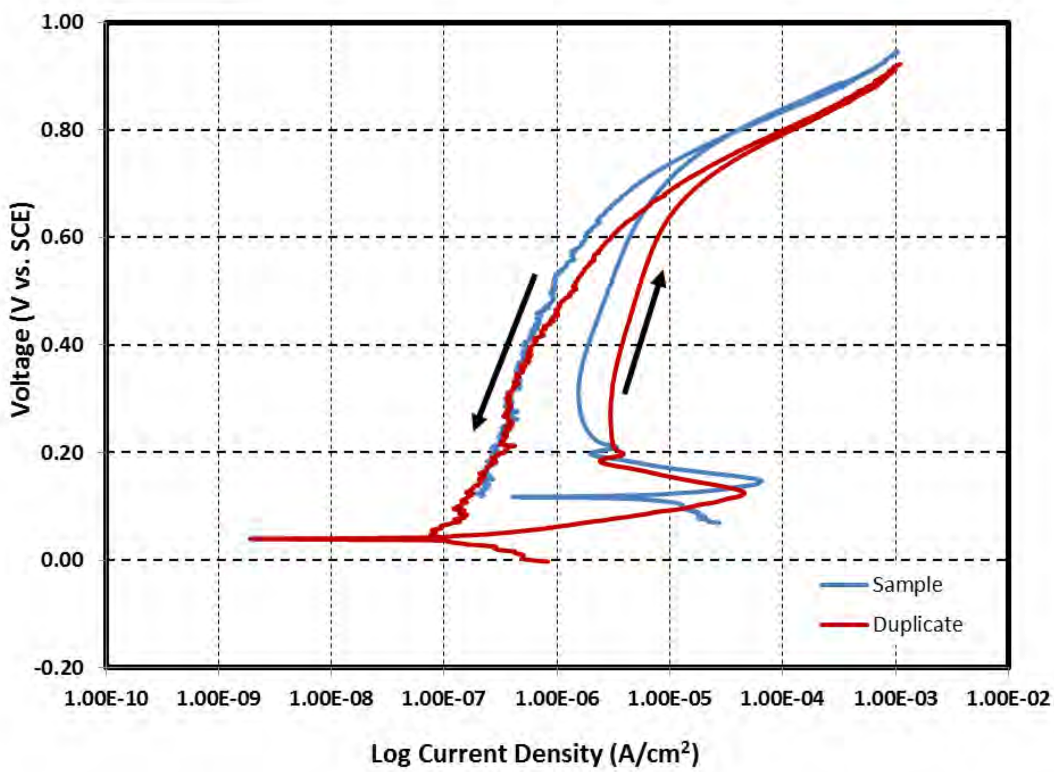


Figure 5-33 CPP curve from FY2014 Test 15.

The CPP curves and photographs of the samples for the 40 tests are shown in Appendix G. A summary of the results is shown in Table 5-11 to 5-19. Important observations from the results included:

- 28 of 40 CPP tests (70%) indicated pitting susceptibility. This proportion is higher than what was observed historically.
- 28 of the new CPP tests agreed with historical results, while there were 12 cases where there was disagreement.
- 10 of the 40 CPP tests (25%) had companion coupon tests for comparison.
- For the FY2014 tests, the results were divided into one of four categories:
    - Category 1, with no pits; a pass condition;
    - Category 1, with pits; a fail condition with additional testing required;
    - Undefined hysteresis with pits; a fail condition with additional testing required;
    - Category 4, with pitting; a fail condition.
- No protection potentials were observed in any of the tests.
- For the pre-1993 CPP data, 16 were at borderline conditions were tested. Of the 16 borderline conditions, 10 new CPP tests were in disagreement with the historical data, while 6 were in agreement. In most cases (i.e., 7 of 10, #10, #15, #20, #22, #29, #31, #39) the disagreement occurred as a previous pass result changed to a fail for the new tests. Minor pitting (i.e., small pits) was typically the cause of noting a failure even though negative hysteresis (Category 1) was observed. For all 7 conditions, the EPOC approach would recommend that additional testing be performed. For the 3 conditions where an historical fail condition changed to a pass for the new tests (#1, #8, #26), it was noted from the CPP curves for the FY2014 tests that the vertex potential was much less than 1.0 V. This observation suggests that during the historical test, where a vertex potential of 1.0 V was specified, the vertex current was greater than 1 mA/cm^2, and that pits may have been initiated at these high potentials. In these 3 cases, the FY2014 test results showed Category 1 behavior with no pitting. Therefore at these conditions, no additional testing would be required based on the FY2014 test result; however, the historical test result would suggest a fail condition or that additional testing would be necessary.
- 5 pre-1993 tests where clear cut pitting or no pitting was observed were tested with the new CPP protocol. In all 5 cases, the new CPP protocol produced identical results.
- Coupon tests were performed at 7 of the pre-1993 CPP test conditions. Four of the 7 cases were at border line conditions. For the borderline conditions, there were 2 cases in which duplicate coupons did not agree (i.e., one exhibited pitting and the other did not at conditions #31 and #39). In one case pitting was observed on duplicate coupons (i.e., #40) and in the other case it was not (i.e.,#26). The new CPP protocol results are in agreement with these coupon test results. For the 3 clear cut pitting or no pitting conditions (i.e., #18,# 21, and #37), the new CPP protocol results were in agreement with the coupon test results.
- For the post-1993 tests, 4 conditions were borderline (#16, #17, #24, #36). Of the 4 borderline conditions 2 new CPP tests were in disagreement with the historical data (#16, #17), while 2 were in agreement (#24, #36). For the two cases that were in disagreement

the historical data indicated that one CPP curve indicated no pitting, while the duplicate CPP scan indicated pitting. In both cases, the FY2014 results indicated a pass condition. In these cases, no additional testing would be required based on the FY2014 test result, however, the historical test result would suggest additional testing would be necessary. For the two cases that were in agreement, additional testing would have been recommended. An example of case where disagreement occurred will be discussed below (#16).

- 15 post-1993 tests, where clear cut pitting of no pitting was observed, were tested with the new CPP protocol. In all 15 cases, the new CPP protocol and historical results were identical.
- Coupon tests were performed at 3 of the post-1993 CPP test conditions. All three conditions produced clear cut pitting on the coupons. The new CPP protocol accurately predicted pitting corrosion in these cases.

Table 5-11 Summary of Historical and 2014 CPP Results

Test Solution	Historical CPP curve available?	Historical Coupon Test Results available?	Historical Result	2014 Result	E_{ocp} (V vs. SCE)	E_{trans} or E_{pit} (V vs. SCE)	E_{prot} (V vs. SCE)	Pitting ?	Hysteresis?	Category?	Comments
1	No [43]	No	Fail	Pass	-0.205	0.618	NA	None	Negative	1	Historical CPP data indicated occasional pitting; borderline condition
2	Yes [51]	No	Pass	Pass	-0.570	0.266	NA	None	Negative	1	Historical CPP data indicated negative hysteresis with not pitting.
3	Yes [49]	No	Fail	Fail	-0.617	-0.087	NA	Major	Positive	4	Historical CPP data indicated positive hysteresis with major pitting.
4	Yes [49]	No	Fail	Fail; AT	-0.628	0.142	NA	Minor	Undefined	Undefined	Historically, 5 CPP tests were performed at this condition; Minor pitting was observed on 3 samples, while no pitting was observed on 2 samples; borderline condition
5	No [43]	No	Pass	Pass	-0.225	0.591	NA	None	Negative	1	Historical CPP data indicated no pitting; line delineating pit/no pit regions passes through data point; borderline condition
6	No [43]	No	Fail	Fail	-0.196	0.406	NA	Major	Positive	4	1.Historical CPP data indicated occasional pitting; high chloride; 2. New CPP curve has strange pattern
7	Yes [49]	No	Fail	Fail	-0.373	-0.070	NA	Major	Positive	4	Historical CPP data indicated positive hysteresis with major pitting.
8	No [43]	No	Fail	Pass	-0.235	0.623	NA	None	Negative	1	Historical CPP data indicated occasional pitting; No pits were observed with what appears to be only a small addition nitrite; borderline condition.

AT: Additional Testing

Table 5-12 Summary of Historical and 2014 CPP Results (continued 1)

Test Solution	Historical CPP curve available?	Historical Coupon Test Results available?	Historical Result	2014 Result	E_{ocp} (V vs. SCE)	E_{trans} or E_{pit} (V vs. SCE)	E_{prot} (V vs. SCE)	Pitting ?	Hysteresis?	Category?	Comments
9	No [50]	Yes [50]	Fail	Fail	-0.319	-0.026	NA	Major	Positive	4	1. Historical CPP data indicated pitting. Positive hysteresis and pitting was observed. 2. Crevice corrosion was observed on coupons after 1 and 6 months. General corrosion was observed on the coupon after 11 months of exposure. 3. Active peak evident in forward scan.
10	No [43]	No	Pass	Fail; AT	-0.232	0.602	NA	Minor	Negative	1	Historical CPP data indicated no pitting; However, at a nitrite concentration that appears to be about 0.01 M less, occasional pitting was observed; borderline condition
11	No [43]	No	Fail	Fail; AT	-0.224	0.625	NA	Minor	Negative	1	Historical CPP data indicated occasional pitting; However, the line that separates the pit/no pit region nearly passes through the data point; borderline condition.
12	No [50]	Yes [50]	Fail	Fail	-0.305	-0.100	NA	Major	Positive	4	1. Historical CPP data indicated pitting. Positive hysteresis and pitting were observed. 2. Crevice corrosion on a coupon was observed after 1 month, pitting corrosion was observed on a coupon after 6 months, and pitting and crevice corrosion were observed on a coupon after 11 months.

AT: Additional Testing

Table 5-13 Summary of Historical and 2014 CPP Results (continued 2)

Test Solution	Historical CPP curve available?	Historical Coupon Test Results available?	Historical Result	2014 Result	E_{ocp} (V vs. SCE)	E_{trans} or E_{pit} (V vs. SCE)	E_{prot} (V vs. SCE)	Pitting ?	Hysteresis?	Category?	Comments
13	No [37]	No	Fail	Fail	-0.027	0.672	NA	Major	Positive	4	1. Historical CPP data indicated occasional pitting; Line delineating pit/no pit region passes through the data point; borderline condition. 2. Active peak evident in forward scan.
14	No [34, 35]	No	Fail	Fail; AT	0.108	0.775	NA	Minor	Negative	1	1. Historical CPP data indicated pitting; Increasing the nitrite concentration by a small amount eliminated pitting; borderline condition. 2. Active peak evident in forward scan.
15	No [34, 35]	No	Pass	Fail; AT	0.078	0.67	NA	Minor	Negative	1	1. Historical CPP data indicated no pitting; borderline condition 2. Active peak evident in forward scan; 3. Coupon test results at a similar nitrate concentration (0.055 M) and the same nitrite/nitrate ratio (0.76) exhibited no pitting.
16	Yes [47]	No	Fail	Pass	-0.270	0.719	NA	None	Negative	1	Historically, one CPP curve had positive hysteresis, the other curve had negative hysteresis; borderline condition.
17	Yes [46]	No	Fail	Pass	-0.257	0.694	NA	None	Negative	1	Historically, one CPP result indicated no pitting, while the second result was negative hysteresis with minor pitting; borderline condition.

AT: Additional Testing

Table 5-14 Summary of Historical and 2014 CPP Results (continued 3)

Test Solution	Historical CPP curve available?	Historical Coupon Test Results available?	Historical Result	2014 Result	E_{ocp} (V vs. SCE)	E_{trans} or E_{pit} (V vs. SCE)	E_{prot} (V vs. SCE)	Pitting ?	Hysteresis?	Category?	Comments
18	No [36]	Yes [57]	Fail	Fail	0.108	0.78	NA	Major	Positive	4	1. Historical CPP data indicated pitting; Increasing the nitrite concentration by a small amount eliminated pitting; borderline condition; 2. Historical coupon test indicated pitting; 3. Active peak evident in forward scan.
19	Yes [47]	No	Fail	Fail; AT	-0.279	0.696	NA	Minor	Positive/ Undefined	4/ Undefined	Historical CPP data indicated positive hysteresis with moderate pitting.
20	No [37]	No	Pass	Fail; AT	0.100	0.737	NA	Minor	Undefined	Undefined	1. Historical CPP data indicated no pitting; Line delineating pit/no pit regions passes through the data point; borderline condition. 2. Active peak evident in forward scan.
21	No [36]	Yes [57]	Fail	Fail; AT	0.128	0.680	NA	Major	Undefined	Undefined	1. Historical CPP data indicated pitting; Increasing the nitrite concentration by a small amount eliminated pitting; borderline condition; 2. Historical coupon test indicated pitting; 3. Active peak evident in forward scan.

AT: Additional Testing

Table 5-15 Summary of Historical and 2014 CPP Results (continued 4)

Test Solution	Historical CPP curve available?	Historical Coupon Test Results available?	Historical Result	2014 Result	E_{ocp} (V vs. SCE)	E_{trans} or E_{pit} (V vs. SCE)	E_{prot} (V vs. SCE)	Pitting ?	Hysteresis?	Category?	Comments
22	No [36]	No	Pass	Fail; AT	0.087	0.695	NA	Minor	Negative	1	1. Historical CPP data indicated that no pitting was observed. However, the line dividing the pitting from no pitting condition was drawn through this data point. This is a borderline condition; 2. Active peak evident in forward scan. 3. Pits could not be seen with the unaided eye.
23	Yes [47]	No	Pass	Pass	-0.274	0.707	NA	None	Negative	1	Historical CPP data showed negative hysteresis with no pitting.
24	Yes [28]	No	Fail	Fail; AT	-0.224	0.684/ 0.606	NA	None/ Minor	Negative/ Undefined	1/ Undefined	1. Historical CPP data indicated negative hysteresis with moderate pitting. A borderline condition. This test condition is that was used for the round robin testing in FY2013 [2]. This condition was used to explore the borderline condition. 2. New CPP data had mixed results. One CPP curve showed negative hysteresis with no pitting on the sample. The second CPP curve exhibited an undefined characteristic, with minor pitting.
25	No [34, 35]	No	Fail	Fail; AT	0.131	0.739	NA	Minor	Negative	1	1. Historically, CPP data indicated occasional pitting; borderline condition 2. Active peak evident in forward scan

AT: Additional Testing

Table 5-16 Summary of Historical and 2014 CPP Results (continued 5)

Test Solution	Historical CPP curve available?	Historical Coupon Test Results available?	Historical Result	2014 Result	E_{ocp} (V vs. SCE)	E_{trans} or E_{pit} (V vs. SCE)	E_{prot} (V vs. SCE)	Pitting ?	Hysteresis?	Category?	Comments
26	No [34, 35]	Yes [27]	Fail	Pass	0.025/ 0.127	0.546/ 0.813	NA	None	Negative	1	1. Historically, 1 CPP curve indicated no pitting, while the replicate indicated pitting; borderline condition 2. Active peak evident in forward scan; 3. Test was not as reproducible as others.
27	Yes [47]	No	Fail	Fail	-0.289	0.400	NA	Major	Positive	4	Historical CPP curves showed undefined or negative hysteresis. Moderate pitting was observed on the sample.
28	Yes [28]	No	Pass	Pass	-0.222	0.692	NA	None	Negative	1	Historical CPP data indicated negative hysteresis with no pitting.
29	No [37]	No	Pass	Fail; AT	0.116	0.787	NA	Minor	Undefined	Undefined	1. Historically, no pits were observed for the CPP test. However, line that separates the pit/no pit region goes through this data point; borderline condition. 2. Two active peaks evident in forward scan.
30	Yes [28]	No	Pass	Pass	-0.247	0.624	NA	None	Negative	1	Historical CPP data indicated negative hysteresis and no pitting.
31	No [36]	Yes [57]	Pass	Fail; AT	0.102	0.705	NA	Minor	Negative	1	1. Historical CPP data indicated no pitting was observed; However, line separating pit/no pit region passes through the data point; borderline condition. 2. Historical coupon tests indicate that 1 in 4 coupons showed evidence of pitting at a similar simulant composition. 3. Active peak evident in forward scan.

AT: Additional Testing

Table 5-17 Summary of Historical and 2014 CPP Results (continued 6)

Test Solution	Historical CPP curve available?	Historical Coupon Test Results available?	Historical Result	2014 Result	E_{ocp} (V vs. SCE)	E_{trans} or E_{pit} (V vs. SCE)	E_{prot} (V vs. SCE)	Pitting ?	Hysteresis?	Category?	Comments
32	No [45]	No	Pass	Pass	-0.249	0.639	NA	None	Negative	1	Historical CPP data indicated no pitting was observed.
33	Yes [47]	Yes [47]	Fail	Fail	-0.200	0.400/ 0.600	NA	Minor	Positive/ Negative	4/1	1. Historical CPP data indicated positive hysteresis with significant pitting on the sample. 2. Partially immersed coupon tests were conducted on as-received and heat treated samples for 19 weeks. The samples exhibited minor weight loss with the maximum pit depths between 18 to 27 mils. Pits were located near liquid air interface. 3. New CPP data had 1 case of positive hysteresis with pitting and 1 case of negative hysteresis with minor pitting.
34	Yes [51]	No	Fail	Fail	-0.242/ -0.171	0.131/ 0.290	NA	Major	Positive	4	Historical CPP data indicated positive hysteresis with major pitting.
35	Yes [47]	No	Fail	Fail	-0.158 /0.126	0.663/ 0.740	NA	Minor	Positive/ Undefined	4/ Undefined	1. Historical CPP curves showed positive hysteresis with major pitting on the sample. 2. New CPP curves showed positive hysteresis or undefined hysteresis with pitting present on the sample. 3. Reproducibility not as good for this test.

Table 5-18 Summary of Historical and 2014 CPP Results (continued 7)

Test Solution	Historical CPP curve available?	Historical Coupon Test Results available?	Historical Result	2014 Result	E_{ocp} (V vs. SCE)	E_{trans} or E_{pit} (V vs. SCE)	E_{prot} (V vs. SCE)	Pitting ?	Hysteresis?	Category?	Comments
36	Yes [48]	No	Fail	Fail; AT	-0.270	0.625	NA	Minor	Negative	1	1. Historical CPP curves showed undefined hysteresis with minor pitting. A borderline condition. 2. New CPP curves exhibited negative hysteresis with minor pitting observed.
37	No [36]	Yes [57]	Fail	Fail; AT	0.093	0.737	NA	Major	Undefined	Undefined	1. Historical CPP data indicated pitting. 2. Historical coupon tests indicated pitting susceptibility. 3. Active peak evident in forward scan.
38	Yes [51]	No	Pass	Pass	-0.300	0.518	NA	None	Negative	1	Historically, CPP curves had negative hysteresis with no pitting on the sample. This was AY-102 Present Interstitial Liquid (PIL) with no nitrite.
39	No [36]	Yes [57]	Pass	Fail; AT	0.102	0.764	NA	Minor	Negative	1	1. Historical CPP data indicated no pitting; However, line separating pit/no pit region passes through the data point; A borderline condition. 2. Historical coupon data indicated that 1 in 4 coupons showed evidence of pitting at a similar simulant composition. 3. Active peak evident in forward scan.

AT: Additional Testing

Table 5-19 Summary of Historical and 2014 CPP Results (continued 8)

Test Solution	Historical CPP curve available?	Historical Coupon Test Results available?	Historical Result	2014 Result	E_{ocp} (V vs. SCE)	E_{trans} or E_{pit} (V vs. SCE)	E_{prot} (V vs. SCE)	Pitting ?	Hysteresis?	Category?	Comments
40	No [36]	Yes [57]	Fail	Fail; AT	0.097	0.800	NA	Minor	Undefined	Undefined	1. Historical CPP data indicated occasional pitting; Line separating pit/no pit region passes through the data point; borderline condition. 2. Historical coupon data indicated that this may be a borderline condition. Pitting was observed at nitrite concentrations slightly below this simulant (0.0085 M) concentration, and no pitting was observed at nitrite concentrations slightly above this simulant concentration (0.03 M). 3. Active peak evident in forward scan.

AT: Additional Testing

Table 5-20 Composition of Post-1993 test and FY2014 Test 16 (M).

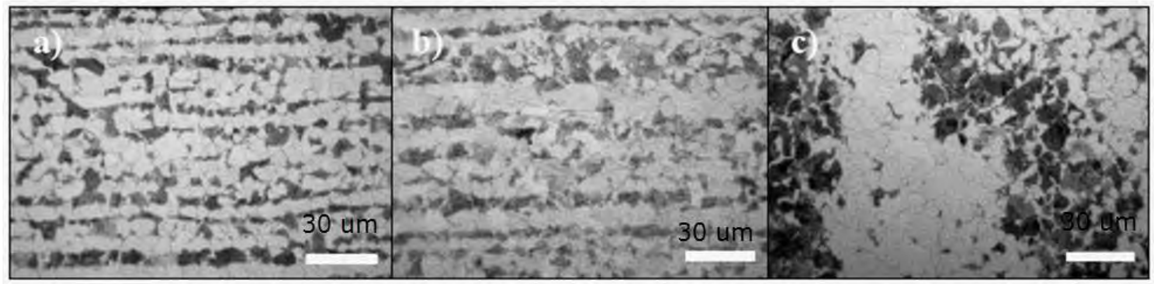
Temperature (°C)	Concentration of Species (M)									pH
	$CO_3^{=}$	$HCO_3^{=}$	Citrate	PO_4^{3-}	Cl^-	F^-	SO_4^{2-}	NO_3^-	NO_2^-	
40	0.0526	0.098	NA	NA	0.0037	NA	0.0451	0.2	0.15	10

Table 5-21 Comparison of Post 1993 CPP Test Protocol and New Standardized CPP Protocol.

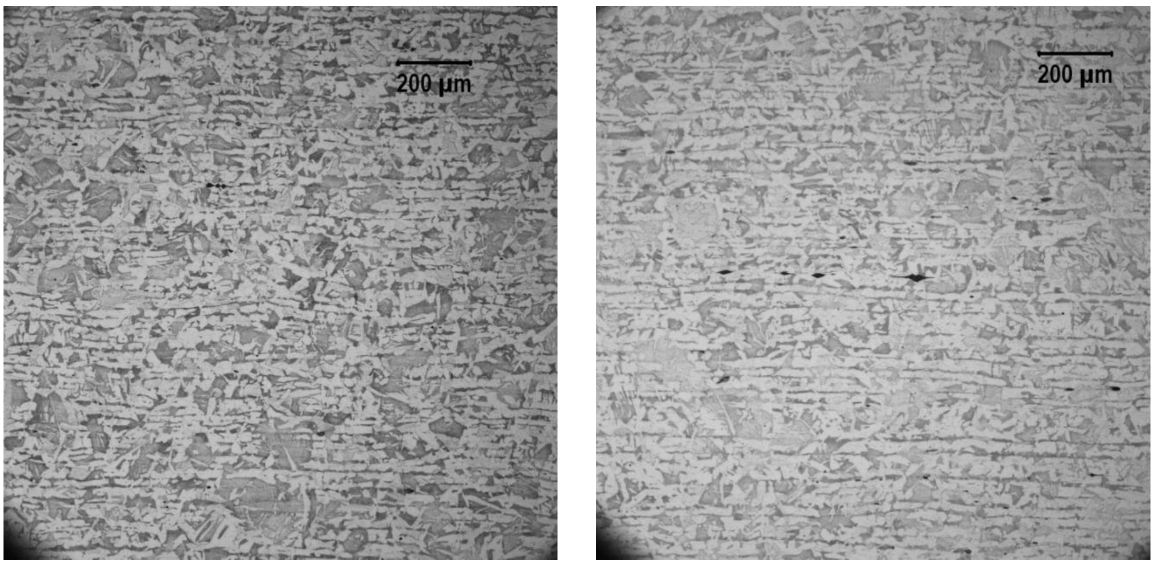
Parameters	Post-1993 SRNL CPP protocol	New Standardized CPP protocol
Potential Stabilization Time (hrs)	2	2
Initial Potential (V vs. OCP)	-0.1	-0.05
Scan Rate (mV/s)	0.5	0.167
Vertex Threshold (V vs. SCE or mA/cm^2)	1.2 V	1 mA/cm^2
Final Potential (V vs. OCP)	0.0	0.0
Sample Geometry	Disk	Bullet
Surface Finish	800 grit	600 grit

An example of a case in which there was disagreement between a post-1993 test and one of the 40 tests that was performed in FY2014, is presented below. The solution that was tested had the composition shown in Table 5-20. At this nitrite to nitrate ratio, pre-1993 CPP data indicates that this may be a borderline condition [55]. A comparison of the CPP protocol that was used for the post-1993 test [47] that produced contrary results and the new CPP protocol (i.e., Test 16) is shown in Table 5-21. There were several differences in the protocol that was performed for this set of tests, the primary being the scan rate and the vertex threshold.

Another difference that existed between the tests is the steel that was tested. ASTM A537 carbon steel was used in the historical test, while the rail car steel was utilized in the current tests. Micrographs of each of the steels are shown in Figure 5-34. Tests were performed with the sample oriented in the short direction (Figure 5-26 (c)). Differences in the grain sizes (i.e., finer grain size for the A537) and manganese sulfide inclusion density (greater for the A537 steel) were noted. The higher density of manganese sulfide inclusions would tend to make a material more susceptible to pitting [59].



(a) **(b)** **(c)**



(d) **(e)**

Figure 5-34 Micrographs (a), (b), and (c) are the longitudinal, transverse, and short directions for the A537 that was tested, while micrographs (d) and (e) are the longitudinal and transverse direction for the rail car steel that was tested.

Figure 5-35 compares the open circuit potential transients for the A537 and rail car steels that was measured during the potential stabilization time. Although both were exposed for two hours, the potential for the rail car steel appears to have stabilized, whereas the potential for the A537 steel continued to increase, which indicates that perhaps the oxide had not stabilized on the surface.

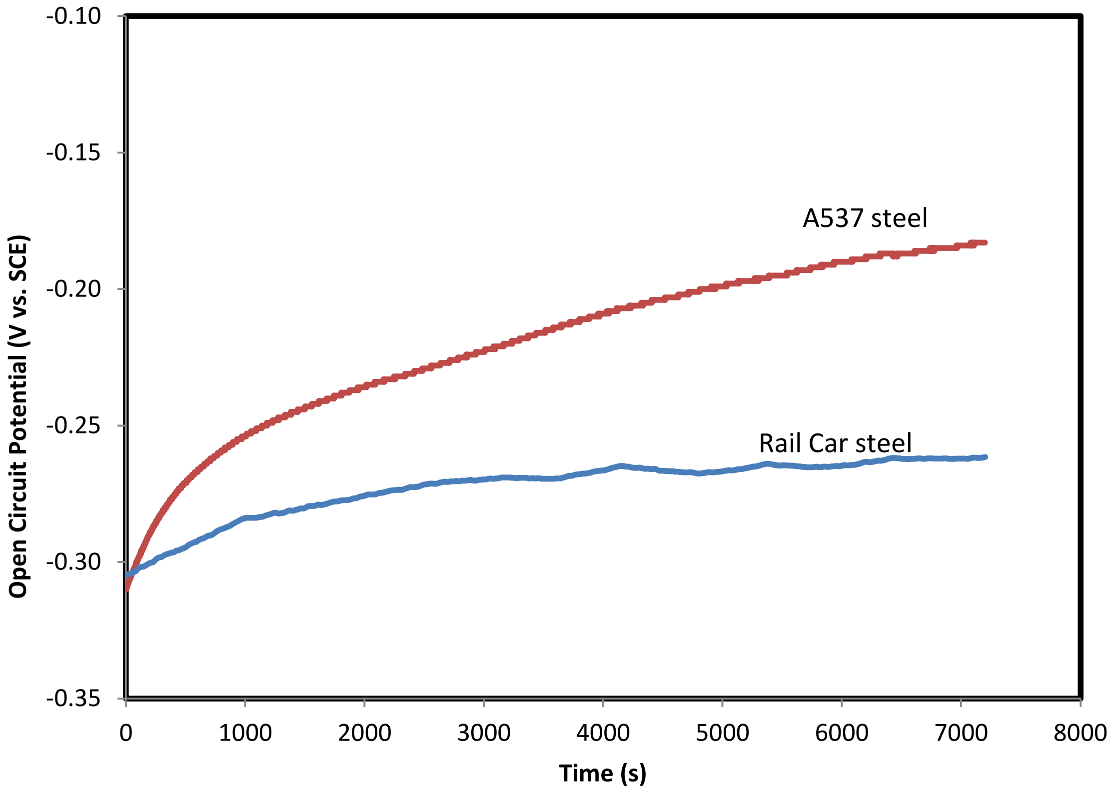


Figure 5-35 Open circuit potential transients for the rail car and A537 steel exposed to test solution 16.

Figure 5-36 compares the CPP curves for the A537 carbon steel and the rail car steel. The higher scan rate and the lack of a stable oxide film are a possible cause for the higher observed current density during the forward scan of the A537 steel compared to the rail car steel. Additionally, the high vertex potential that was utilized for the A537 resulted in a higher vertex current density. This coupled with the higher density of inclusions may have resulted in the small degree of positive hysteresis and the initiation of the small pits that were observed on the sample (see Figure 5-37). The rail car steel, on the other hand, exhibited negative hysteresis and no pits were observed as shown in Figure 5-37.

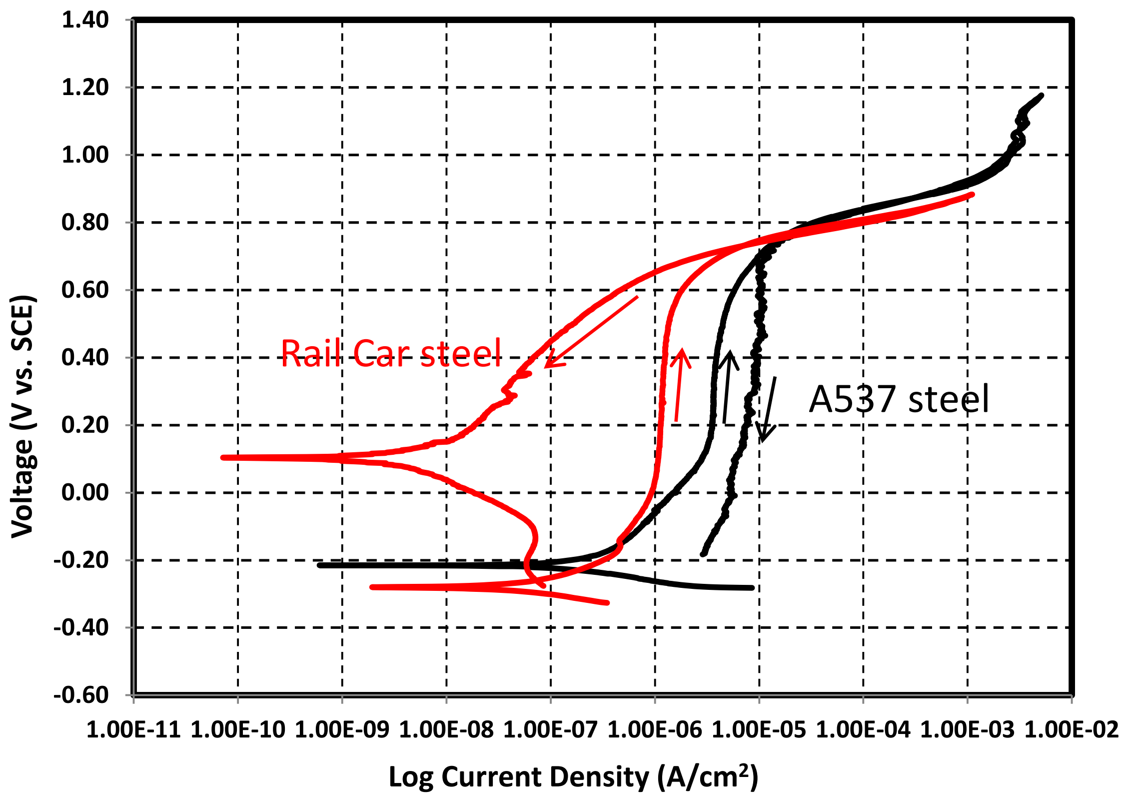
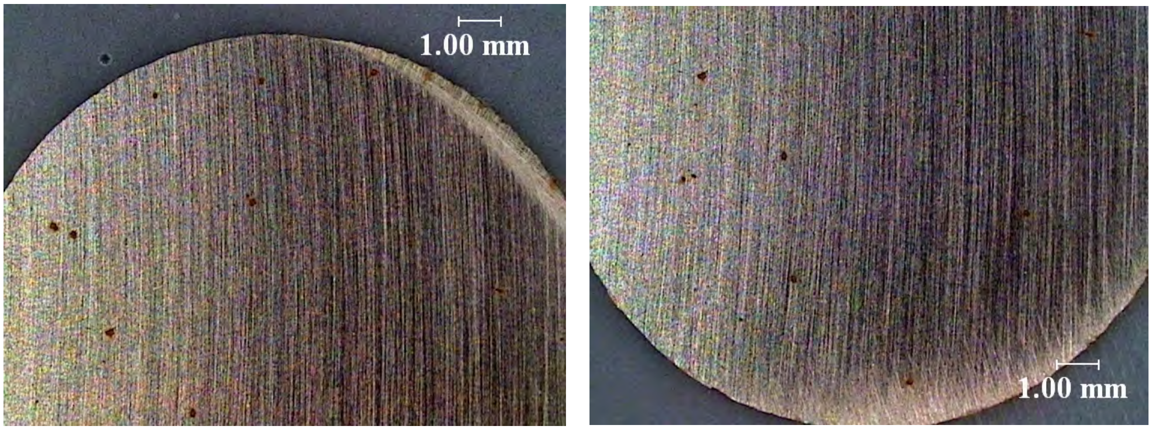
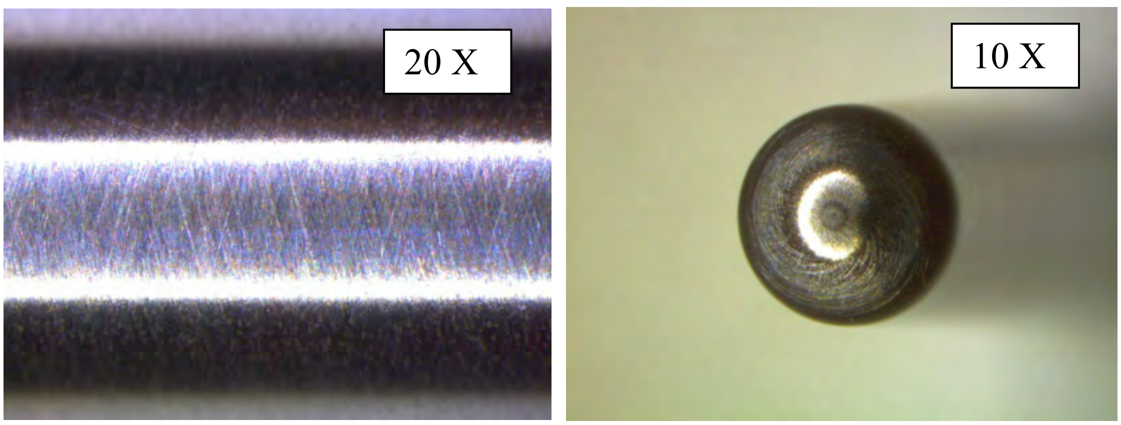


Figure 5-36 CPP curves for the rail car and A537 steel exposed to test solution 16.

Two principle observations can be made from this testing. For environmental conditions where there is clear-cut pitting or no pitting on an electrode, the historical and new CPP protocol data are in agreement. The CPP curves (i.e., positive or negative hysteresis) were also in agreement with observations on the sample. Long-term coupon tests demonstrated agreement with the CPP tests. On the other hand, for environmental conditions that are borderline, agreement is not guaranteed. Borderline environmental conditions can result in contradictions between the CPP curve and the observation of pits (i.e., negative hysteresis with minor pitting) and difficulty in replicating coupon test results (i.e., one coupon exhibits pitting, while no pitting is observed on a duplicate coupon). The disagreement in the CPP test results may be a result of differences in the test protocol or differences in the microstructure of the material that was tested. Therefore, if the historical data is applied to evaluate current conditions in the tanks or future corrosion controls a careful review of the test parameters and steel utilized is required.



(a)



(b)

Figure 5-37 Post-CPP test observation of samples after tests in solution 16 (a) A537 steel and (b) Rail Car steel.

6.0 Conclusions

For FY2014, four task activities were performed and the results were arranged in five parts and discussed in section 5. Below is a summary and conclusions for every part:

6.1 Secondary Wall of AY-102 Tank Corrosion Studies

LAI and VS corrosion tests were performed using LDP residue (Solutions 12 and 13) and GW simulants (Solutions 14 and 15). For LAI samples after two months, aggressive corrosion was sustained for all samples. For the partially immersed samples after two months of exposure, the corrosion occurred at the water line and below. By the fourth month, the corrosion increased above the water line of the coupon as well. The corrosion rate was steady for the 4 month test at approximately 10 mpy. A similar corrosion rate was observed for samples that were totally immersed in the LDP and GW simulants. For VS samples, corrosion was more prominent for the coupons exposed to GW simulant (Solution 8) than the coupons exposed to LDP residue (Solution 7). More aggressive attack was observed on the samples closest to the liquid level (Level 1 > Level 2 > Level 3) for the coupons from GW simulant.

6.2 Waste Buffering of simulant from DST AN-102

Electrochemical testing using waste buffering simulants based on waste from tank AN-102 at different hydroxide, nitrate and nitrite concentrations was performed. All the samples showed no pitting and the CPP curve had negative hysteresis. Also an OCP of -0.600 V vs. SCE was common, except one test (test 16 duplicate). The results demonstrated that hydroxide concentrations as low as 0.032 M can still offer inhibition for corrosion in carbon steel provided sufficient nitrite is present. The four month LAI tests showed no significant corrosion. Under the microscope pits from 0.5 to 1.3 mils in depth were seen sporadically at the LAI and above while none were found below. These results concur with electrochemical testing in that the solutions studied inhibited the development of pits when carbon steel is immersed and creates very small pits that do not seem to grow or increase in quantity over time.

6.3 Vapor Space Corrosion tests at new SCC limits with different concentrations of Ammonia gas in Air

VSC tests were executed with three simulants based on the new SCC corrosion control guideline. The simulants contained the minimum nitrite/nitrate ratio of 0.15 and nitrate concentrations of 0.4, 2 and 4.5 M. The vapor space above each simulant had either 50 or 550 ppm ammonia. The samples after four-months of exposure showed no indications of VSC at levels 3 and 2 with minor corrosion areas at Level 1 for the 550 ppm ammonia in each of the three simulants. The same was true at 50 ppm, as there was no significant VSC. When the cold mount was removed from the coupons, some crevice attack had occurred in some instances. The crevice corrosion seemed more aggressive in these samples than for the samples exposed with LDP and GW simulant. The results tend to indicate that even at 50 ppm ammonia with solutions comprised of the new SCC control limits VSC can be inhibited.

6.4 Liquid Air Interface tests at new SCC limits

Eight different solutions were prepared with compositions that were at or near the new SCC control limits. After two and fourth months of exposure none of the samples exhibited LAI corrosion or any attack in the immersed area. Typically any corrosion seemed to initiate at the top of the coupon and develop an area of general corrosion and that continues to spread above the LAI. The smallest ratio of nitrite to nitrite (0.12) was solution 8 and during the contact with the carbon steel coupon it developed a film that completely covered the coupon and protected it from corrosion attack even though the ratio is less than the new minimum SCC control limits. The corrosion appeared to be more severe for the more dilute solutions at a given nitrite/nitrate ratio.

6.5 Pitting Corrosion studies using the standardized CPP protocol

CPP tests were conducted to compare historical data with data that was collected using the new standardized CPP protocol. The purpose was to determine the effect of the CPP parameters on the results and also compare the results from the new CPP test protocol with long-term coupon tests. Forty test conditions were selected for testing during FY2014 from the more than 900 historical test conditions. In cases where either a clear-cut pitting or no pitting case, there was 100% agreement between the historical CPP results and the present testing. On the other hand if the environment was a borderline condition (i.e., transition from pitting to not pitting) agreement was not as good. Both the CPP test parameters and the microstructure of the material may have had a role in these contrary results. The historical data and new CPP protocol still remain useful as in both cases the behavior at the borderline condition was consistent. Both the historical data and the new CPP test protocol were consistent with coupon results that indicated either clear-cut pitting or no pitting results and borderline conditions.

7.0 Quality Assurance

Data were recorded in the electronic laboratory notebook system, notebook number G8519-00126.

Requirements for performing reviews of technical reports and the extent of review are established in manual E7 2.60. SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.

8.0 Acknowledgements

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10.0 Appendices

Appendix A
Chemical Composition of Simulants used in Vapor Space Corrosion Testing

Appendix B
Pictures of Vapor Space Corrosion Samples After Test

Appendix C
Chemical Composition of Simulants used in Liquid Air Interface Corrosion Testing

Appendix D
Pictures of Liquid Air Interface Corrosion Samples after Test

Appendix E
Open Circuit Potential, pH and Temperature vs. Time plots for Liquid Air Interface Solutions

Appendix F
Chemical Composition of Simulants used in Waste Buffering (Task 3) with Electrochemical Results and After Pictures

Appendix G
Chemical Composition of Simulants used in Pitting Corrosion (Task 4) with Electrochemical Results and After Pictures

Appendix H
Test Conditions from Previous Electrochemical Results (Task 4)

Appendix A

Chemical Composition of Simulants used in Vapor Space Corrosion Testing

Composition of simulant for VS-Solution 1

Volume 1.5 L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.1314	0.0002	0.1125
Sodium Chloride	NaCl	58.4400	0.01	0.8766
Sodium Fluoride	NaF	41.9882	0.003	0.1889
Sodium Sulfate	Na_2SO_4	142.0400	0.005	1.0653
Ammonium Nitrate	NH_4NO_3	80.0520	0.0012	0.1441
Sodium Hydroxide	NaOH	40.0000	0.01	0.6000
Sodium Phosphate	$Na_3PO_{4.}12H_2O$	380.1200	0.0005	0.2851
Sodium Carbonate	Na_2CO_3	105.9885	0.1	15.8983
Sodium Nitrate	$NaNO_3$	84.9947	0.400	50.9968
Sodium Nitrite	$NaNO_2$	68.9953	0.060	6.2096

Composition of simulant for VS-Solution 2

Volume 1.5 L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.1314	0.0020	1.1254
Sodium Chloride	NaCl	58.4400	0.04	3.5064
Sodium Fluoride	NaF	41.9882	0.01	0.6298
Sodium Sulfate	Na_2SO_4	142.0400	0.050	10.6530
Ammonium Nitrate	NH_4NO_3	80.0520	0.0012	0.1441
Sodium Hydroxide	NaOH	40.0000	0.01	0.6000
Sodium Phosphate	$Na_3PO_{4.}12H_2O$	380.1200	0.01	5.7018
Sodium Carbonate	Na_2CO_3	105.9885	0.5	79.4914
Sodium Nitrate	$NaNO_3$	84.9947	2	254.9841
Sodium Nitrite	$NaNO_2$	68.9953	0.3	31.0479

Composition of simulant for VS-Solution 3

Volume 1.5 L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.1314	0.0033	1.8569
Sodium Chloride	NaCl	58.4400	0.10	8.7660
Sodium Fluoride	NaF	41.9882	0.020	1.2596
Sodium Sulfate	Na_2SO_4	142.0400	0.100	21.3060
Ammonium Nitrate	NH_4NO_3	80.0520	0.0011	0.1321
Sodium Hydroxide	NaOH	40.0000	0.010	0.6000
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.1200	0.0500	28.5090
Sodium Carbonate	Na_2CO_3	105.9885	1.0	158.9828
Sodium Nitrate	$NaNO_3$	84.9947	4.500	573.7142
Sodium Nitrite	$NaNO_2$	68.9953	0.675	69.8577

Composition of simulant for VS-Solution 4

Volume 1.5 L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.1314	0.0002	0.1125
Sodium Chloride	NaCl	58.4400	0.01	0.8766
Sodium Fluoride	NaF	41.9882	0.003	0.1889
Sodium Sulfate	Na_2SO_4	142.0400	0.005	1.0653
Ammonium Nitrate	NH_4NO_3	80.0520	0.0012	0.1441
Sodium Hydroxide	NaOH	40.0000	0.01	0.6000
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.1200	0.0005	0.2851
Sodium Carbonate	Na_2CO_3	105.9885	0.1	15.8983
Sodium Nitrate	$NaNO_3$	84.9947	0.400	50.9968
Sodium Nitrite	$NaNO_2$	68.9953	0.060	6.2096

Composition of simulant for VS-Solution 5

Volume 1.5 L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.1314	0.0020	1.1254
Sodium Chloride	NaCl	58.4400	0.04	3.5064
Sodium Fluoride	NaF	41.9882	0.01	0.6298
Sodium Sulfate	Na_2SO_4	142.0400	0.050	10.6530
Ammonium Nitrate	NH_4NO_3	80.0520	0.0132	1.5850
Sodium Hydroxide	NaOH	40.0000	0.01	0.6000
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.1200	0.01	5.7018
Sodium Carbonate	Na_2CO_3	105.9885	0.5	79.4914
Sodium Nitrate	$NaNO_3$	84.9947	2	254.9841
Sodium Nitrite	$NaNO_2$	68.9953	0.3	31.0479

Composition of simulant for VS-Solution 6

Volume 1.5 L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum Nitrate	$Al(NO_3)_3.9H_2O$	375.1314	0.0033	1.8569
Sodium Chloride	NaCl	58.4400	0.10	8.7660
Sodium Fluoride	NaF	41.9882	0.020	1.2596
Sodium Sulfate	Na_2SO_4	142.0400	0.100	21.3060
Ammonium Nitrate	NH_4NO_3	80.0520	0.0122	1.4650
Sodium Hydroxide	NaOH	40.0000	0.010	0.6000
Sodium Phosphate	$Na_3PO_4.12H_2O$	380.1200	0.0500	28.5090
Sodium Carbonate	Na_2CO_3	105.9885	1.0	158.9828
Sodium Nitrate	$NaNO_3$	84.9947	4.500	573.7142
Sodium Nitrite	$NaNO_2$	68.9953	0.675	69.8577

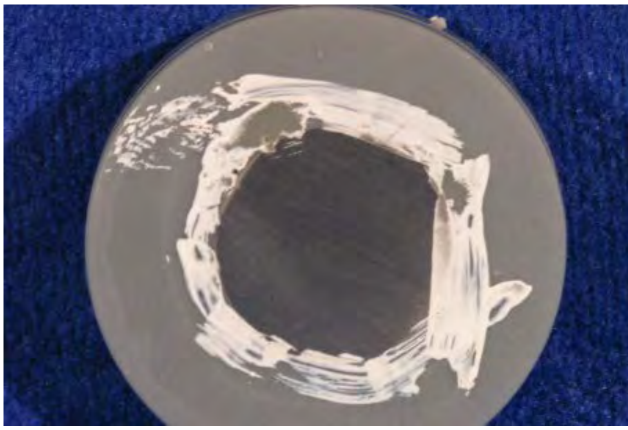
Appendix B

Pictures of Vapor Space Corrosion Samples After Test

Vessel 1: Level 3

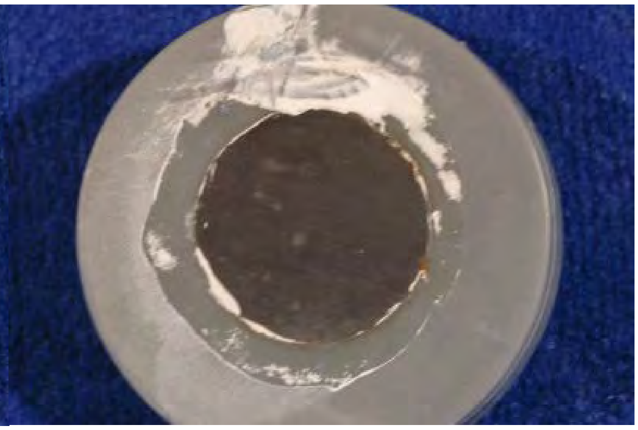
1 month

RC128-1



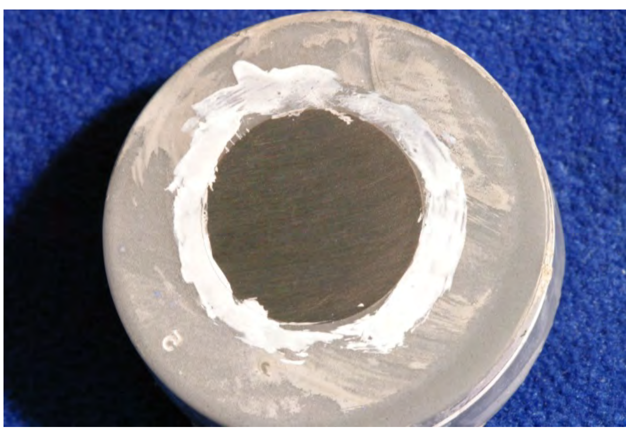
2 months

RC128-2



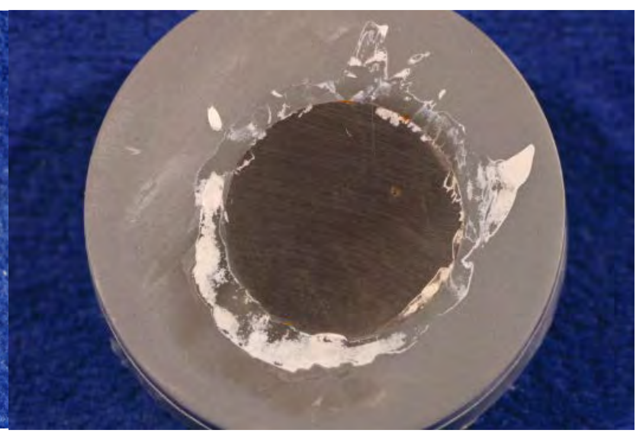
3 months

RC128-4



4 months

RC128-3



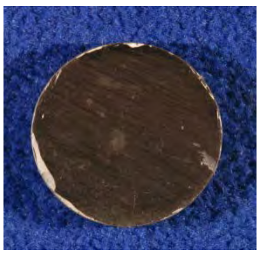
Vessel 1: Level 3

Before cleaning | **After cleaning**


1 month

RC128-1


Front **Back** **Front** **Back**



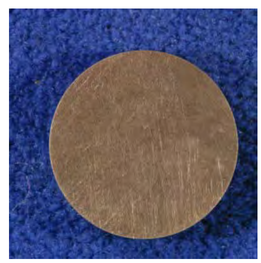

2 months

RC128-2

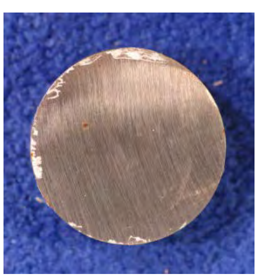

Front **Back** **Front** **Back**


3 months

RC128-4




Front **Back** **Front** **Back**




4 months

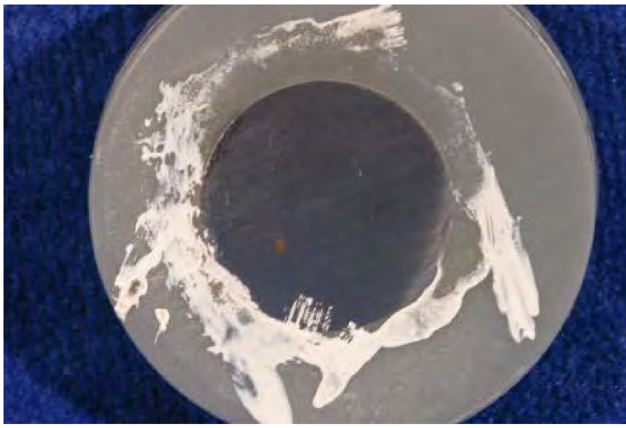
RC128-3


Front **Back** **Front** **Back**

Vessel 1: Level 2

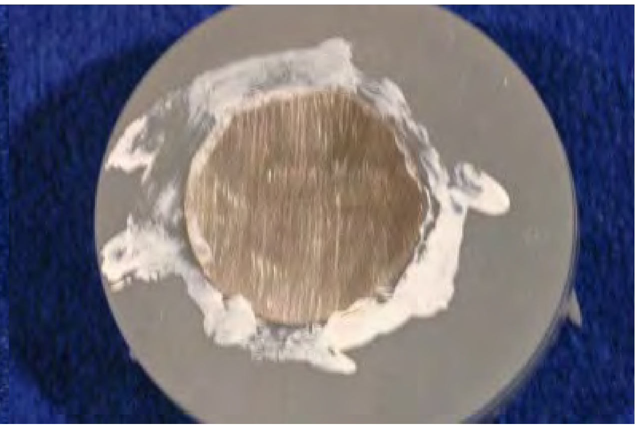
1 month

RC128-5



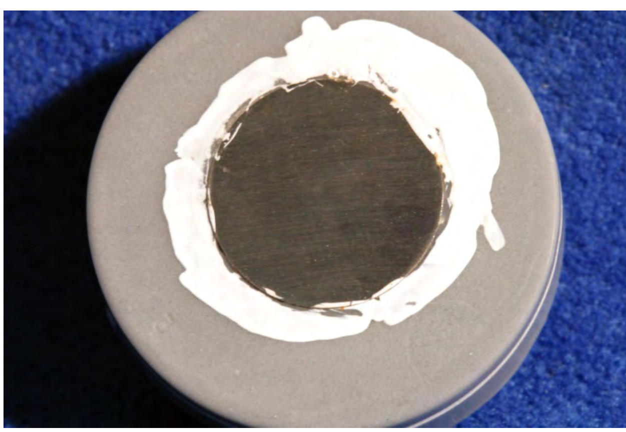
2 months

RC128-8



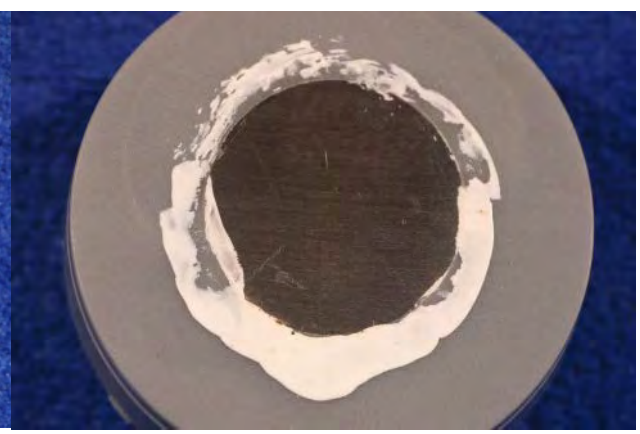
3 months

RC128-7



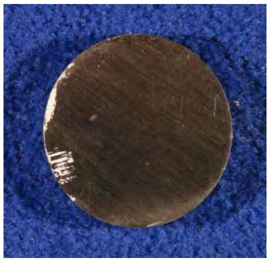
4 months

RC128-6



Vessel 1: Level 2

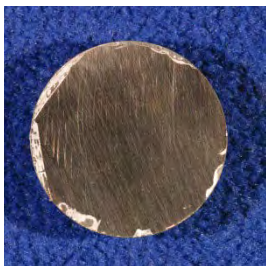
Before cleaning | **After cleaning**




1 month

RC128-5

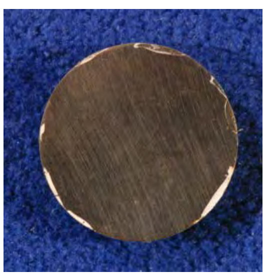

Front **Back** **Front** **Back**




2 months

RC128-8

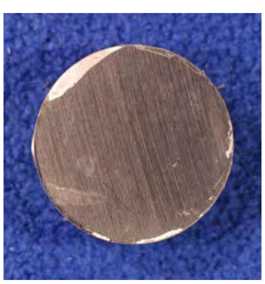

Front **Back** **Front** **Back**




3 months

RC128-7


Front **Back** **Front** **Back**




4 months

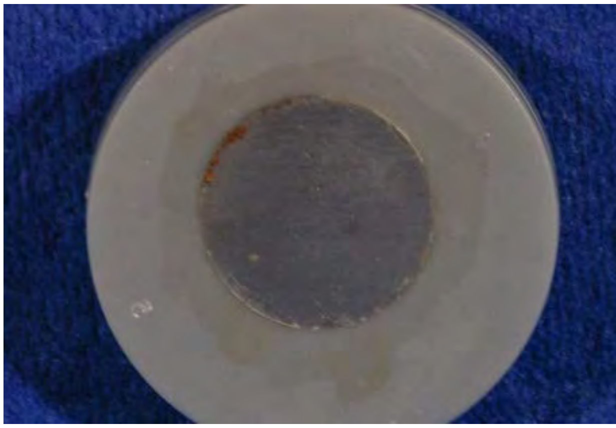
RC128-6


Front **Back** **Front** **Back**

Vessel 1: Level 1

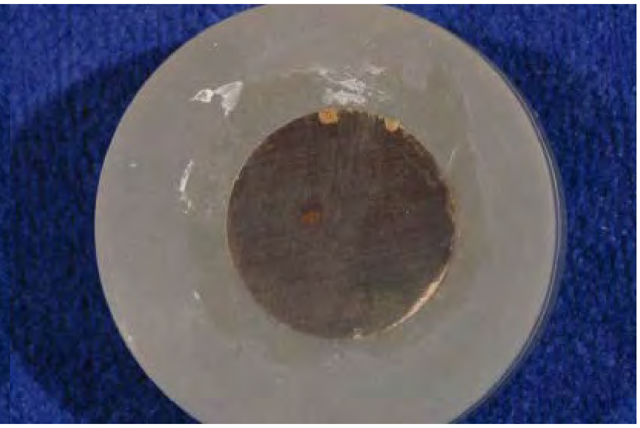
1 month

RC128-9



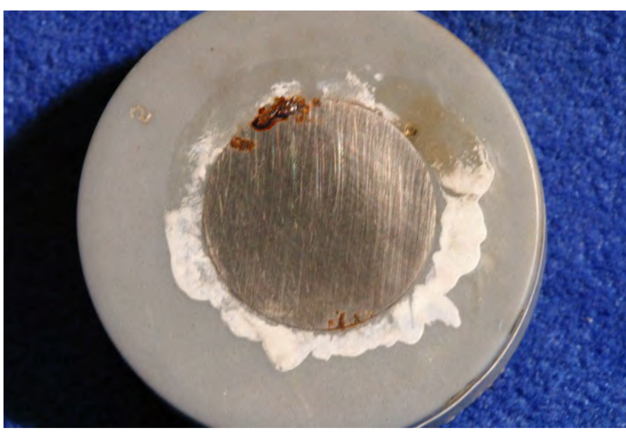
2 months

RC128-12



3 months

RC128-11

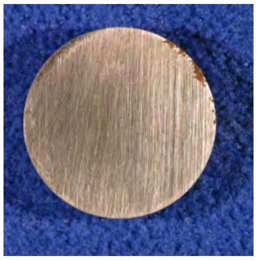


4 months

RC128-10

Vessel 1: Level 1

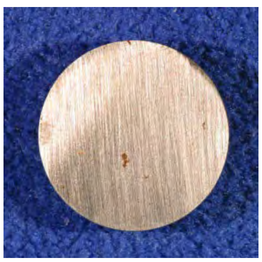
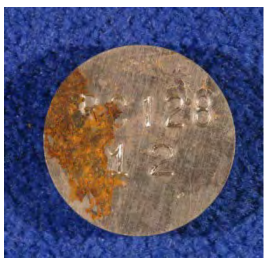
Before cleaning | **After cleaning**




1 month

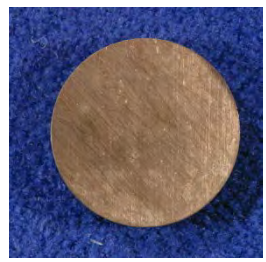
RC128-9


Front **Back** **Front** **Back**

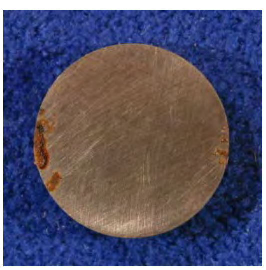



2 months

RC128-12



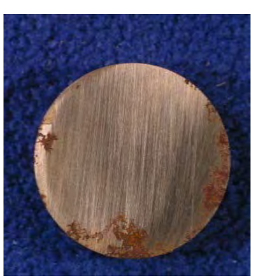

Front **Back** **Front** **Back**




3 months

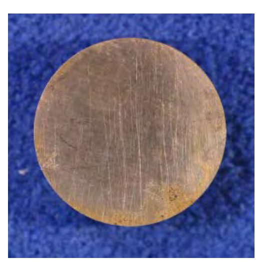
RC128-11


Front **Back** **Front** **Back**




4 months

RC128-10

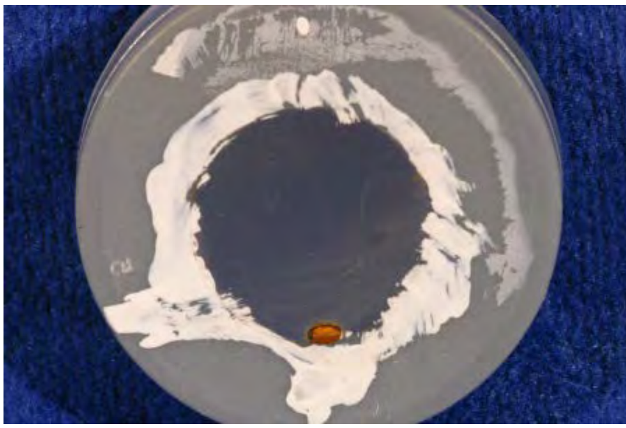



Front **Back** **Front** **Back**

Vessel 2: Level 3

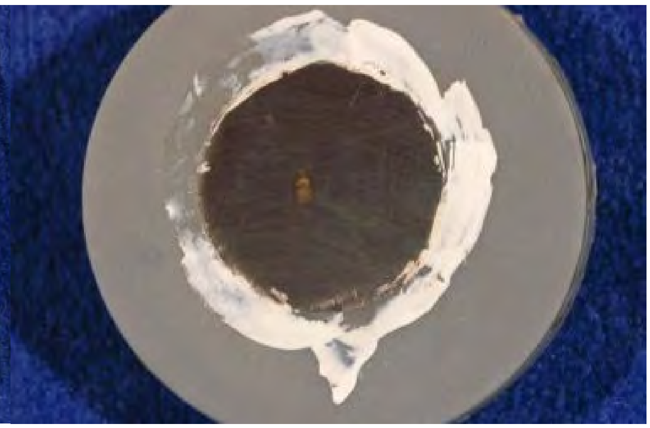
1 month

RC128-13



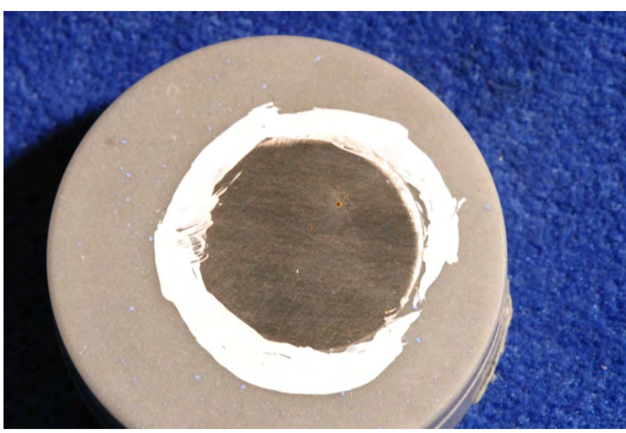
2 months

RC128-16



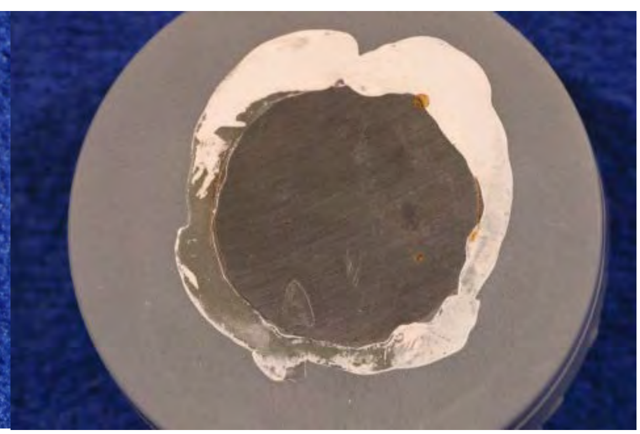
3 months

RC128-14



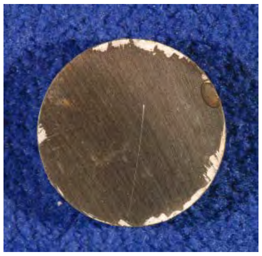
4 months

RC128-15



Vessel 2: Level 3

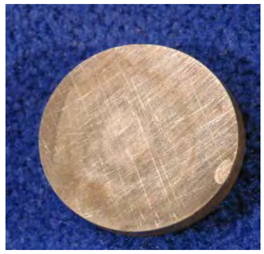
Before cleaning | **After cleaning**



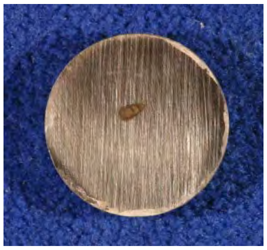

Front **Back**

1 month

RC128-13




Front **Back**




Front **Back**

2 months

RC128-16

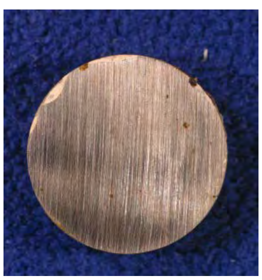

Front **Back**


Front **Back**

3 months

RC128-14


Front **Back**




Front **Back**

4 months

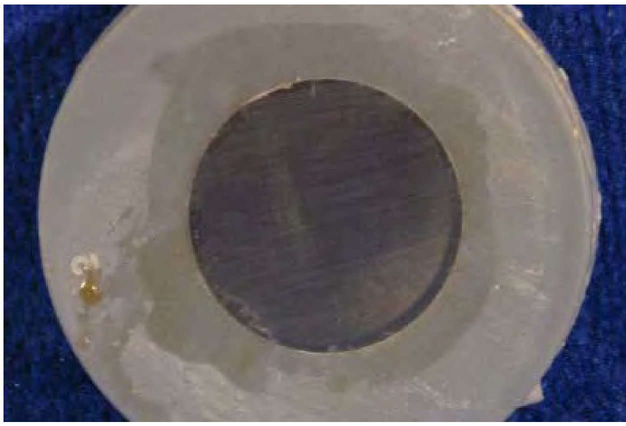
RC128-15


Front **Back**

Vessel 2: Level 2

1 month

RC128-17

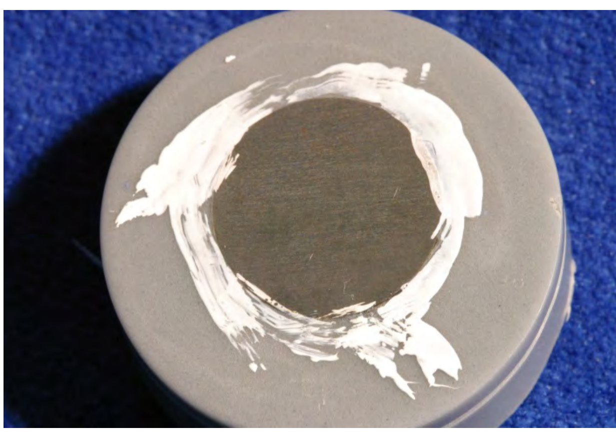


2 months

RC128-20

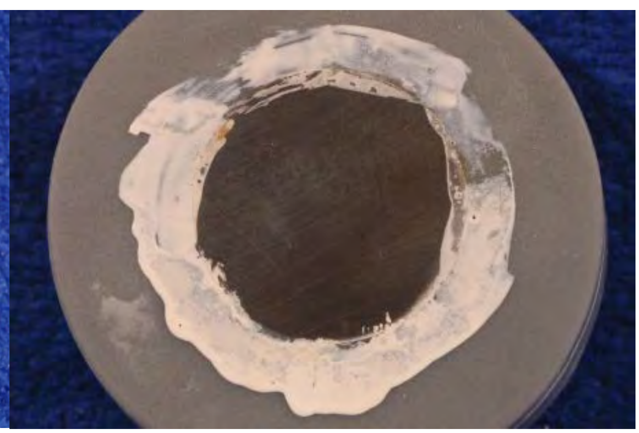
3 months

RC128-18



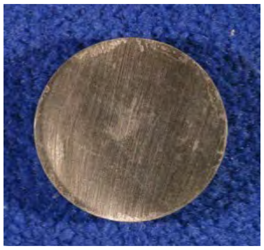
4 months

RC128-19



Vessel 2: Level 2

Before cleaning | **After cleaning**


Front

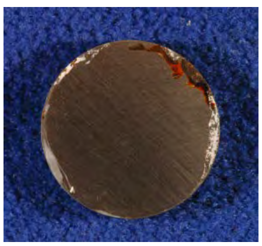

Back

1 month

RC128-17


Front

Back


Front

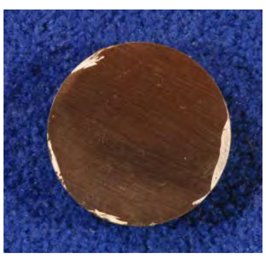

Back

2 months

RC128-20


Front

Back


Front

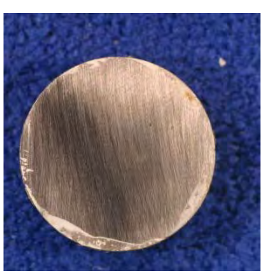

Back

3 months

RC128-18


Front

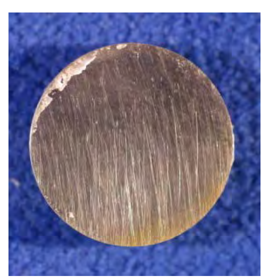
Back


Front


Back

4 months

RC128-19

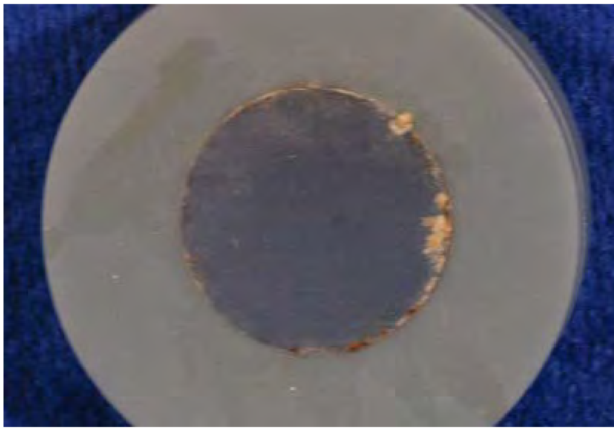

Front

Back

Vessel 2: Level 1

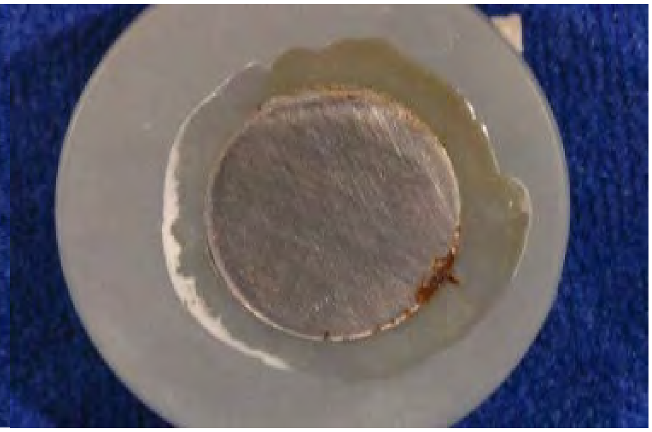
1 month

RC128-21



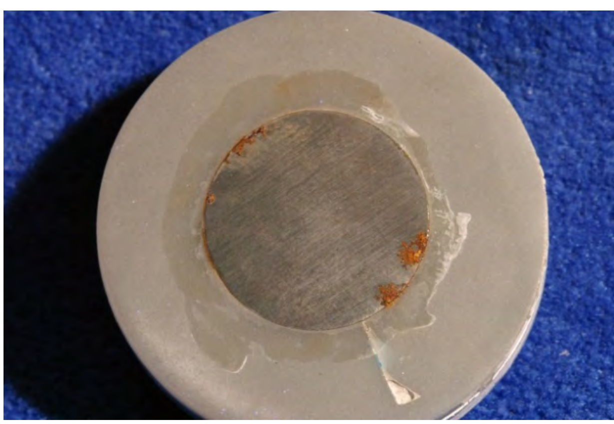
2 months

RC128-22



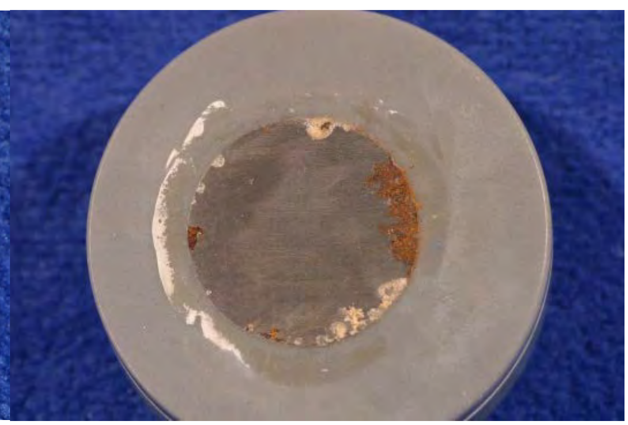
3 months

RC128-24



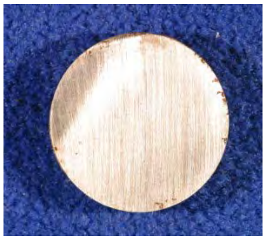
4 months

RC128-23



Vessel 2: Level 1

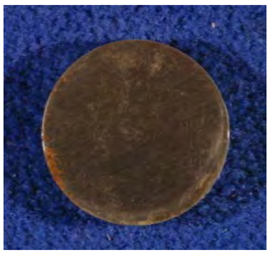
Before cleaning | **After cleaning**



1 month

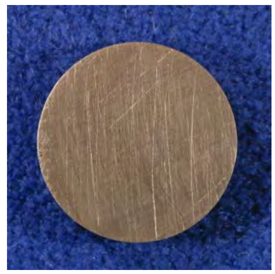
RC128-21


Front **Back** **Front** **Back**

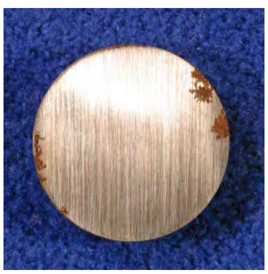



2 months

RC128-22




Front **Back** **Front** **Back**



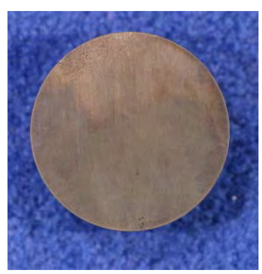

3 months

RC128-24


Front **Back** **Front** **Back**


4 months

RC128-23




Front **Back** **Front** **Back**

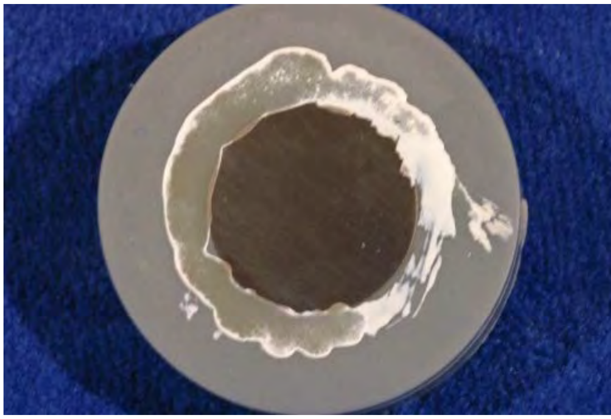
Vessel 3: Level 3

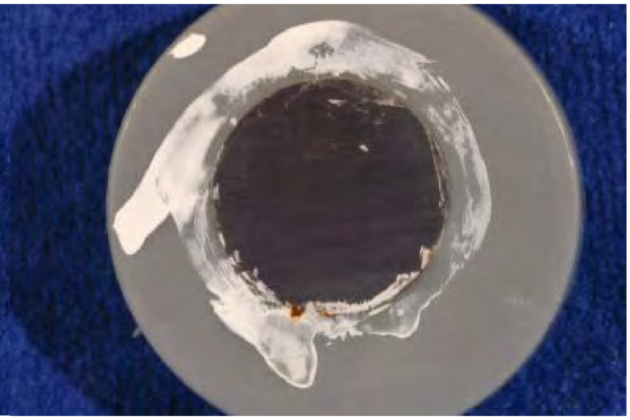
1 month

RC128-25

2 months

RC128-27



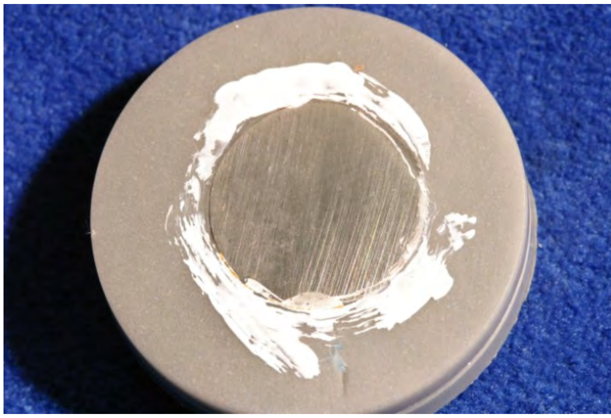


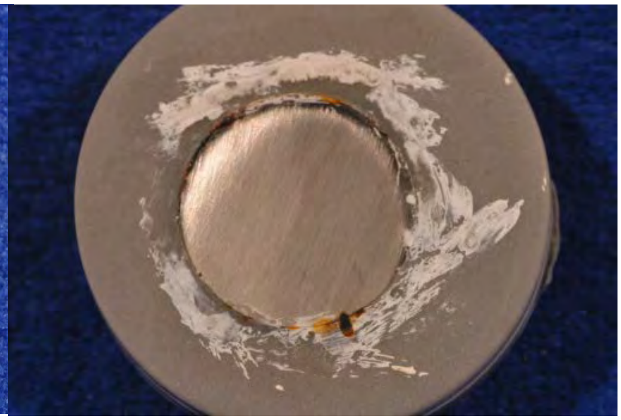
3 months

RC128-28

4 months

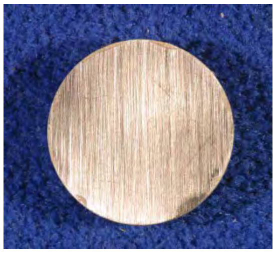
RC128-26





Vessel 3: Level 3

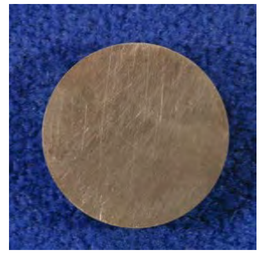
Before cleaning | **After cleaning**

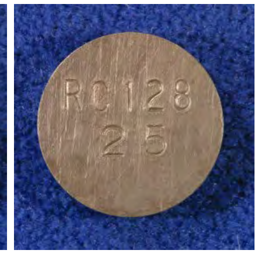

Front

Back

1 month

RC128-25


Front



Back


Front

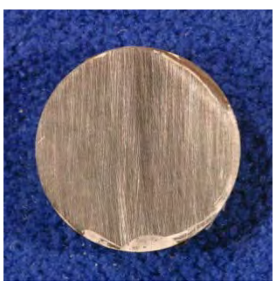

Back

2 months

RC128-27


Front

Back


Front

Back

3 months

RC128-28


Front

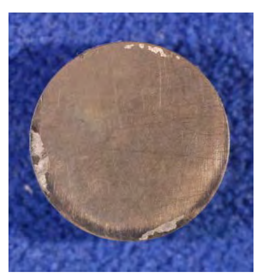
Back


Front


Back

4 months

RC128-26


Front


Back

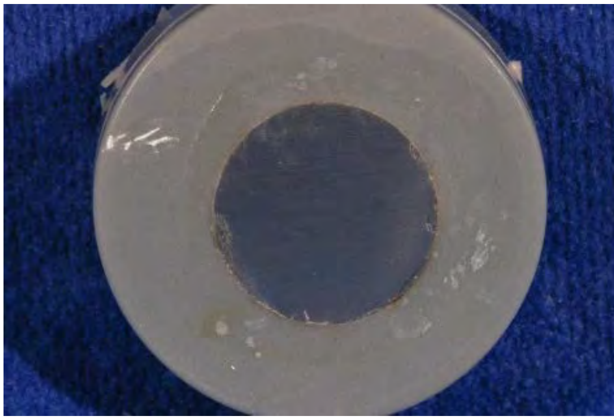
Vessel 3: Level 2

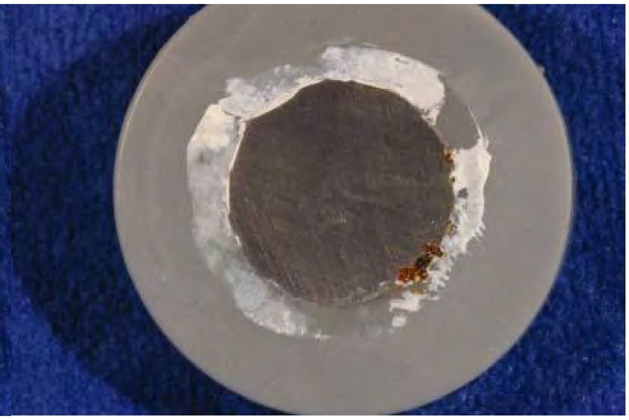
1 month

RC128-29

2 months

RC128-32



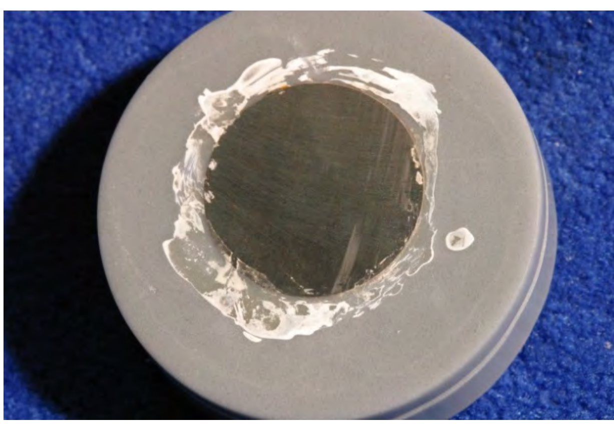


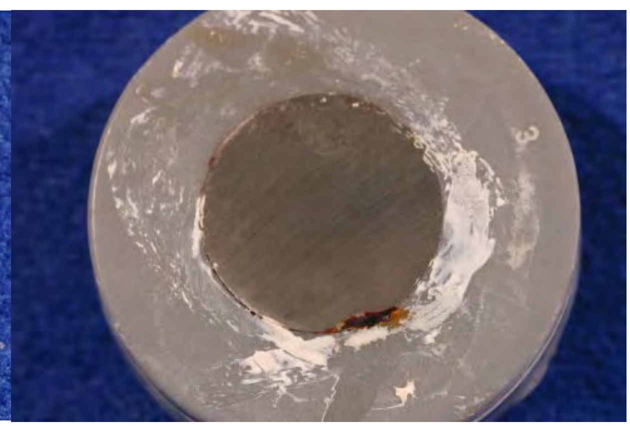
3 months

RC128-30

4 months

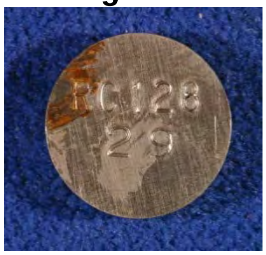
RC128-31





Vessel 3: Level 2

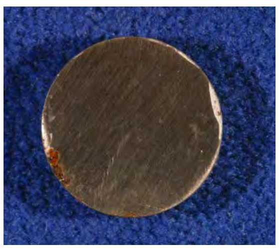
Before cleaning | **After cleaning**

1 month

RC128-29

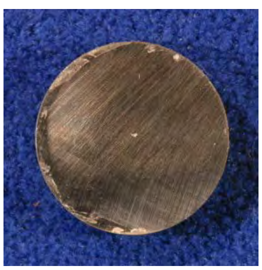

Front **Back** **Front** **Back**




2 months

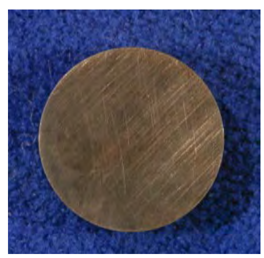
RC128-32


Front **Back** **Front** **Back**

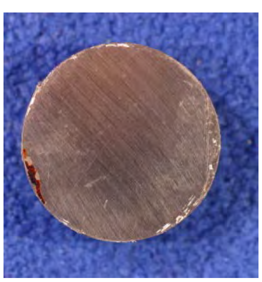



3 months

RC128-30

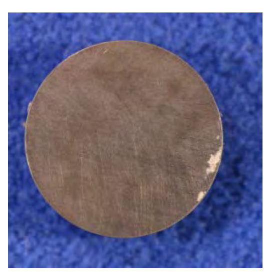



Front **Back** **Front** **Back**




4 months

RC128-31




Front **Back** **Front** **Back**

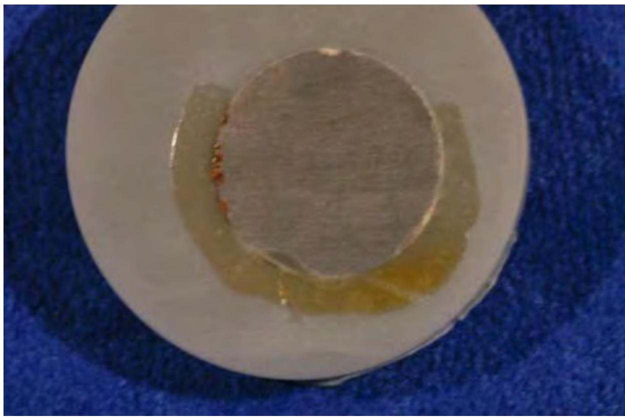
Vessel 3: Level 1

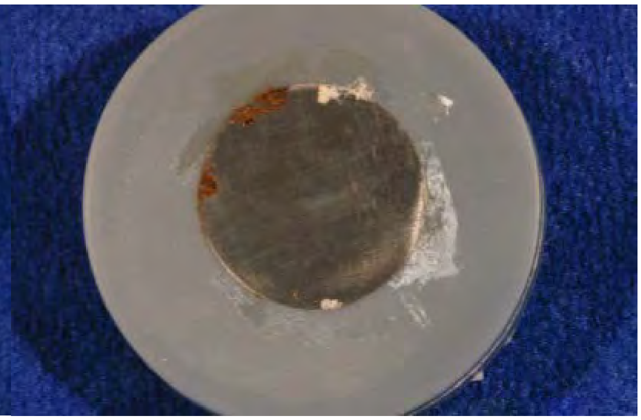
1 month

RC128-33

2 months

RC128-34



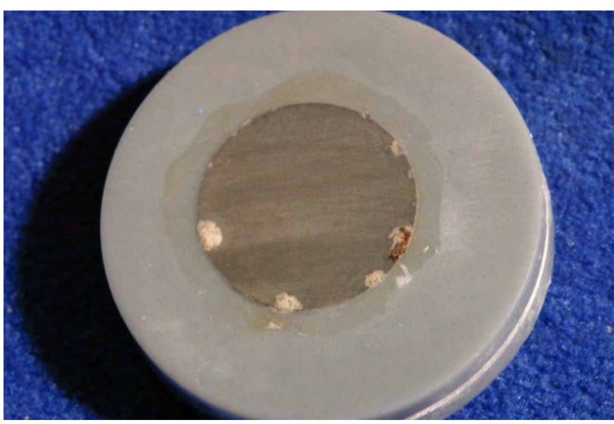


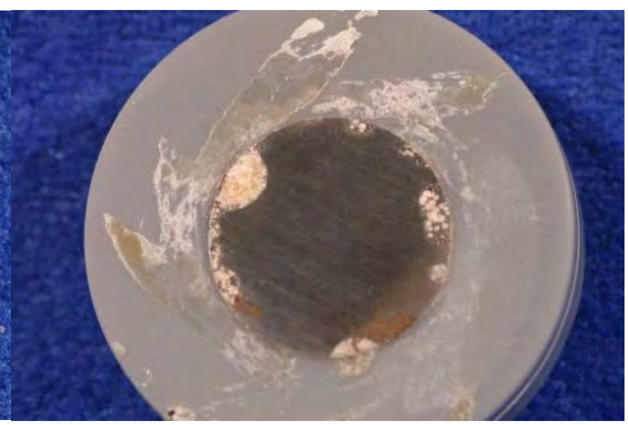
3 months

RC128-35

4 months

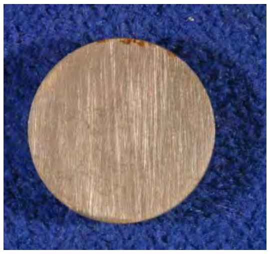
RC128-36





Vessel 3: Level 1

Before cleaning | **After cleaning**




1 month

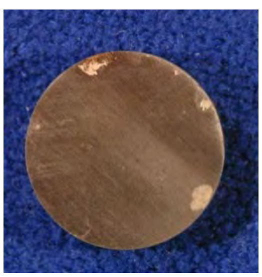
RC128-33


Front **Back** **Front** **Back**


2 months

RC128-34

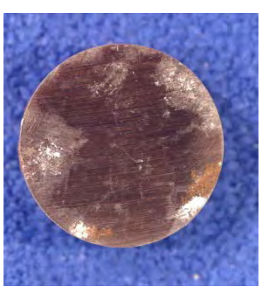

Front **Back** **Front** **Back**




3 months

RC128-35


Front **Back** **Front** **Back**




4 months

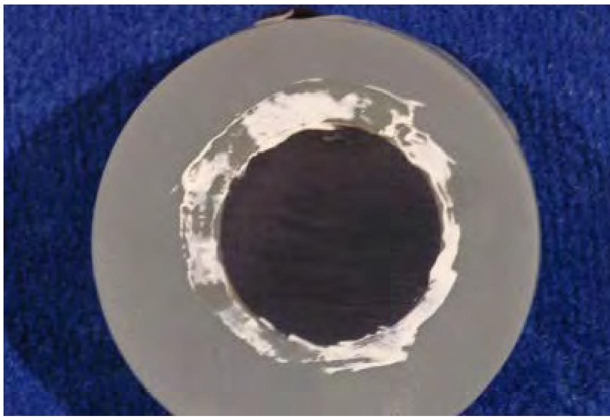
RC128-36


Front **Back** **Front** **Back**

Vessel 4: Level 3

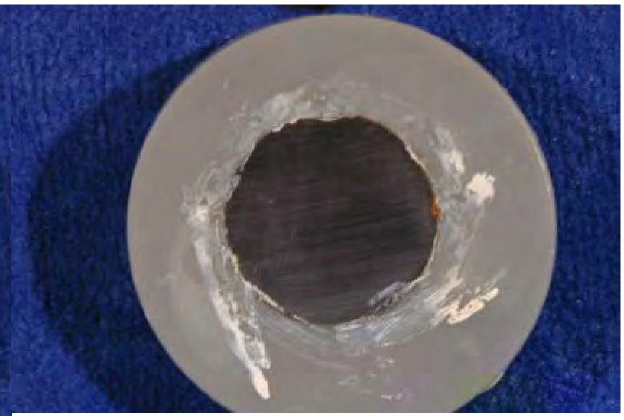
1 month

RC128-38



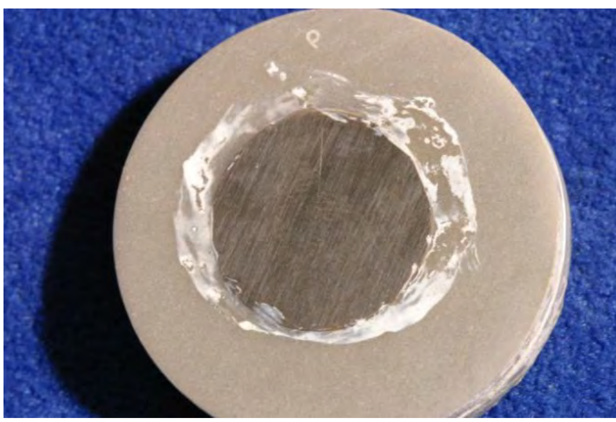
2 months

RC128-39



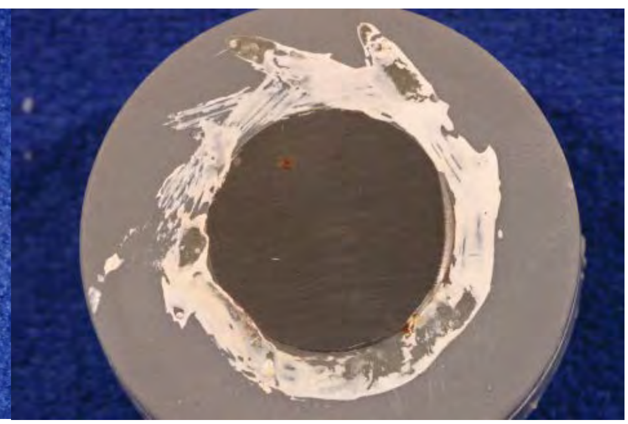
3 months

RC128-37



4 months

RC128-40

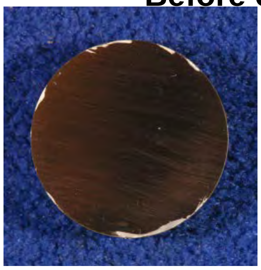


Vessel 4: Level 3

Before cleaning | **After cleaning**

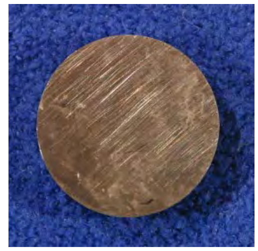
1 month

RC128-38



Front

Back

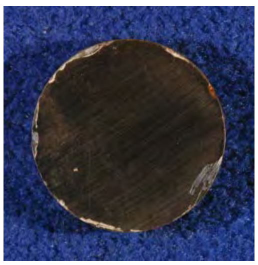


Front

Back

2 months

RC128-39



Front

Back

Front

Back

3 months

RC128-37

Front

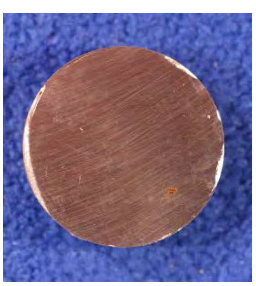
Back

Front

Back

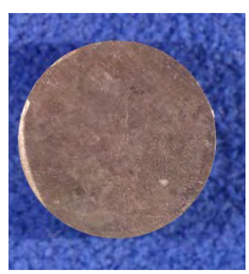
4 months

RC128-40



Front

Back



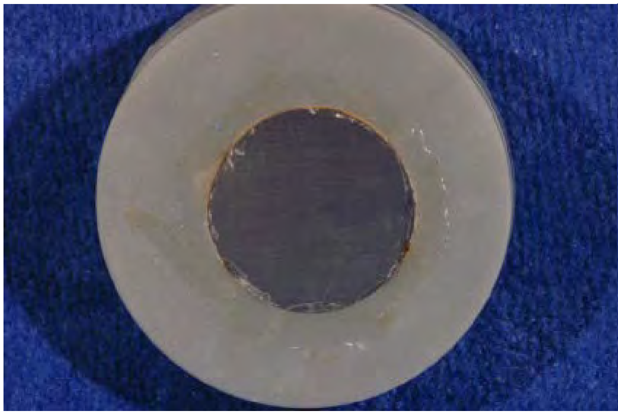
Front

Back

Vessel 4: Level 2

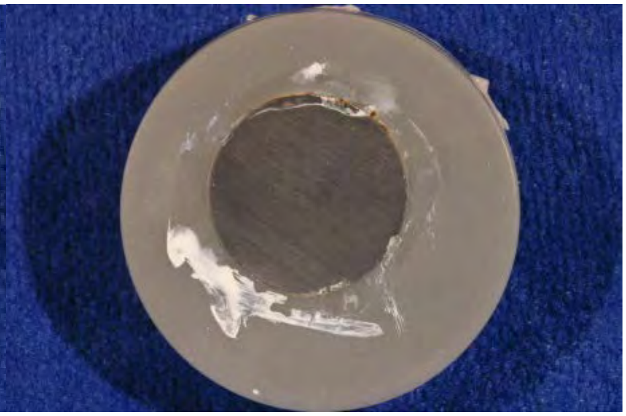
1 month

RC128-44



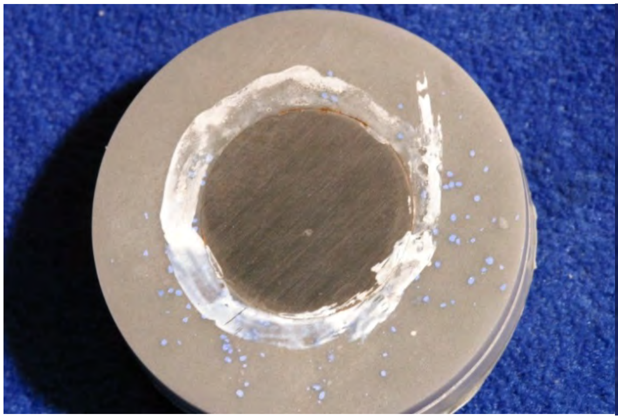
2 months

RC128-42



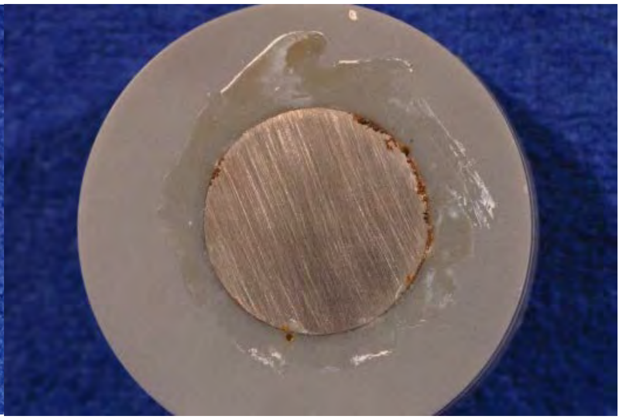
3 months

RC128-41

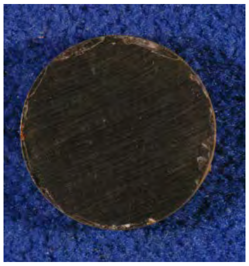
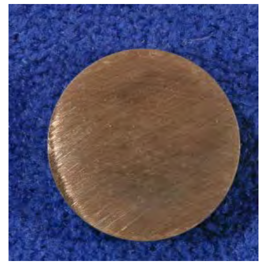
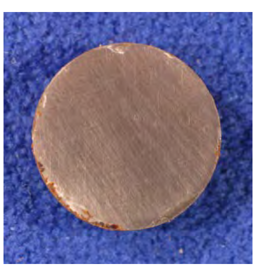
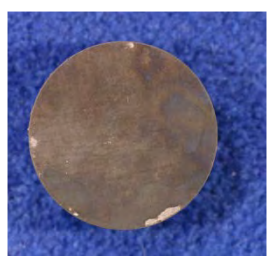


4 months

RC128-43



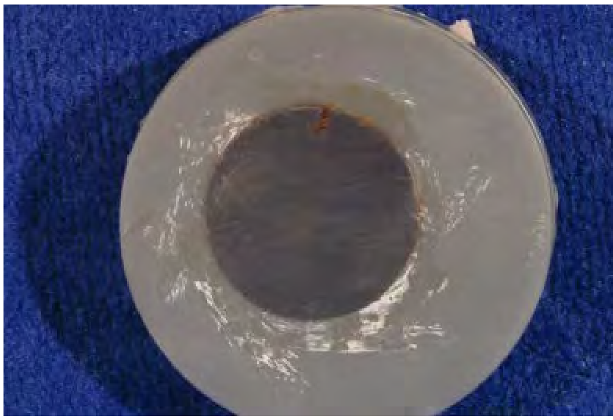
Vessel 4: Level 2

Before cleaning			After cleaning	
		1 month RC128-44		
Front	Back		Front	Back
		2 months RC128-42		
Front	Back		Front	Back
		3 months RC128-41		
Front	Back		Front	Back
		4 months RC128-43		
Front	Back		Front	Back

Vessel 4: Level 1

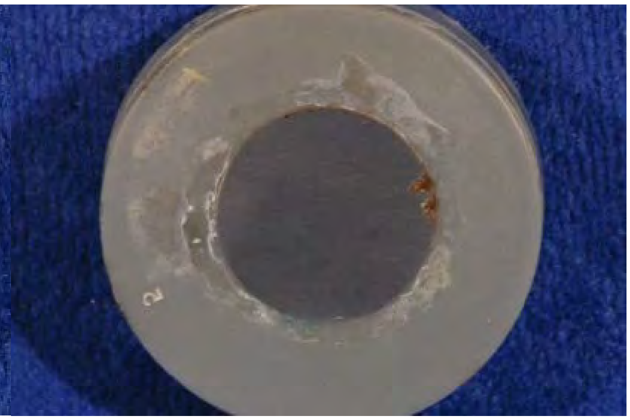
1 month

RC128-47



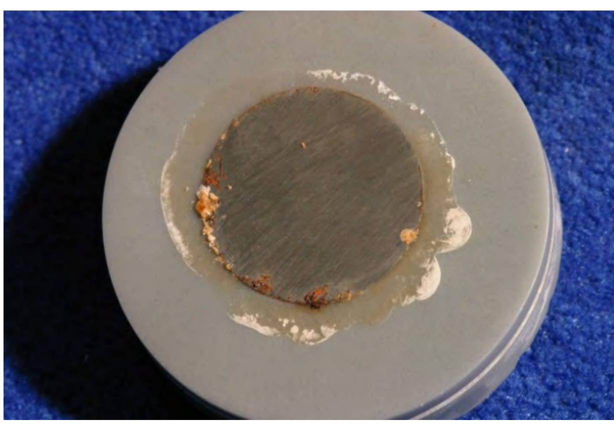
2 months

RC128-46



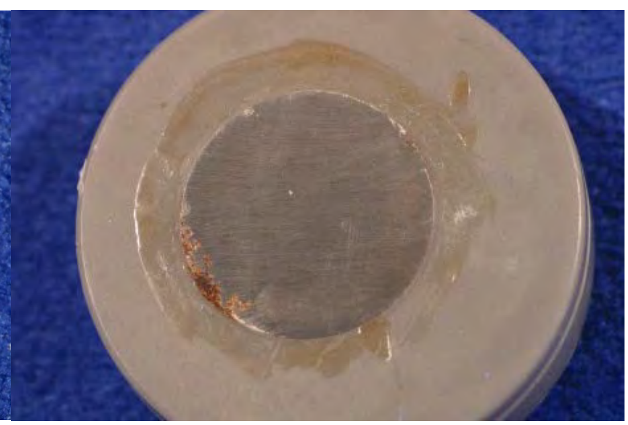
3 months

RC128-48



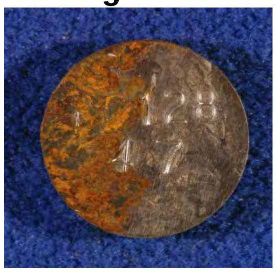
4 months

RC128-45



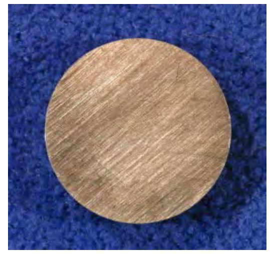
Vessel 4: Level 1

Before cleaning | **After cleaning**

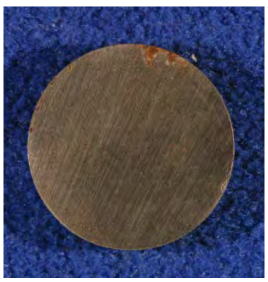



1 month

RC128-47

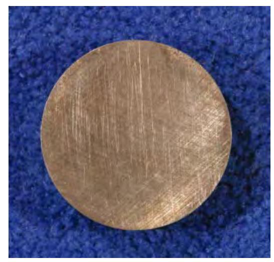



Front **Back** **Front** **Back**

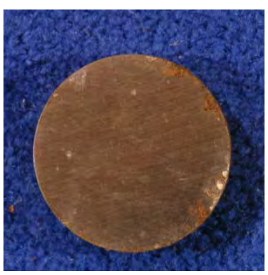



2 months

RC128-46



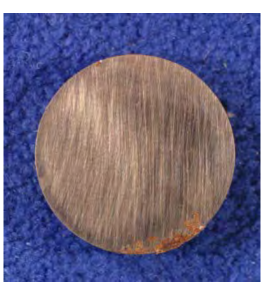

Front **Back** **Front** **Back**




3 months

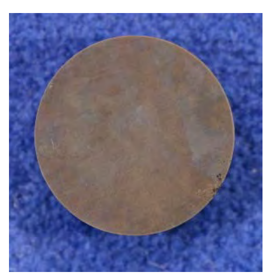
RC128-48


Front **Back** **Front** **Back**




4 months

RC128-45

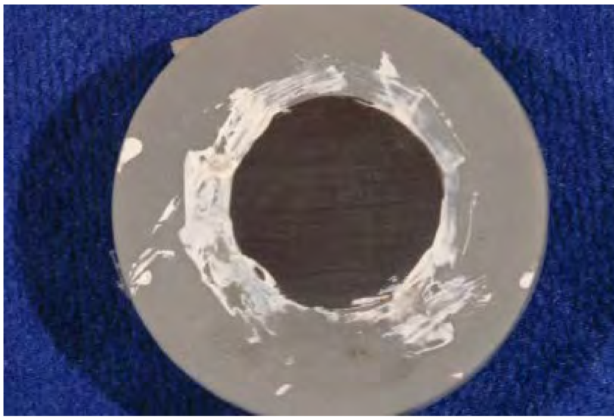



Front **Back** **Front** **Back**

Vessel 5: Level 3

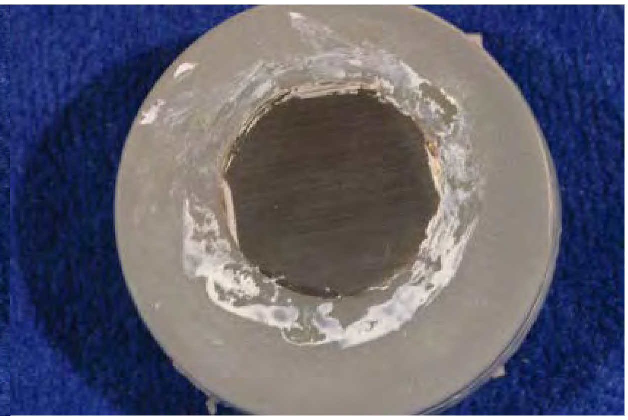
1 month

RC128-51



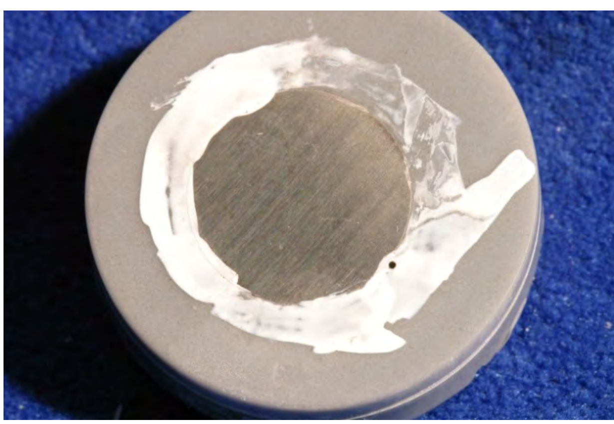
2 months

RC128-50



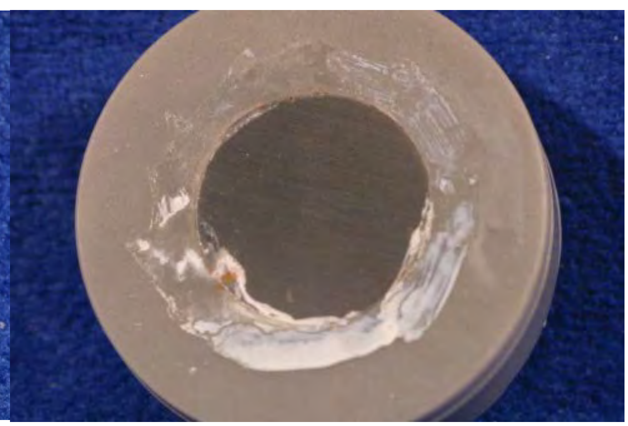
3 months

RC128-52



4 months

RC128-49



Vessel 5: Level 3

Before cleaning | **After cleaning**


Front

Back

1 month

RC128-51


Front

Back


Front


Back

2 months

RC128-50


Front

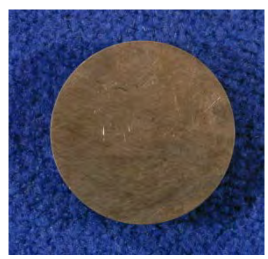
Back


Front


Back

3 months

RC128-52


Front

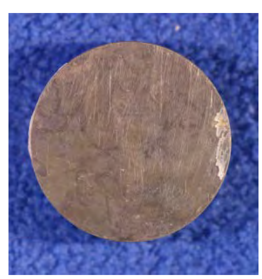
Back


Front


Back

4 months

RC128-49


Front

Back

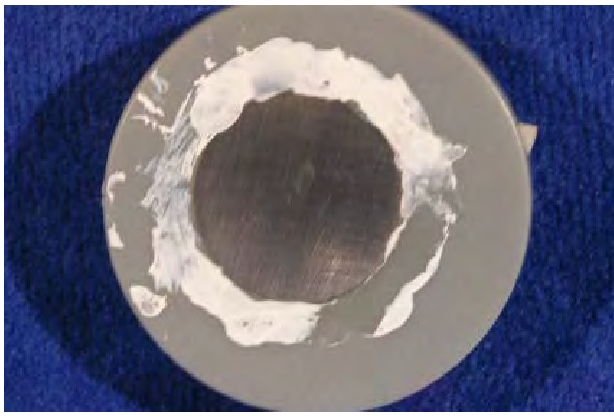
Vessel 5: Level 2

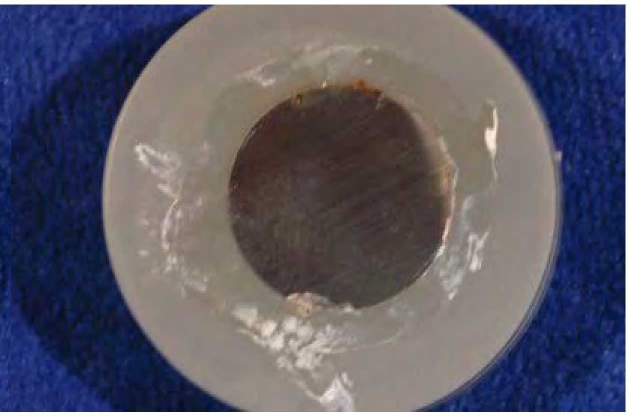
1 month

RC128-55

2 months

RC128-56



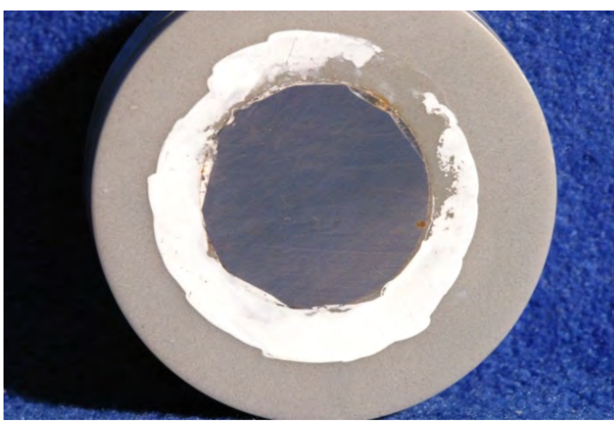


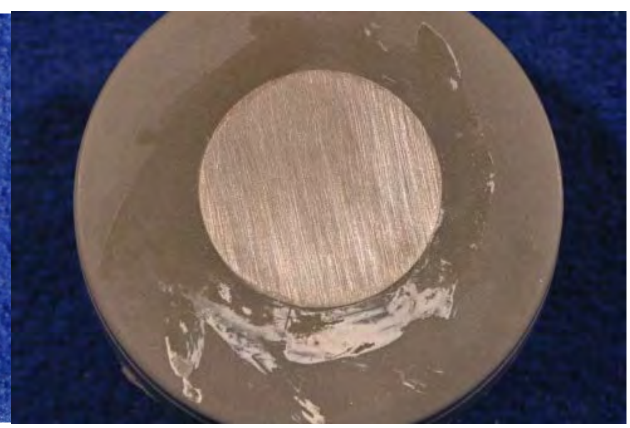
3 months

RC128-54

4 months

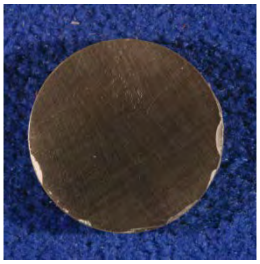
RC128-53





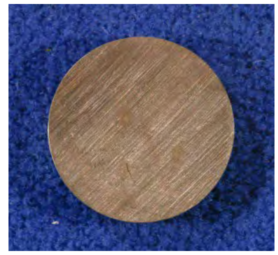
Vessel 5: Level 2

Before cleaning | **After cleaning**

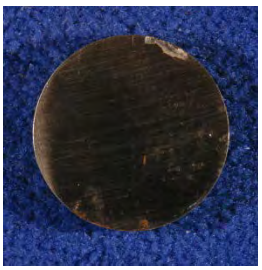



1 month

RC128-55




Front **Back** **Front** **Back**



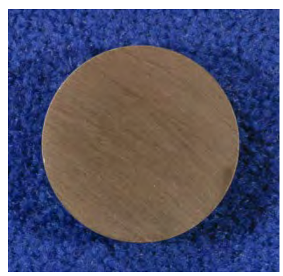

2 months

RC128-56

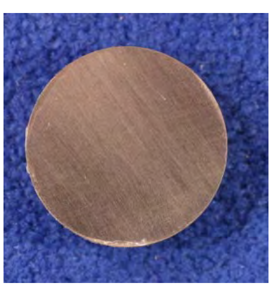

Front **Back** **Front** **Back**


3 months

RC128-54




Front **Back** **Front** **Back**




4 months

RC128-53


Front **Back** **Front** **Back**

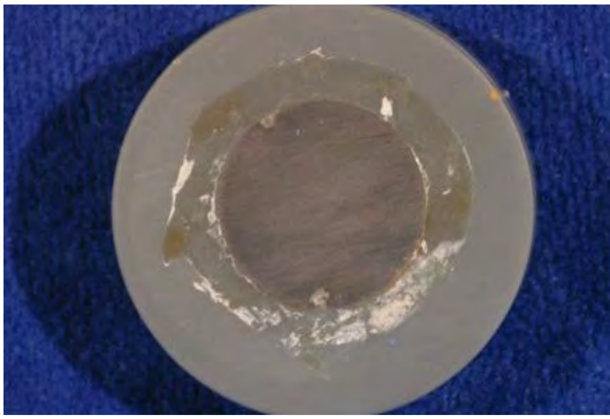
Vessel 5: Level 1

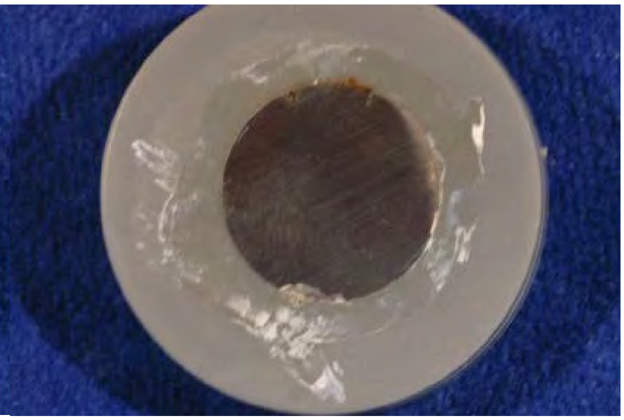
1 month

RC128-57

2 months

RC128-59



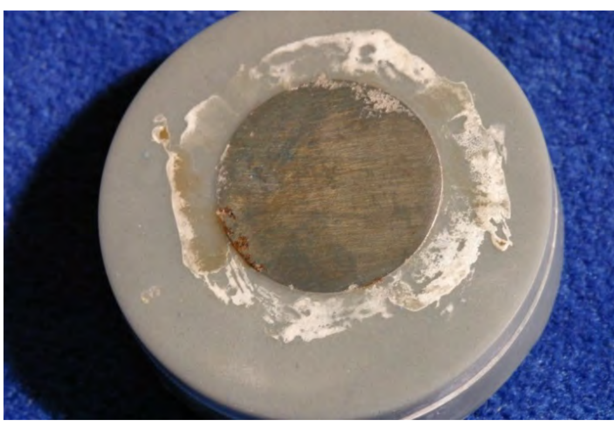


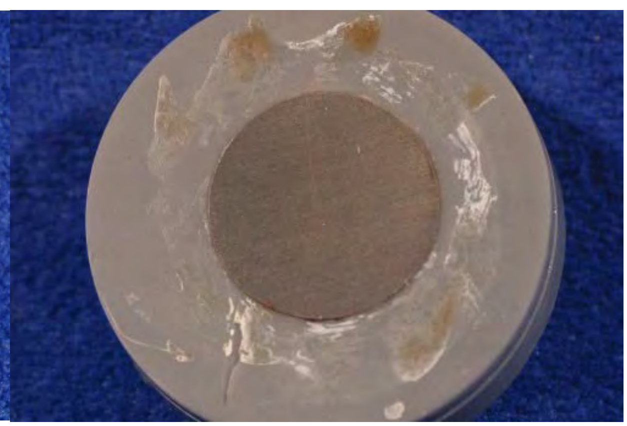
3 months

RC128-60

4 months

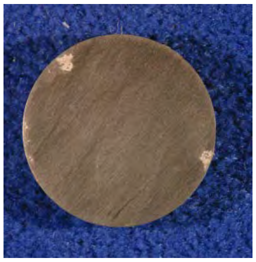
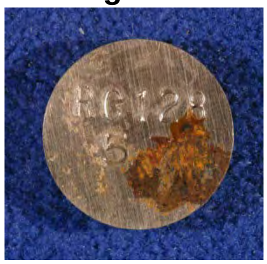
RC128-58





Vessel 5: Level 1

Before cleaning | **After cleaning**

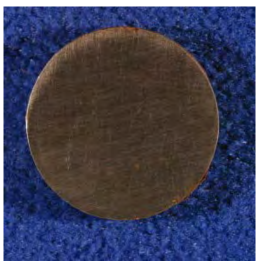



Front Back

1 month

RC128-57

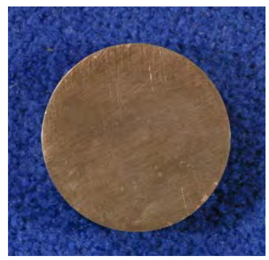

Front Back



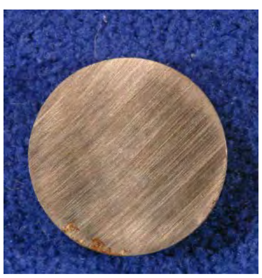

Front Back

2 months

RC128-59




Front Back

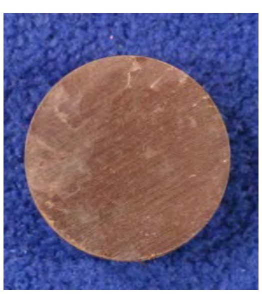



Front Back

3 months

RC128-60

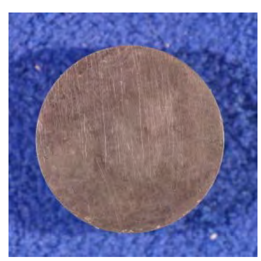

Front Back




Front Back

4 months

RC128-58

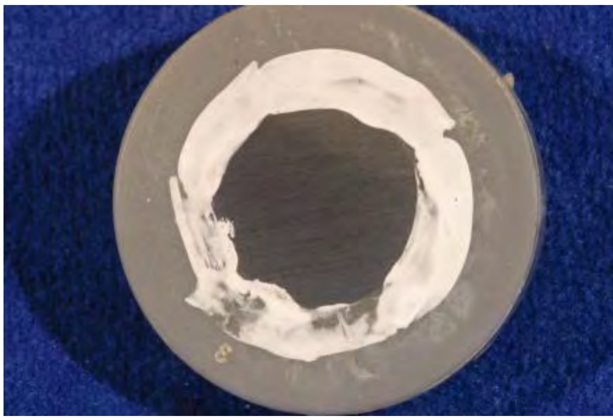



Front Back

Vessel 6: Level 3

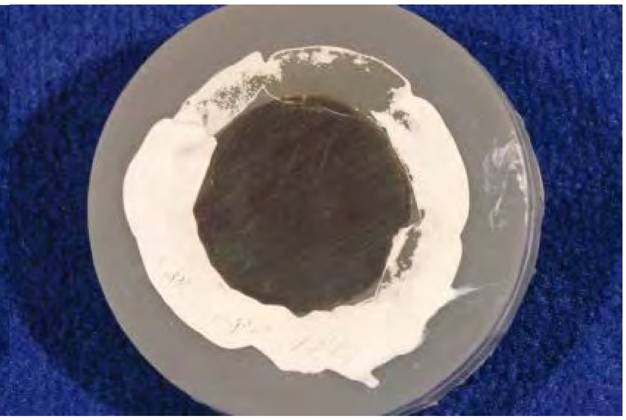
1 month

RC128-64



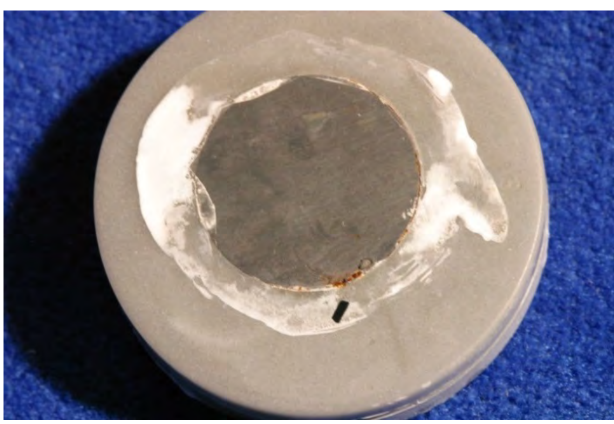
2 months

RC128-61



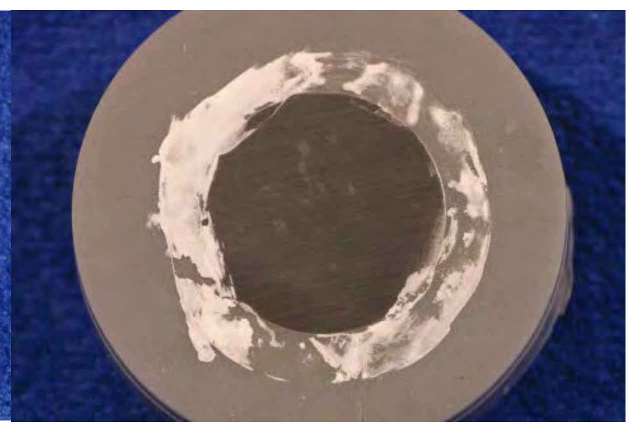
3 months

RC128-63



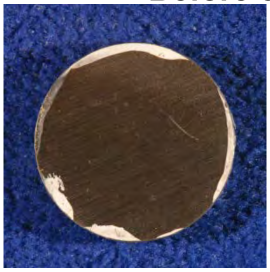
4 months

RC128-62



Vessel 6: Level 3

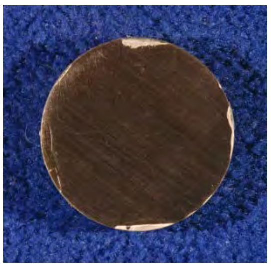
Before cleaning | **After cleaning**




1 month

RC128-64


Front **Back** **Front** **Back**



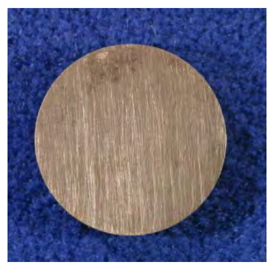

2 months

RC128-61

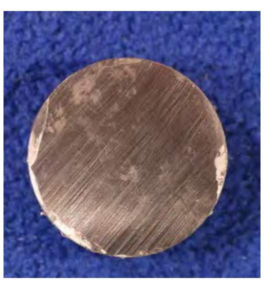

Front **Back** **Front** **Back**


3 months

RC128-63

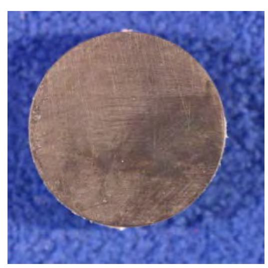



Front **Back** **Front** **Back**




4 months

RC128-62

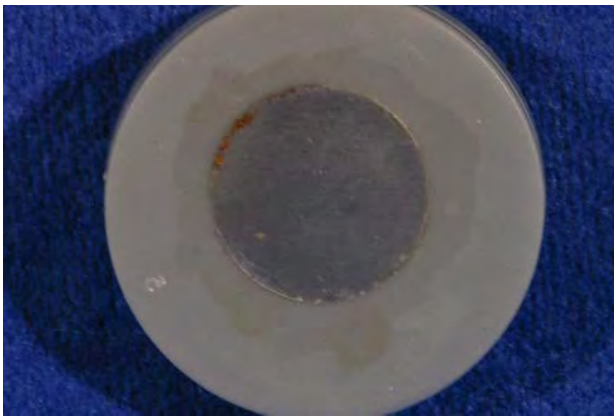



Front **Back** **Front** **Back**

Vessel 6: Level 2

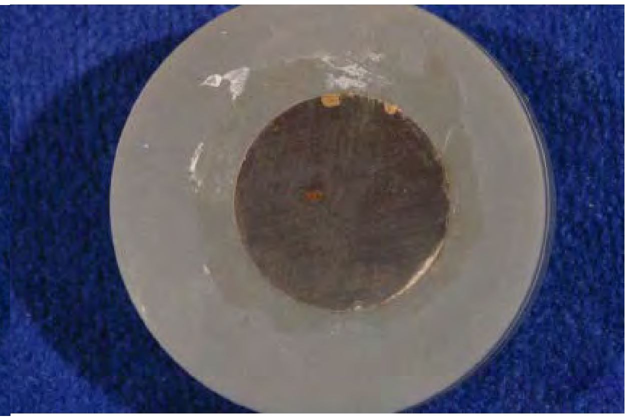
1 month

RC128-66



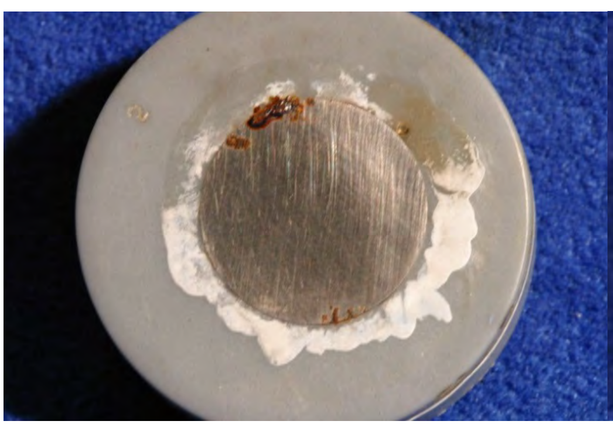
2 months

RC128-68



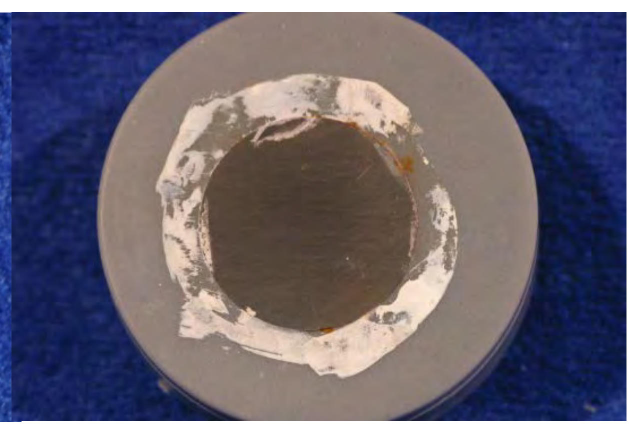
3 months

RC128-67



4 months

RC128-65



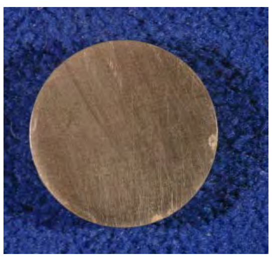
Vessel 6: Level 2

Before cleaning | **After cleaning**


1 month

RC128-66

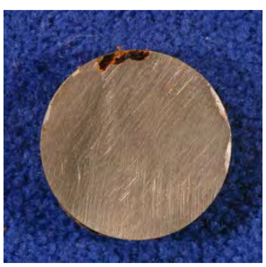

Front **Back** **Front** **Back**




2 months

RC128-68


Front **Back** **Front** **Back**




3 months

RC128-67


Front **Back** **Front** **Back**


4 months

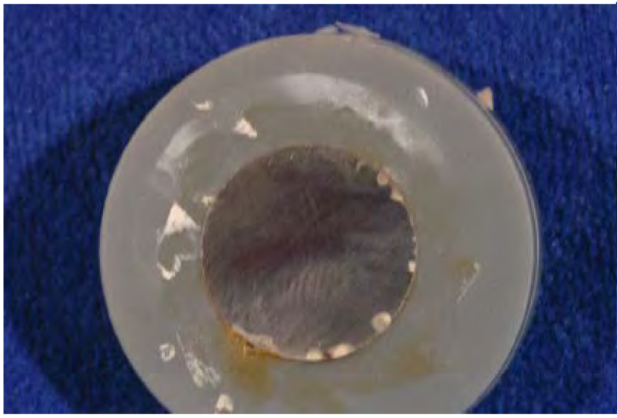
RC128-65


Front **Back** **Front** **Back**

Vessel 6: Level 1

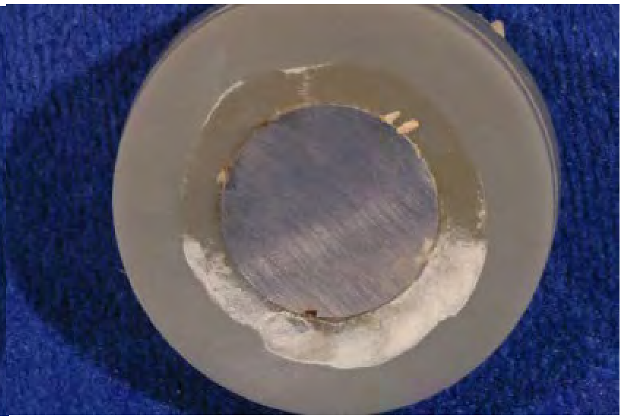
1 month

RC128-70



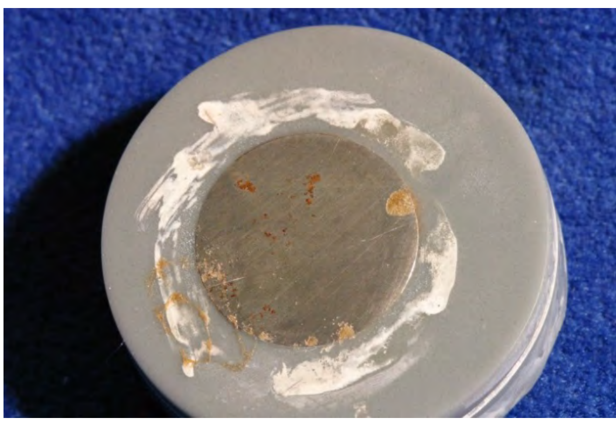
2 months

RC128-71



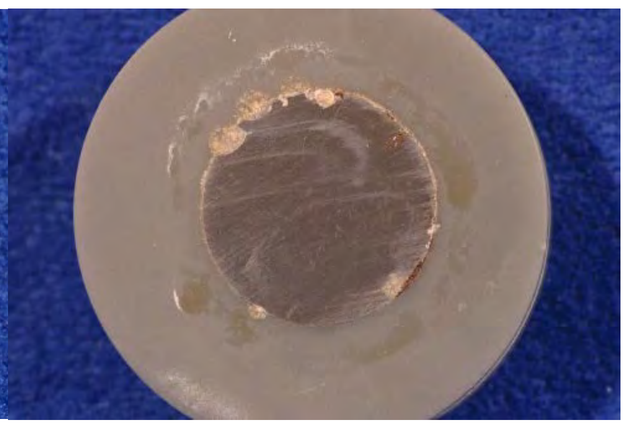
3 months

RC128-69



4 months

RC128-72



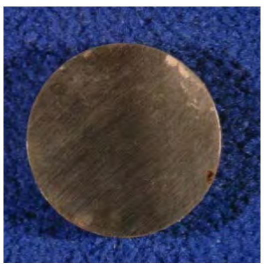
Vessel 6: Level 1

Before cleaning | **After cleaning**


1 month

RC128-70

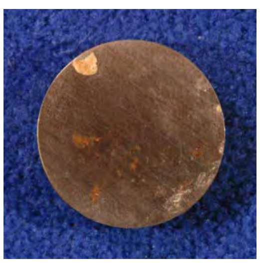

Front **Back** | **Front** **Back**




2 months

RC128-71

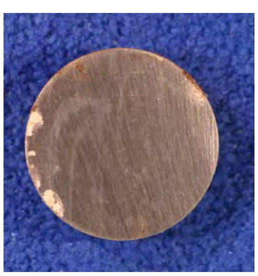

Front **Back** | **Front** **Back**




3 months

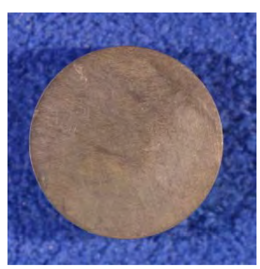
RC128-69


Front **Back** | **Front** **Back**




4 months

RC128-72




Front **Back** | **Front** **Back**

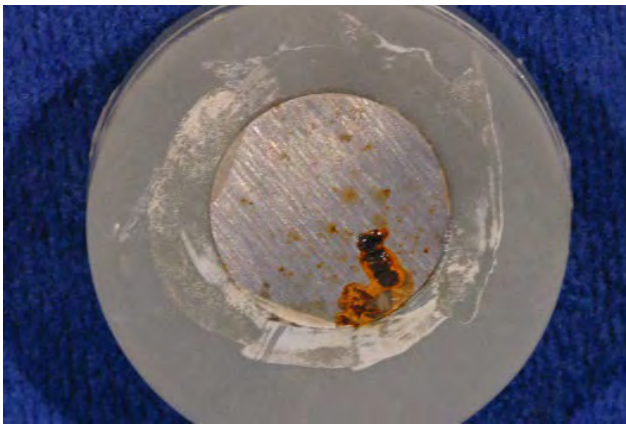
Vessel 7: Level 3

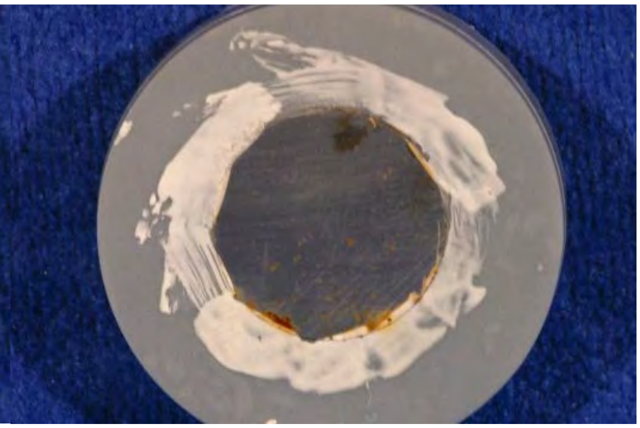
1 month

RC128-76

2 months

RC128-75



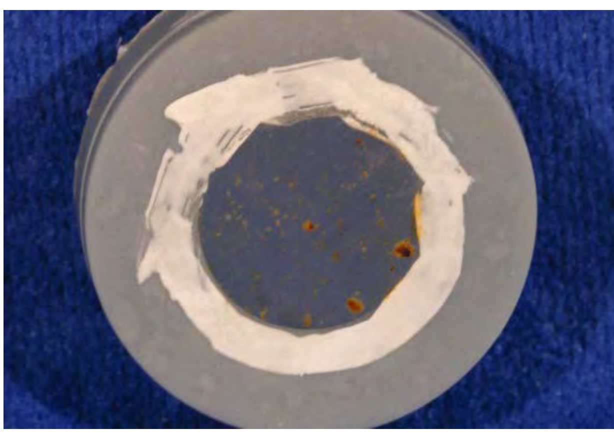


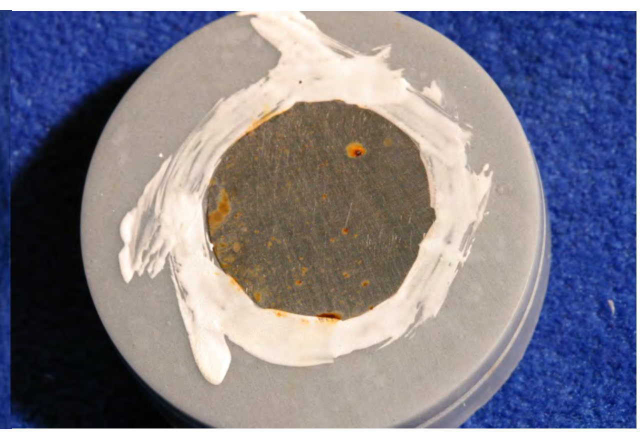
3 months

RC128-74

4 months

RC128-73



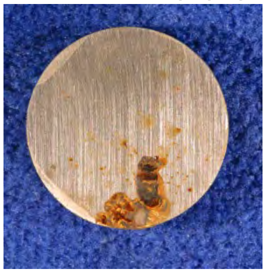


Vessel 7: Level 3

Before cleaning | **After cleaning**

1 month

RC128-76



Front

Back

Front

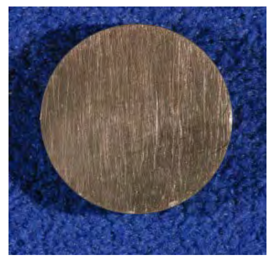
Back

2 months

RC128-75

Front

Back

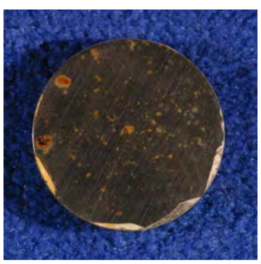


Front

Back

3 months

RC128-74



Front

Back

Front

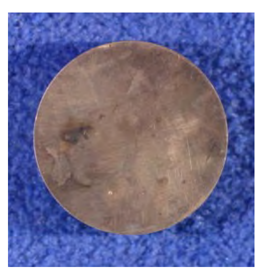
Back

4 months

RC128-73

Front

Back



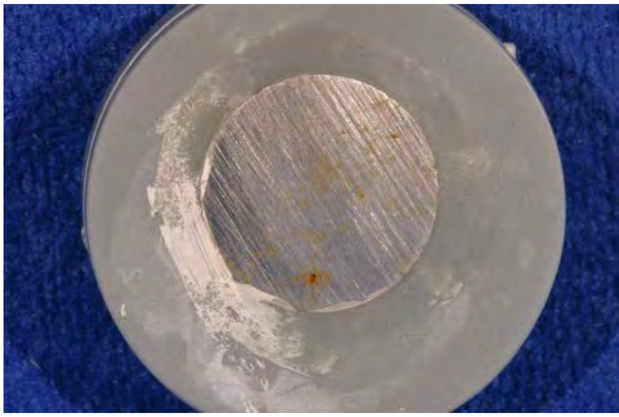
Front

Back

Vessel 7: Level 2

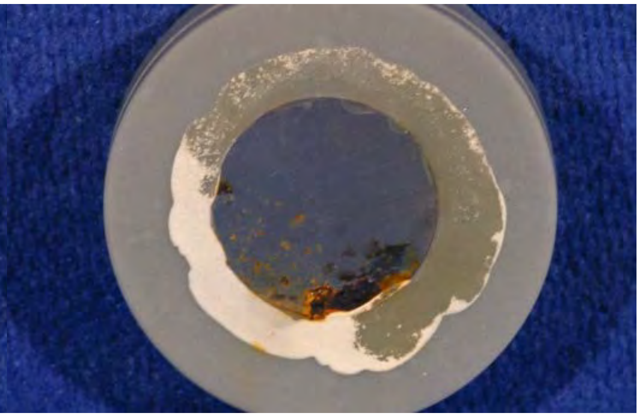
1 month

RC128-78



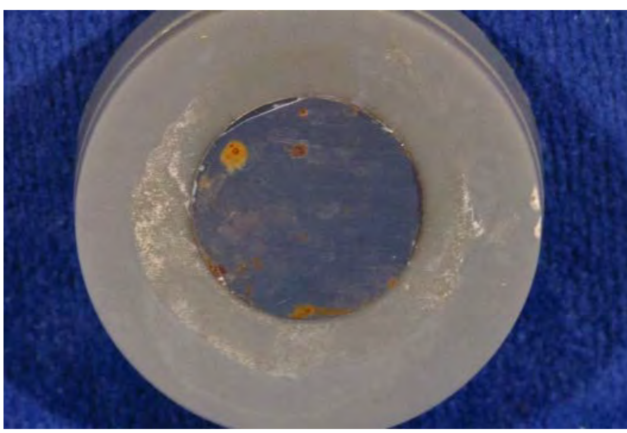
2 months

RC128-79



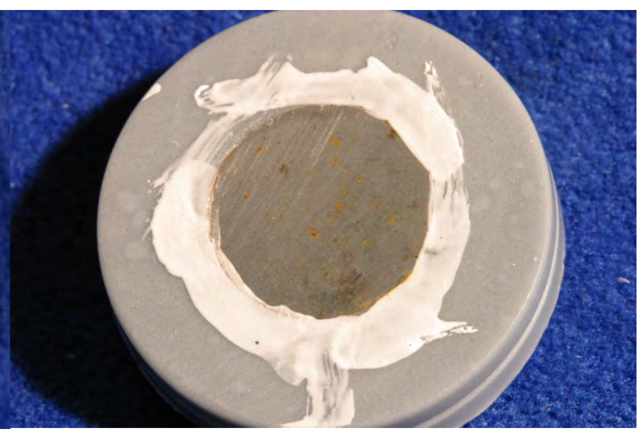
3 months

RC128-80



4 months

RC128-77

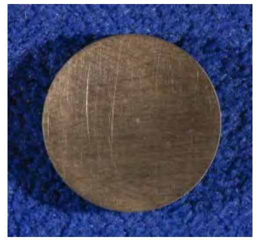


Vessel 7: Level 2

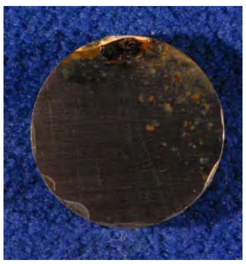
Before cleaning | **After cleaning**

1 month

RC128-78



Front **Back** **Front** **Back**



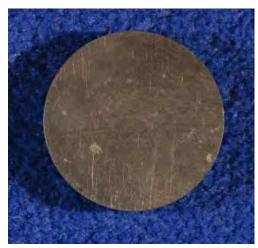
2 months

RC128-79

Front **Back** **Front** **Back**

3 months

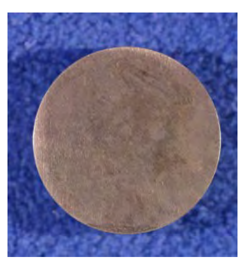
RC128-80



Front **Back** **Front** **Back**

4 months

RC128-77

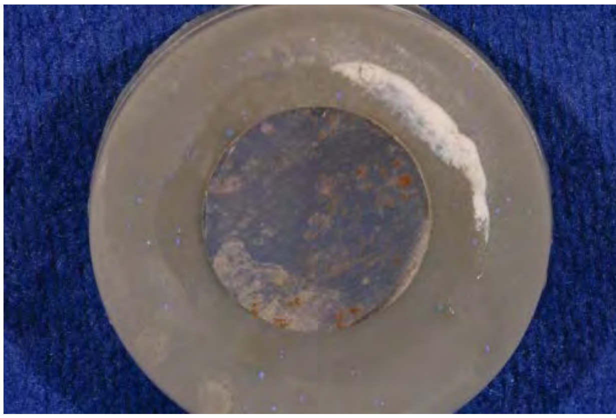


Front **Back** **Front** **Back**

Vessel 7: Level 1

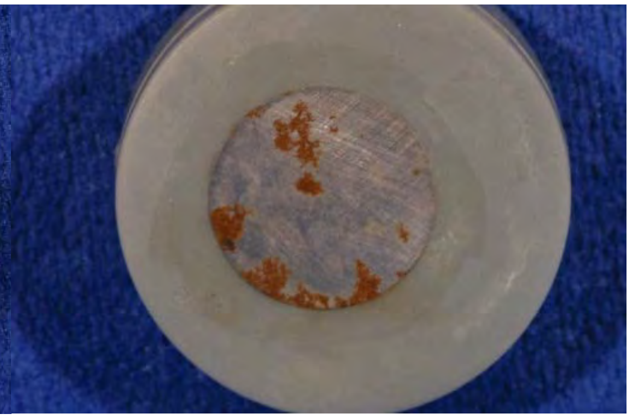
1 month

RC128-84



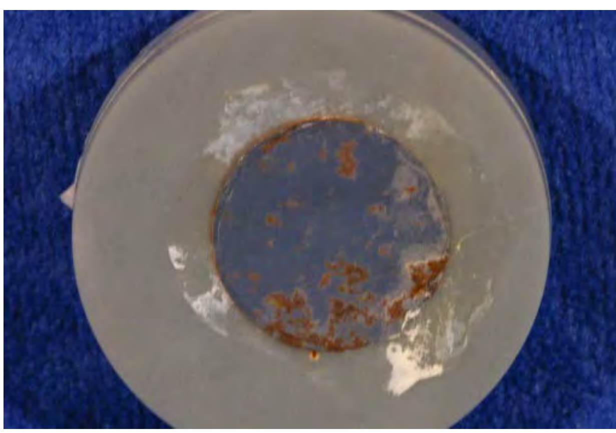
2 months

RC128-83



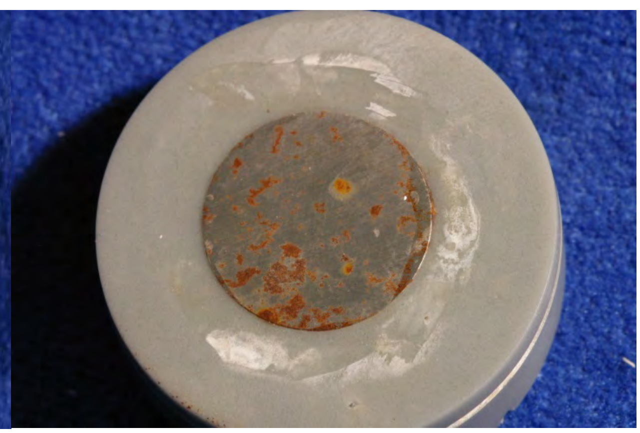
3 months

RC128-81



4 months

RC128-82



Vessel 7: Level 1

Before cleaning | **After cleaning**


1 month

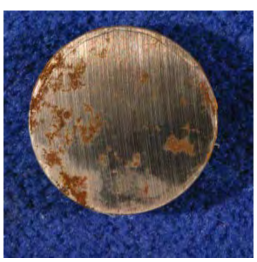
RC128-84


Front **Back** **Front** **Back**


2 months

RC128-83


Front **Back** **Front** **Back**




3 months

RC128-81


Front **Back** **Front** **Back**


4 months

RC128-82


Front **Back** **Front** **Back**

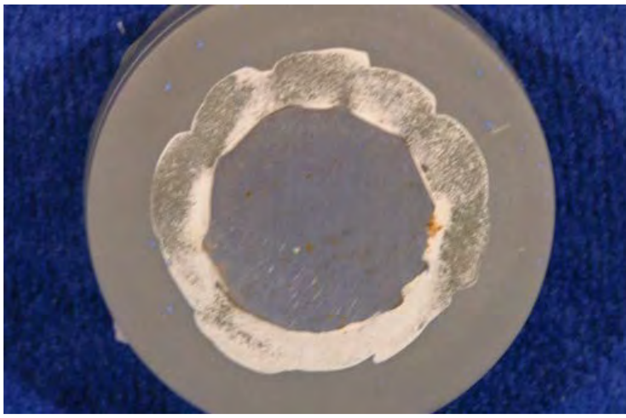
Vessel 8: Level 3

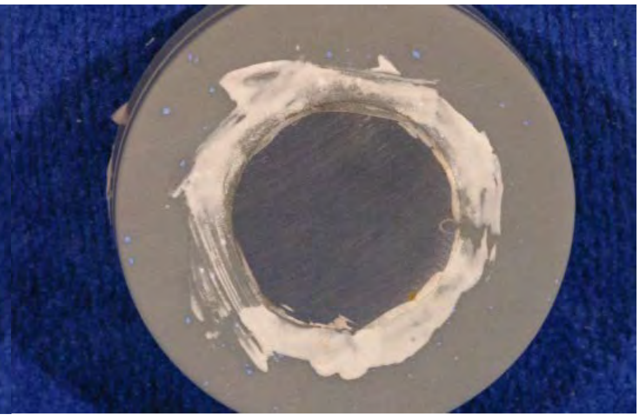
1 month

RC128-88

2 months

RC128-87



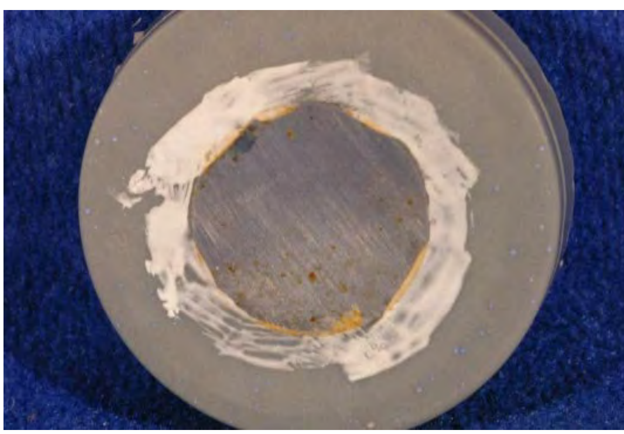


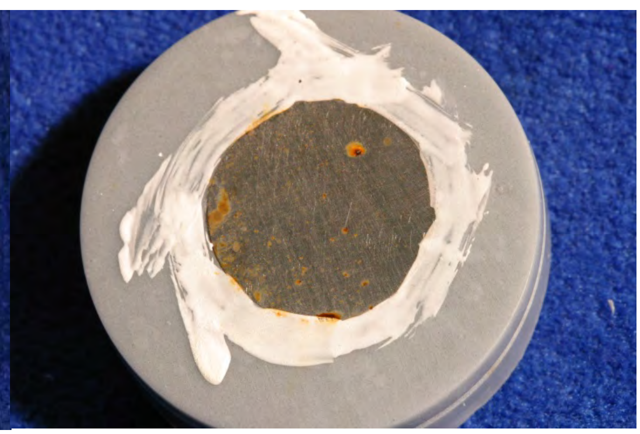
3 months

RC128-85

4 months

RC128-86





Vessel 8: Level 3

Before cleaning | **After cleaning**


Front **Back**

1 month

RC128-88


Front **Back**


Front **Back**

2 months

RC128-87

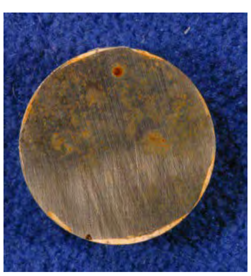

Front **Back**


Front **Back**

3 months

RC128-85

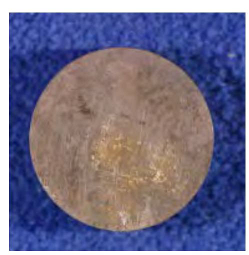

Front **Back**




Front **Back**

4 months

RC128-86

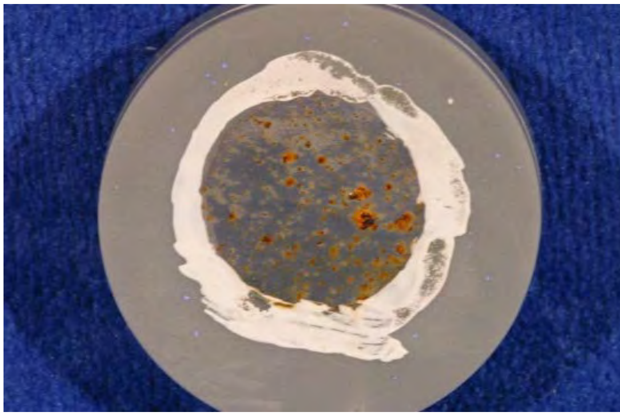



Front **Back**

Vessel 8: Level 2

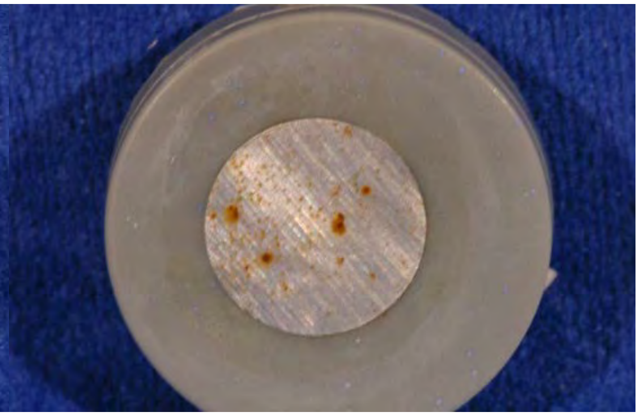
1 month

RC128-93



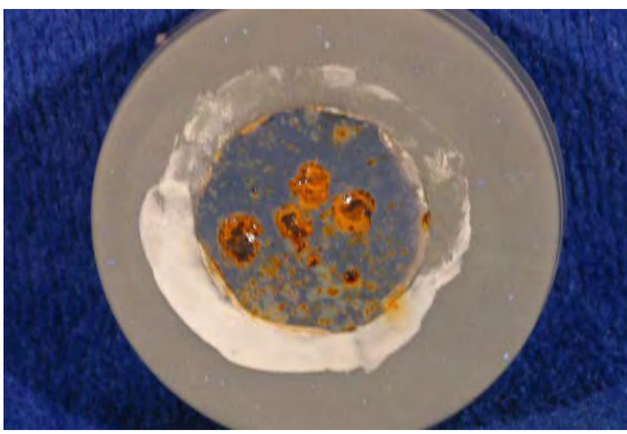
2 months

RC128-92



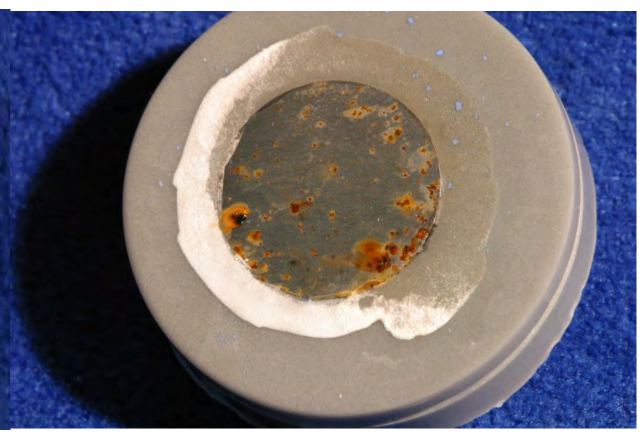
3 months

RC128-90



4 months

RC128-89

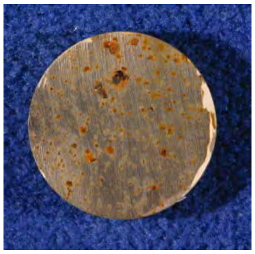


Vessel 8: Level 2

Before cleaning | **After cleaning**

1 month

RC128-93



Front

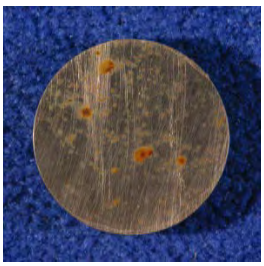
Back

Front

Back

2 months

RC128-92



Front

Back

Front

Back

3 months

RC128-90

Front

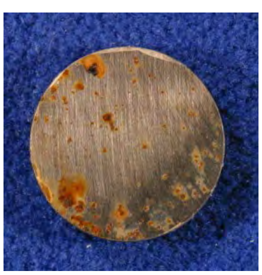
Back

Front

Back

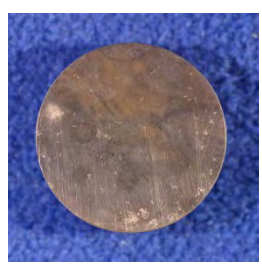
4 months

RC128-89



Front

Back



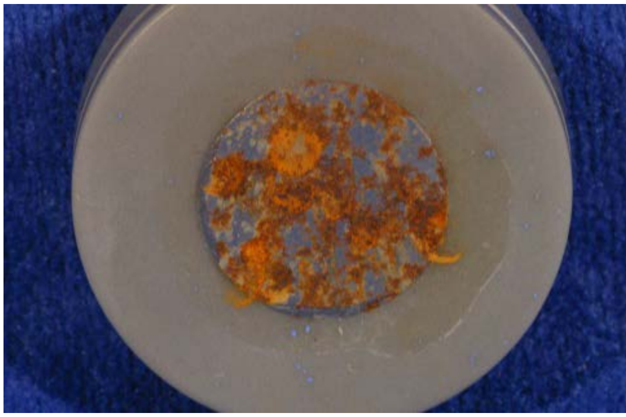
Front

Back

Vessel 8: Level 1

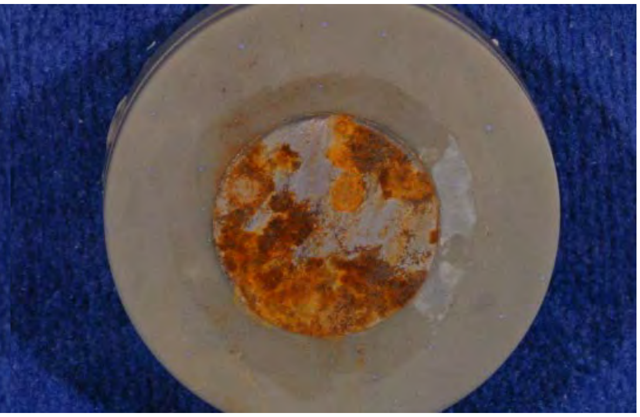
1 month

RC128-97



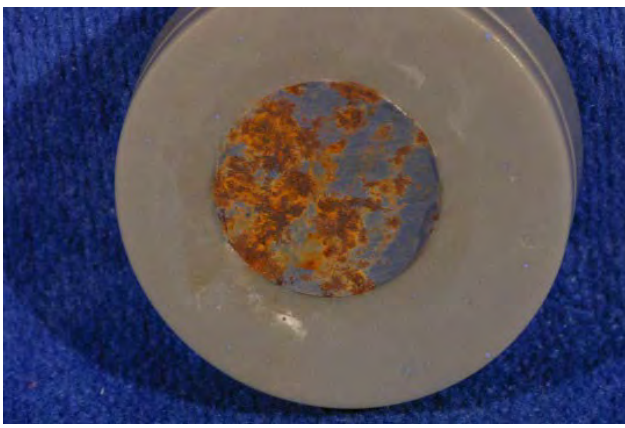
2 months

RC128-96



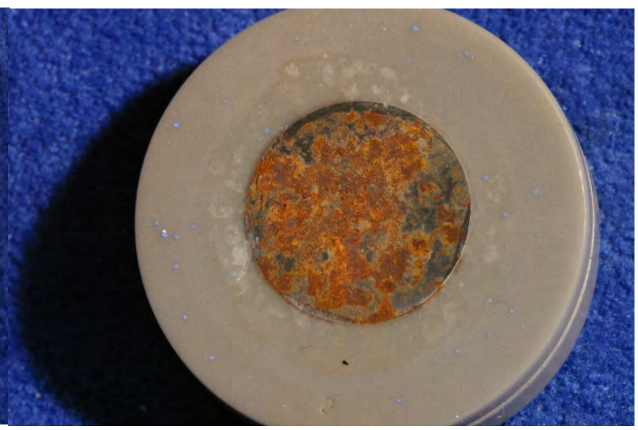
3 months

RC128-95



4 months

RC128-94



Vessel 8: Level 1

Before cleaning | **After cleaning**


1 month

RC128-97


Front **Back** **Front** **Back**


2 months

RC128-96


Front **Back** **Front** **Back**


3 months

RC128-95


Front **Back** **Front** **Back**


4 months

RC128-94


Front **Back** **Front** **Back**

Appendix C

Chemical Composition of Simulants used in Liquid Air Interface Corrosion Testing

Composition of simulant for LAI-Solution 1

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.1314	0.00005	0.0094
Sodium chloride	NaCl	58.4400	0.0025	0.0731
Sodium fluoride	NaF	41.9882	0.00075	0.0157
Sodium sulfate	Na_2SO_4	142.0400	0.0013	0.0888
Sodium hydroxide	NaOH	39.9971	0.01	0.2000
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.1200	0.000125	0.0238
Sodium carbonate	Na_2CO_3	105.9885	0.1	5.2994
Sodium nitrate	$NaNO_3$	84.9947	0.1	4.2497
Sodium nitrite	$NaNO_2$	68.9953	0.0500	1.7249

Composition of simulant for LAI-Solution 2

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.1314	0.00005	0.0094
Sodium chloride	NaCl	58.4400	0.0025	0.0731
Sodium fluoride	NaF	41.9882	0.00075	0.0157
Sodium sulfate	Na_2SO_4	142.0400	0.00125	0.0888
Sodium hydroxide	NaOH	39.9971	0.01	0.2000
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.1200	0.000125	0.0238
Sodium carbonate	Na_2CO_3	105.9885	0.1	5.2994
Sodium nitrate	$NaNO_3$	84.9947	0.1	4.2497
Sodium nitrite	$NaNO_2$	68.9953	0.166	5.7266

Composition of simulant for LAI-Solution 3

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.1314	0.0002	0.0375
Sodium chloride	NaCl	58.4400	0.01	0.2922
Sodium fluoride	NaF	41.9882	0.003	0.0630
Sodium sulfate	Na_2SO_4	142.0400	0.005	0.3551
Sodium hydroxide	NaOH	39.9971	0.01	0.2000
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.1200	0.0005	0.0950
Sodium carbonate	Na_2CO_3	105.9885	0.1	5.2994
Sodium nitrate	$NaNO_3$	84.9947	0.5	21.2487
Sodium nitrite	$NaNO_2$	68.9953	0.075	2.5873

Composition of simulant for LAI-Solution 4

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.1314	0.0002	0.0375
Sodium chloride	NaCl	58.4400	0.01	0.2922
Sodium fluoride	NaF	41.9882	0.0030	0.0630
Sodium sulfate	Na_2SO_4	142.0400	0.0050	0.3551
Sodium hydroxide	NaOH	39.9971	0.01	0.2000
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.1200	0.0005	0.0950
Sodium carbonate	Na_2CO_3	105.9885	0.1000	5.2994
Sodium nitrate	$NaNO_3$	84.9947	0.5	21.2487
Sodium nitrite	$NaNO_2$	68.9953	0.83	28.6330

Composition of simulant for LAI-Solution 5

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.1314	0.001	0.1876
Sodium chloride	NaCl	58.4400	0.02	0.5844
Sodium fluoride	NaF	41.9882	0.005	0.1050
Sodium sulfate	Na_2SO_4	142.0400	0.025	1.7755
Sodium hydroxide	NaOH	39.9971	0.01	0.2000
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.1200	0.005	0.9503
Sodium carbonate	Na_2CO_3	105.9885	0.25	13.2486
Sodium nitrate	$NaNO_3$	84.9947	1	42.4974
Sodium nitrite	$NaNO_2$	68.9953	0.1500	5.1746

Composition of simulant for LAI-Solution 6

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.1314	0.001	0.1876
Sodium chloride	NaCl	58.4400	0.02	0.5844
Sodium fluoride	NaF	41.9882	0.005	0.1050
Sodium sulfate	Na_2SO_4	142.0400	0.025	1.7755
Sodium hydroxide	NaOH	39.9971	0.01	0.2000
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.1200	0.005	0.9503
Sodium carbonate	Na_2CO_3	105.9885	0.25	13.2486
Sodium nitrate	$NaNO_3$	84.9947	1	42.4974
Sodium nitrite	$NaNO_2$	68.9953	0.6	20.6986

Composition of simulant for LAI-Solution 7

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.1314	0.001	0.1876
Sodium chloride	NaCl	58.4400	0.02	0.5844
Sodium fluoride	NaF	41.9882	0.005	0.1050
Sodium sulfate	Na_2SO_4	142.0400	0.025	1.7755
Sodium hydroxide	NaOH	39.9971	0.01	0.2000
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.1200	0.005	0.9503
Sodium carbonate	Na_2CO_3	105.9885	0.25	13.2486
Sodium nitrate	$NaNO_3$	84.9947	1	42.4974
Sodium nitrite	$NaNO_2$	68.9953	1.66	57.2661

Composition of simulant for LAI-Solution 8

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.1314	0.0033	0.6190
Sodium chloride	NaCl	58.4400	0.1	2.9220
Sodium fluoride	NaF	41.9882	0.02	0.4199
Sodium sulfate	Na_2SO_4	142.0400	0.1	7.1020
Sodium hydroxide	NaOH	39.9971	0.01	0.2000
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.1200	0.05	9.5030
Sodium carbonate	Na_2CO_3	105.9885	1	52.9943
Sodium nitrate	$NaNO_3$	84.9947	5	212.4868
Sodium nitrite	$NaNO_2$	68.9953	0.6	20.6986

Composition of simulant for LAI-Solution 9

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.4970	93.1875
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.0006	0.0852
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.0100	1.1800
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.0004	0.0437
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.0006	0.1162
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0001	0.0187
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.0007	0.1086
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.0003	0.0321
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.0068	0.9821
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	2.3432
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.0481	8.9481
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.0190	2.6396
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.0253	2.7599
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.1114	11.6978
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.0076	0.7254
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.1127	7.4928
Sodium chloride	NaCl	58.4000	0.1060	3.0952
Sodium sulfate	Na_2SO_4	142.0000	0.1280	9.0880
Ammonium Chloride	NH_4Cl	55.4920	0.0050	0.1382
Glycolic acid	$C_2H_4O_3$	76.1000	0.1610	6.1261
Sodium hydroxide	NaOH	40.0000	3.0012	60.0246
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.0000	0.0514	9.7660
Sodium formate	Na(CHO2)	68.0000	0.2330	7.9220
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	1.4144
Sodium carbonate	Na_2CO_3	106.0000	1.1200	59.3600
Sodium nitrate	$NaNO_3$	85.0000	1.5362	65.2877
Sodium nitrite	$NaNO_2$	69.0000	1.9500	67.2750

Composition of simulant for LAI-Solution 10

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.4970	93.1875
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.0006	0.0852
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.0100	1.1800
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.0004	0.0437
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.0006	0.1162
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0001	0.0187
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.0007	0.1086
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.0003	0.0321
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.0068	0.9821
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	2.3432
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.0481	8.9481
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.0190	2.6396
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.0253	2.7599
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.1114	11.6978
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.0076	0.7254
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.1127	7.4928
Sodium chloride	NaCl	58.4000	0.1060	3.0952
Sodium sulfate	Na_2SO_4	142.0000	0.1280	9.0880
Ammonium Chloride	NH_4Cl	55.4920	0.0050	0.1382
Glycolic acid	$C_2H_4O_3$	76.1000	0.1610	6.1261
Sodium hydroxide	NaOH	40.0000	2.9612	59.2246
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	9.7660
Sodium formate	Na(CHO2)	68.0000	0.2330	7.9220
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	1.4144
Sodium carbonate	Na_2CO_3	106.0000	1.1200	59.3600

Sodium nitrate	$NaNO_3$	85.0000	1.4862	63.1622
Sodium nitrite	$NaNO_2$	69.0000	1.9100	65.8950

Composition of simulant for LAI-Solution 11

Temperature	40	°C
pH	12	
Volume	0.5	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	Weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.4970	93.1875
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.0006	0.0852
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.0100	1.1800
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.0004	0.0437
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.0006	0.1162
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0001	0.0187
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.0007	0.1086
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.0003	0.0321
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.0068	0.9821
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	2.3432
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.0481	8.9481
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.0190	2.6396
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.0253	2.7599
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.1114	11.6978
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.0076	0.7254
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.1127	7.4928
Sodium chloride	NaCl	58.4000	0.1060	3.0952
Sodium sulfate	Na_2SO_4	142.0000	0.1280	9.0880
Ammonium Chloride	NH_4Cl	55.4920	0.0050	0.1382
Glycolic acid	$C_2H_4O_3$	76.1000	0.1610	6.1261
Sodium hydroxide	NaOH	40.0000	3.1912	63.8246
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	9.7660
Sodium formate	Na(CHO2)	68.0000	0.2330	7.9220
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	1.4144

Sodium carbonate	Na_2CO_3	106.0000	1.1200	59.3600
Sodium nitrate	$NaNO_3$	85.0000	1.4262	60.6122
Sodium nitrite	$NaNO_2$	69.0000	1.0000	34.5000

Composition of simulant for LAI-Solutions 12 and 13

Temperature	45	°C
pH	7.6	
Volume	1	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	Weight required (g)
Sodium bicarbonate	$NaHCO_3$	84.0100	1.12E-03	0.0941
Calcium hydroxide	$Ca(OH)_2$	74.0930	1.21E-04	0.0090
Potassium nitrate	KNO_3	101.1032	6.75E-05	0.0068
Magnesium Nitrate, 6-hydrate	$Mg(NO_3)_2.6H_2O$	256.4100	1.52E-05	0.0039
Strontium Nitrate	$Sr(NO_3)_2$	211.6300	4.04E-06	0.0009
Sodium sulfate	Na_2SO_4	142.0400	1.83E-06	0.0003
Sodium Metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.1400	4.57E-05	0.0097
Ferric chloride	$FeCl_3$	162.2000	2.67E-06	0.0004
Manganese Nitrate	$Mn(NO_3)_2$	178.9500	3.43E-07	0.0001
Acetic Acid	$C_2H_4O_2$	60.0500	3.00E-04	0.0180

Composition of simulant for LAI-Solutions 14 and 15

Temperature	45	°C
pH	7.6	
Volume	1	L

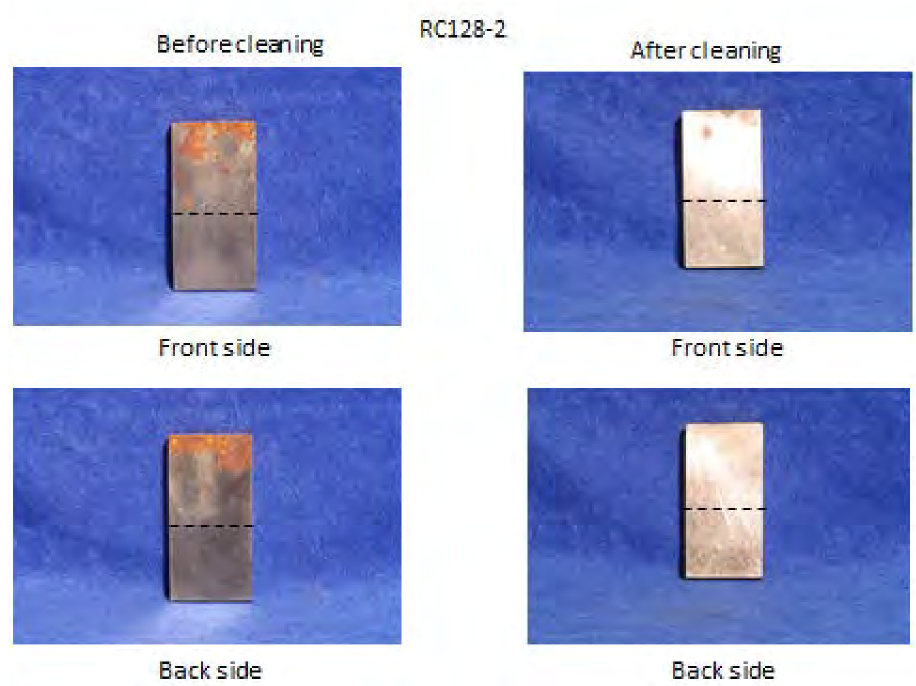
Simulant Source	Formula	Molecular weight (g/mol)	Concentration (M)	Weight required (g)
Sodium bicarbonate	$NaHCO_3$	84.0100	1.75E-03	0.1470
Calcium hydroxide	$Ca(OH)_2$	74.0930	1.50E-03	0.1111
Potassium nitrate	KNO_3	101.1032	2.40E-04	0.0243
Ferric sulfate	$Fe_2(SO_4)_3$	399.8800	6.25E-04	0.2499
Ferric chloride	$FeCl_3$	162.2000	7.67E-05	0.0124
Strontium Nitrate	$Sr(NO_3)_2$	211.6300	2.87E-06	0.0006
Sodium Metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.1400	6.00E-04	0.1273
Magnesium Chloride	MgCl2	95.2110	3.10E-04	0.0295
Acetic Acid	$C_2H_4O_2$	60.0500	3.00E-04	0.0180

Appendix D

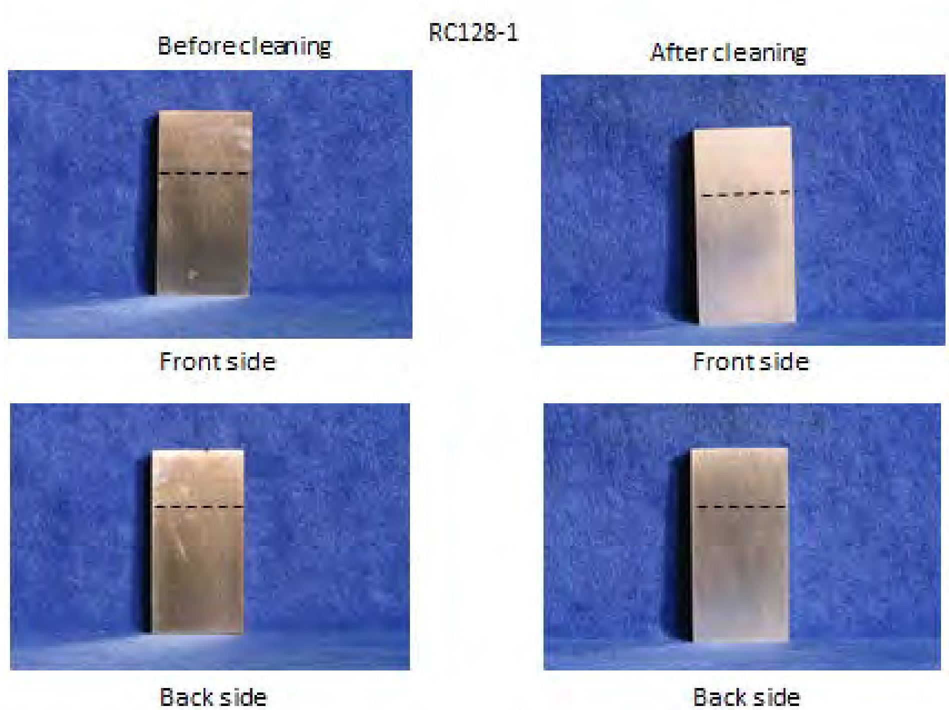
Pictures of Liquid Air Interface Corrosion Samples after Test

Solution 1

2 month exposure



4 month exposure

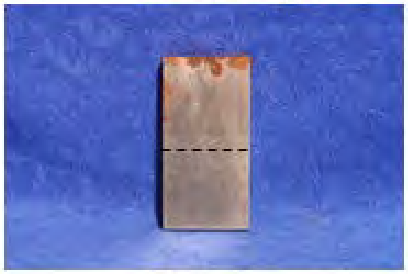


Solution 2

2 month exposure

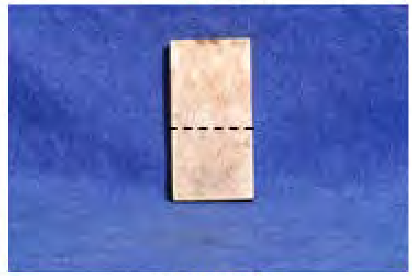
RC128-4

Before cleaning



Front side

After cleaning



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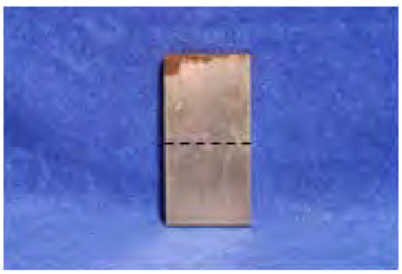

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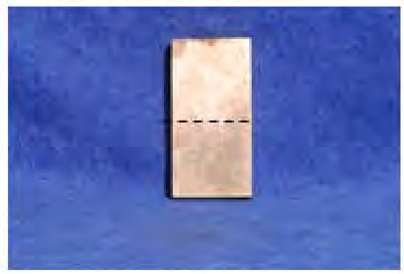
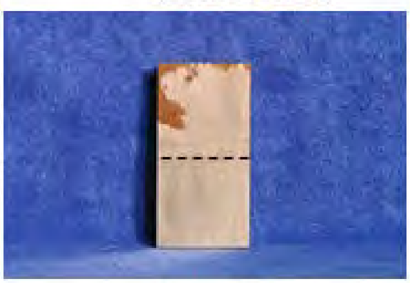


Back side

4 month exposure

RC128-3

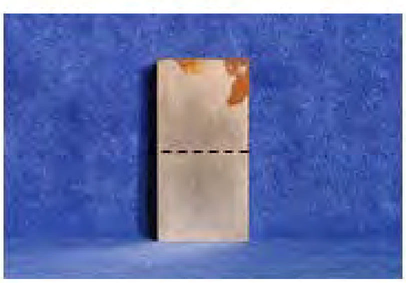
Before cleaning



Front side

After cleaning

Front side



Back side

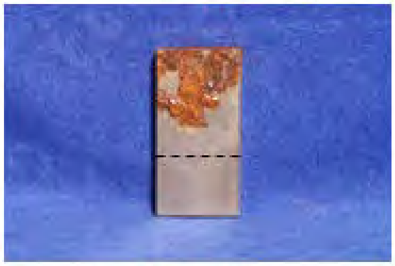
Back side

Solution 3

2 month exposure

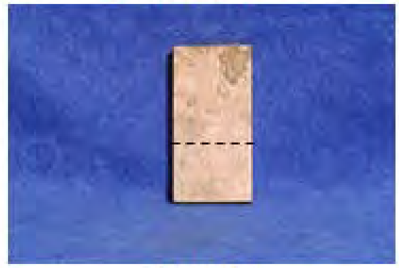
RC128-6

Before cleaning

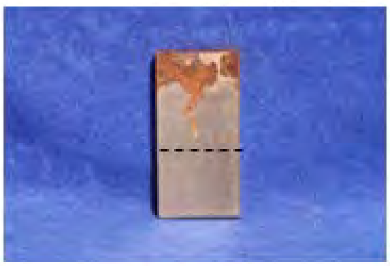


Front side

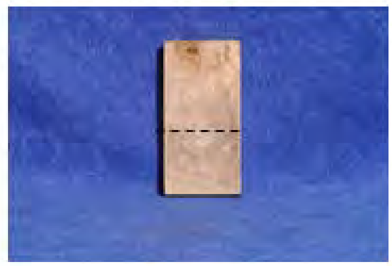
After cleaning



Front side



Back side



Back side

4 month exposure

RC128-5

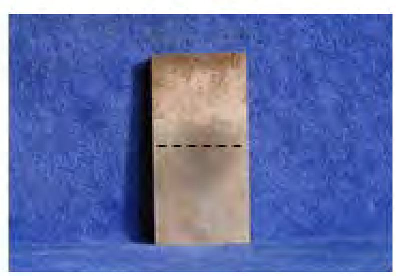
Before cleaning

Front side

After cleaning

Front side

Back side



Back side

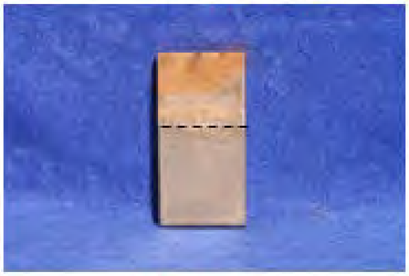
Solution 4

2 month exposure

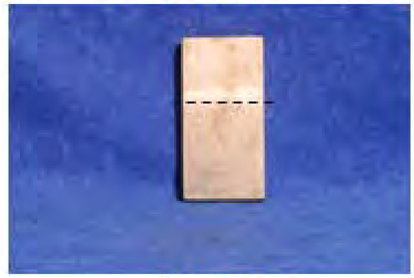
RC128-8

Before cleaning

After cleaning

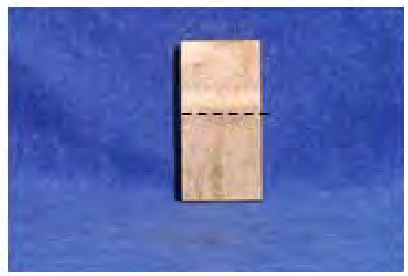


Front side



Front side

Back side



Back side

4 month exposure

RC128-7

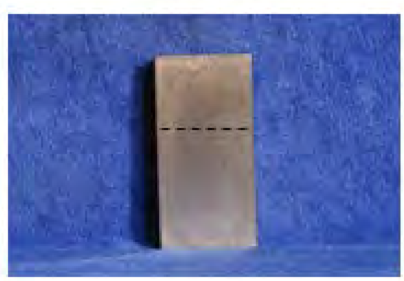
Before cleaning

After cleaning

Front side

Front side

Back side

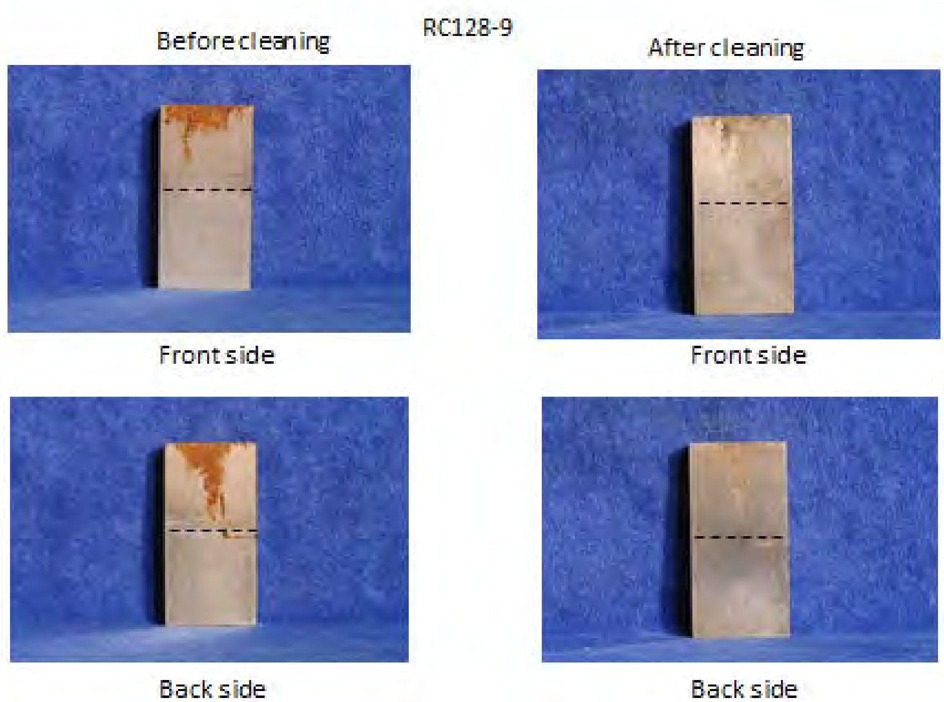


Back side

Solution 5

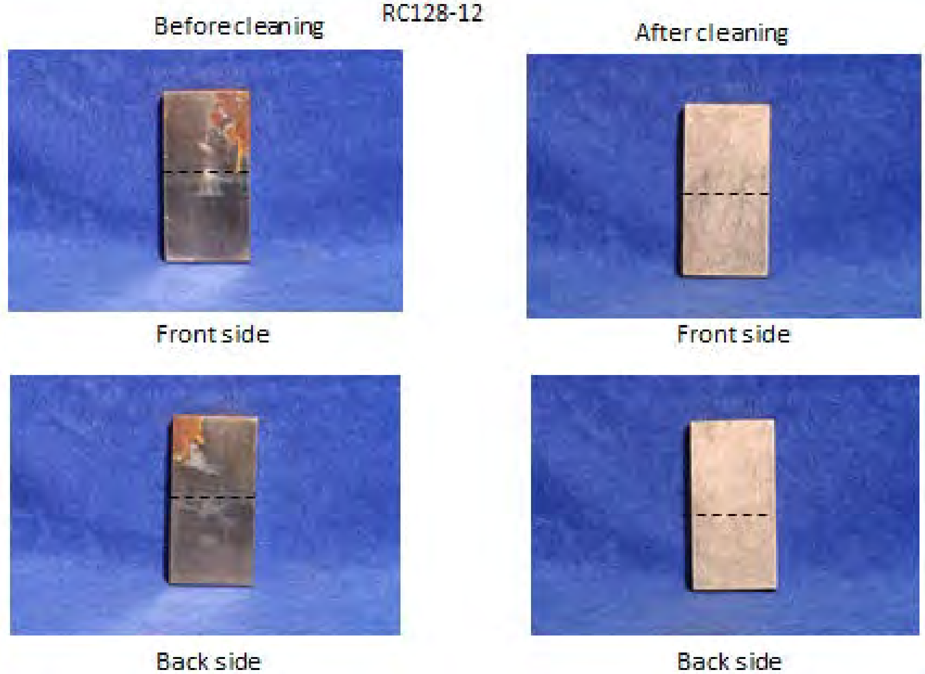
2 month exposure

4 month exposure

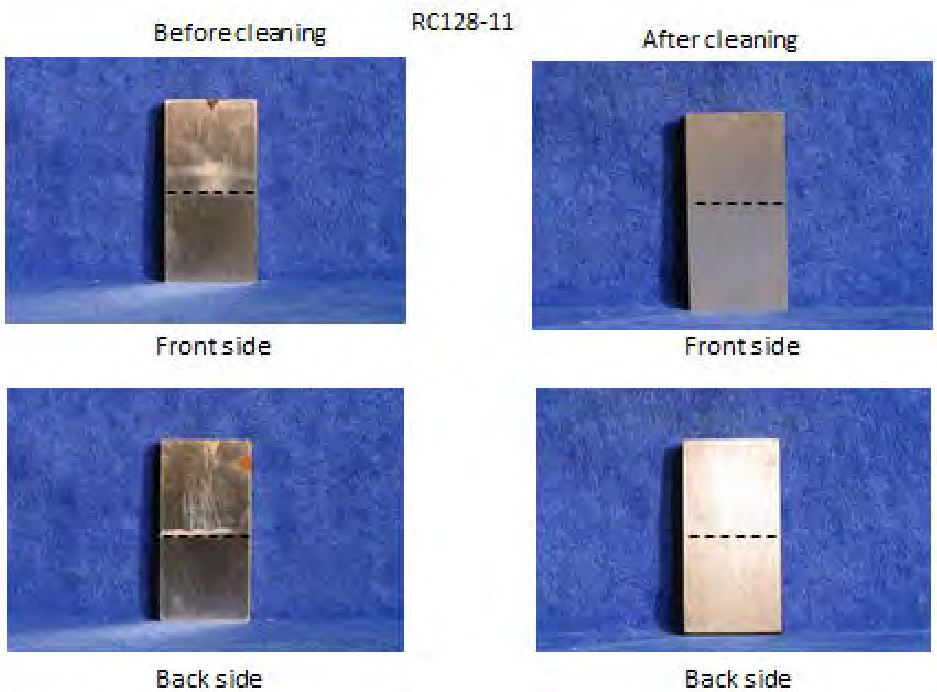


Solution 6

2 month exposure

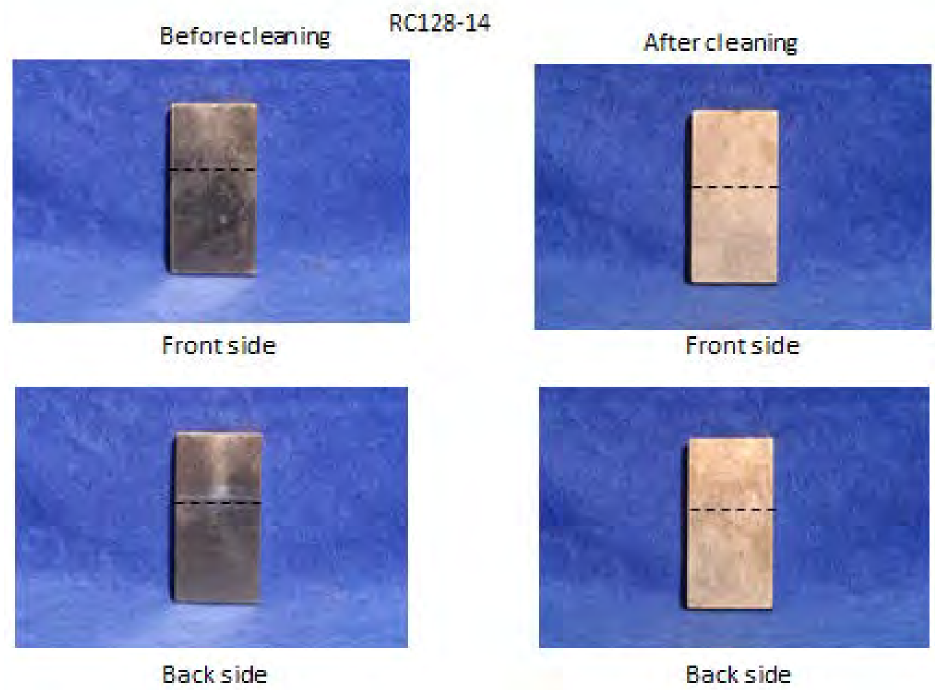


4 month exposure

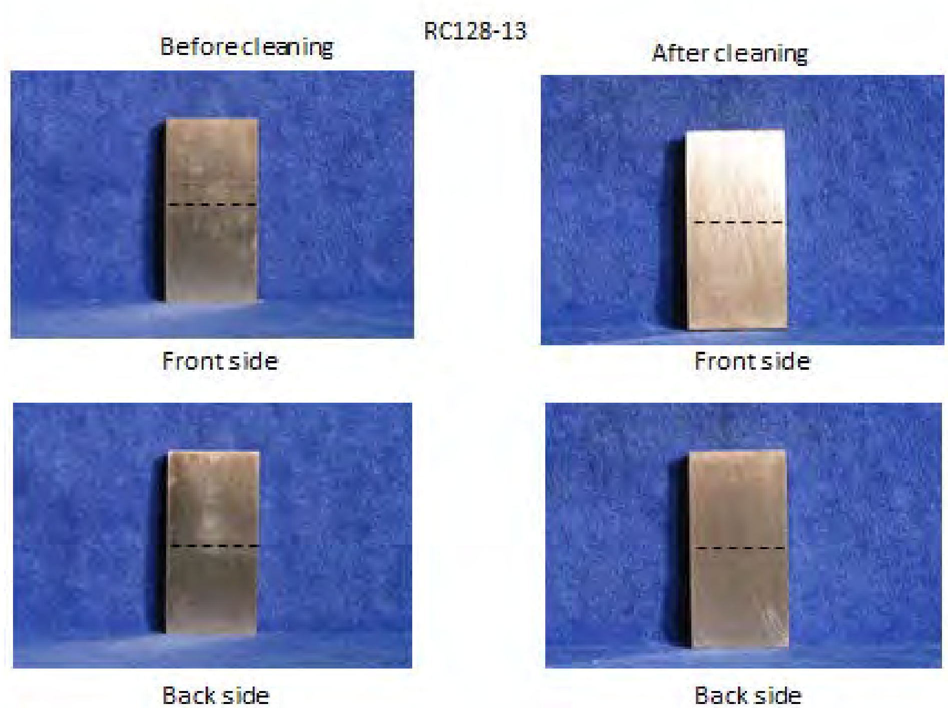


Solution 7

2 month exposure

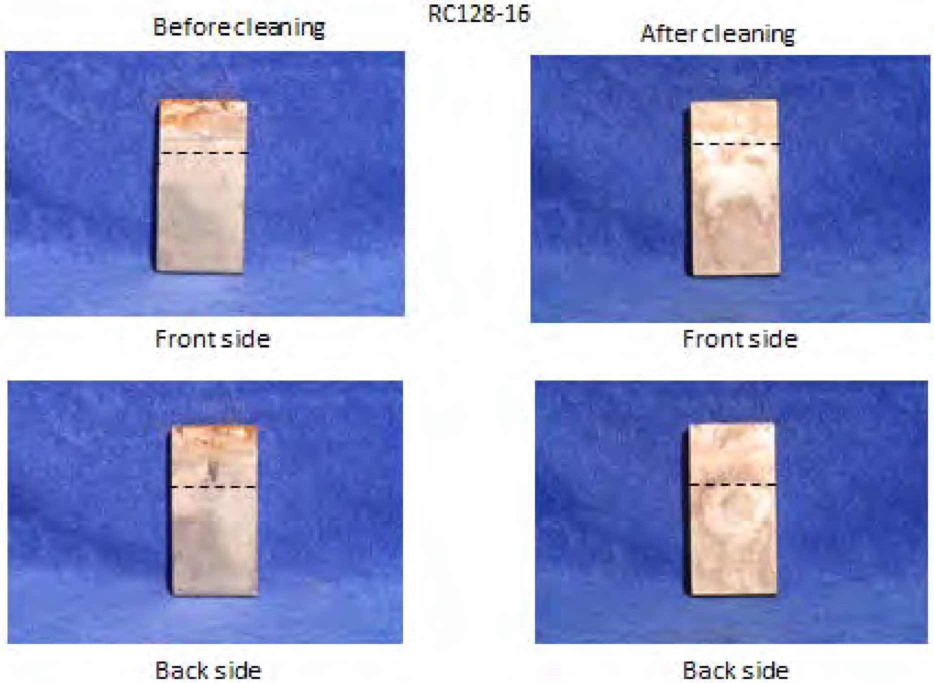


4 month exposure

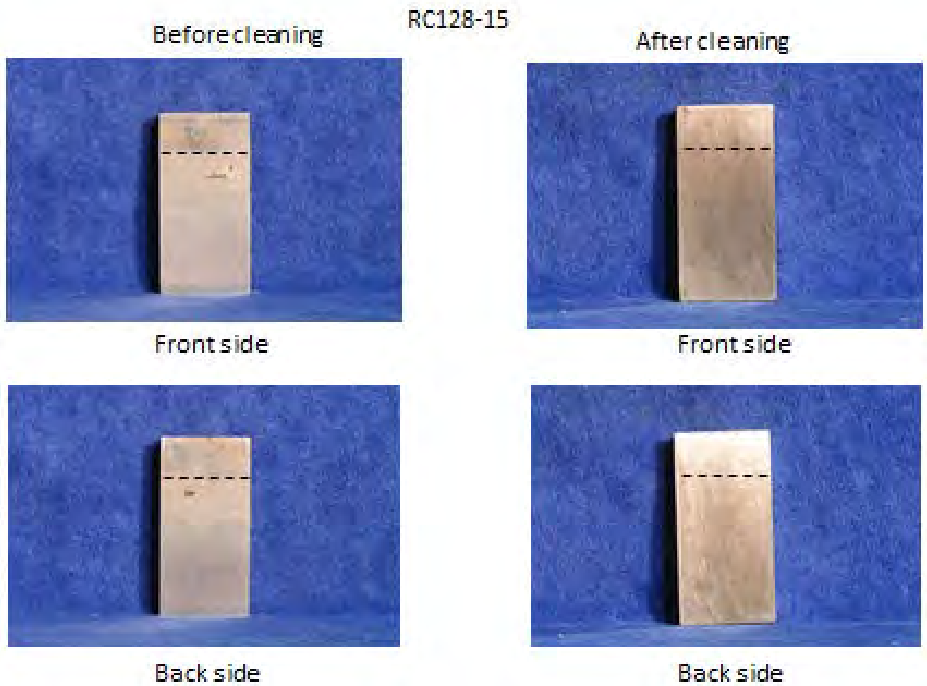


Solution 8

2 month exposure



4 month exposure



Solution 9

2 month exposure

RC128-18

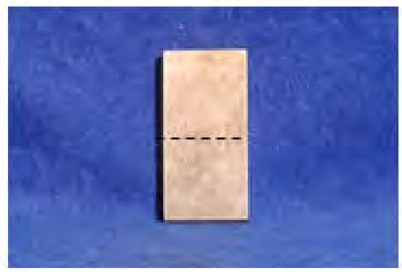
Before cleaning

Front side

After cleaning

Front side

Back side



Back side

4 month exposure

RC128-17

Before cleaning

Front side

After cleaning

Front side

Back side

Back side

Solution 10

2 month exposure

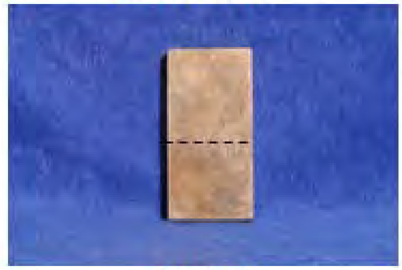
RC128-20

Before cleaning

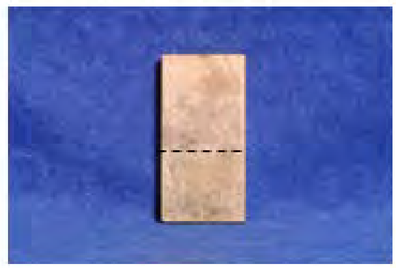
Front side

Back side

After cleaning



Front side



Back side

4 month exposure

RC128-19

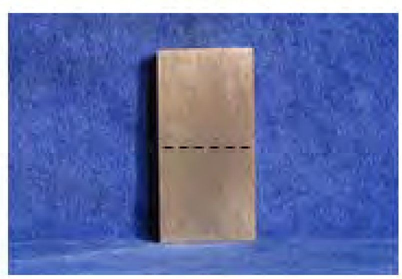
Before cleaning

Front side

Back side

After cleaning

Front side

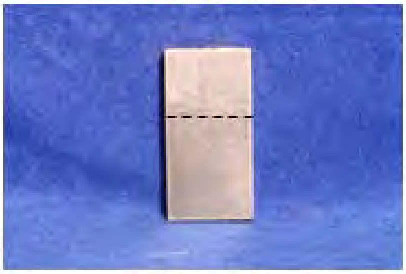


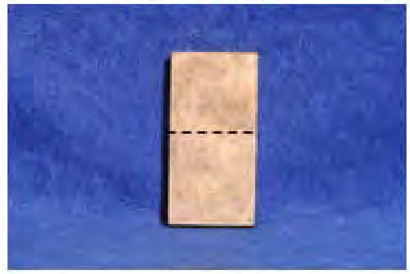
Back side

Solution 11

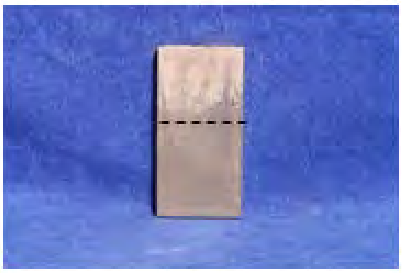
2 month exposure

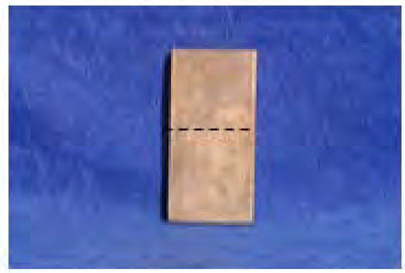
Before cleaning | RC128-22 | After cleaning





Front side | Front side

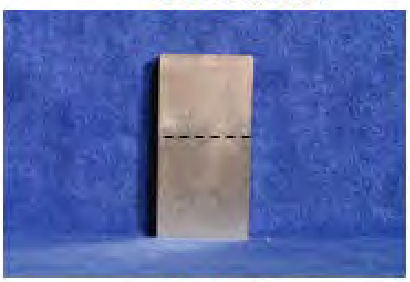




Back side | Back side

4 month exposure

Before cleaning | RC128-21 | After cleaning

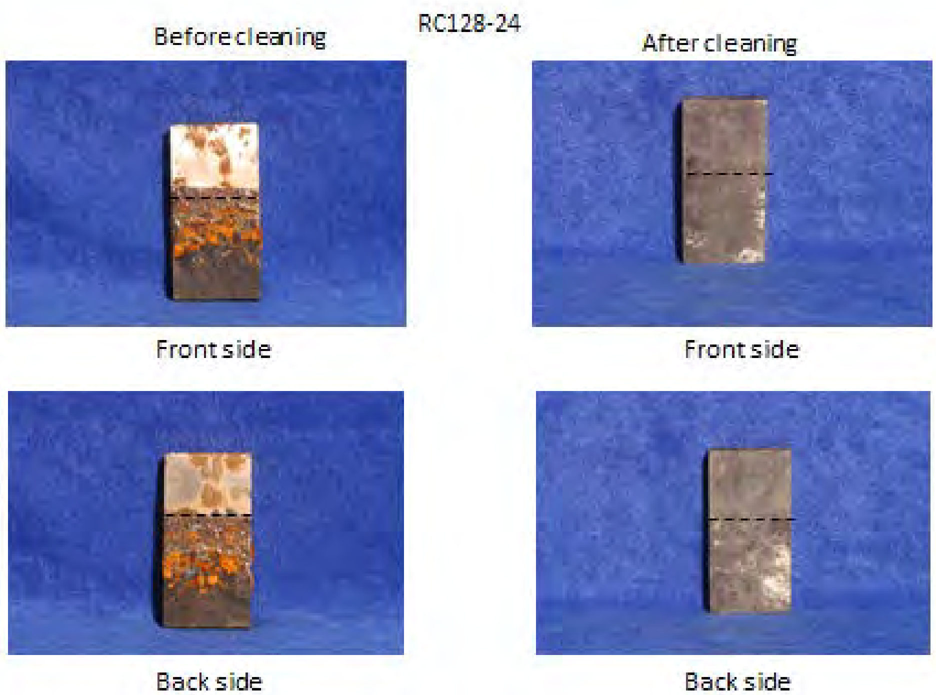


Front side | Front side

Back side | Back side

Solution 12

2 month exposure



4 month exposure

Solution 13

2 month exposure

RC128-26

Before cleaning

Front side

Back side

After cleaning

Front side

Back side

4 month exposure

RC128-25

Before cleaning

Front side

Back side

After cleaning

Front side

Back side

Solution 14

2 month exposure

RC128-28

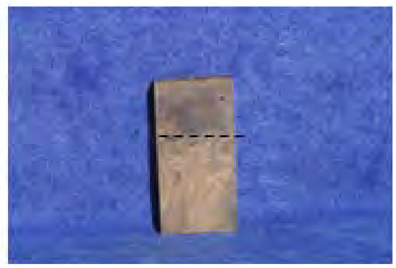
Before cleaning

Front side

Back side

After cleaning

Front side



Back side

4 month exposure

RC128-27

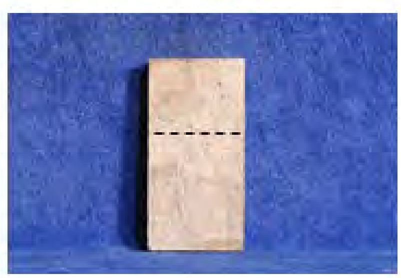
Before cleaning

Front side

Back side

After cleaning

Front side



Back side

Solution 15

2 month exposure

RC128-30

Before cleaning

Front side

After cleaning

Front side

Back side

Back side

4 month exposure

RC128-29

Before cleaning

Front side

After cleaning

Front side

Back side

Back side

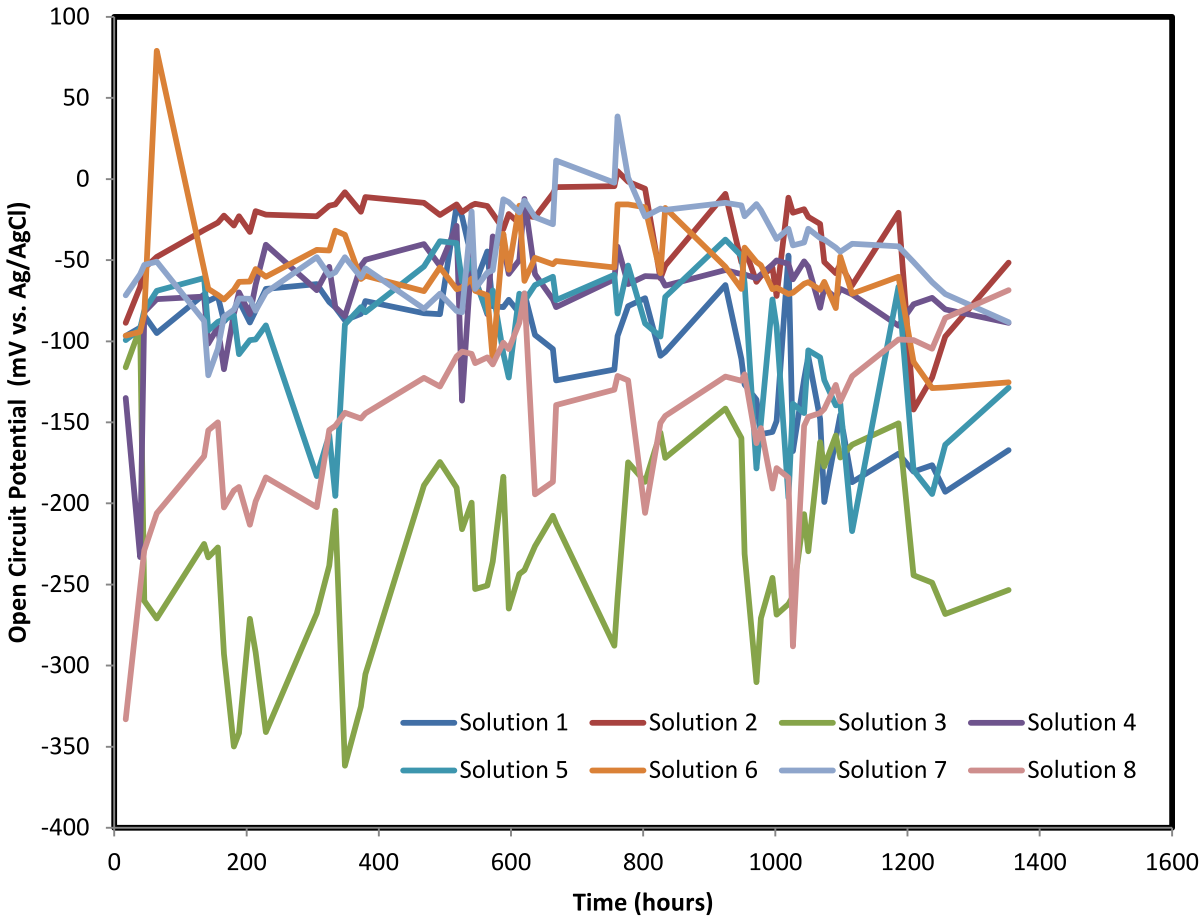
Appendix E

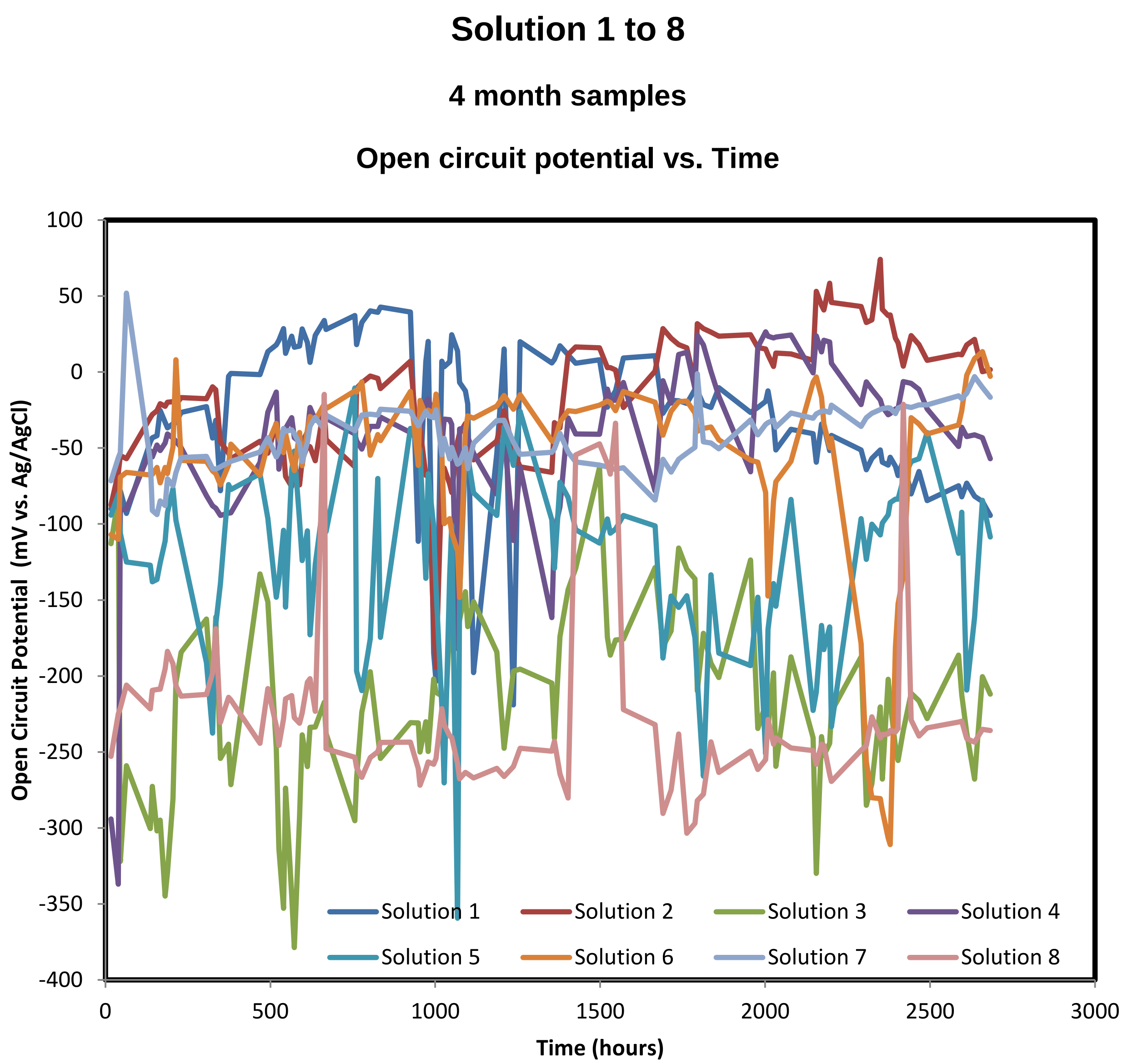
Open Circuit Potential, pH and Temperature vs. Time plots for Liquid Air Interface Solutions

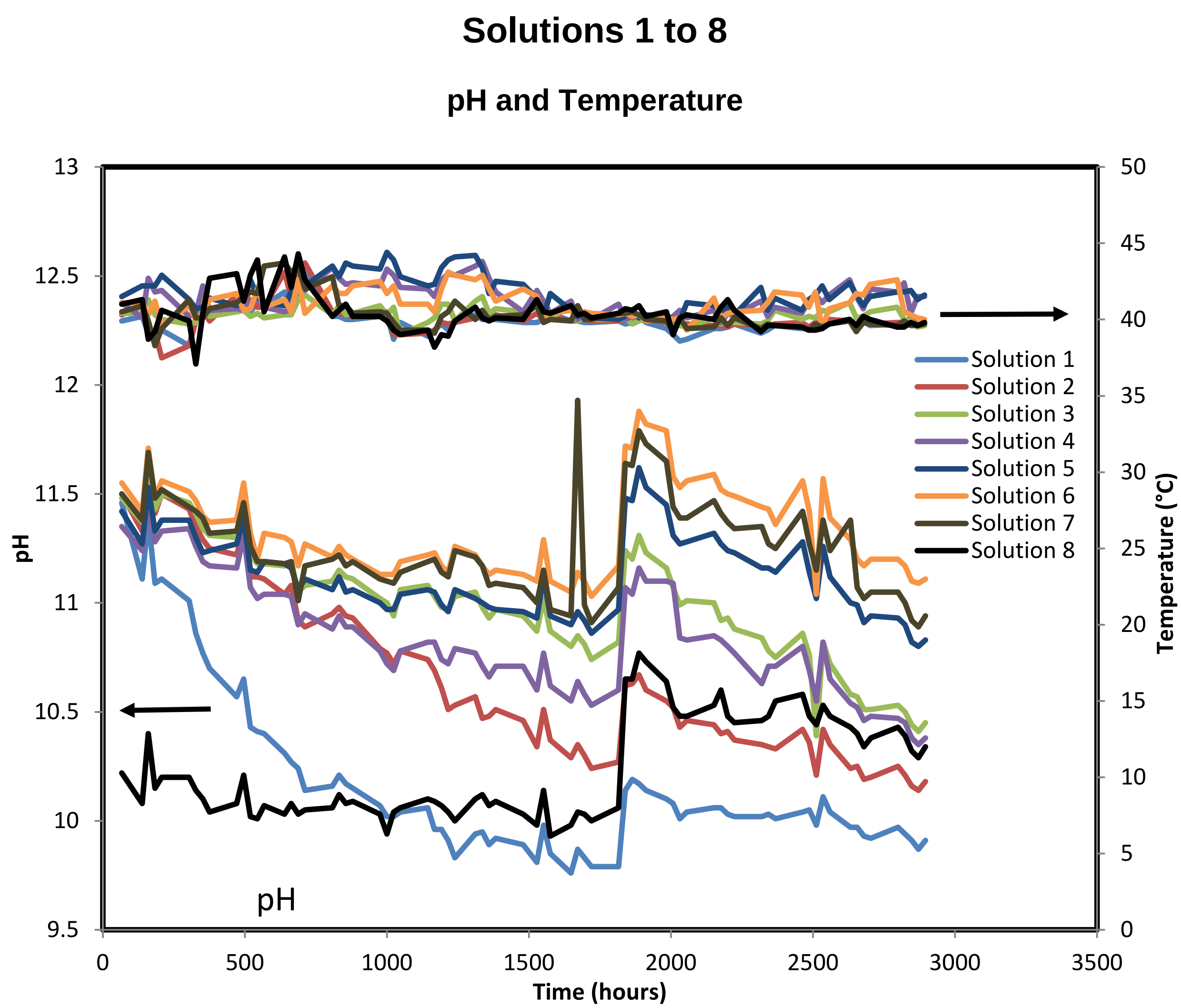
Solution 1 to 8

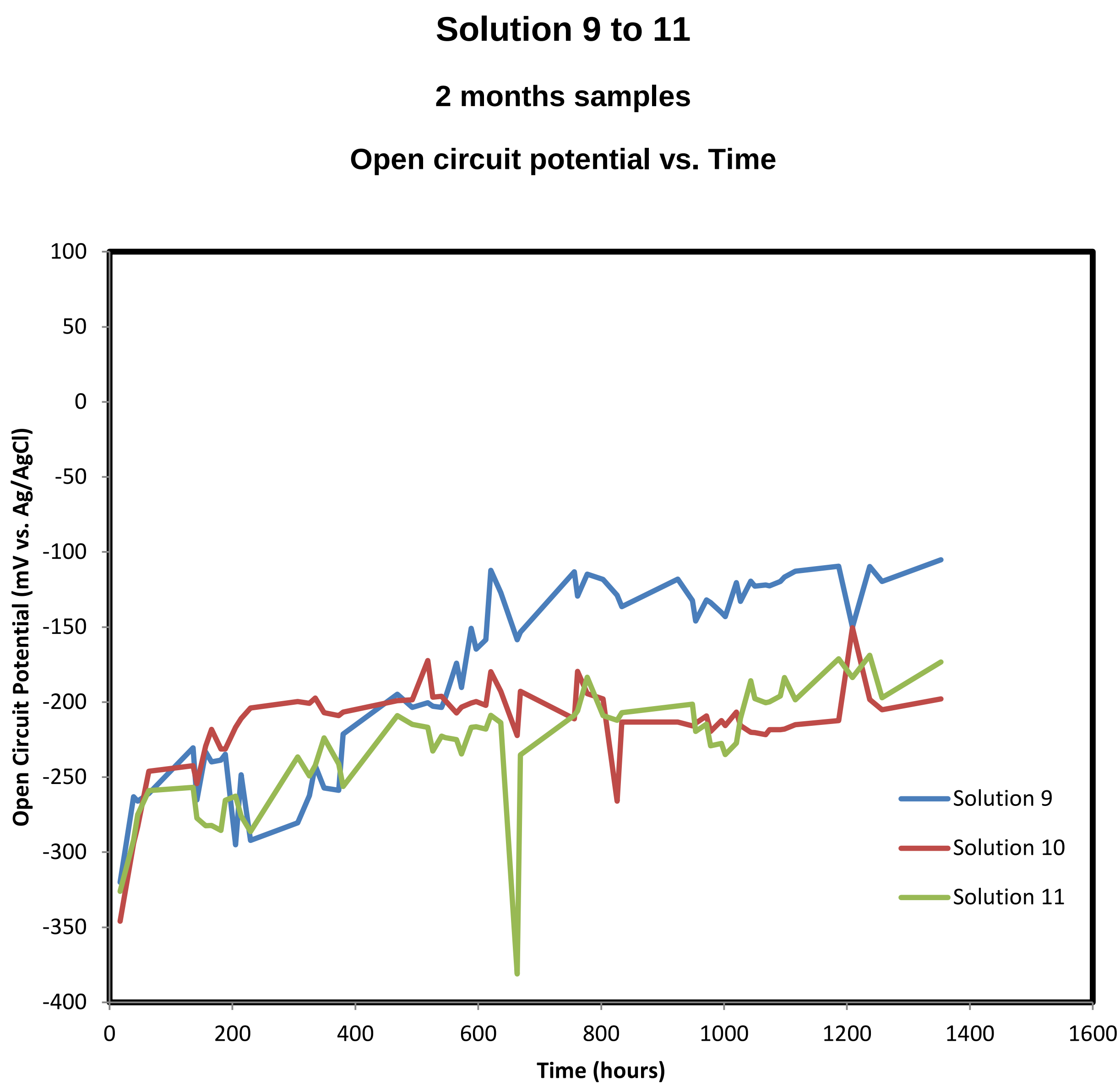
2 months samples

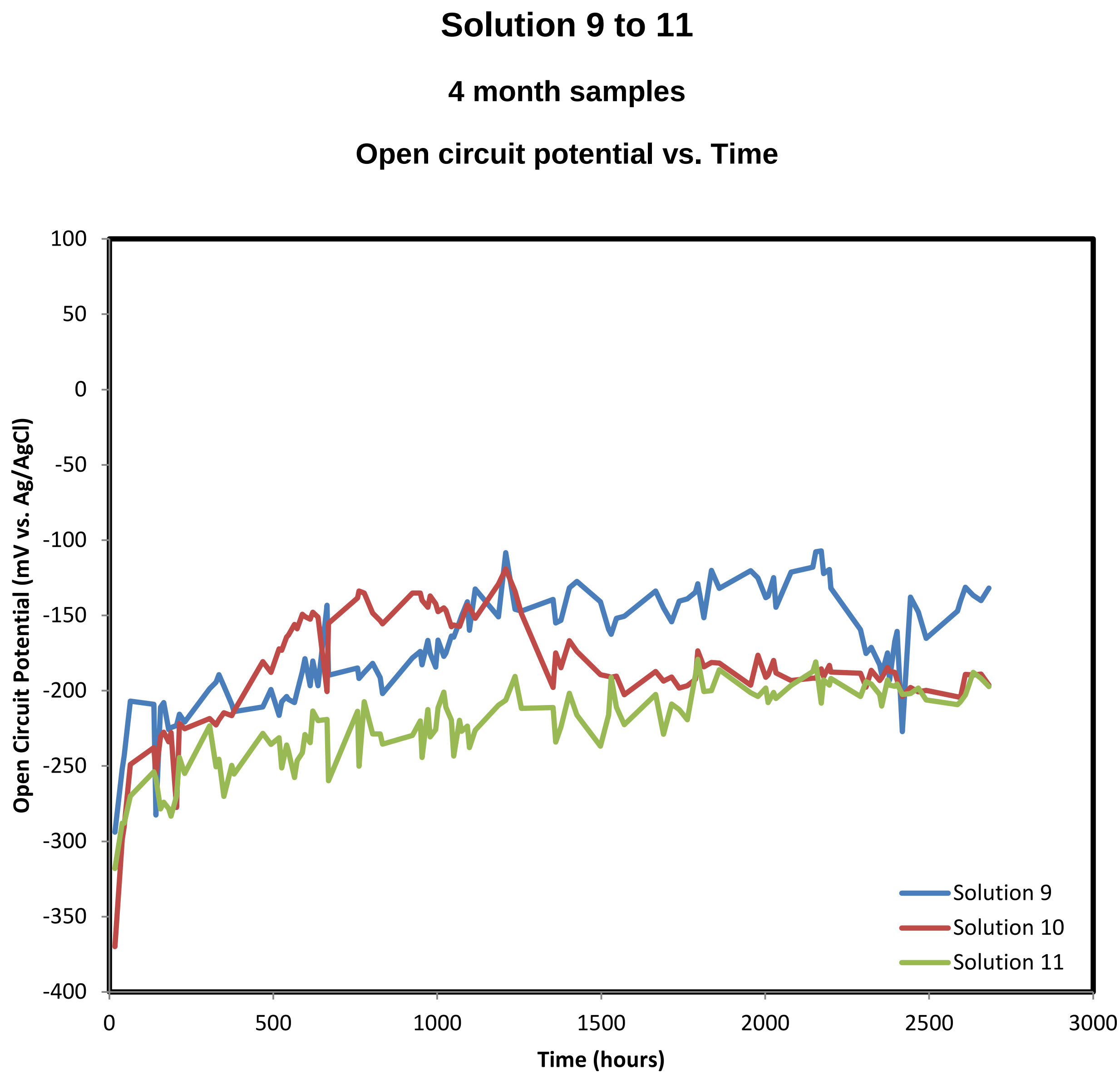
Open circuit potential vs. Time



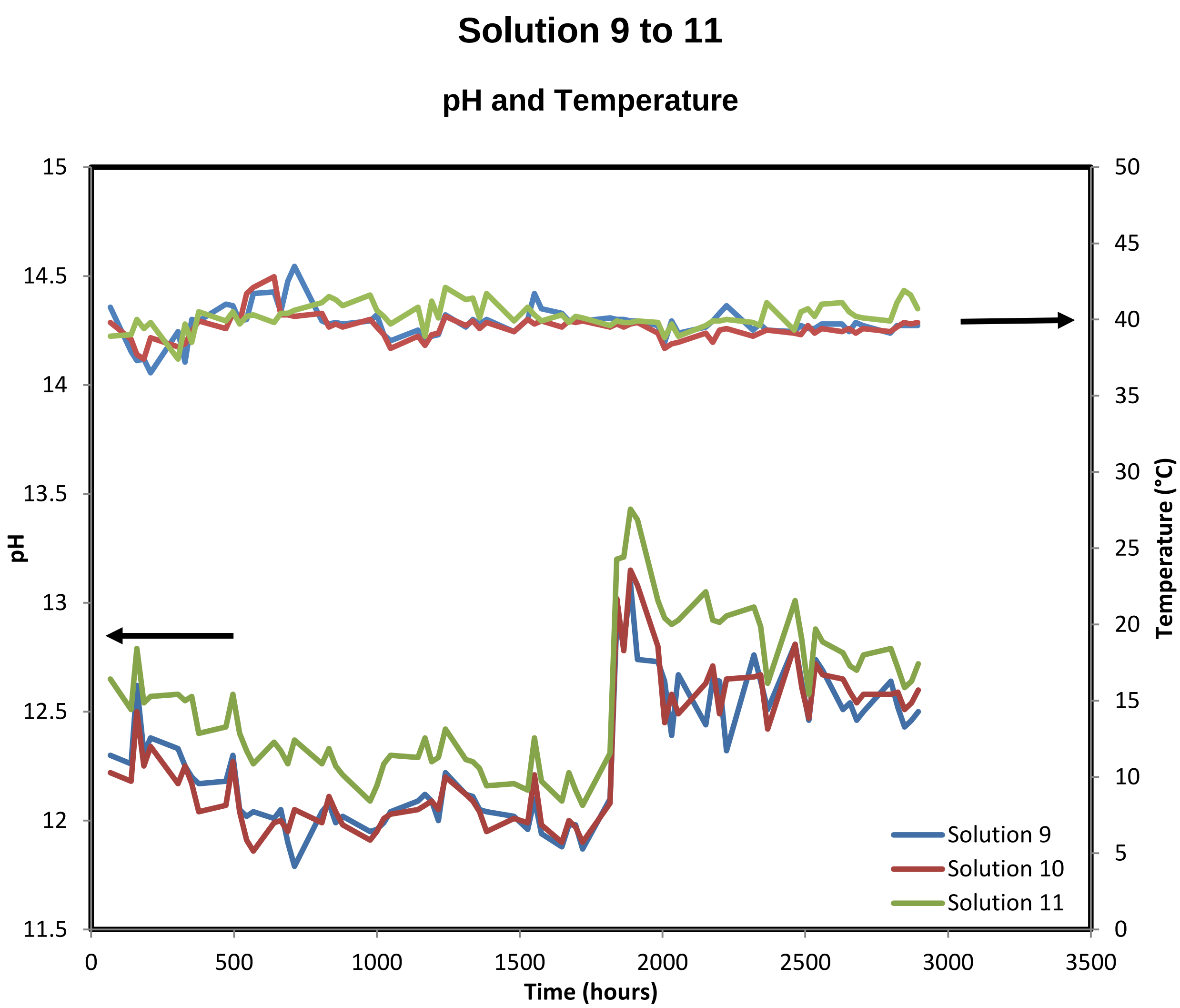

Solution 1 to 8
4 month samples
Open circuit potential vs. Time
Open Circuit Potential (mV vs. Ag/AgCl)
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
0
500
1000
1500
2000
2500
3000
Time (hours)
Solution 1
Solution 2
Solution 3
Solution 4
Solution 5
Solution 6
Solution 7
Solution 8


Solutions 1 to 8
pH and Temperature
pH
Temperature (°C)
Time (hours)
Solution 1
Solution 2
Solution 3
Solution 4
Solution 5
Solution 6
Solution 7
Solution 8
13
12.5
12
11.5
11
10.5
10
9.5
50
45
40
35
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
3500


Solution 9 to 11
2 months samples
Open circuit potential vs. Time
Open Circuit Potential (mV vs. Ag/AgCl)
Time (hours)
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
0
200
400
600
800
1000
1200
1400
1600
Solution 9
Solution 10
Solution 11



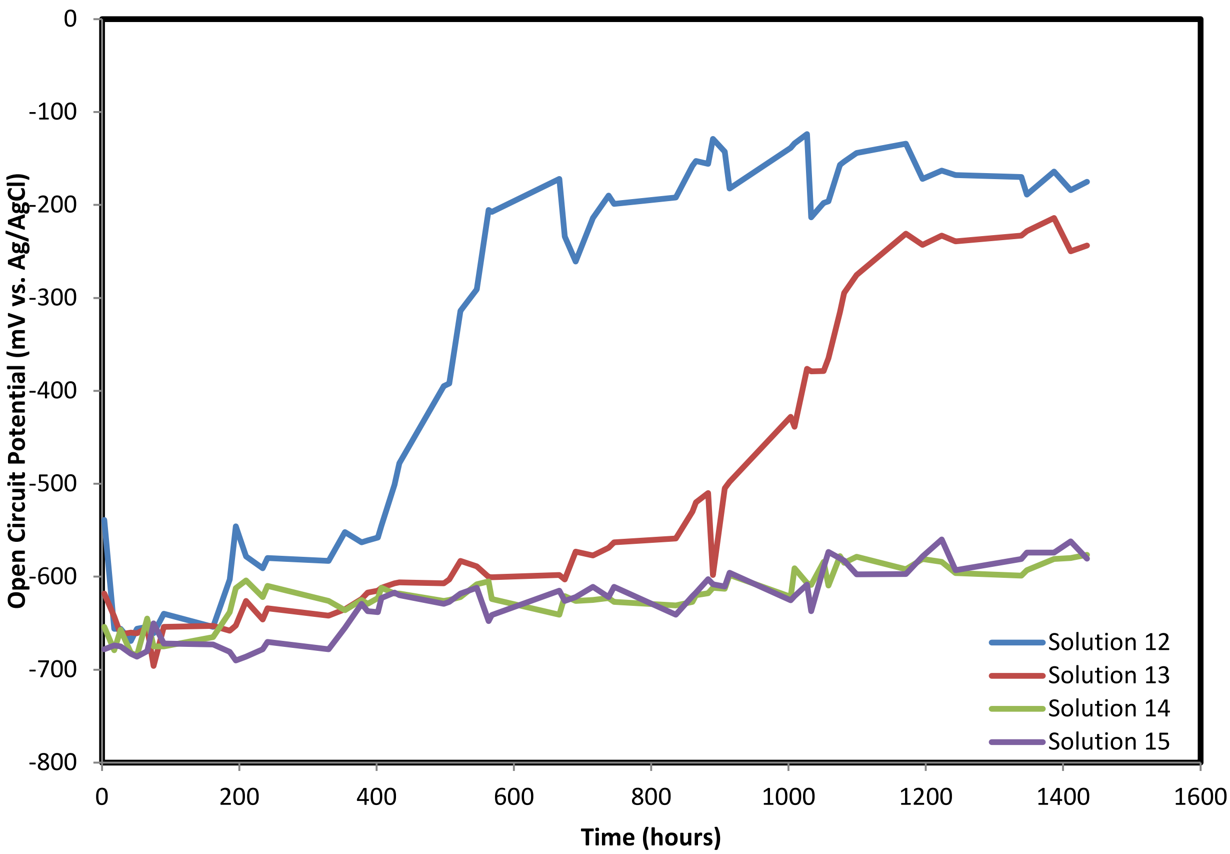
Solution 9 to 11
4 month samples
Open circuit potential vs. Time
Open Circuit Potential (mV vs. Ag/AgCl)
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
0
500
1000
1500
2000
2500
3000
Time (hours)
Solution 9
Solution 10
Solution 11


Solution 9 to 11
pH and Temperature
pH
Temperature (°C)
Time (hours)
15
14.5
14
13.5
13
12.5
12
11.5
50
45
40
35
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
3500
Solution 9
Solution 10
Solution 11

Solution 12 to 15

2 months samples

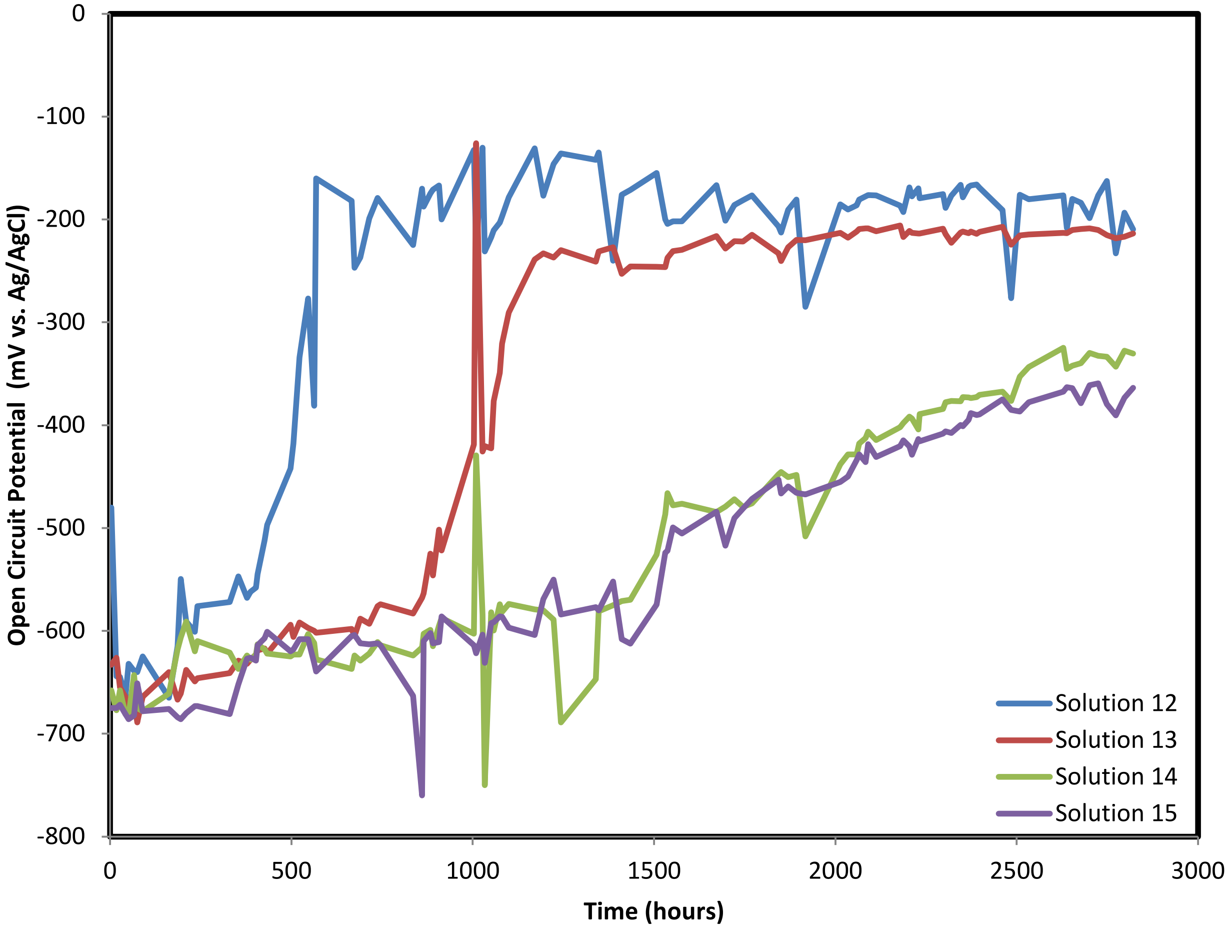
Open circuit potential vs. Time

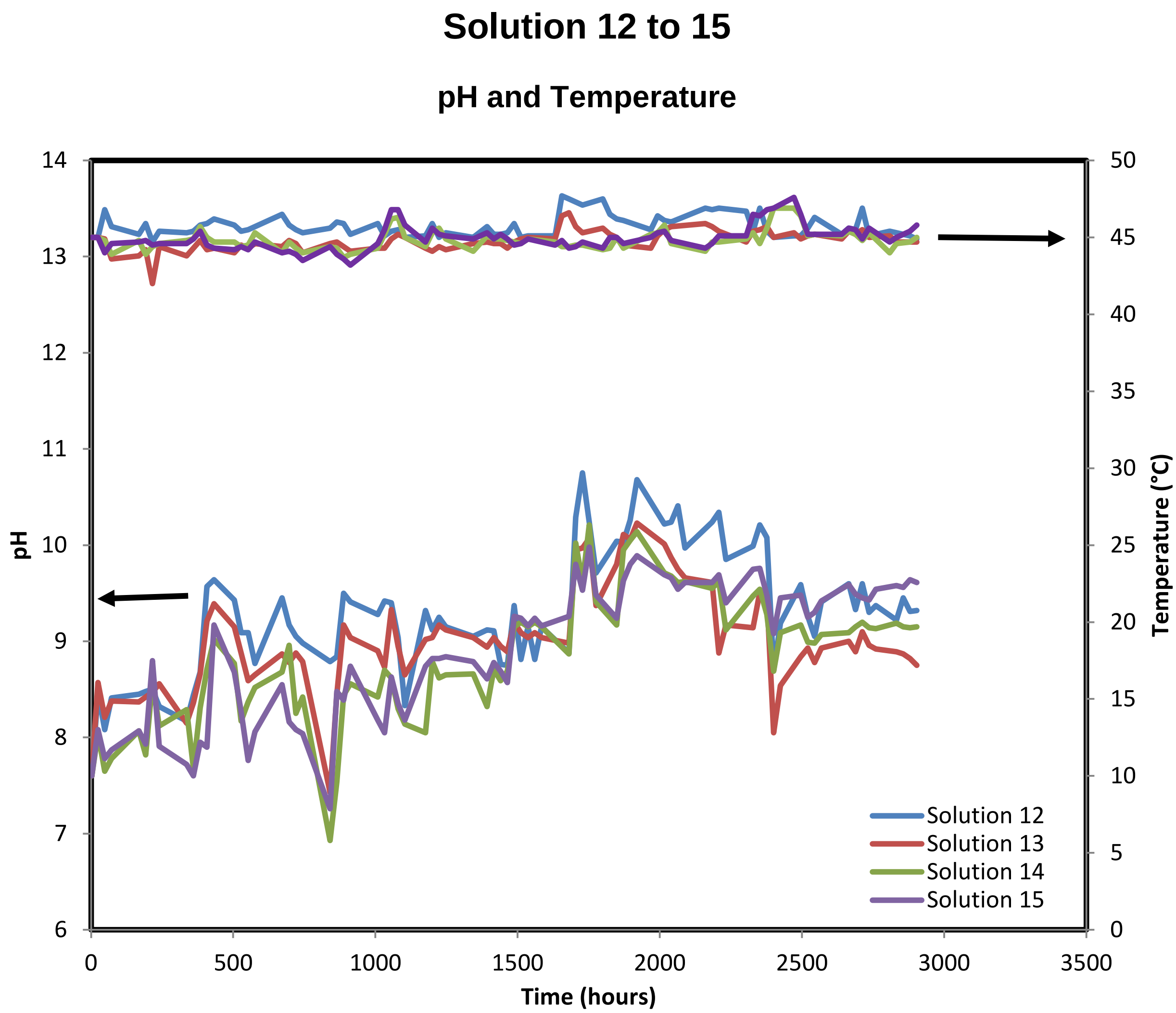


Solution 12 to 15

4 month samples

Open circuit potential vs. Time




Solution 12 to 15
pH and Temperature
pH
Temperature (°C)
Time (hours)
Solution 12
Solution 13
Solution 14
Solution 15
14
13
12
11
10
9
8
7
6
50
45
40
35
30
25
20
15
10
5
0
0
500
1000
1500
2000
2500
3000
3500

Appendix F

Chemical Composition of Simulants used in Waste Buffering (Task 3) with Electrochemical Results and After Pictures

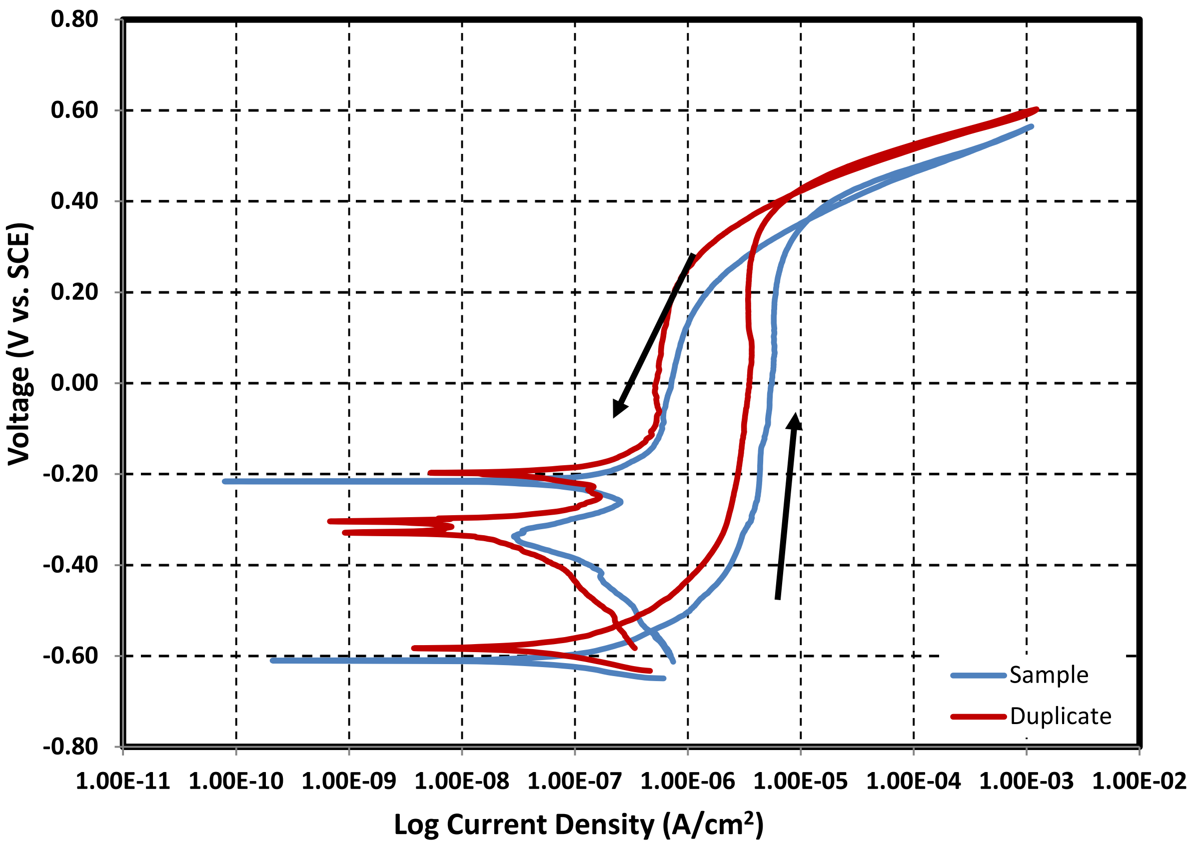
Composition of simulant for waste buffering-Test 1

Test 1

Temperature	40	°C
Volume	1.4	L
pH	12.49	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	NaCl	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	NaOH	40.0000	3.19122604	178.7087
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.426	169.6940
Sodium nitrite	$NaNO_2$	69.0000	1	96.6000

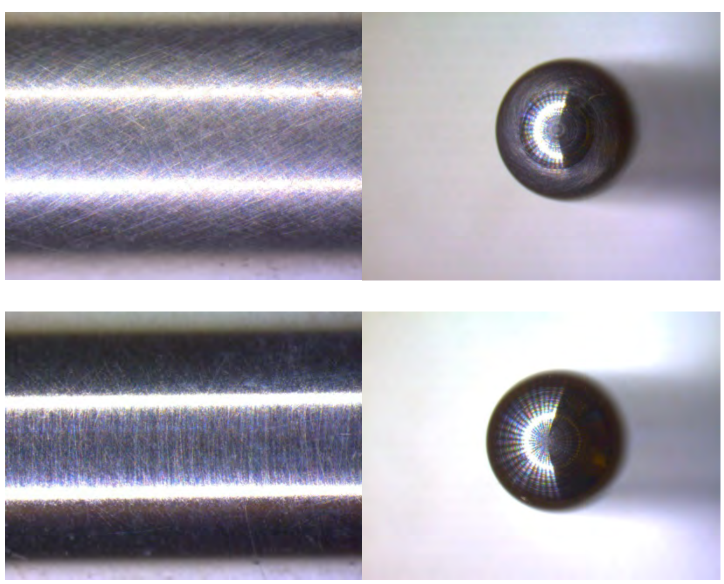
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 1

Test 1D



Shank (20X) Nose (10X)

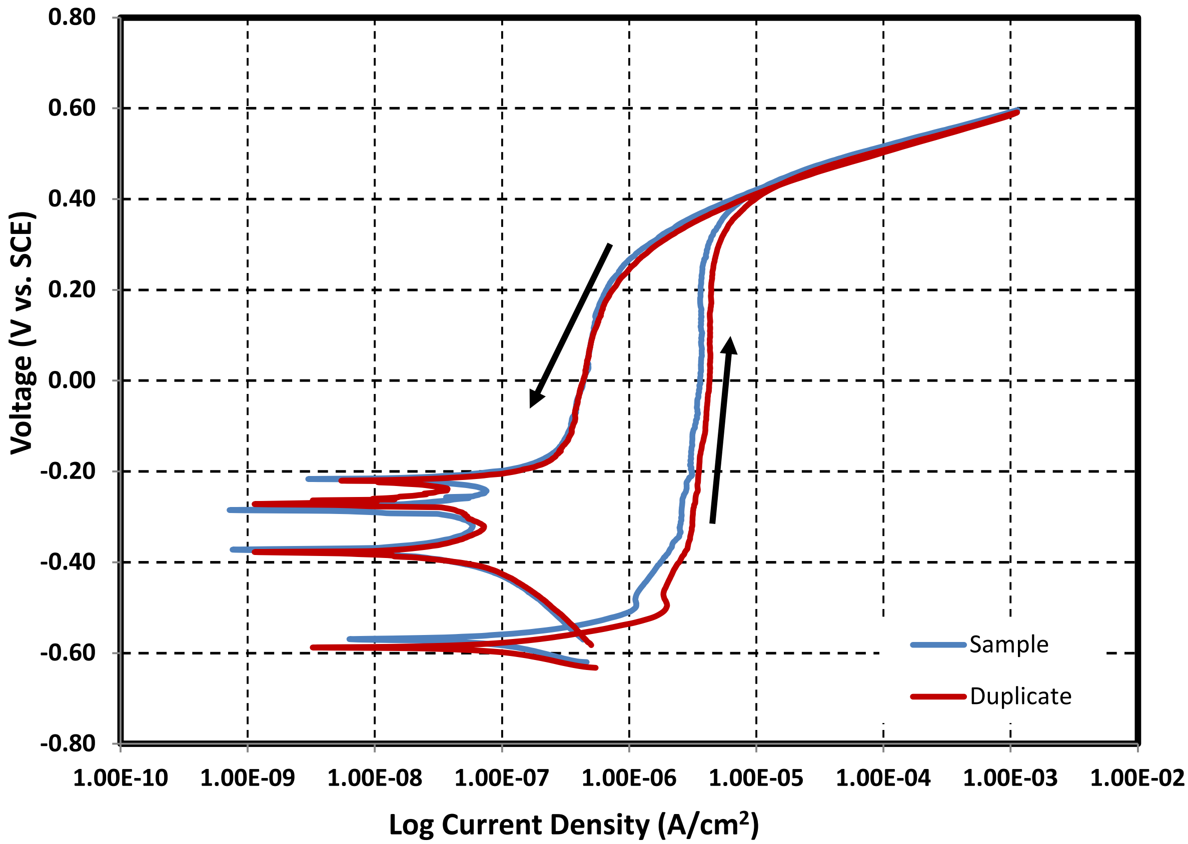
Composition of simulant for waste buffering-Test 2

Test 2

Temperature	50	°C
Volume	1.4	L
pH	12-13	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	$NaCl$	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	$NaOH$	40.0000	3.19122604	178.7087
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.426	169.6940
Sodium nitrite	$NaNO_2$	69.0000	2	193.2000

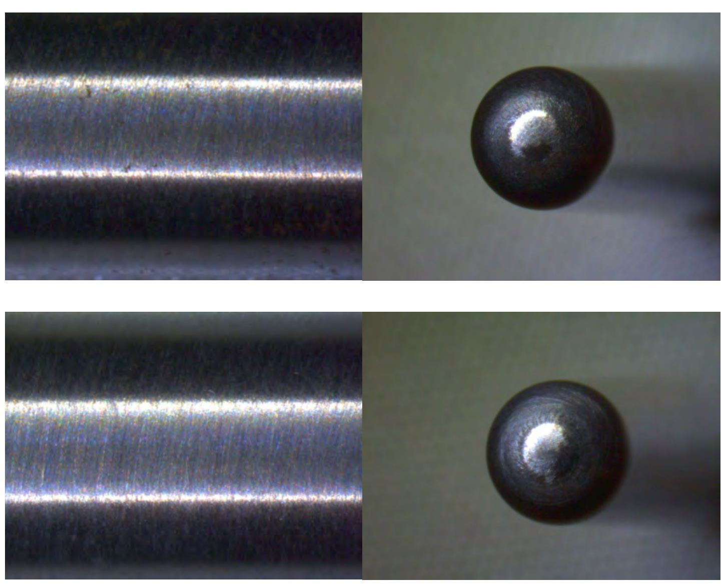
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 2

Test 2D



Shank (20X) **Nose (10X)**

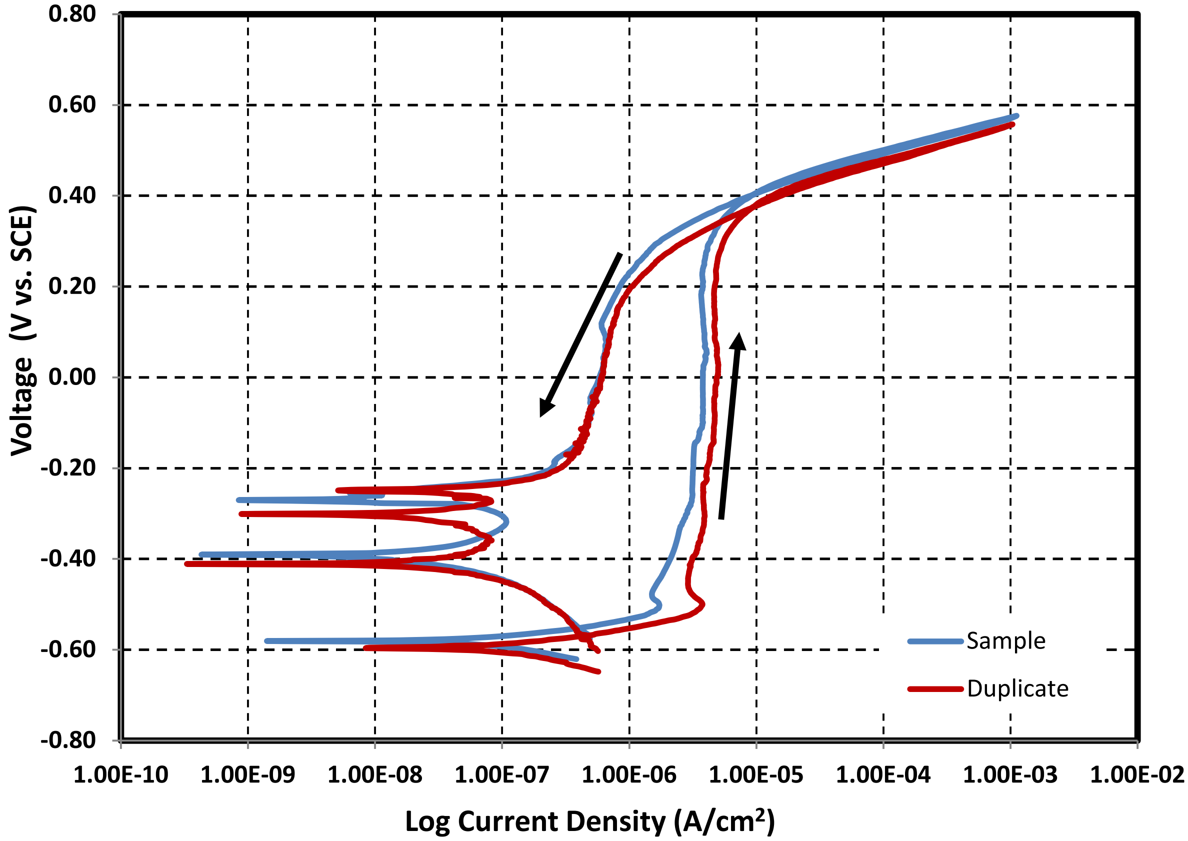
Composition of simulant for waste buffering-Test 3

Test 3

Temperature	50	°C
Volume	1.4	L
pH	12-13	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	NaCl	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	NaOH	40.0000	3.19122604	178.7087
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	27.3448
Sodium formate	Na(CHO2)	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.426	169.6940
Sodium nitrite	$NaNO_2$	69.0000	2.5	241.5000

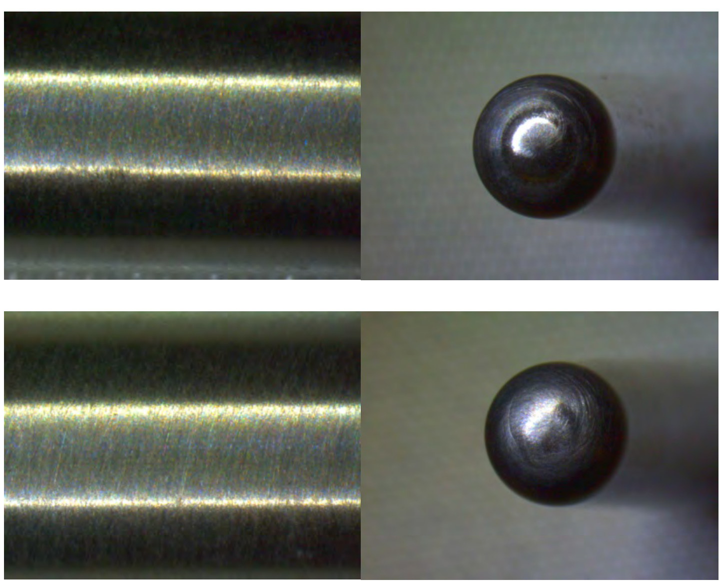
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 3

Test 3D



Shank (20X) **Nose (10X)**

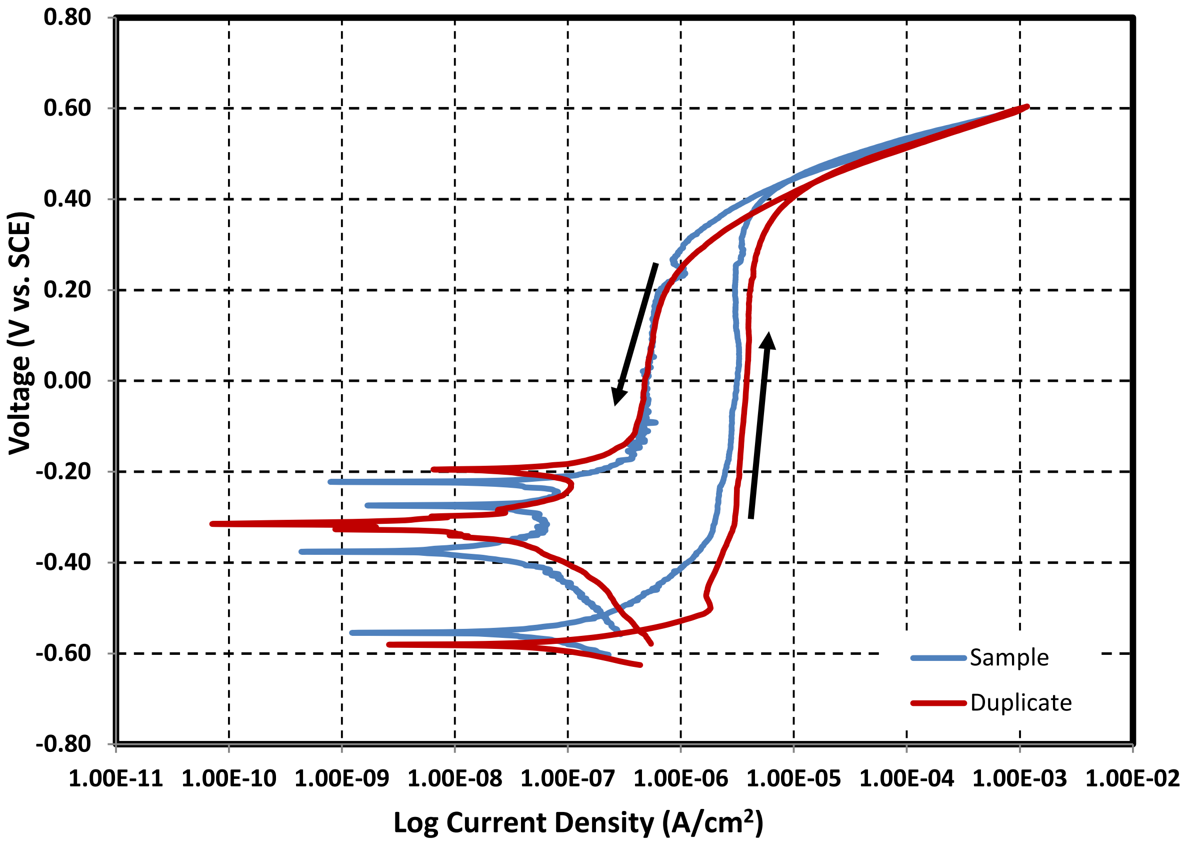
Composition of simulant for waste buffering-Test 4

Test 4

Temperature	50	°C
Volume	1.4	L
pH	12-13	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	$NaCl$	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	$NaOH$	40.0000	3.09122604	173.1087
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.426	169.6940
Sodium nitrite	$NaNO_2$	69.0000	1	96.6000

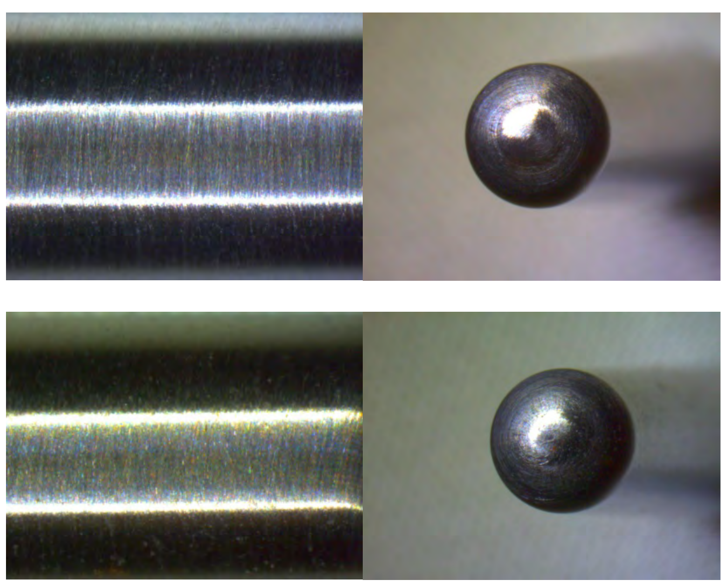
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 4

Test 4D



Shank (20X) Nose (10X)

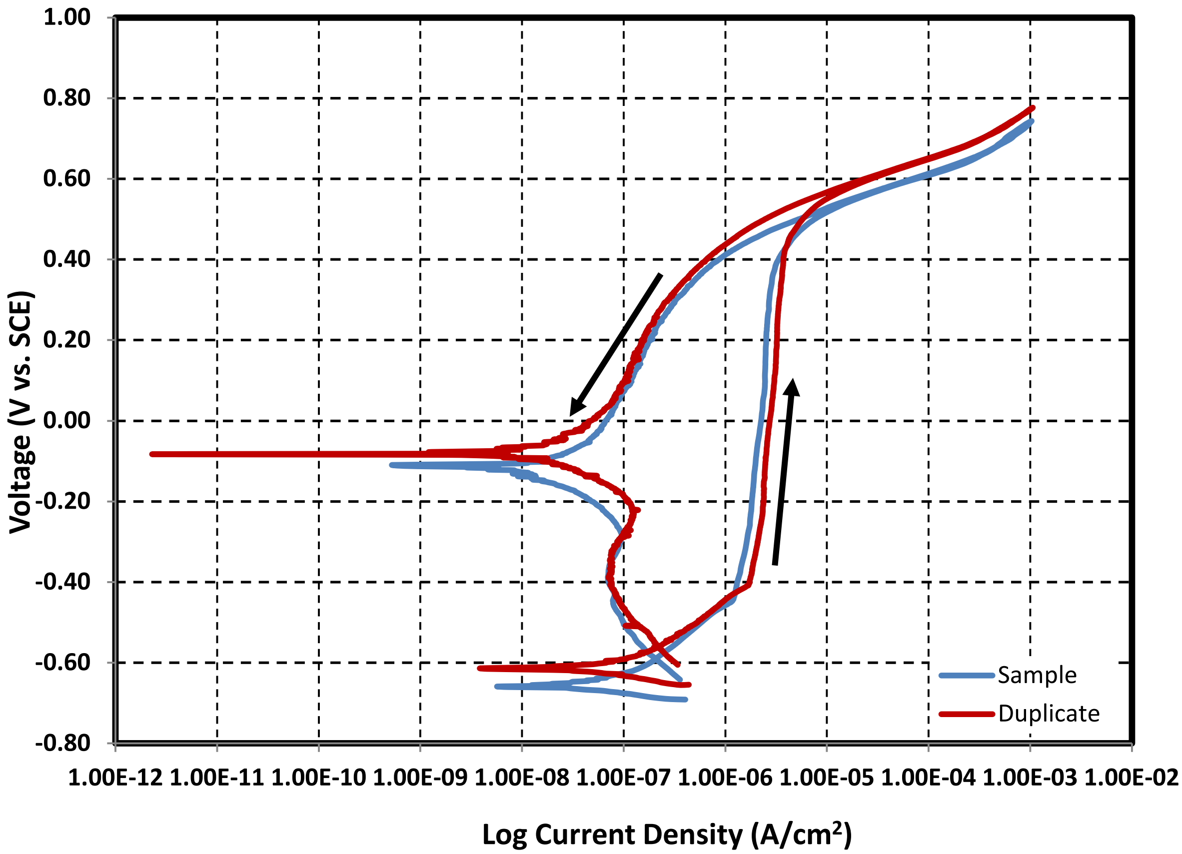
Composition of simulant for waste buffering-Test 5

Test 5

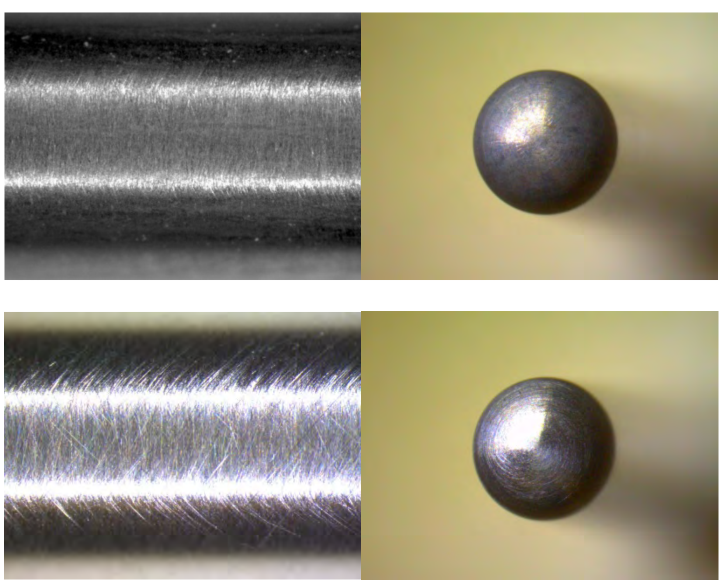
Temperature	30	°C
Volume	1.4	L
pH	12.62	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	NaCl	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	NaOH	40.0000	3.00122604	168.0687
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.536	182.7840
Sodium nitrite	$NaNO_2$	69.0000	1.95	188.3700

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



Test 5

Test 5D

Shank (20X) **Nose (10X)**

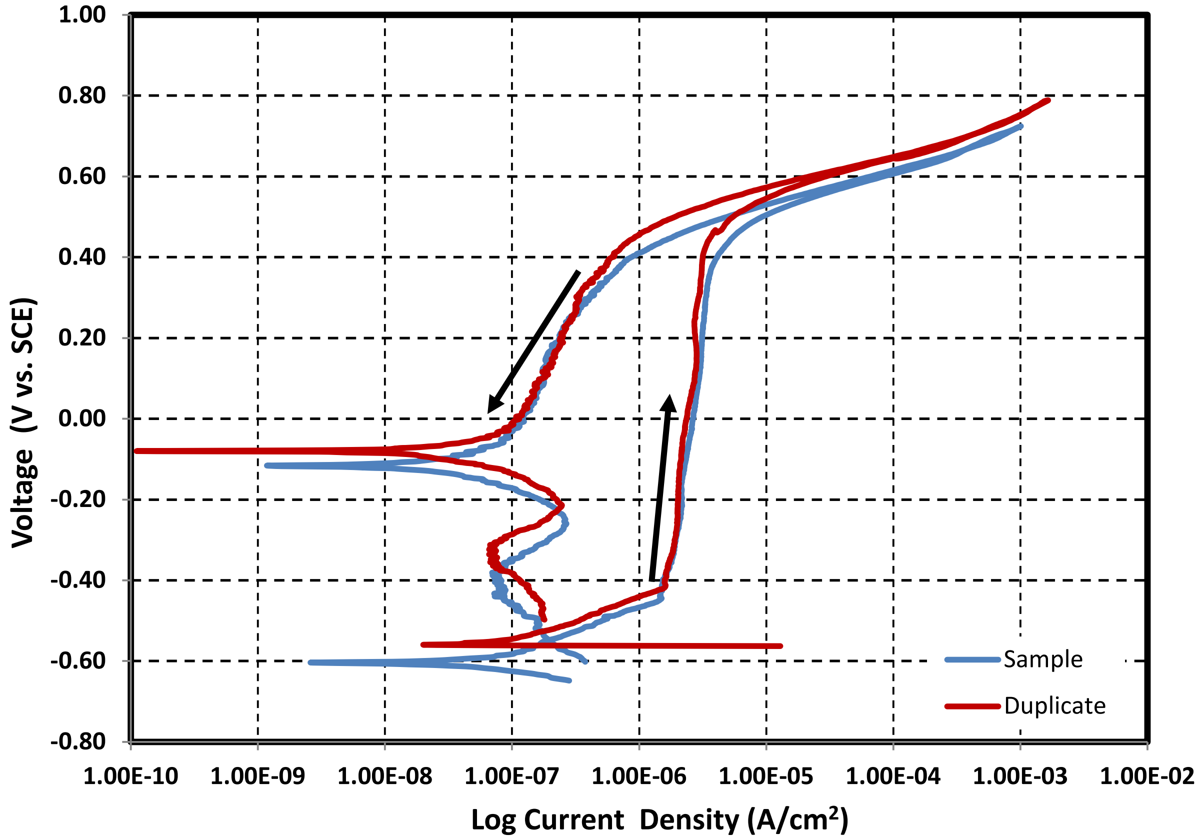
Composition of simulant for waste buffering-Test 6

Test 6

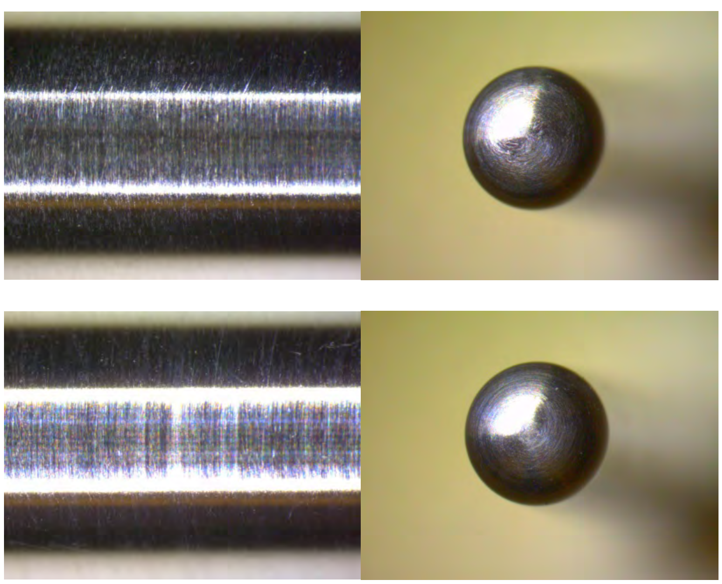
Temperature	40	°C
Volume	1.4	L
pH	12.62	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	$NaCl$	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	$NaOH$	40.0000	3.00122604	168.0687
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.536	182.7840
Sodium nitrite	$NaNO_2$	69.0000	1.95	188.3700

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



Test 6

Test 6D

Shank (20X) **Nose (10X)**

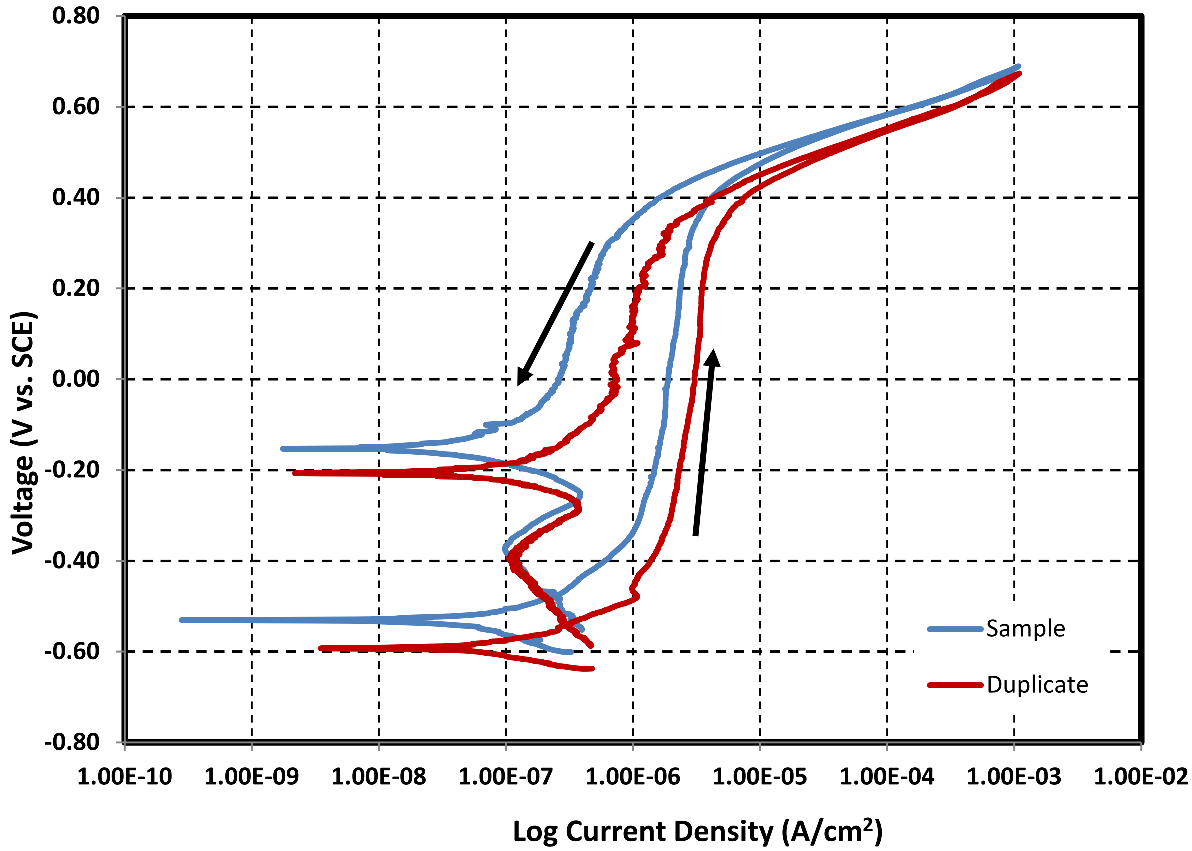
Composition of simulant for waste buffering-Test 7

Test 7

Temperature	50	°C
Volume	1.4	L
pH	12.62	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	$NaCl$	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	$NaOH$	40.0000	3.00122604	168.0687
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.536	182.7840
Sodium nitrite	$NaNO_2$	69.0000	1.95	188.3700

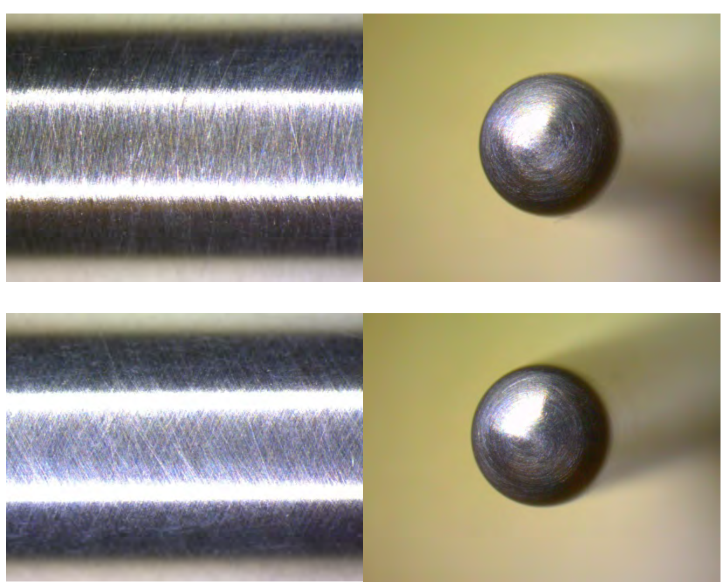
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 7

Test 7D



Shank (20X) **Nose (10X)**

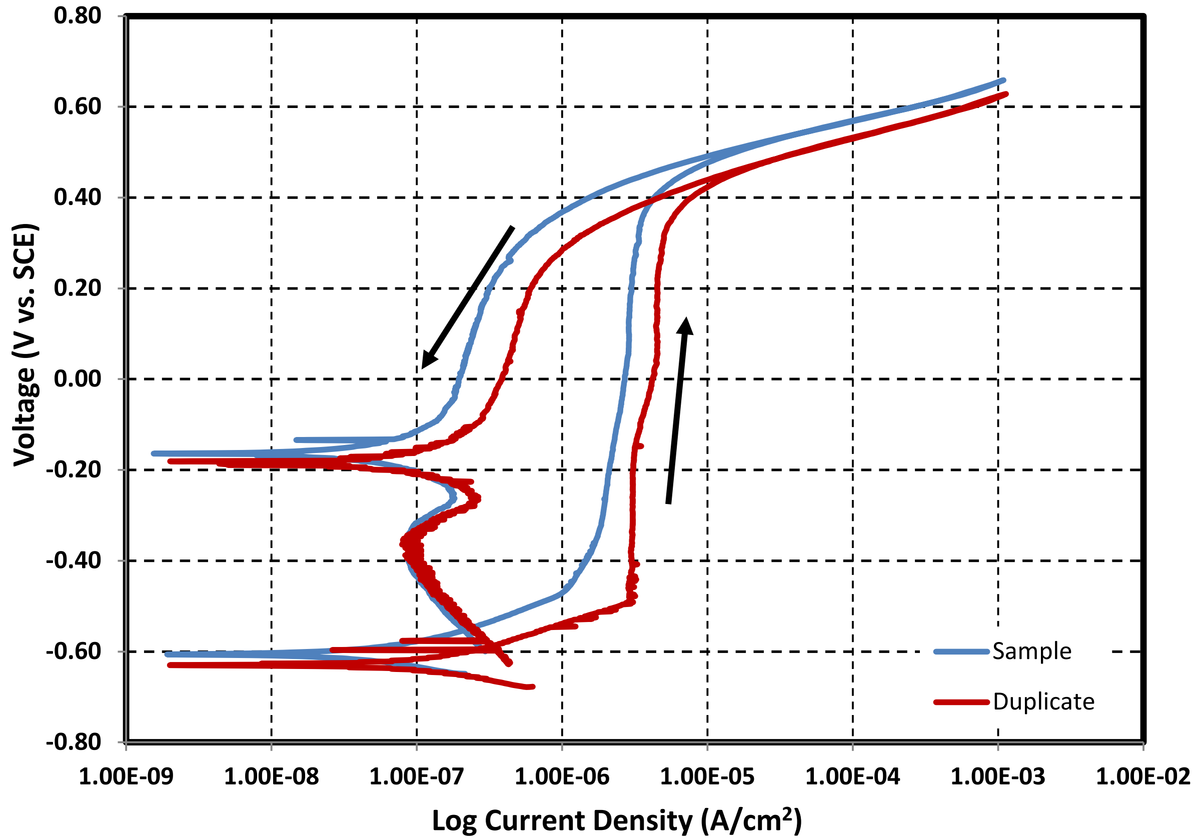
Composition of simulant for waste buffering-Test 8

Test 8

Temperature	50	°C
Volume	1.4	L
pH	12.00	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	$NaCl$	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	$NaOH$	40.0000	2.99122604	167.5087
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.326	157.7940
Sodium nitrite	$NaNO_2$	69.0000	1.94	187.4040

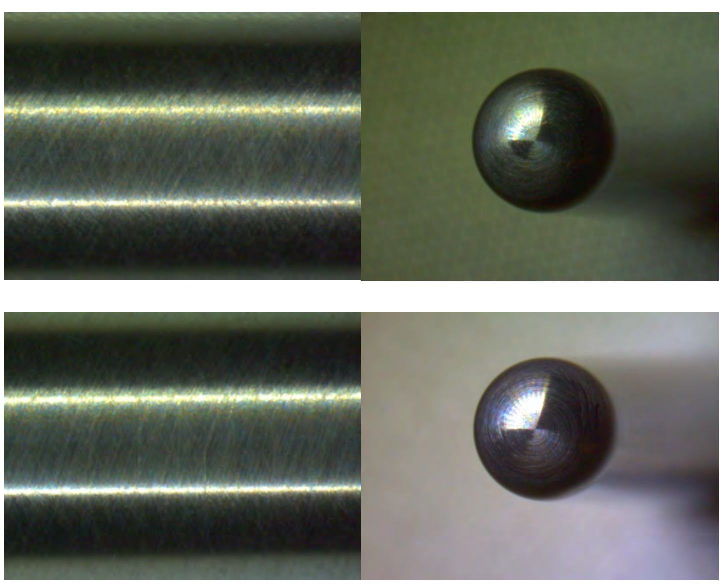
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 8

Test 8D



Shank (20X) **Nose (10X)**

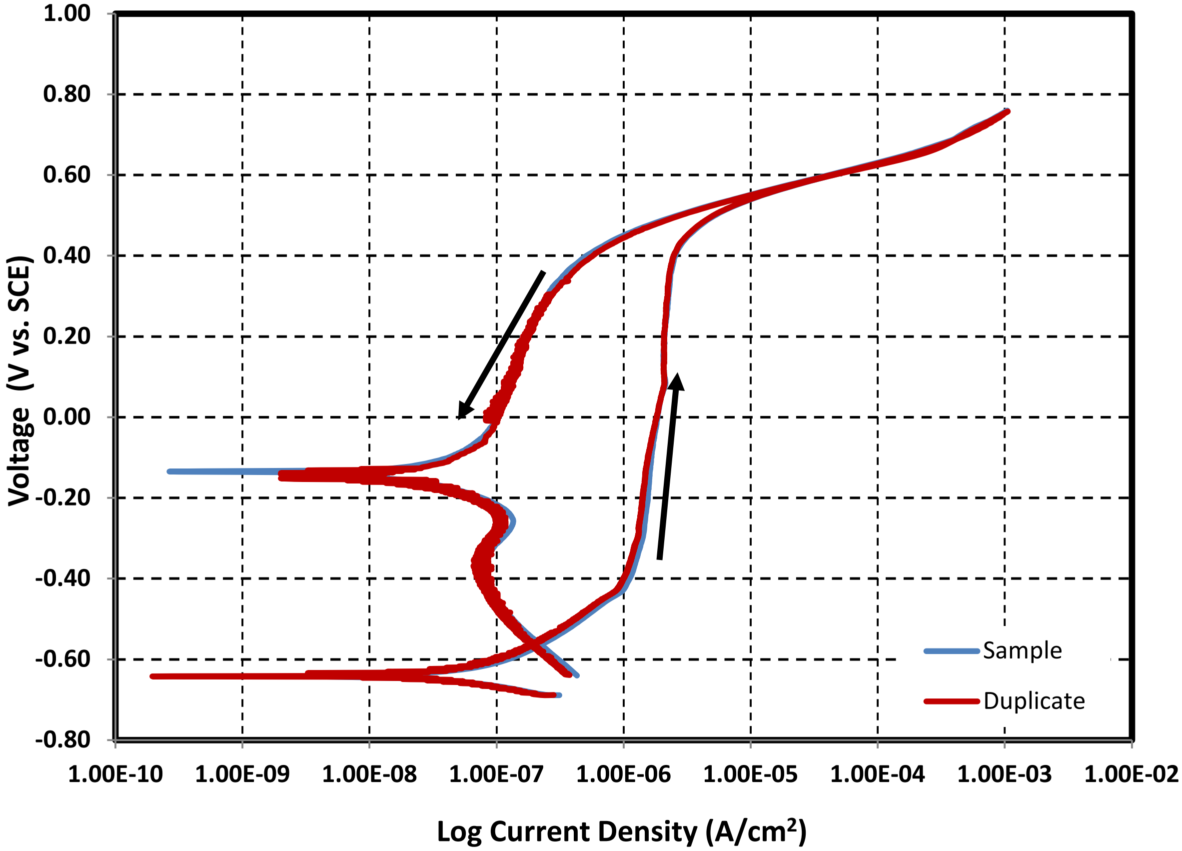
Composition of simulant for waste buffering-Test 9

Test 9

Temperature	30	°C
Volume	1.4	L
pH	12.78	

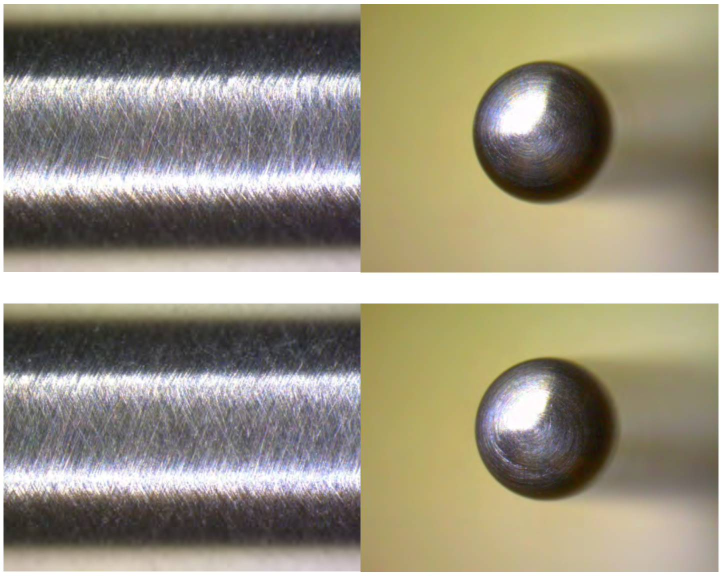
Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	NaCl	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	NaOH	40.0000	2.98122604	166.9487
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	2.196	261.3240
Sodium nitrite	$NaNO_2$	69.0000	2.24	216.3840

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 9		
Test 9D		



Shank (20X) Nose (10X)

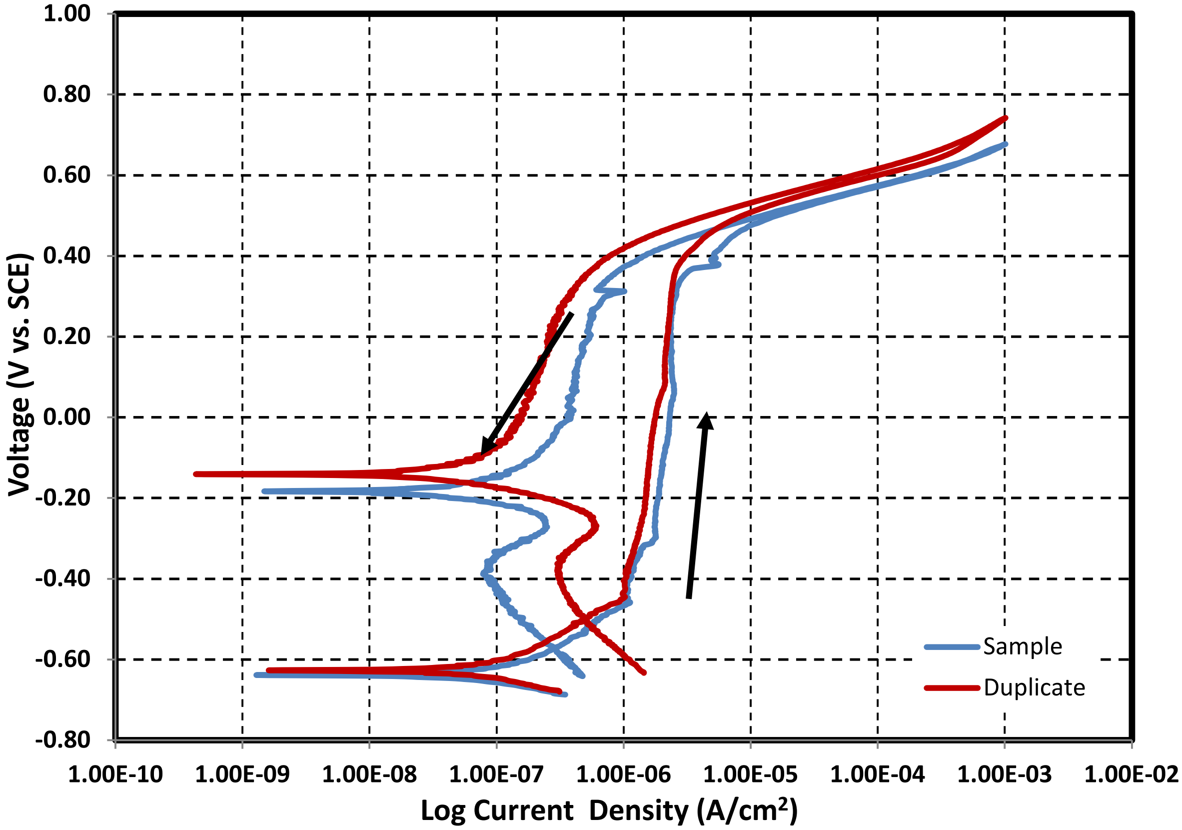
Composition of simulant for waste buffering-Test 10

Test 10

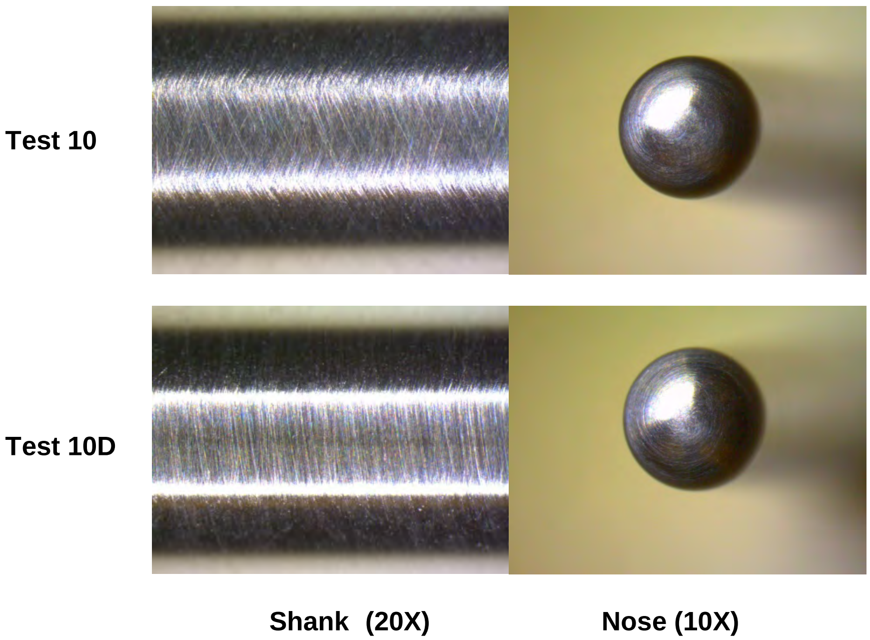
Temperature	40	°C
Volume	1.4	L
pH	12.78	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	$NaCl$	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	$NaOH$	40.0000	2.98122604	166.9487
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	2.196	261.3240
Sodium nitrite	$NaNO_2$	69.0000	2.24	216.3840

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



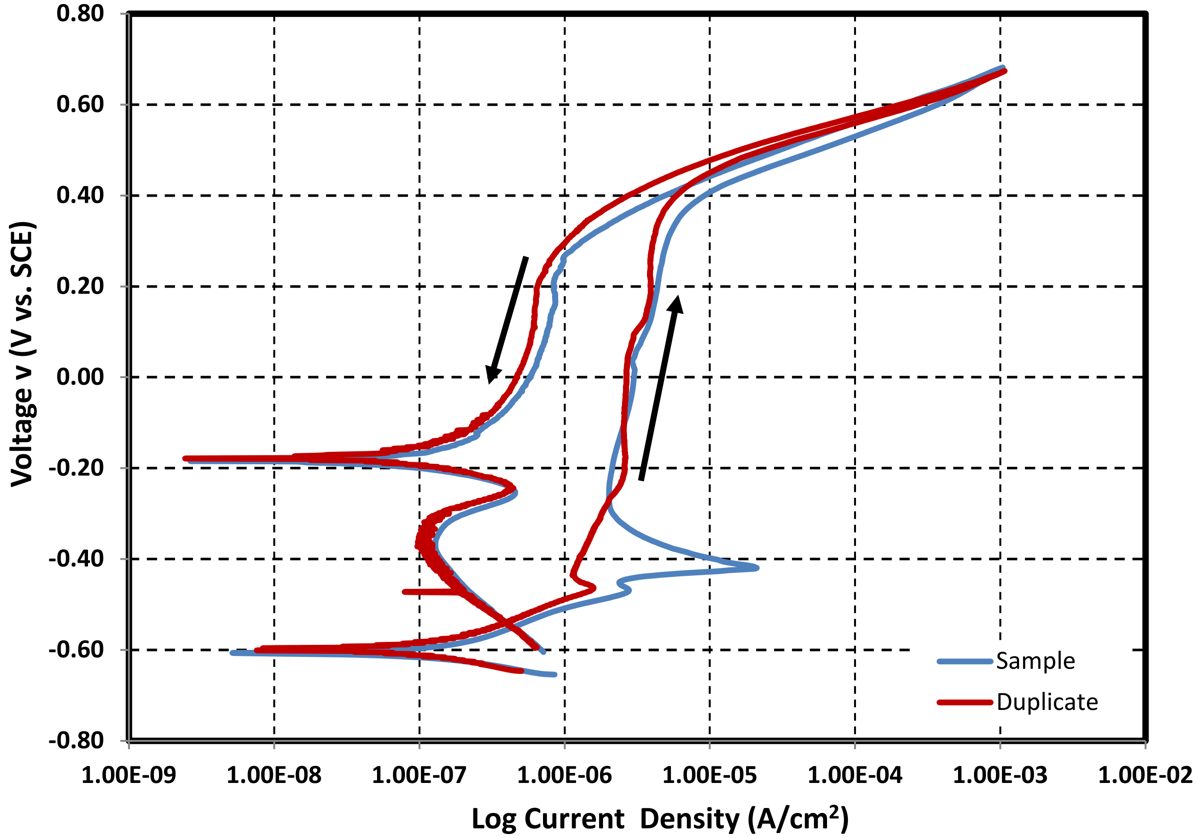
Composition of simulant for waste buffering-Test 11

Test 11

Temperature	50	°C
Volume	1.4	L
pH	12.78	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	$NaCl$	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	$NaOH$	40.0000	2.98122604	166.9487
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	2.196	261.3240
Sodium nitrite	$NaNO_2$	69.0000	2.24	216.3840

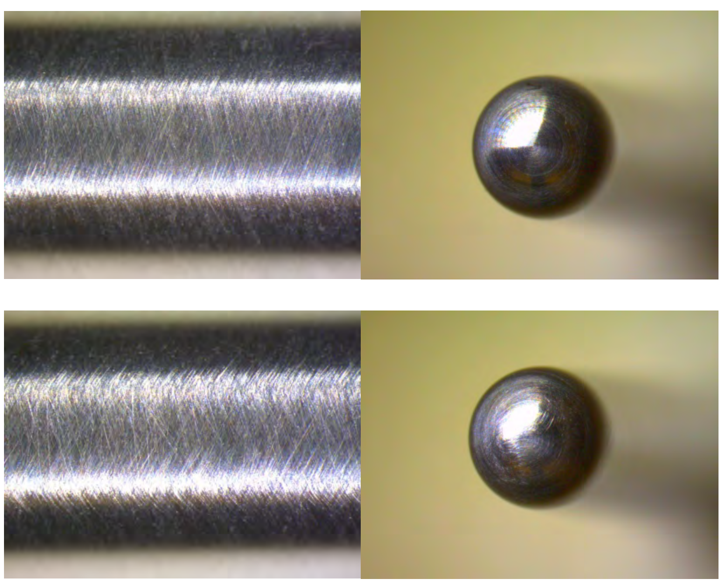
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 11

Test 11D



Shank (20X)

Nose (10X)

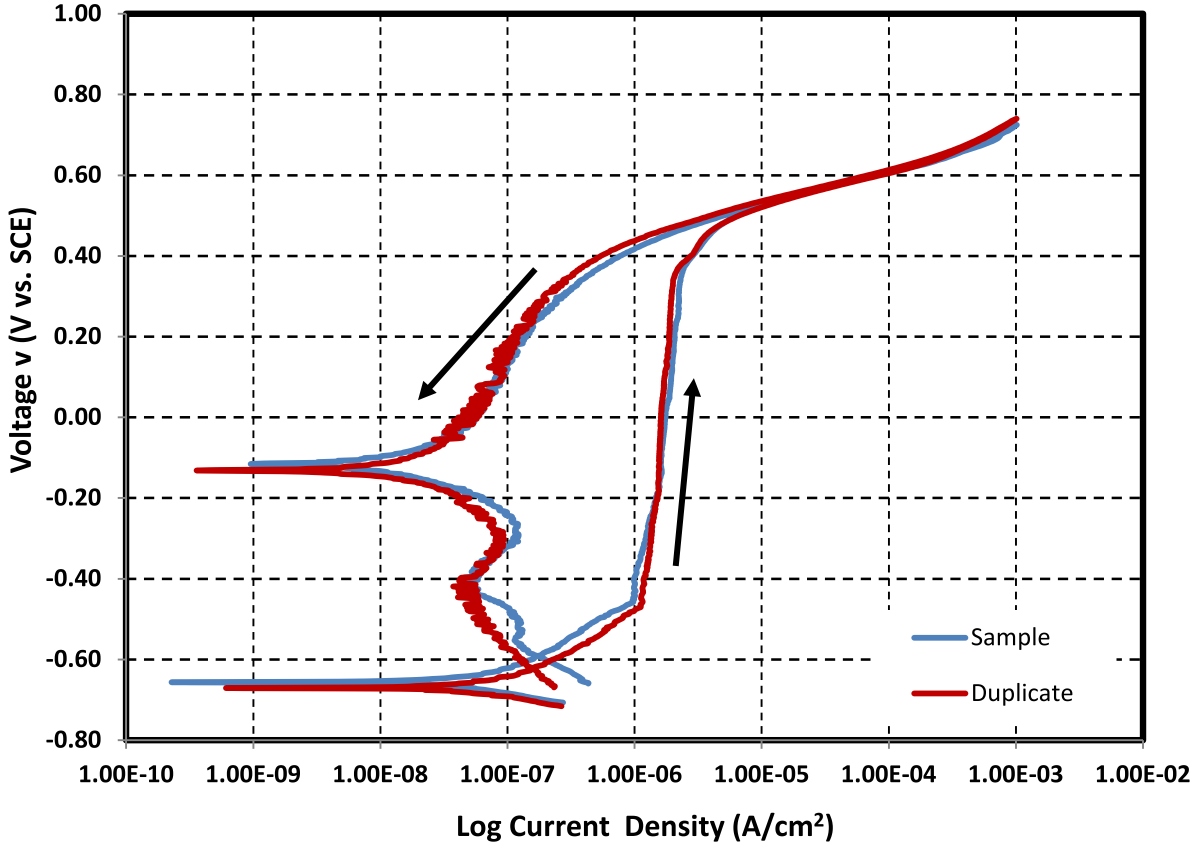
Composition of simulant for waste buffering-Test 12

Test 12

Temperature	30	°C
Volume	1.4	L
pH	12-13	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	NaCl	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	NaOH	40.0000	2.96122604	165.8287
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.486	176.8340
Sodium nitrite	$NaNO_2$	69.0000	1.91	184.5060

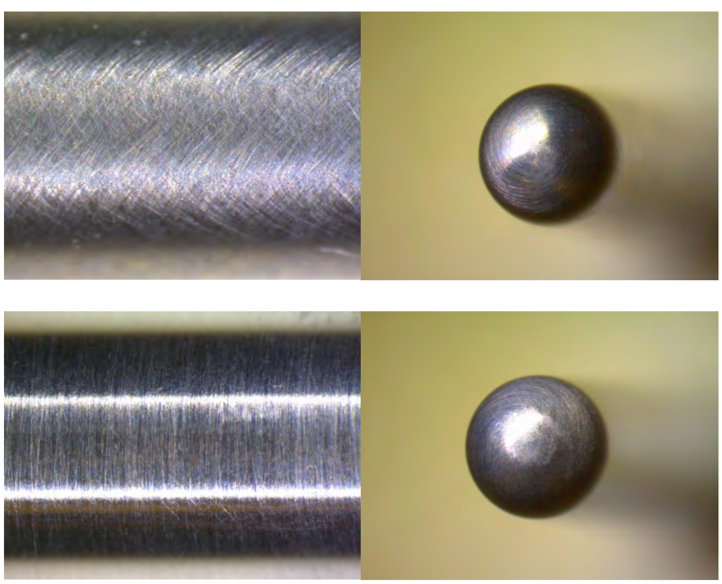
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 12

Test 12D



Shank (20X) **Nose (10X)**

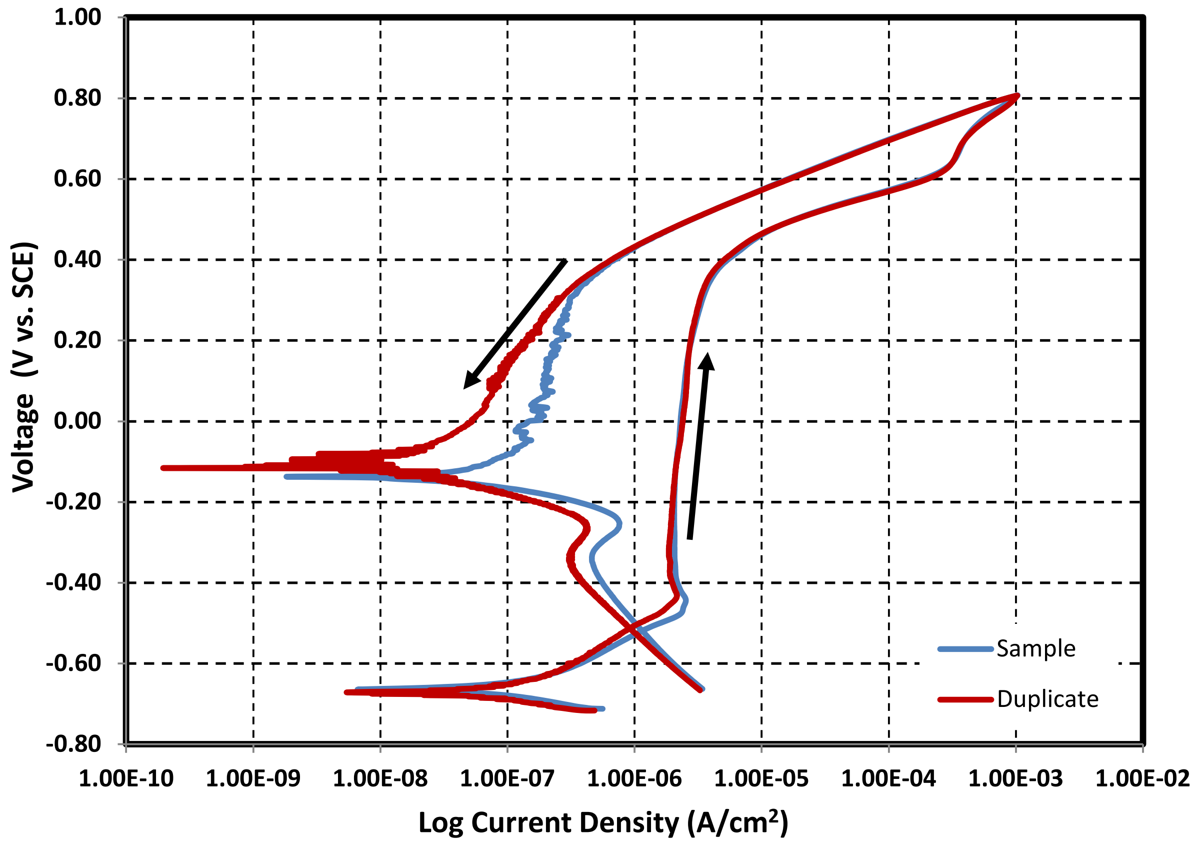
Composition of simulant for waste buffering-Test 13

Test 13

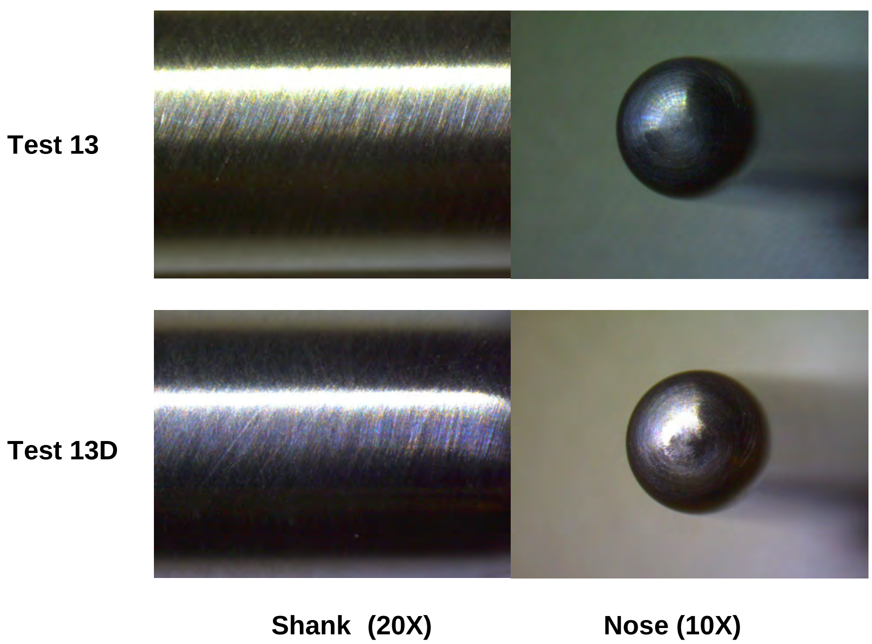
Temperature	30	°C
Volume	1.4	L
pH	12-13	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	$NaCl$	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	$NaOH$	40.0000	2.96122604	165.8287
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.826	217.2940
Sodium nitrite	$NaNO_2$	69.0000	2.13	205.7580

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



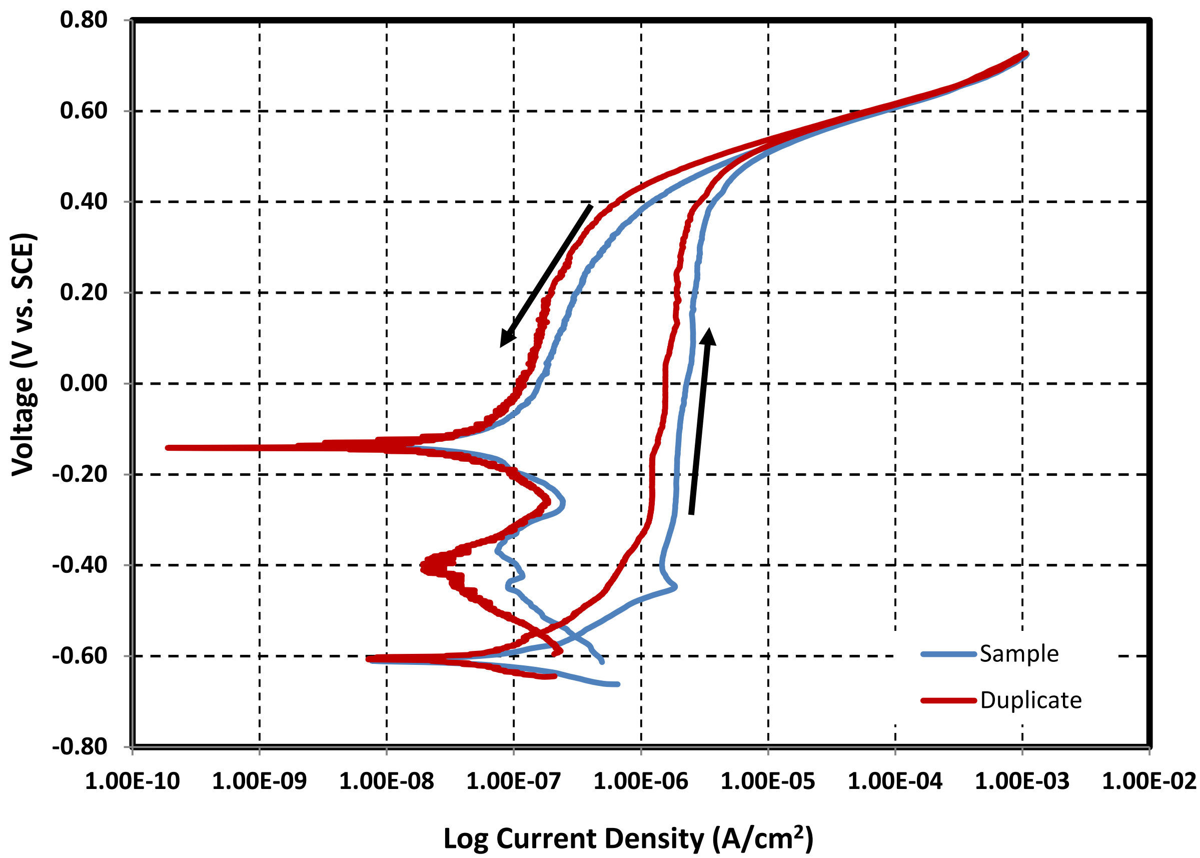
Composition of simulant for waste buffering-Test 14

Test 14

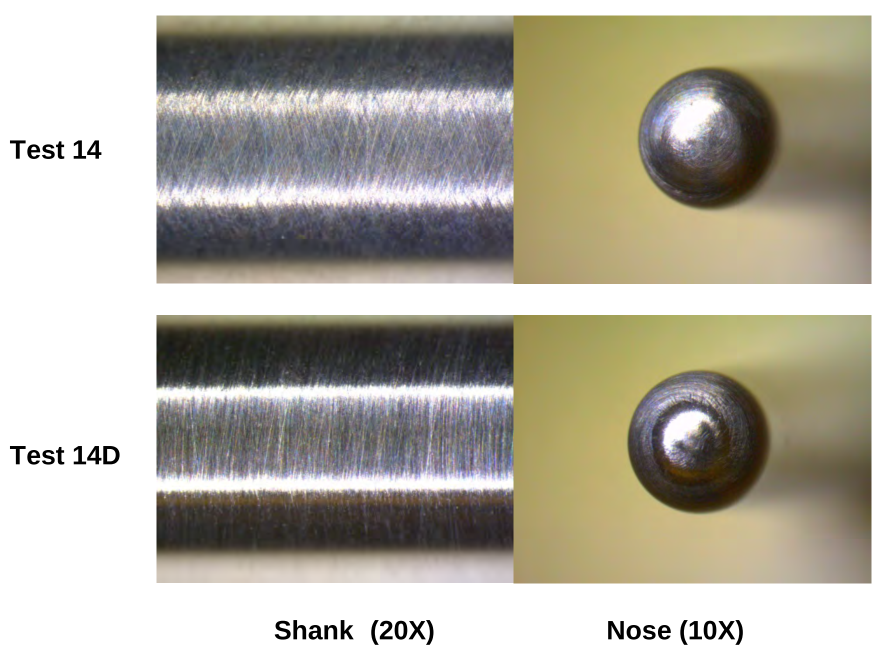
Temperature	40	°C
Volume	1.4	L
pH	12-13	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	NaCl	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	NaOH	40.0000	2.96122604	165.8287
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.486	176.8340
Sodium nitrite	$NaNO_2$	69.0000	1.91	184.5060

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



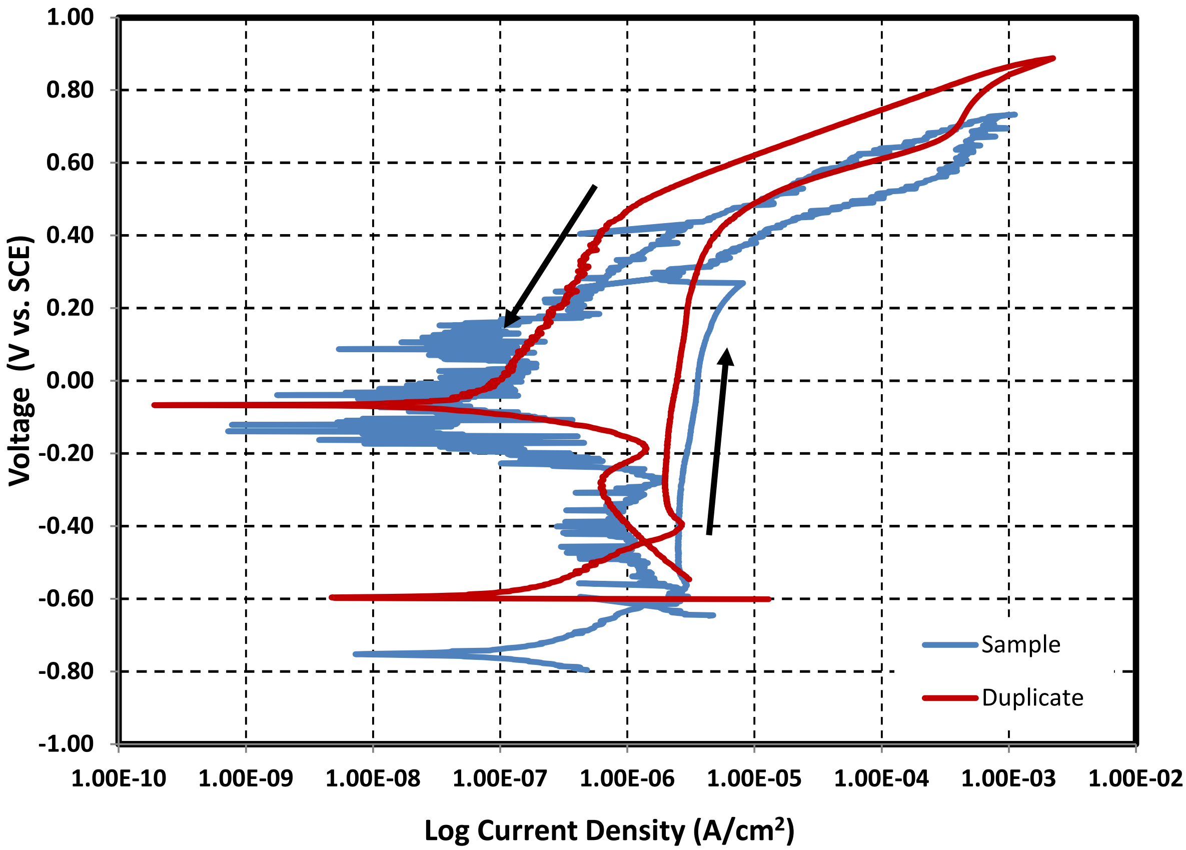
Composition of simulant for waste buffering-Test 15

Test 15

Temperature	40	°C
Volume	1.4	L
pH	12-13	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	$NaCl$	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	$NaOH$	40.0000	2.96122604	165.8287
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.826	217.2940
Sodium nitrite	$NaNO_2$	69.0000	2.13	205.7580

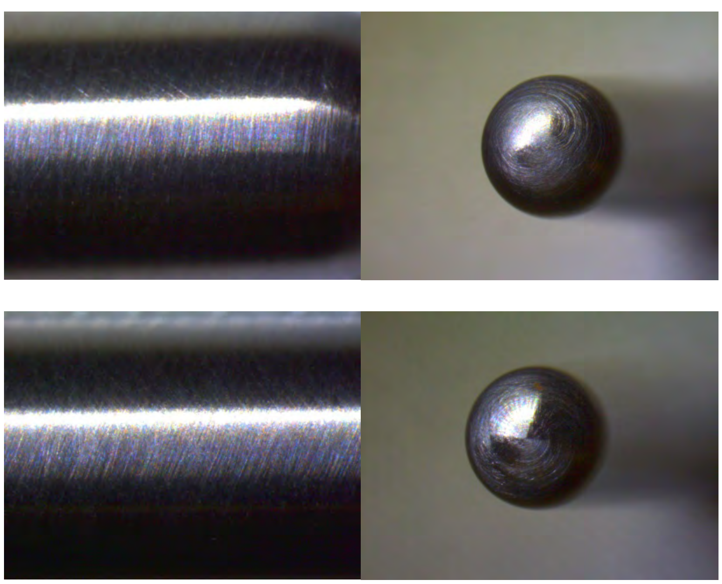
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 15

Test 15D



Shank (20X) Nose (10X)

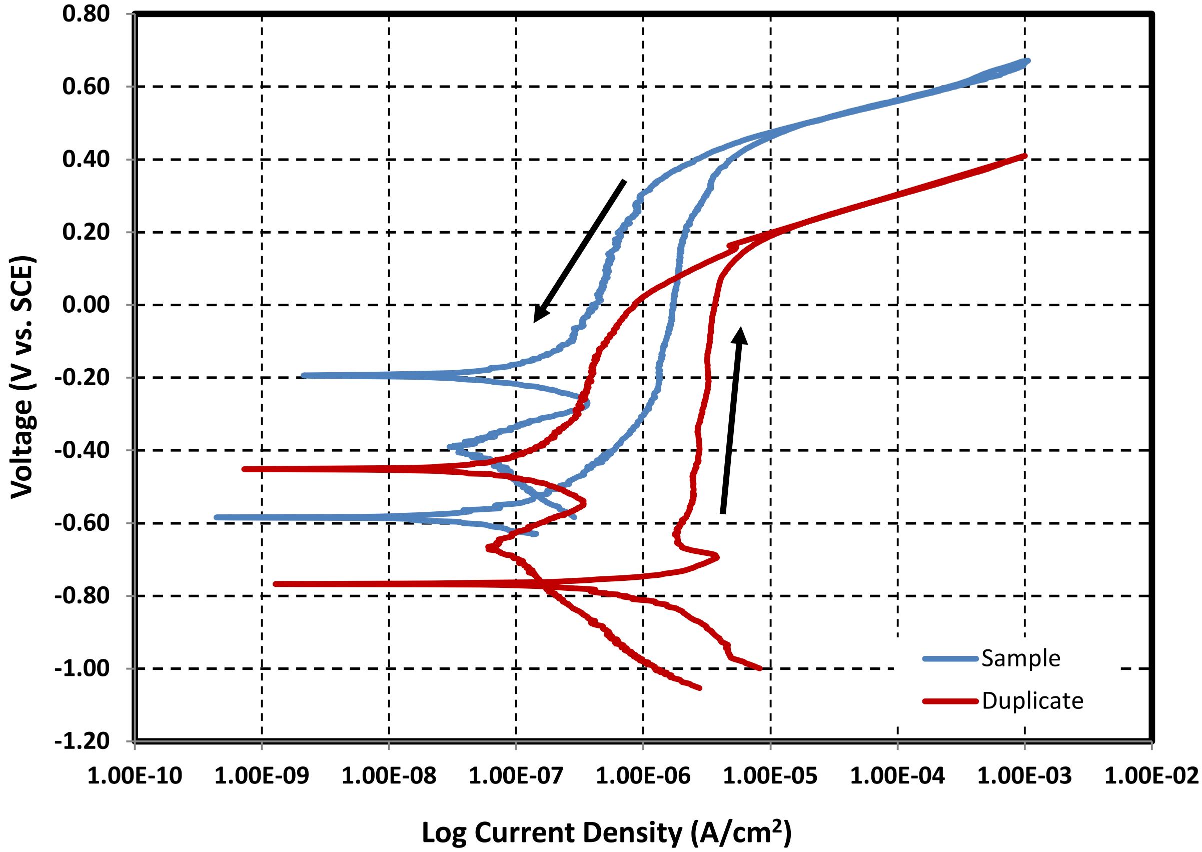
Composition of simulant for waste buffering-Test 16

Test 16

Temperature	50	°C
Volume	1.4	L
pH	12-13	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	$NaCl$	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	$NaOH$	40.0000	2.96122604	165.8287
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.486	176.8340
Sodium nitrite	$NaNO_2$	69.0000	1.91	184.5060

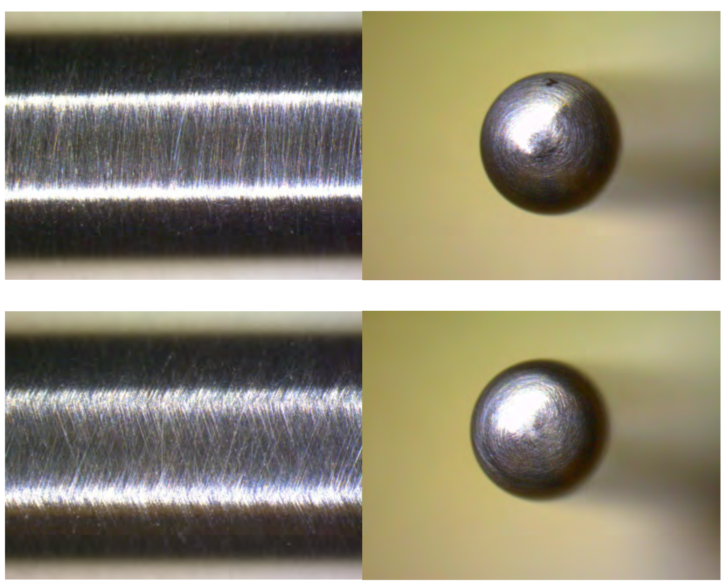
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 16

Test 16D



Shank (20X) Nose (10X)

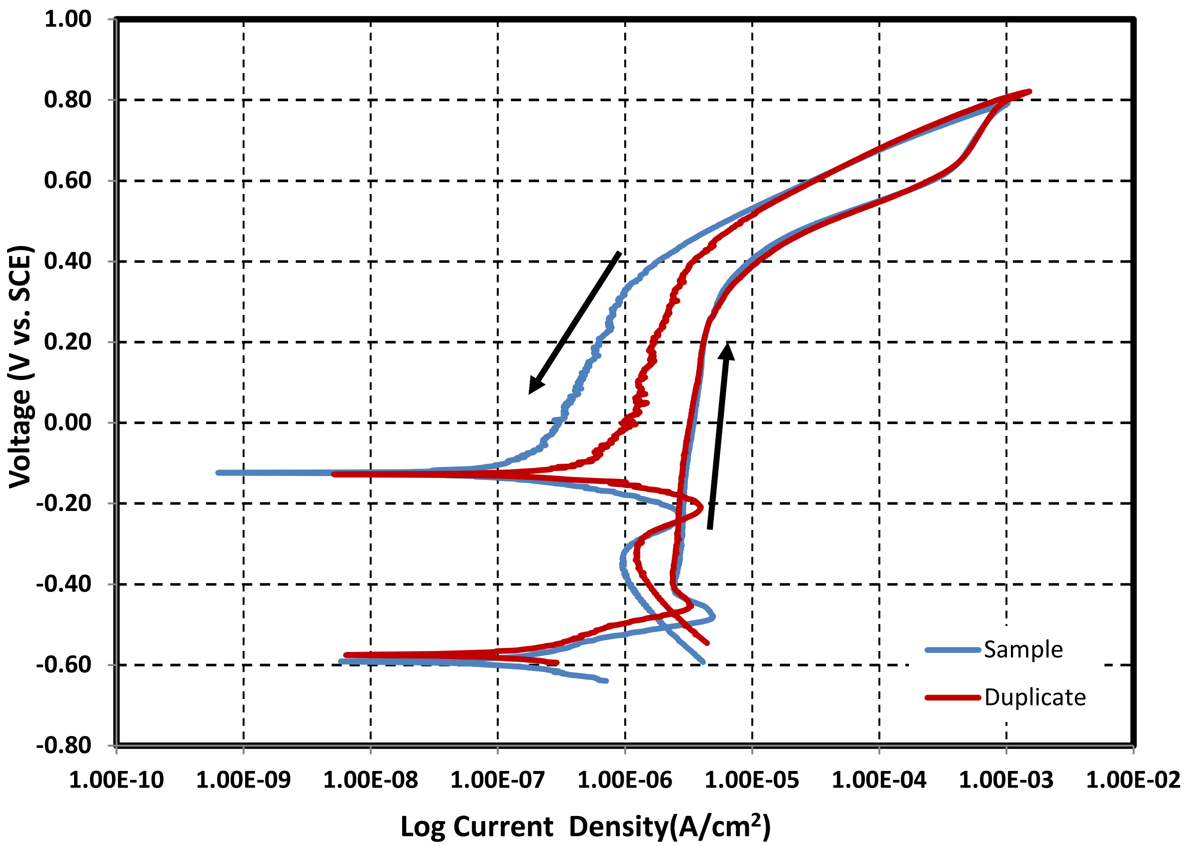
Composition of simulant for waste buffering-Test 17

Test 17

Temperature	50	°C
Volume	1.4	L
pH	12-13	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.0000	0.497	260.9250
Cadmium nitrate, 4-hydrate	$Cd(NO_3)_2.4H_2O$	308.0000	0.000553	0.2385
Calcium nitrate, 4-hydrate	$Ca(NO_3)_2.4H_2O$	236.0000	0.01	3.3040
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.0000	0.000375	0.1223
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.0000	0.000575	0.3252
Lanthanum nitrate, 6-hydrate	$La(NO_3)_3.6H_2O$	433.0000	0.0000864	0.0524
Lead nitrate	$Pb(NO_3)_2$	331.0000	0.000656	0.3040
Manganous chloride, 4-hydrate	$MnCl_2.4H_2O$	198.0000	0.000324	0.0898
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.0000	0.00675	2.7500
Potassium nitrate	$K(NO_3)$	101.0000	0.0464	6.5610
Disodium EDTA	$Na_2C_{10}H_{14}O_8.2H_2O$	372.0000	0.048108	25.0546
HEDTA	$C_{10}H_{18}N_2O_7$	278.0000	0.01899	7.3909
Sodium gluconate	$C_6H_{11}O_7Na$	218.0000	0.02532	7.7277
Citric acid, 1-hydrate	$C_6H_8O_7.H_2O$	210.0000	0.111408	32.7540
Nitrilotriacetic Acid	$C_6H_9NO_6$	191.0000	0.007596	2.0312
Iminodiacetic Acid	$C_4H_7NO_2$	133.0000	0.112674	20.9799
Sodium chloride	NaCl	58.4000	0.106	8.6666
Sodium sulfate	Na_2SO_4	142.0000	0.128	25.4464
Ammonium Chloride	NH_4Cl	55.4920	0.00498	0.3869
Glycolic acid	$C_2H_4O_3$	76.1000	0.161	17.1529
Sodium hydroxide	NaOH	40.0000	2.96122604	165.8287
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.0000	0.0514	27.3448
Sodium formate	$Na(CHO_2)$	68.0000	0.233	22.1816
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.0208	3.9603
Sodium carbonate	Na_2CO_3	106.0000	1.12	166.2080
Sodium nitrate	$NaNO_3$	85.0000	1.826	217.2940
Sodium nitrite	$NaNO_2$	69.0000	2.13	205.7580

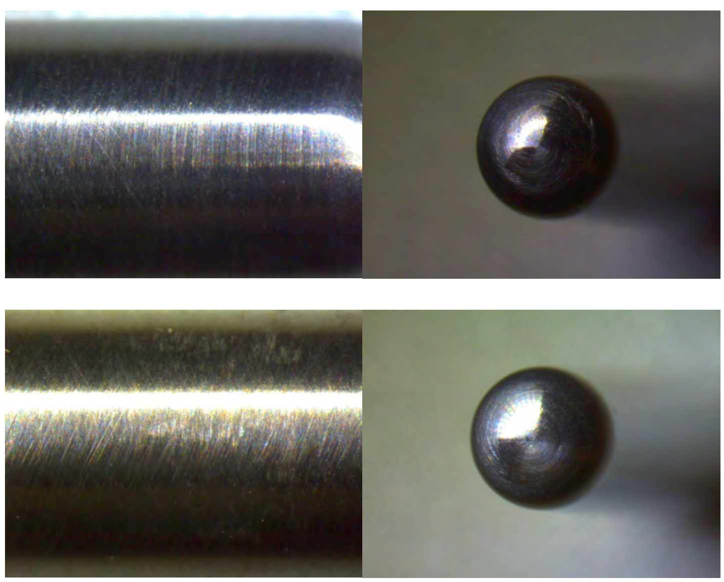
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 17

Test 17D



Shank (20X) Nose (10X)

Appendix G

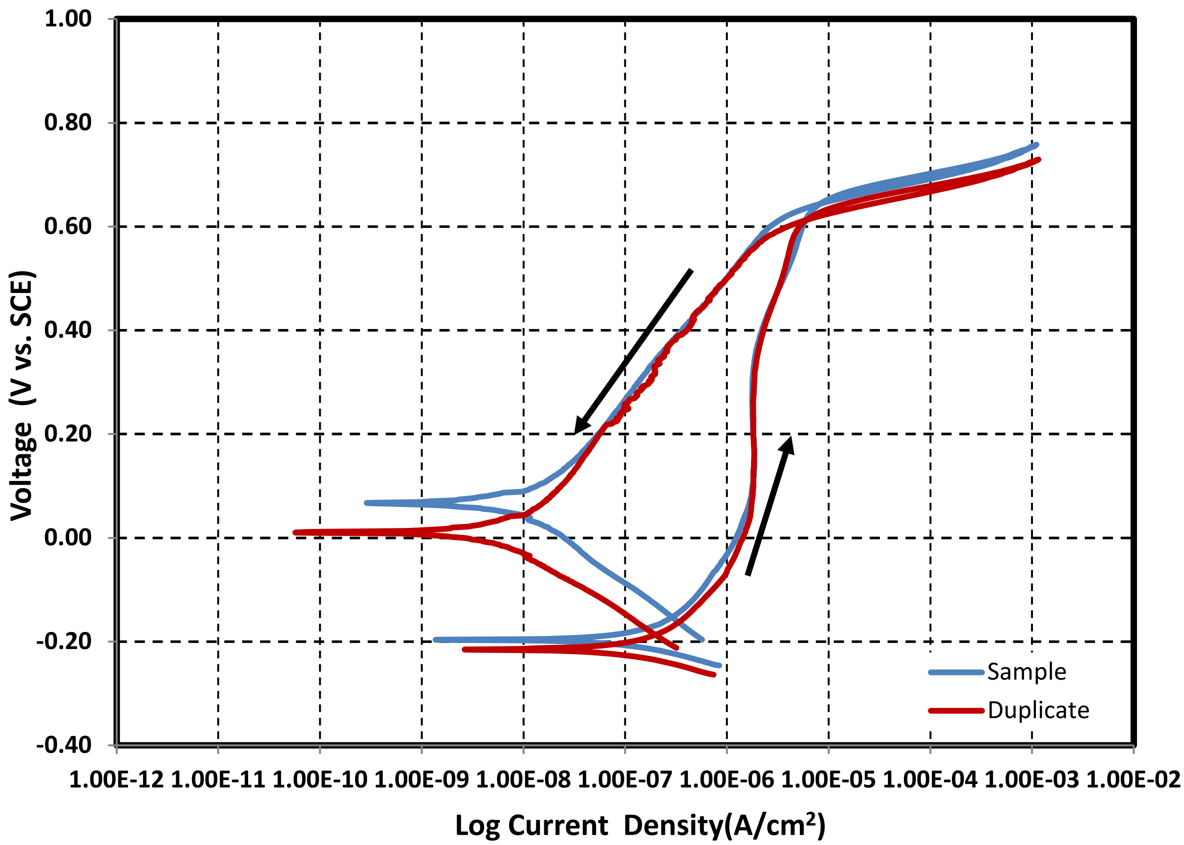
Chemical Composition of Simulants used in Pitting Corrosion (Task 4) with Electrochemical Results and After Pictures

Composition of simulant for pitting corrosion-Test 1

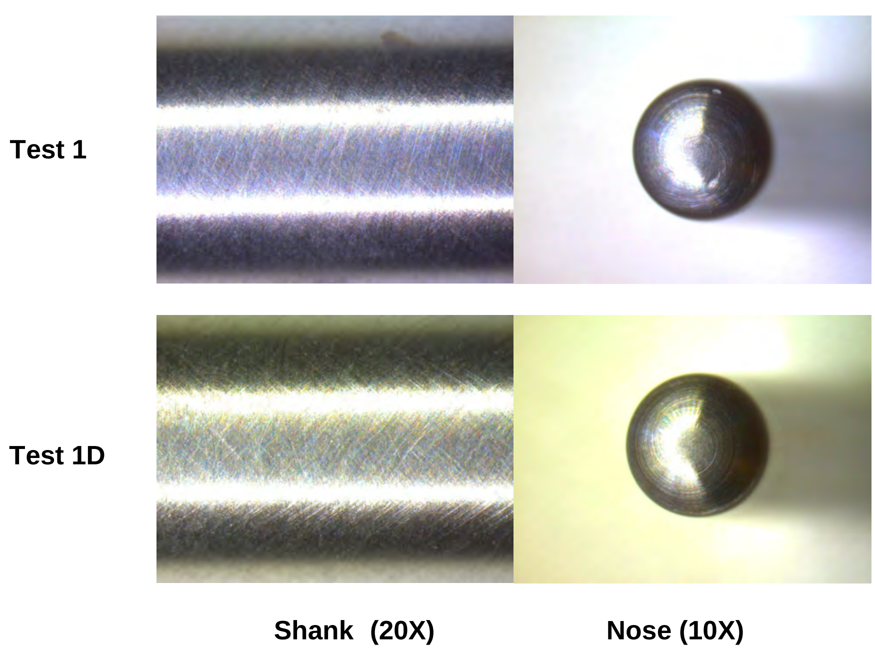
Reference 10	Temperature	40	°C
Test 1	pH	12.50	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium Carbonate	Na_2CO_3	106.00	0.0173	2.5673
Sodium Oxalate	$Na_2C_2O_4$	134.00	0.0000726	0.0136
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	0.00000387	0.0013
Sodium Metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.00002944	0.0087
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.00	0.00008272	0.0440
Sodium chloride	NaCl	58.40	0.0003185	0.0260
Sodium Fluoride	NaF	41.99	0.00015345	0.0090
Sodium sulfate	Na_2SO_4	142.00	0.0013674	0.2718
Sodium nitrate	$NaNO_3$	85.00	0.04	4.7600
Sodium nitrite	$NaNO_2$	69.00	0.015	1.4490
Sodium Hydroxide	NaOH	40.00	0.0304	1.7024

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

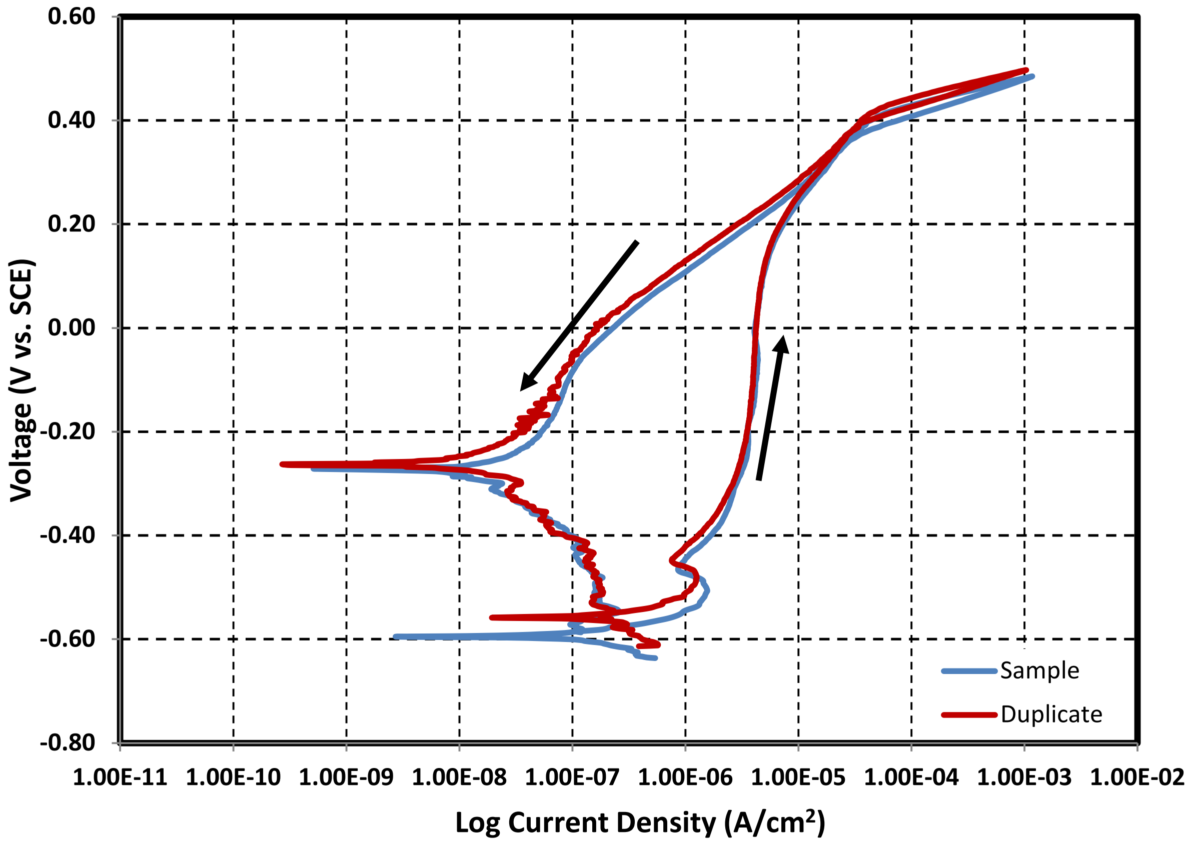


Composition of simulant for pitting corrosion -Test 2

Reference 19	Temperature	50	°C
Test 2	pH	14.50	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.868	103.2798
Sodium chloride	NaCl	58.44	0.046	3.7635
Sodium fluoride	NaF	42.00	0.084	4.9392
Sodium nitrite	$NaNO_2$	69.00	1.27	122.6820
Sodium hydroxide	NaOH	40.00	1.243	69.6080
Sodium carbonate	$Na_2(CO_3)$	106.00	1.118	165.9112
Sodium sulfate	Na_2SO_4	142.04	0.028	5.5680
Potassium Nitrate	KNO_3	101.1	0.767	108.5612
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.00	0.009	4.7880
Sodium aluminate	$NaAlO_2$	81.97	0.288	33.0503

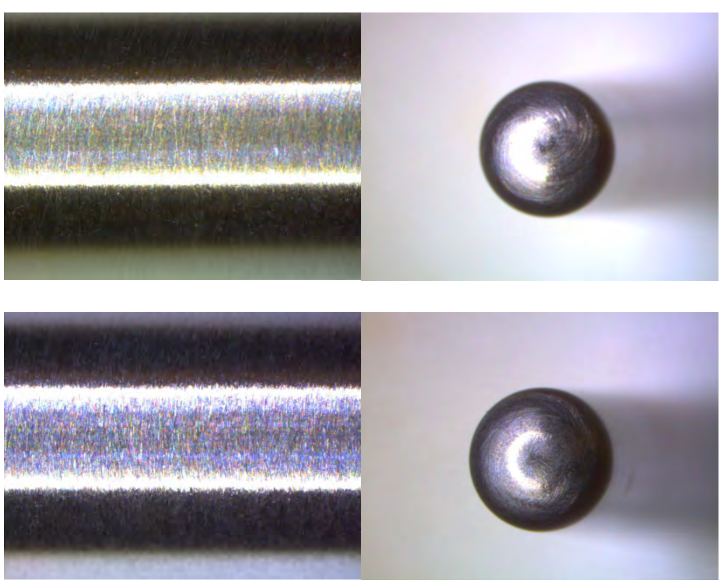
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 2

Test 2D



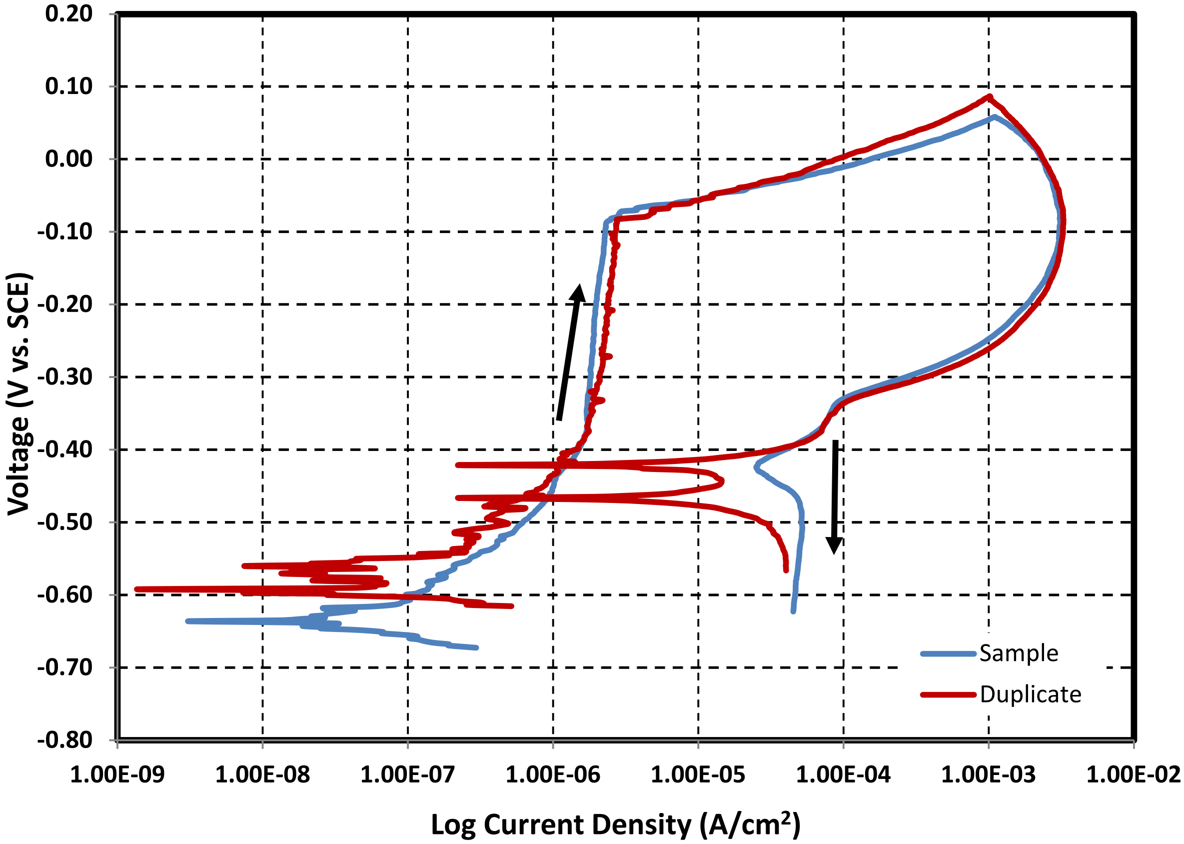
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion -Test 3

Reference 17	Temperature	50	°C
Test 3	pH	13.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	7	832.9020
Sodium nitrite	$NaNO_2$	69.00	0.1	9.6600
Sodium hydroxide	NaOH	40.00	0.1	5.6000
Sodium chloride	NaCl	58.44	0.1	8.1816
Sodium sulfate	Na_2SO_4	142.04	0.1	19.8856
Sodium carbonate	$Na_2(CO_3)$	106.00	0.1	14.8400
Sodium aluminate	$NaAlO_2$	81.97	0.5	57.3790
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.00	0.05	26.6000

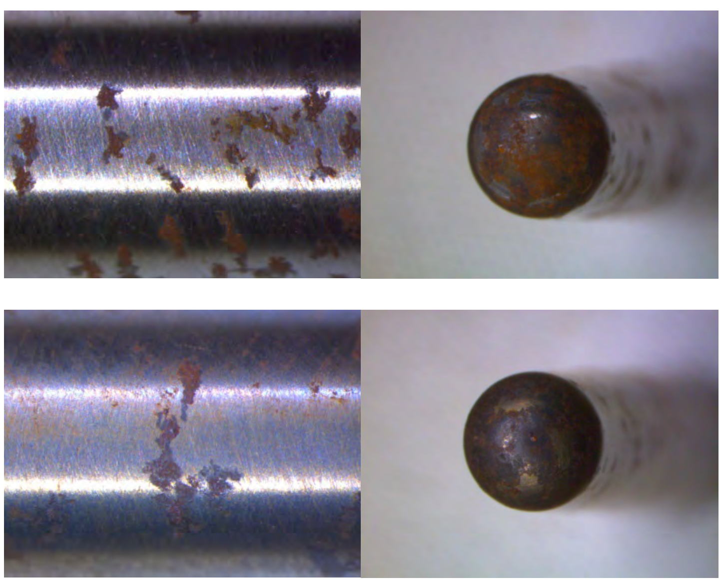
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 3

Test 3D



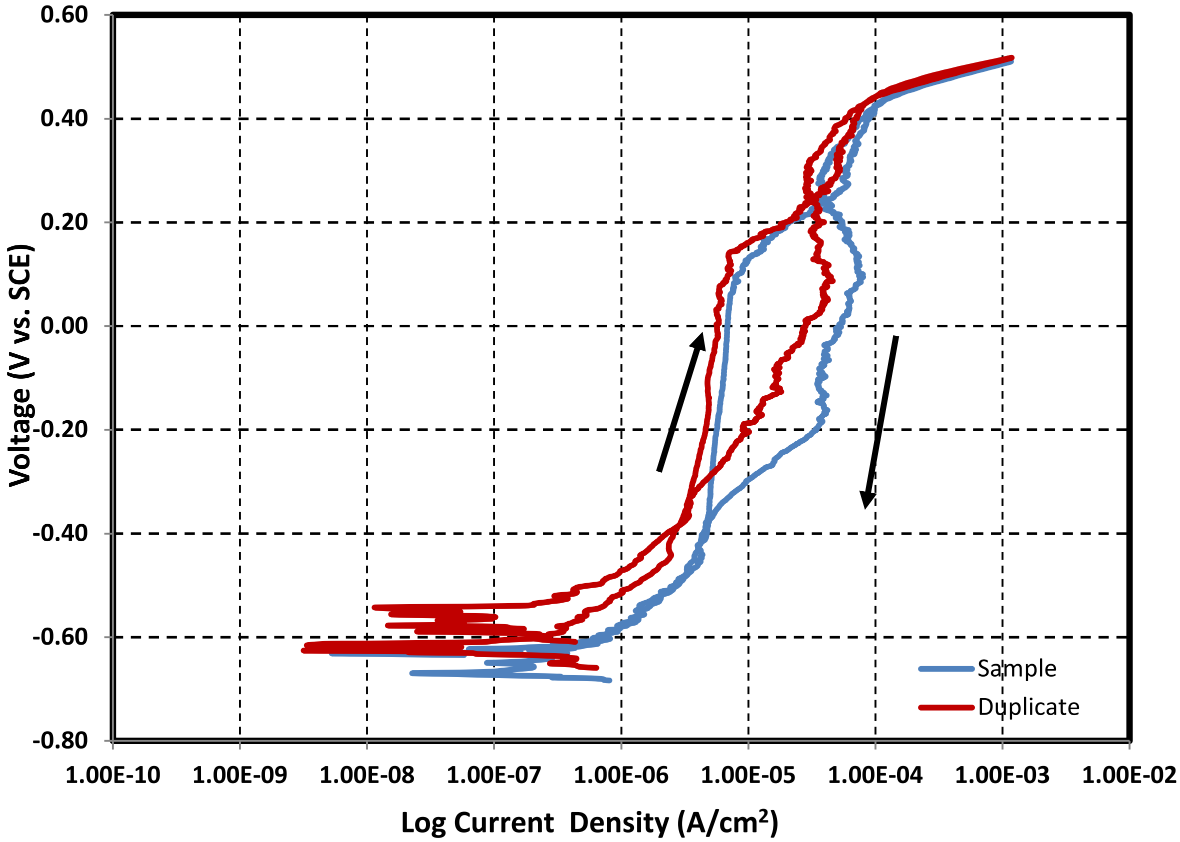
Shank (20X) **Nose (10X)**

Composition of simulant for pitting corrosion -Test 4

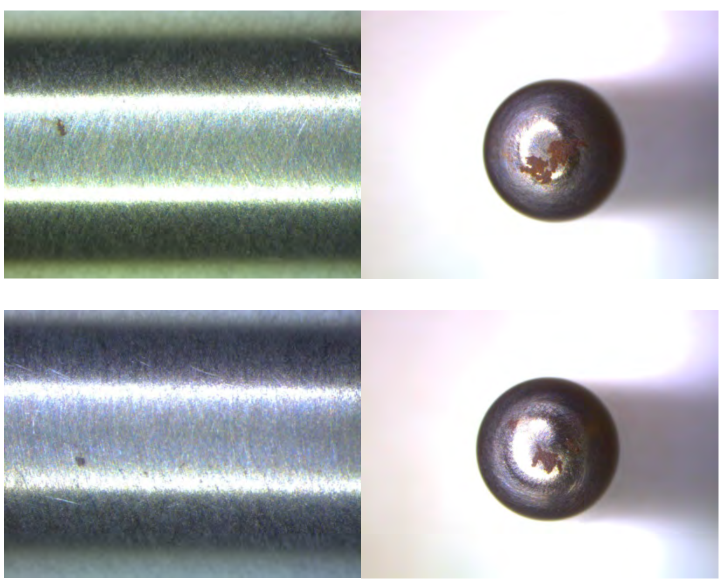
Reference 17	Temperature	50	°C
Test 4	pH	13.80	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	5.5	654.4230
Sodium nitrite	$NaNO_2$	69.00	0.2	19.3200
Sodium hydroxide	NaOH	40.00	0.6	33.6000
Sodium chloride	NaCl	58.44	0.1	8.1816
Sodium sulfate	Na_2SO_4	142.04	0.1	19.8856
Sodium carbonate	$Na_2(CO_3)$	106.00	0.1	14.8400
Sodium aluminate	$NaAlO_2$	81.97	0.5	57.3790
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.00	0.05	26.6000

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



Test 4

Test 4D

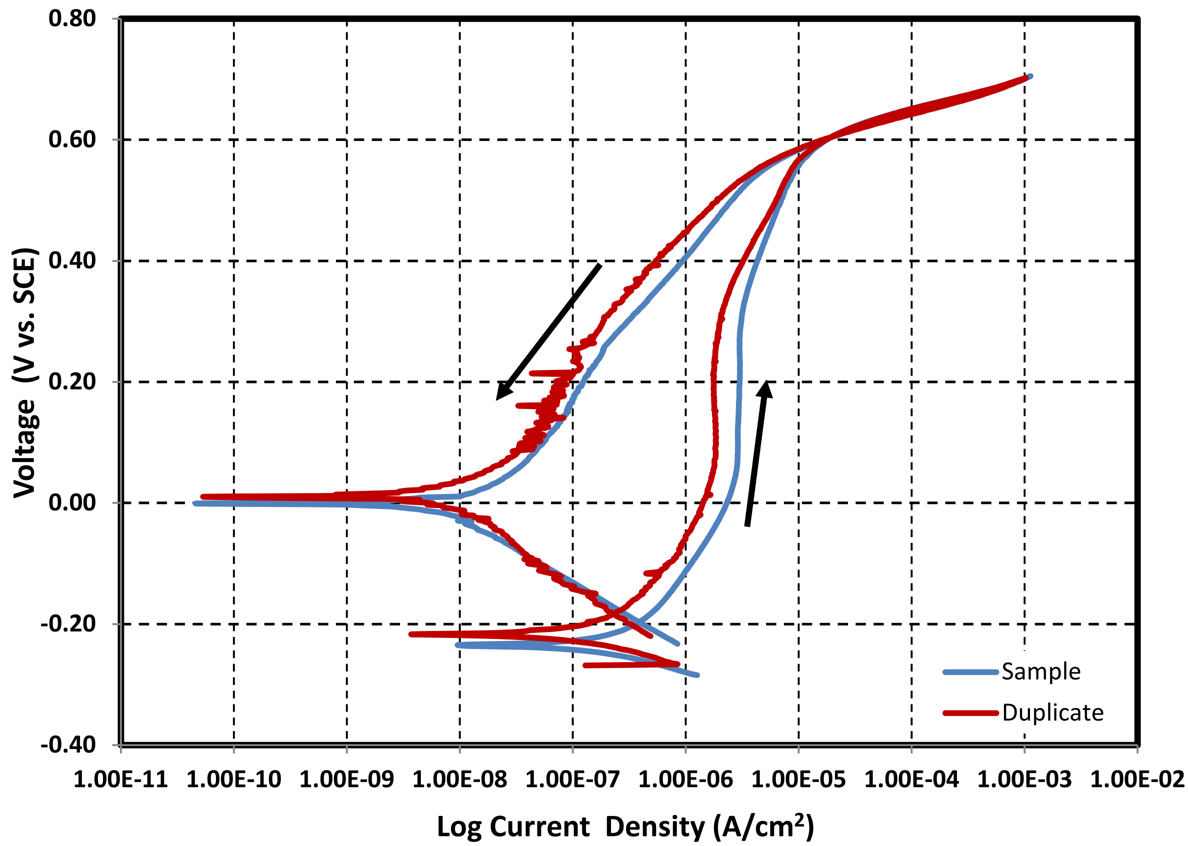
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion -Test 5

Reference 10	Temperature	40	°C
Test 5	pH	12.50	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium Carbonate	Na_2CO_3	106.00	0.00148	0.2196
Sodium Oxalate	$Na_2C_2O_4$	134.00	0.0000726	0.0136
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	0.00000387	0.0013
Sodium Metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.00002944	0.0087
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.00	0.00008272	0.0440
Sodium chloride	NaCl	58.40	0.01	0.8176
Sodium Fluoride	NaF	41.99	0.00015345	0.0090
Sodium sulfate	Na_2SO_4	142.00	0.0013674	0.2718
Sodium nitrate	$NaNO_3$	85.00	0.04	4.7600
Sodium nitrite	$NaNO_2$	69.00	0.325	31.3950
Sodium Hydroxide	NaOH	40.00	0.0304	1.7024

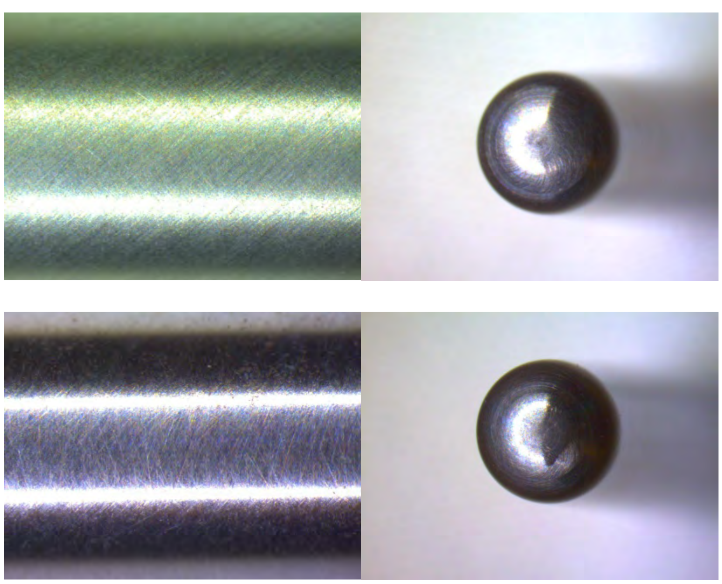
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 5

Test 5D



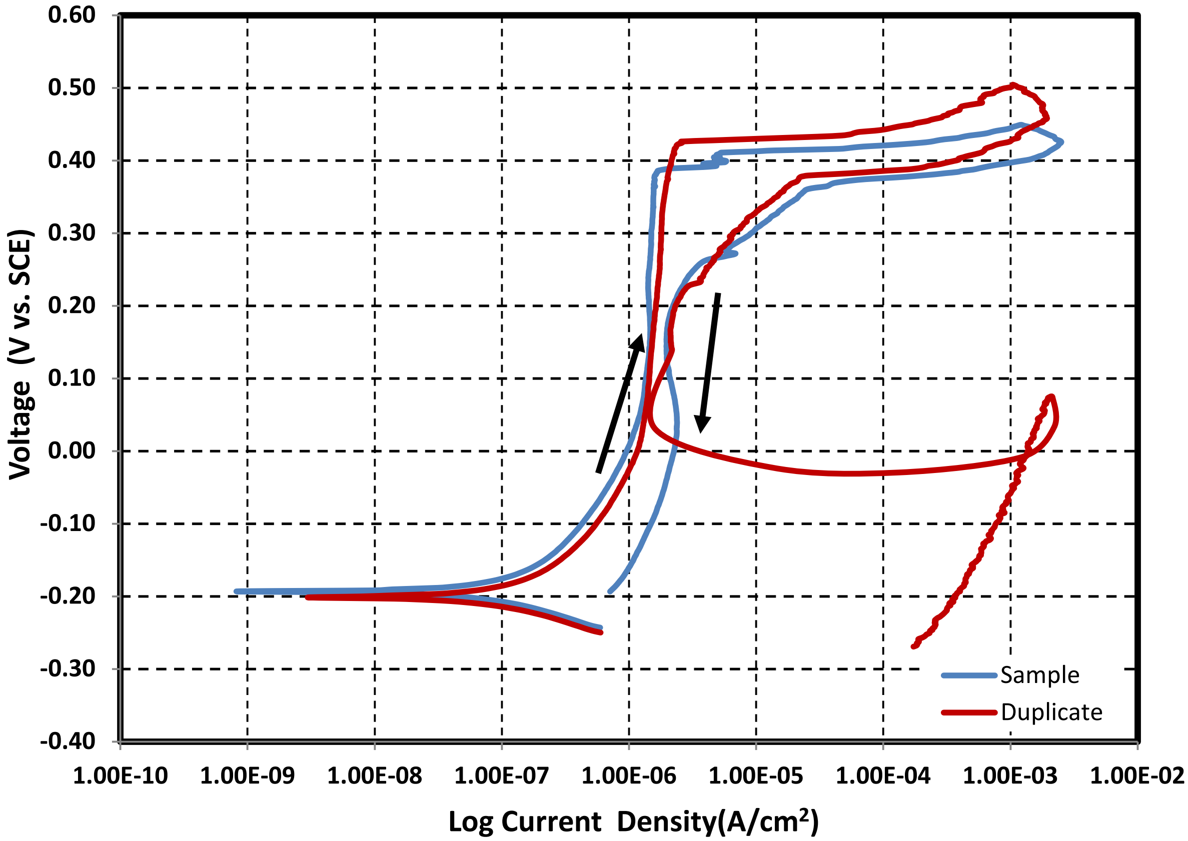
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion -Test 6

Reference 10	Temperature	40	°C
Test 6	pH	12.50	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium Carbonate	Na_2CO_3	106.00	0.00148	0.2196
Sodium Oxalate	$Na_2C_2O_4$	134.00	0.0000726	0.0136
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	0.00000387	0.0013
Sodium Metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.00002944	0.0087
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.00	0.00008272	0.0440
Sodium chloride	NaCl	58.40	0.025	2.0440
Sodium Fluoride	NaF	41.99	0.00015345	0.0090
Sodium sulfate	Na_2SO_4	142.00	0.0013674	0.2718
Sodium nitrate	$NaNO_3$	85.00	0.04	4.7600
Sodium nitrite	$NaNO_2$	69.00	0.9	86.9400
Sodium Hydroxide	NaOH	40.00	0.0304	1.7024

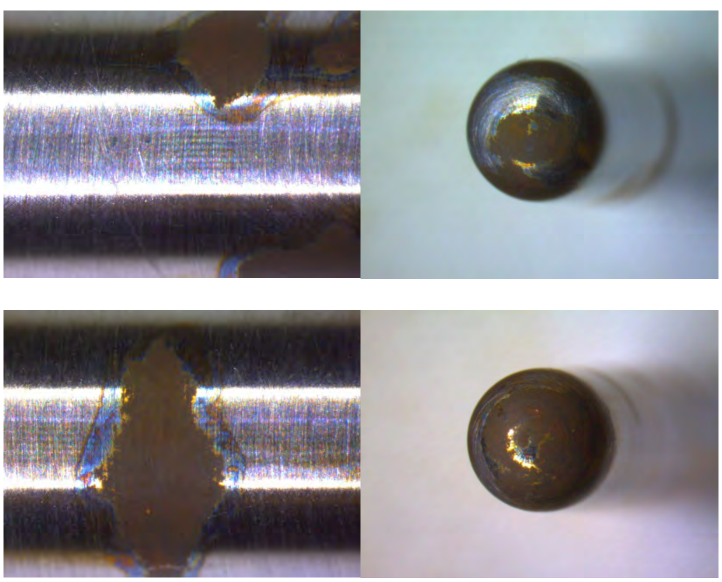
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 6

Test 6D



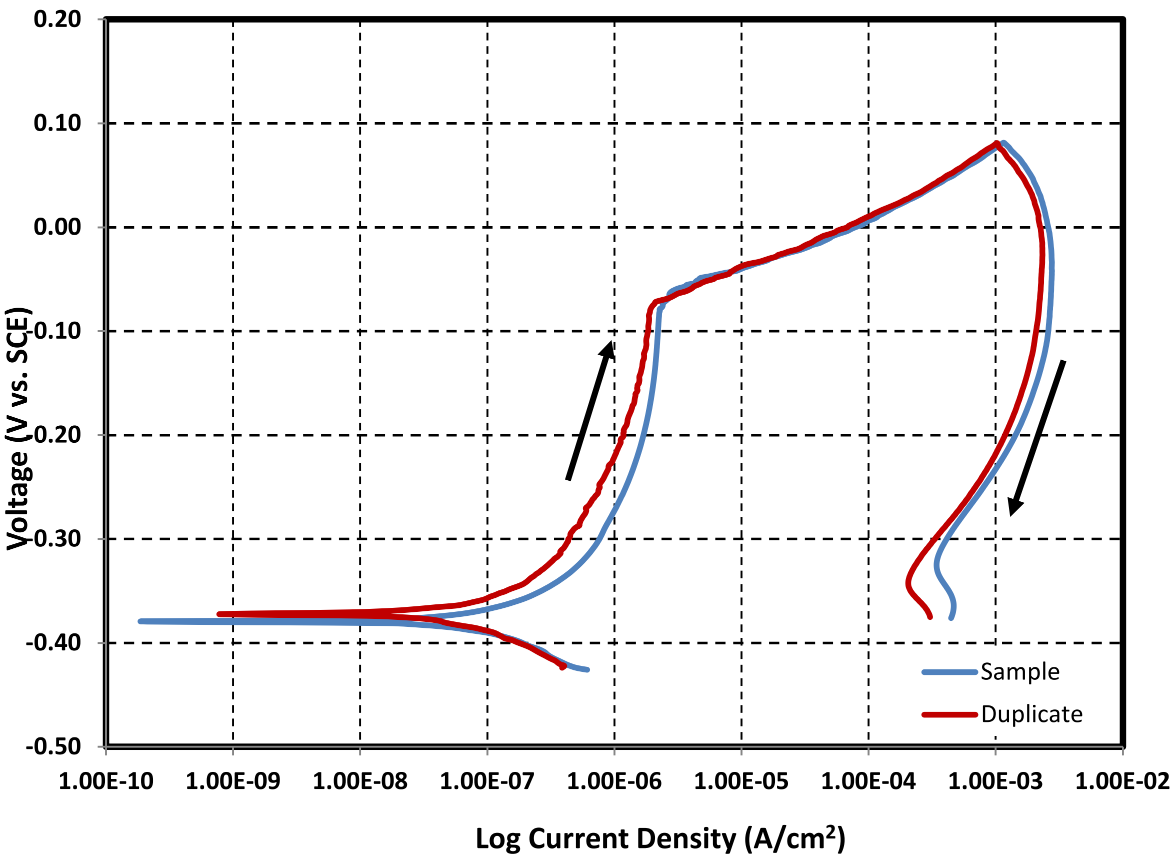
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion -Test 7

Reference 17	Temperature	25	°C
Test 7	pH	12.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	7	832.9020
Sodium nitrite	$NaNO_2$	69.00	0.01	0.9660
Sodium hydroxide	NaOH	40.00	0.01	0.5600
Sodium chloride	NaCl	58.44	0.1	8.1816
Sodium sulfate	Na_2SO_4	142.04	0.1	19.8856
Sodium carbonate	$Na_2(CO_3)$	106.00	0.1	14.8400
Sodium aluminate	$NaAlO_2$	81.97	0.5	57.3790
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.00	0.05	26.6000

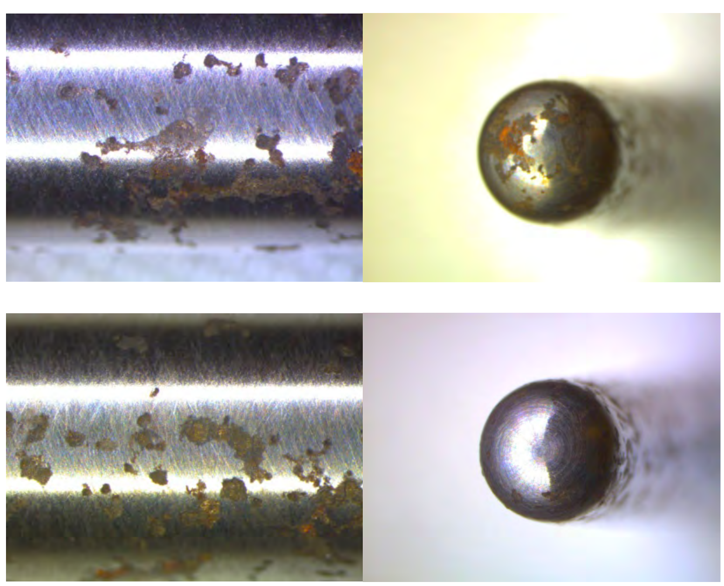
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 7

Test 7D



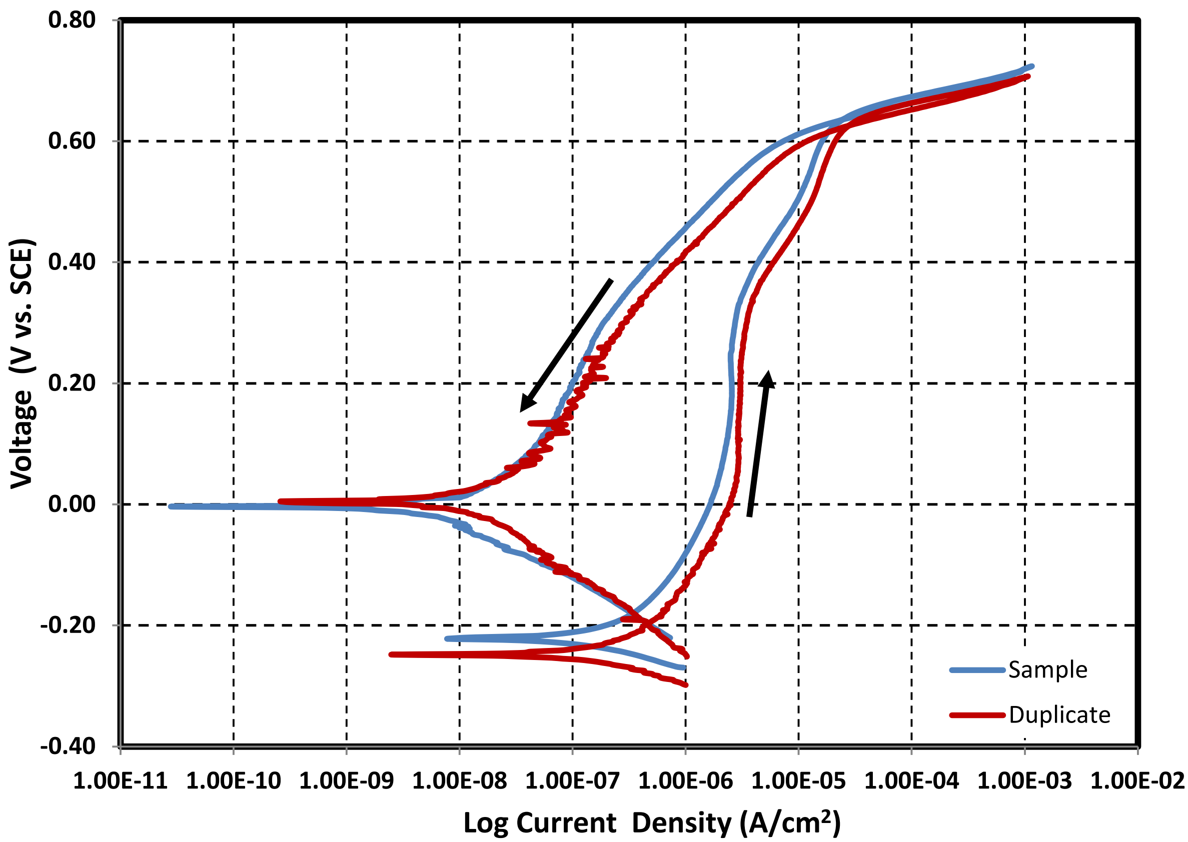
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion -Test 8

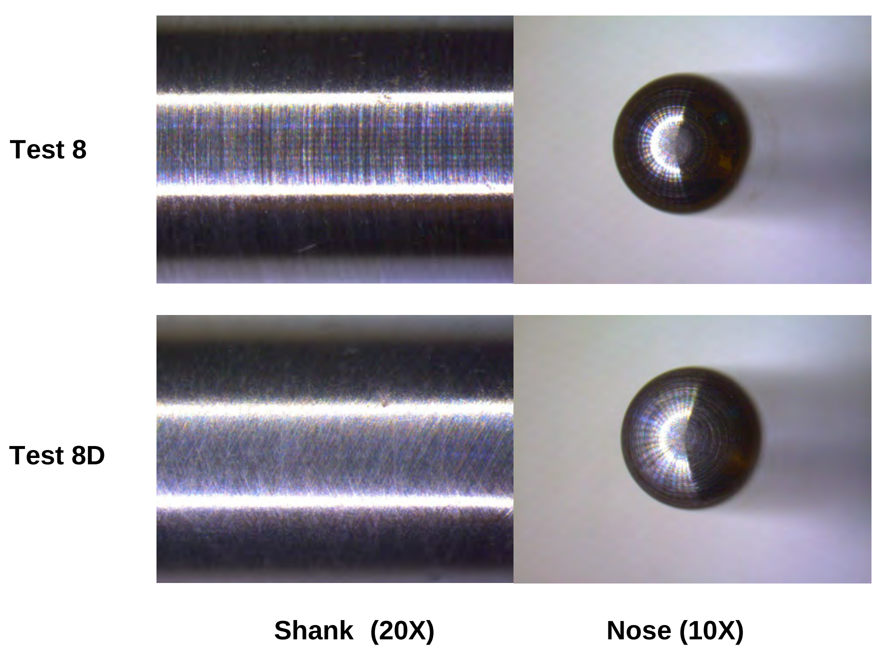
Reference 10	Temperature	40	°C
Test 8	pH	12.50	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium Carbonate	Na_2CO_3	106.00	0.00148	0.2196
Sodium Oxalate	$Na_2C_2O_4$	134.00	0.0000726	0.0136
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	0.00000387	0.0013
Sodium Metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.00002944	0.0087
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.00	0.00008272	0.0440
Sodium chloride	NaCl	58.40	0.0003185	0.0260
Sodium Fluoride	NaF	41.99	0.00015345	0.0090
Sodium sulfate	Na_2SO_4	142.00	0.1	19.8800
Sodium nitrate	$NaNO_3$	85.00	0.04	4.7600
Sodium nitrite	$NaNO_2$	69.00	0.12	11.5920
Sodium Hydroxide	NaOH	40.00	0.0304	1.7024

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

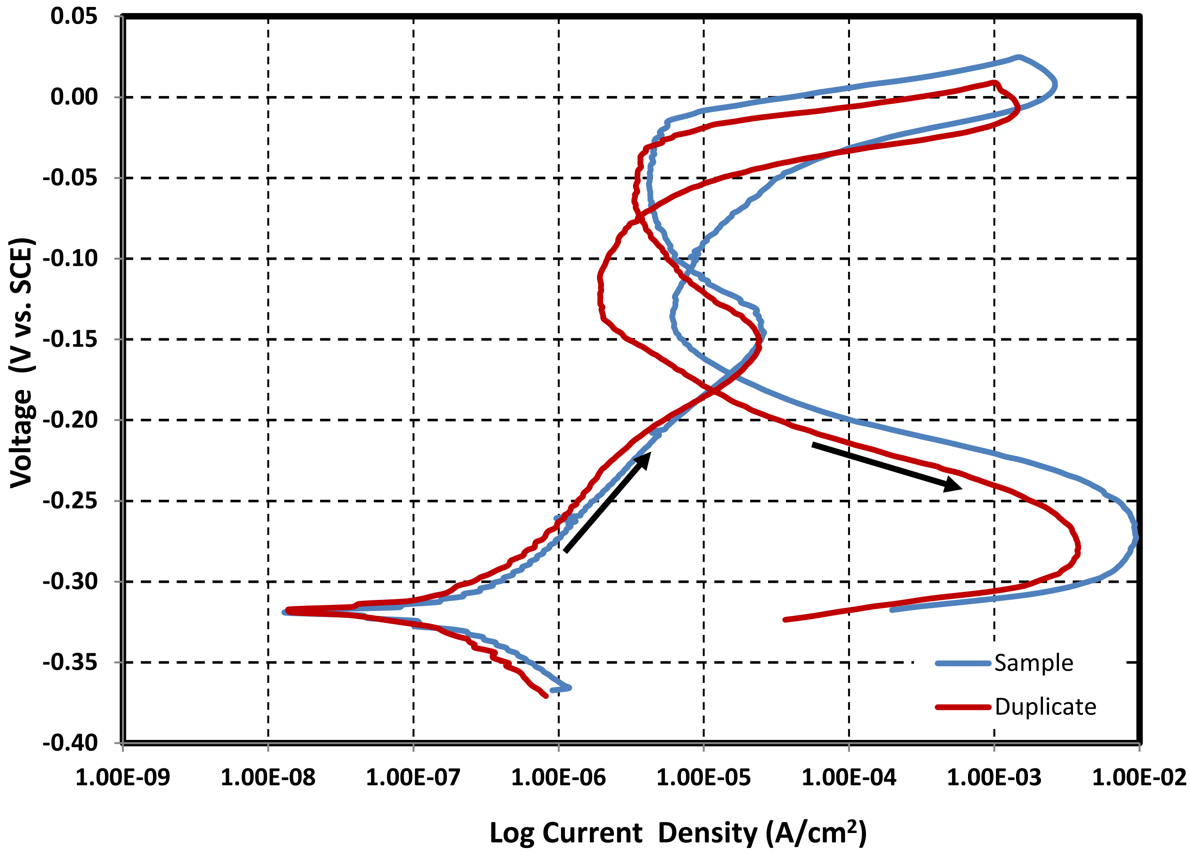


Composition of simulant for pitting corrosion -Test 9

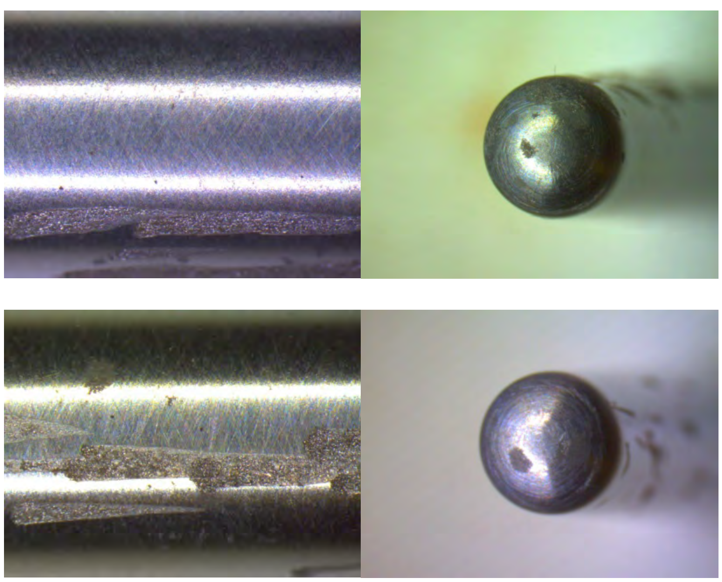
Reference 18	Temperature	40	°C
Test 9	pH	12.12	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.1	11.8986
Sodium chloride	NaCl	58.44	0.4	32.7264
Sodium fluoride	NaF	42.00	0.05	2.9400
Sodium nitrite	$NaNO_2$	69.00	0.5	48.3000
Sodium hydroxide	NaOH	40.00	0.01	0.5600
Sodium carbonate	$Na_2(CO_3)$	106.00	0.02	2.9680
Trisodium citrate dihydrate	$Na_3C_6H_5O_7.2H_2O$	294.1000	0.6	247.0440
Sodium sulfate	Na_2SO_4	142.04	0.1	19.8856
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.00	0.0005	0.2660

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



Test 9

Test 9D

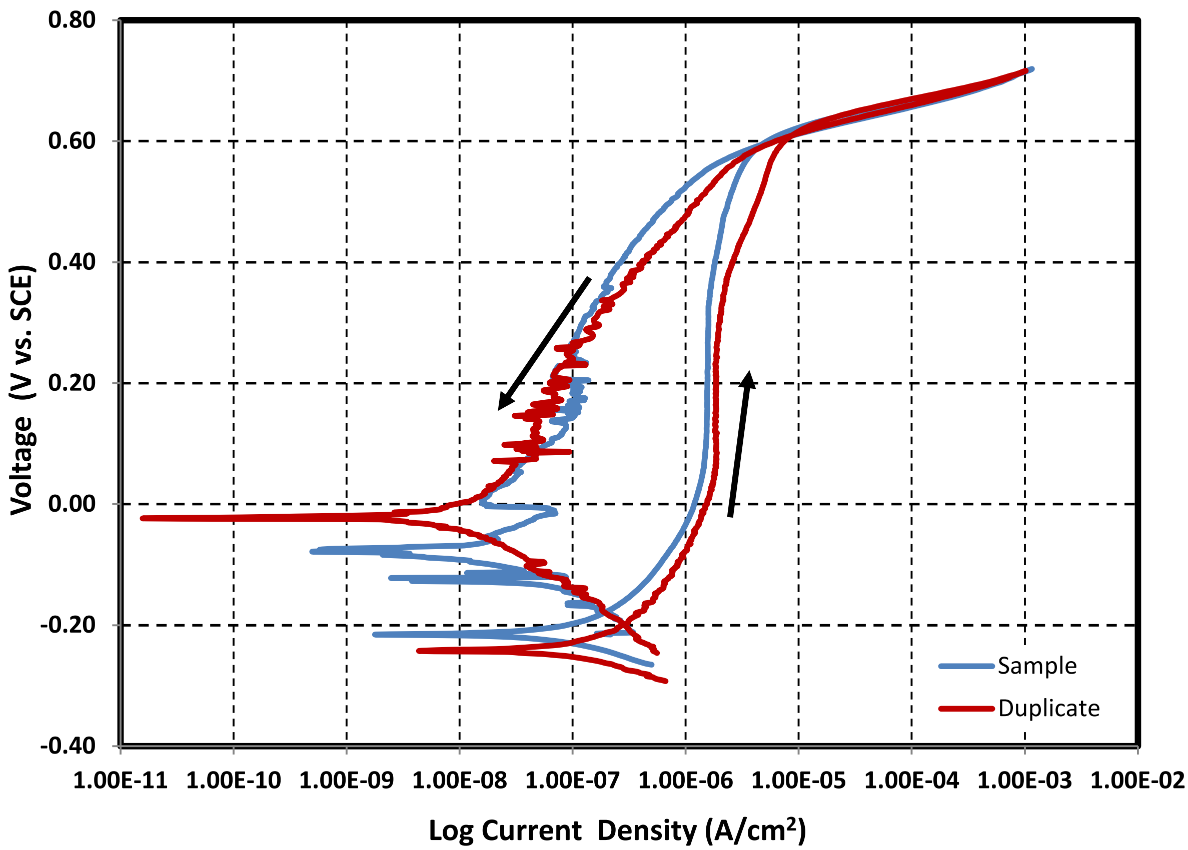
Shank (20X) | Nose (10X)

Composition of simulant for pitting corrosion -Test 10

Reference 10	Temperature	40	°C
Test 10	pH	12.50	
	Volume	1.4	L

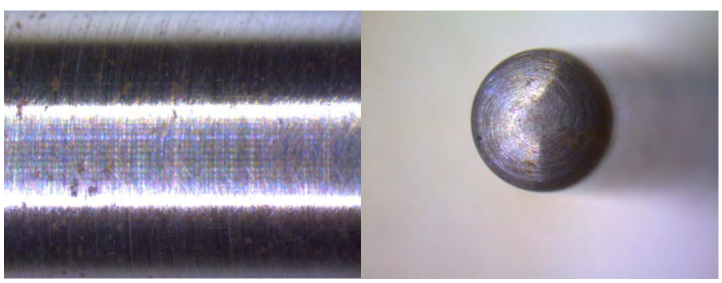
Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium Carbonate	Na_2CO_3	106.00	0.00148	0.2196
Sodium Oxalate	$Na_2C_2O_4$	134.00	0.0000726	0.0136
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	0.00000387	0.0013
Sodium Metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.00002944	0.0087
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.00	0.00008272	0.0440
Sodium chloride	NaCl	58.40	0.0003185	0.0260
Sodium Fluoride	NaF	41.99	0.00015345	0.0090
Sodium sulfate	Na_2SO_4	142.00	0.1	19.8800
Sodium nitrate	$NaNO_3$	85.00	0.04	4.7600
Sodium nitrite	$NaNO_2$	69.00	0.18	17.3880
Sodium Hydroxide	NaOH	40.00	0.0304	1.7024

Cyclic Potentiodynamic Polarization

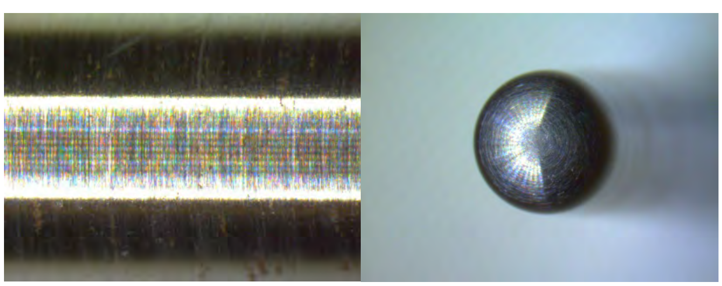


Images of bullet samples after electrochemical tests

Test 10



Test 10D



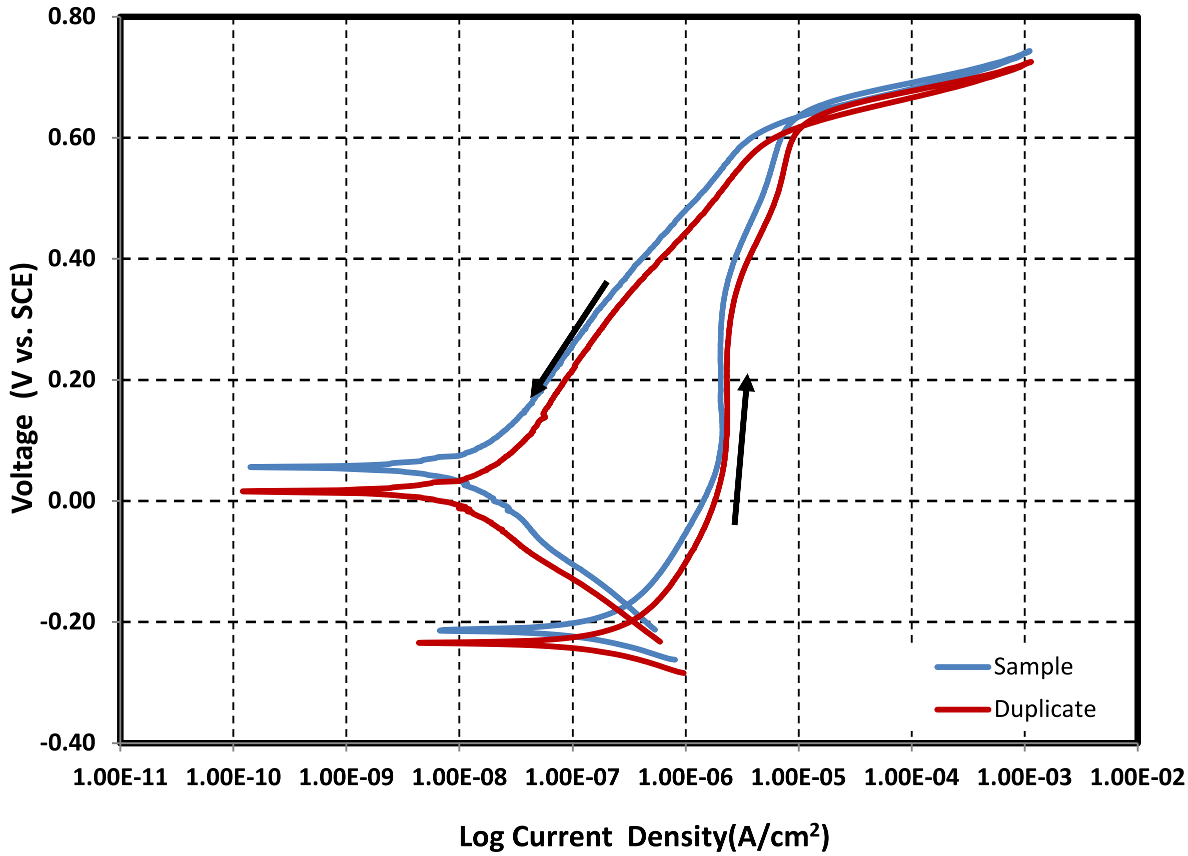
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion -Test 11

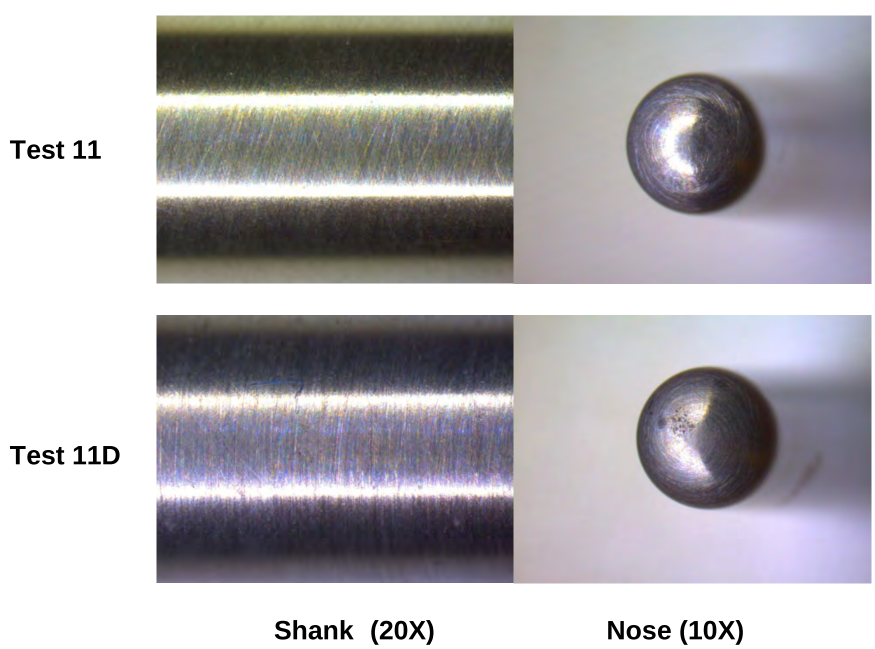
Reference 10	Temperature	40	°C
Test 11	pH	12.50	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium Carbonate	Na_2CO_3	106.00	0.0173	2.5673
Sodium Oxalate	$Na_2C_2O_4$	134.00	0.0000726	0.0136
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	0.00000387	0.0013
Sodium Metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.00002944	0.0087
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.00	0.00008272	0.0440
Sodium chloride	NaCl	58.40	0.0003185	0.0260
Sodium Fluoride	NaF	41.99	0.00015345	0.0090
Sodium sulfate	Na_2SO_4	142.00	0.02	3.9760
Sodium nitrate	$NaNO_3$	85.00	0.04	4.7600
Sodium nitrite	$NaNO_2$	69.00	0.04	3.8640
Sodium Hydroxide	NaOH	40.00	0.0304	1.7024

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

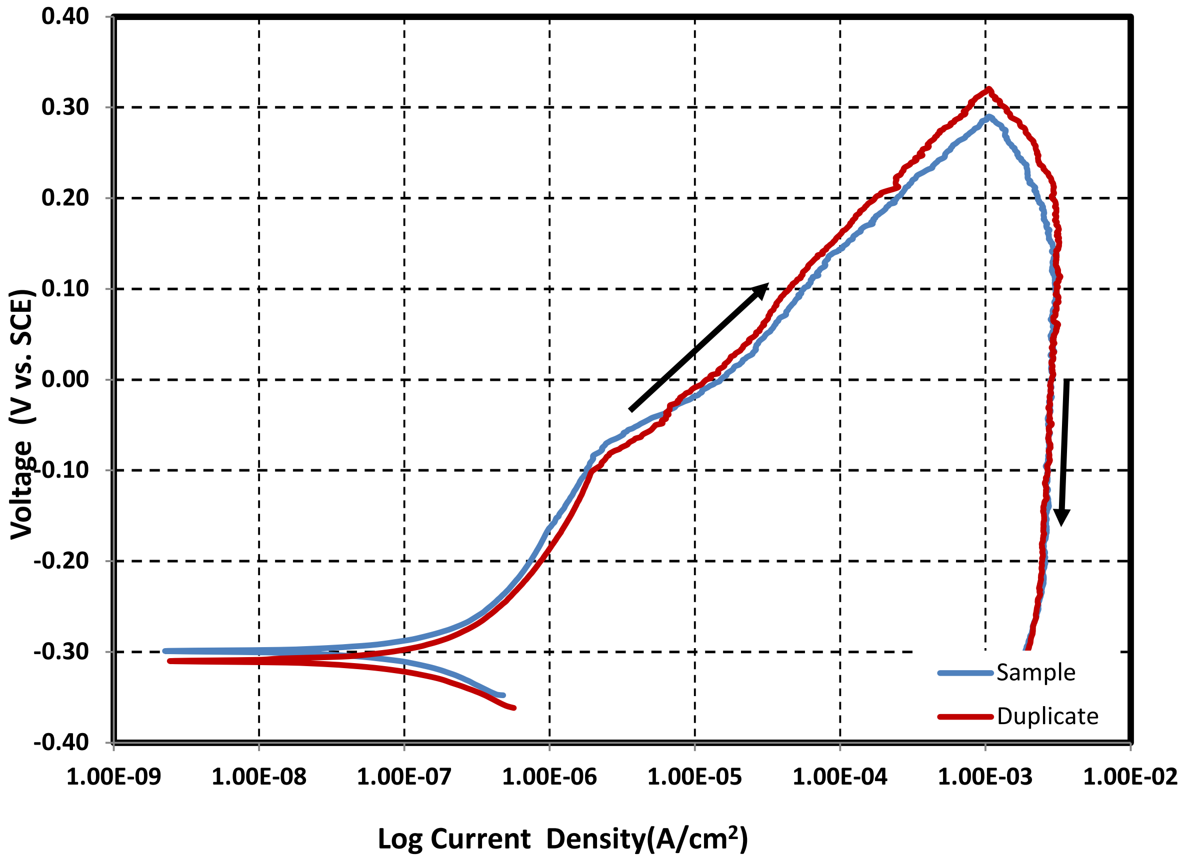


Composition of simulant for pitting corrosion -Test 12

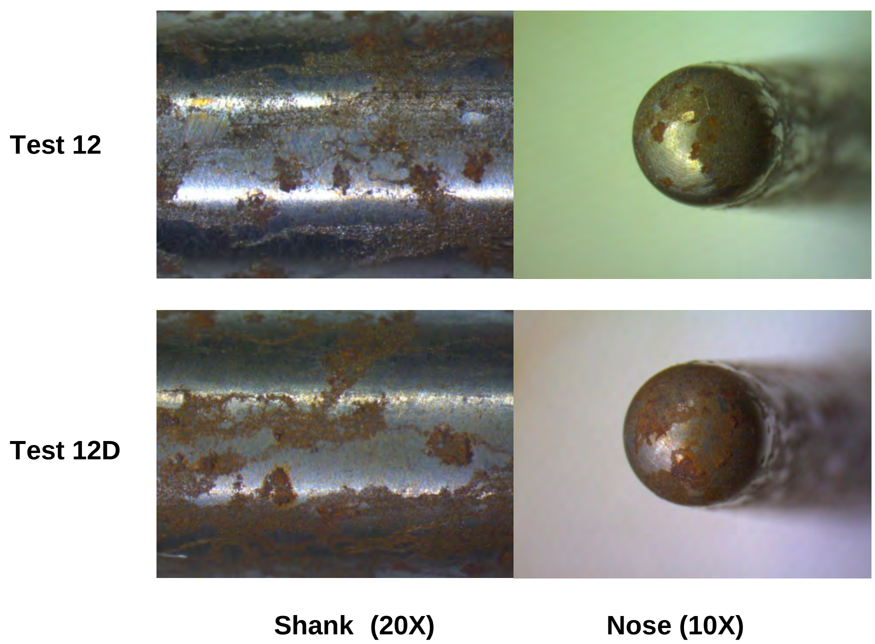
Reference 18	Temperature	40	°C
Test 12	pH	11.70	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.7	83.2902
Sodium chloride	NaCl	58.44	0.06	4.9090
Sodium fluoride	NaF	42.00	0.02	1.1760
Sodium nitrite	$NaNO_2$	69.00	0.02	1.9320
Sodium hydroxide	NaOH	40.00	0.01	0.5600
Sodium carbonate	$Na_2(CO_3)$	106.00	0.2	29.6800
Trisodium citrate dihydrate	$Na_3C_6H_5O_7.2H_2O$	294.1000	0.04	16.4696
Sodium sulfate	Na_2SO_4	142.04	0.1	19.8856
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.00	0.05	26.6000

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

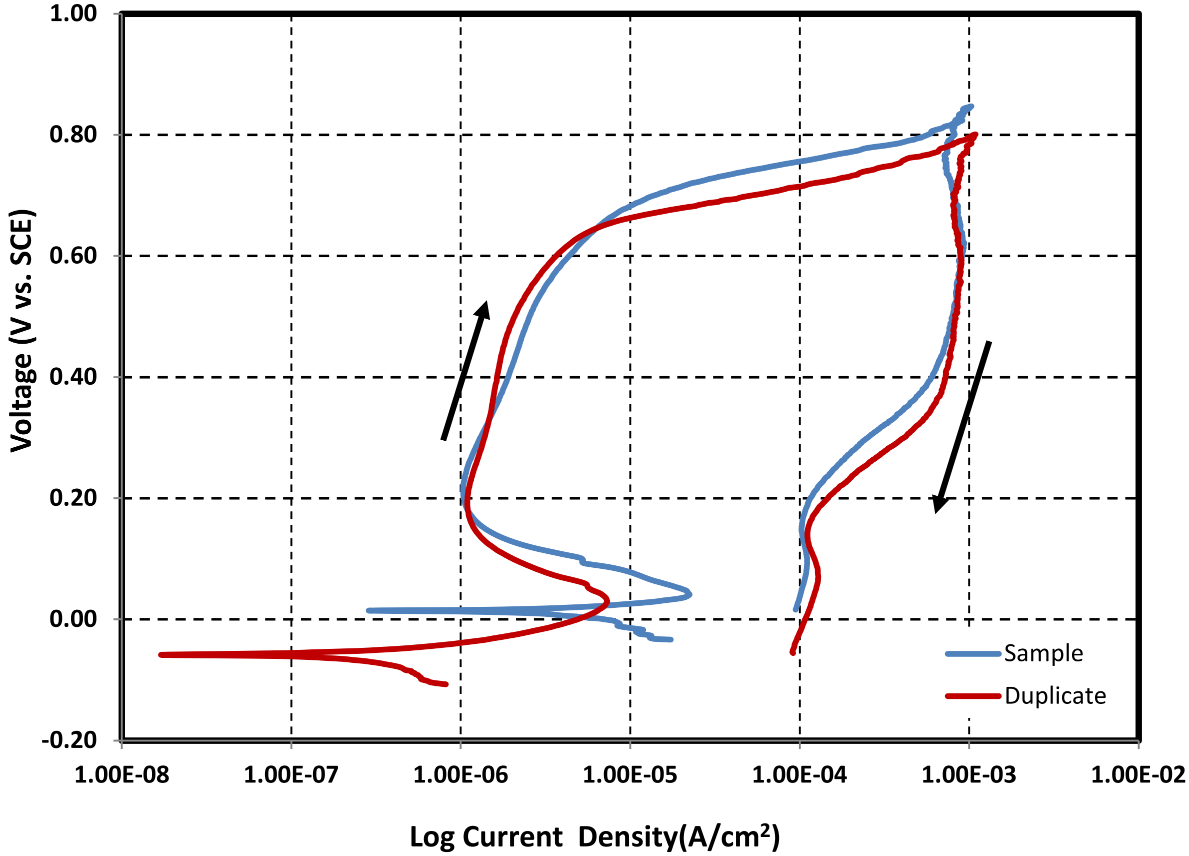


Composition of simulant for pitting corrosion -Test 13

Reference 4	Temperature	40	°C
Test 13	pH	9.6	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.13	0.000159945	0.0840
Ferric Nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	4.9505E-05	0.0280
Sodium hydroxide	NaOH	40.00	0.0305	1.7080
Sodium nitrite	$NaNO_2$	69.00	0.010028986	0.9688
Sodium oxalate	$Na_2(C_2O_4)$	134.00	0.002885572	0.5413
Sodium sulfate	Na_2SO_4	142.04	0.001980663	0.3939
Sodium carbonate	$Na_2(CO_3)$	106.00	0.004679245	0.6944
Sodium Bicarbonate	$NaHCO_3$	84.00	0.019333333	2.2736
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.12	9.16903E-05	0.0488
Calcium Carbonate	$CaCO_3$	100.00	0.000220133	0.0308
Sodium chloride	NaCl	58.44	0.000382729	0.0313
Sodium fluoride	NaF	42.00	0.000243175	0.0143
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	6.15066E-06	0.0021
Manganese Dioxide	MnO_2	86.94	0.000380032	0.0463
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	290.81	0.000173355	0.0706
Mercury (II) nitrate	$Hg(NO_3)_2$	342.62	0.000146	0.0700
Sodium silicate, 9-hydrate	$Na_2SiO_3.9H_2O$	284.00	5.33803E-05	0.0212
Zinc nitrate, 6-hydrate	$Zn(NO_3)_2.6H_2O$	297.49	1.37147E-05	0.0057
Lead nitrate	$Pb(NO_3)_2$	331.21	6.48129E-06	0.0030
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	8.18312E-06	0.0027

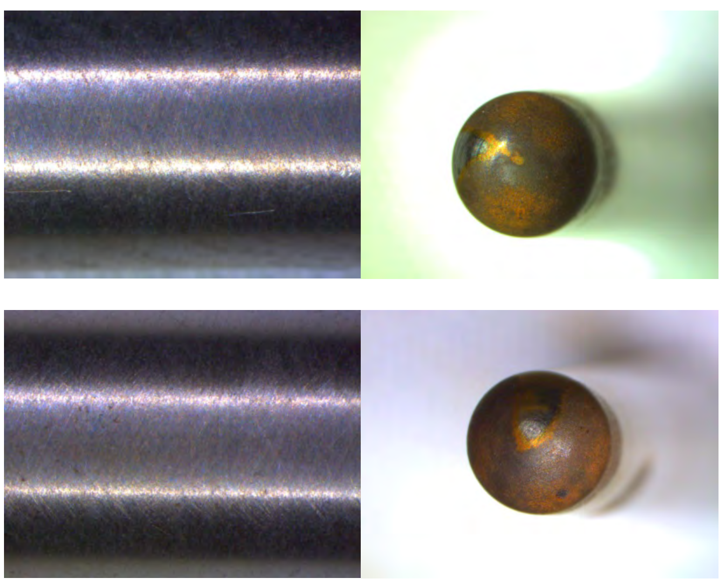
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 13

Test 13D



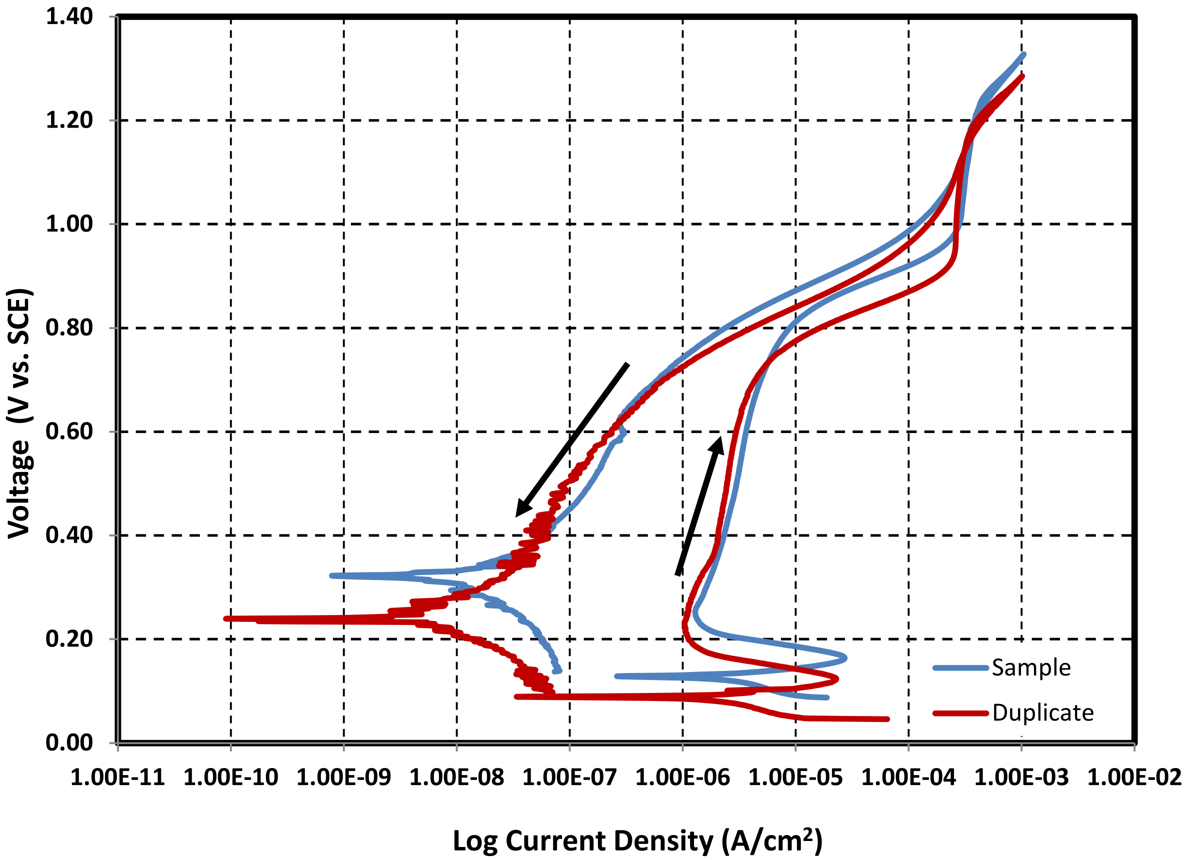
Shank (20X) **Nose (10X)**

Composition of simulant for pitting corrosion -Test 14

Reference 1	Temperature	23	°C
Test 14	pH	9.73	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium carbonate	Na_2CO_3	106.00	0.0173	2.5673
Sodium bicarbonate	$NaHCO_3$	84.01	0.0446	5.2456
Sodium oxalate	$Na_2C_2O_4$	134.00	0.000194	0.0364
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	0.0000103	0.0035
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.0000786	0.0233
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.00	0.000223	0.1186
Sodium chloride	NaCl	58.40	0.0008635	0.0706
Sodium fluoride	NaF	41.99	0.000413	0.0243
Sodium sulfate	Na_2SO_4	142.00	0.00363	0.7216
Sodium nitrate	$NaNO_3$	85.00	0.0546	6.4974
Sodium nitrite	$NaNO_2$	69.00	0.015	1.4490
Sodium aluminate	$NaAlO_2$	81.97	0.00045	0.0516
Cobalt nitrate, 6-hydrate	$Co(NO_3)_2.6H_2O$	291.03	0.00003	0.0122
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.00	0.0015	0.6111
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.000248	0.1403
Mercury (II) nitrate	$Hg(NO_3)_2$	324.60	0.00025	0.1136
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	0.000043	0.0140
Manganese dioxide	MnO_2	86.94	0.00575	0.6999

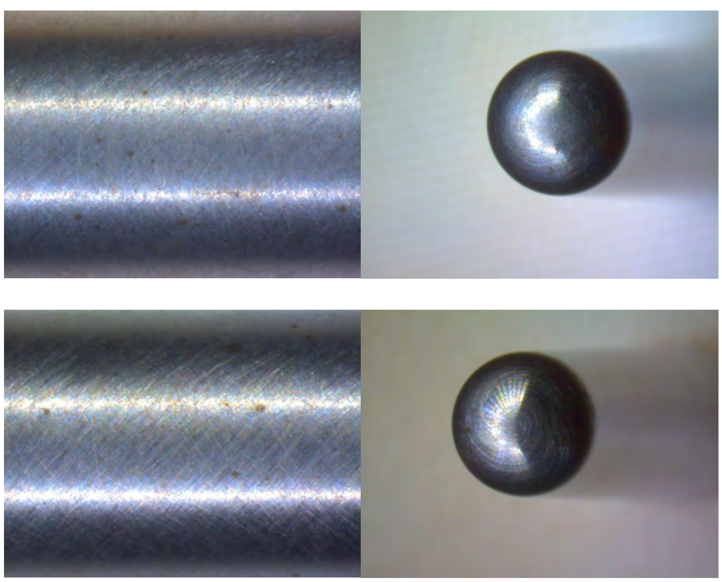
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 14

Test 14D



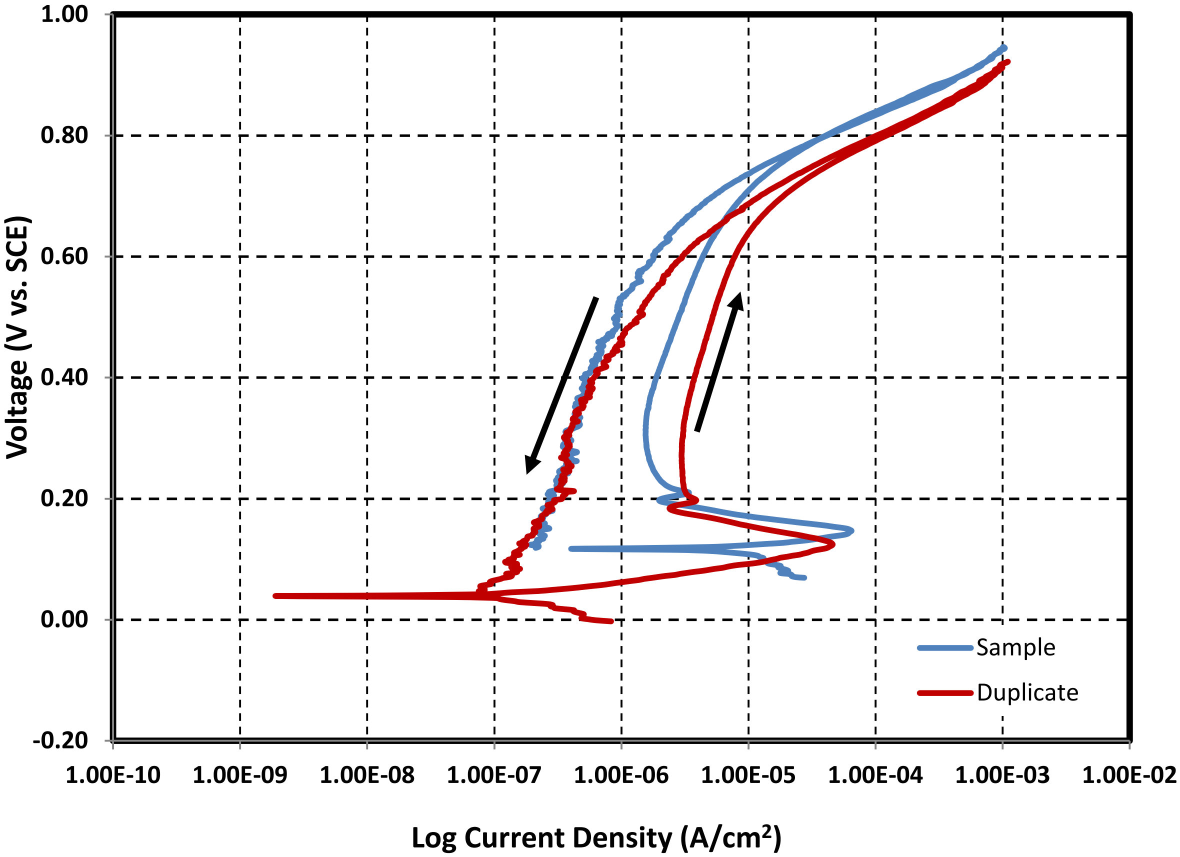
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion -Test 15

Reference 1	Temperature	40	°C
Test 15	pH	9.79	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium carbonate	Na_2CO_3	106.00	0.0263	3.9029
Sodium bicarbonate	$NaHCO_3$	84.01	0.0564	6.6334
Sodium oxalate	$Na_2C_2O_4$	134.00	0.000268	0.0503
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	0.0000143	0.0048
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.000109	0.0324
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.00	0.000309	0.1644
Sodium chloride	NaCl	58.40	0.0011875	0.0971
Sodium fluoride	NaF	41.99	0.000573	0.0337
Sodium sulfate	Na_2SO_4	142.00	0.00503	1.0000
Sodium nitrate	$NaNO_3$	85.00	0.0758	9.0202
Sodium nitrite	$NaNO_2$	69.00	0.058	5.6028
Sodium aluminate	$NaAlO_2$	81.97	0.00045	0.0516
Cobalt nitrate, 6-hydrate	$Co(NO_3)_2.6H_2O$	291.03	0.00003	0.0122
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.00	0.0015	0.6111
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.000248	0.1403
Mercury (II) nitrate	$Hg(NO_3)_2$	324.60	0.00025	0.1136
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	0.000043	0.0140
Manganese dioxide	MnO_2	86.94	0.00575	0.6999

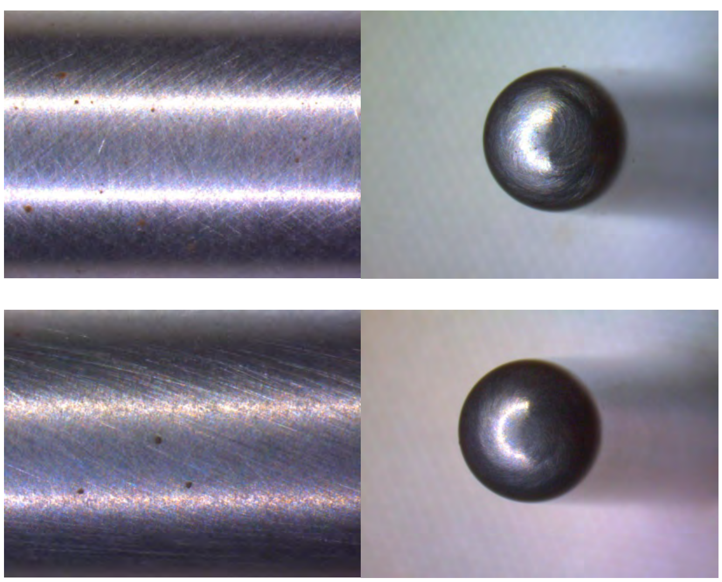
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 15

Test 15D



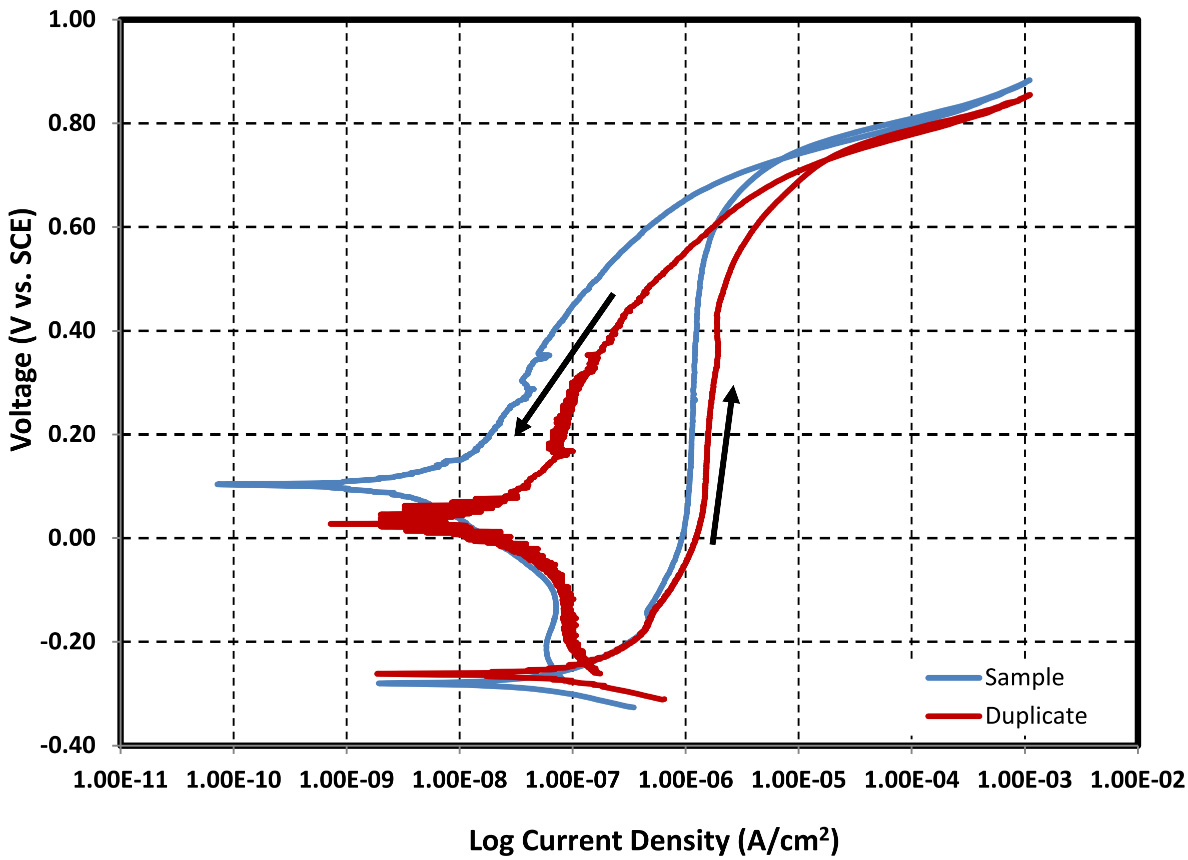
Shank (20X) **Nose (10X)**

Composition of simulant for pitting corrosion -Test 16

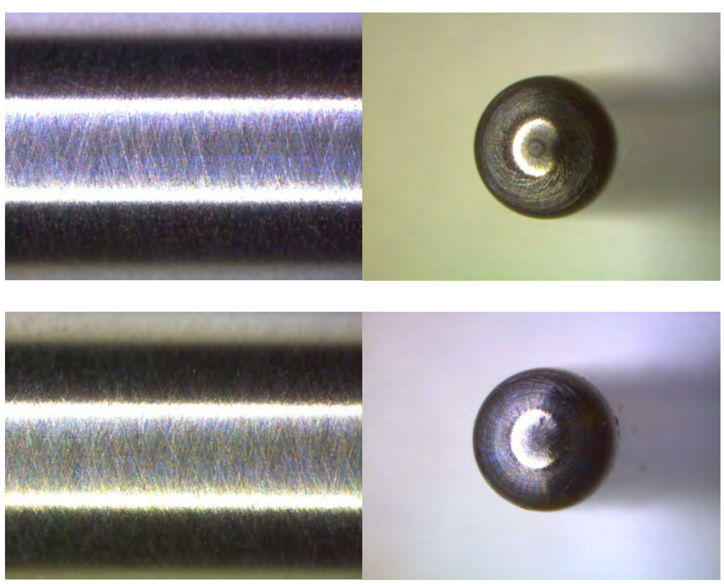
Reference 14	Temperature	40	°C
Test 16	pH	10.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.2	23.7972
Sodium nitrite	$NaNO_2$	69.00	0.15	14.4900
Sodium chloride	$NaCl$	58.44	0.0037	0.3027
Sodium sulfate	Na_2SO_4	142.04	0.0451	8.9684
Sodium carbonate	$Na_2(CO_3)$	106.00	0.0526	7.8058
Sodium bicarbonate	$NaHCO_3$	84.00	0.098	11.5248

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



Test 16

Test 16D

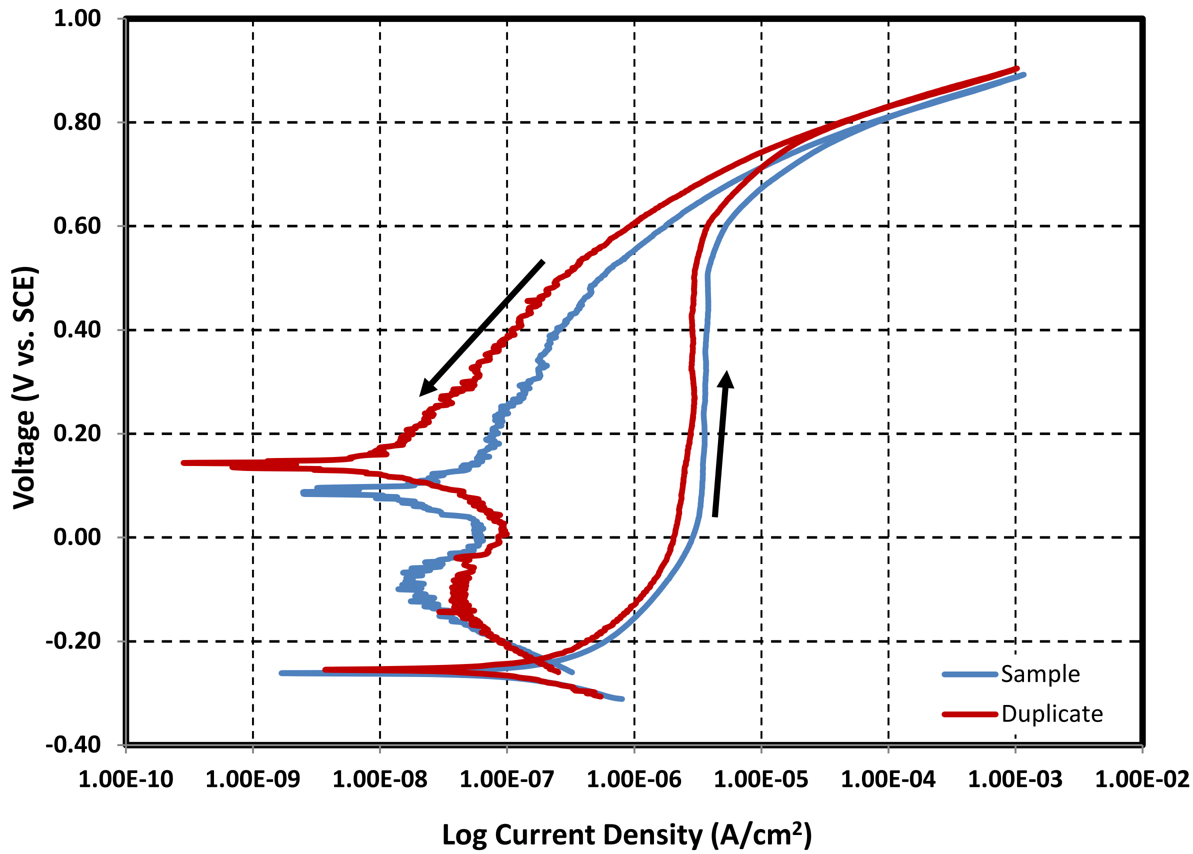
Shank (20X) **Nose (10X)**

Composition of simulant for pitting corrosion -Test 17

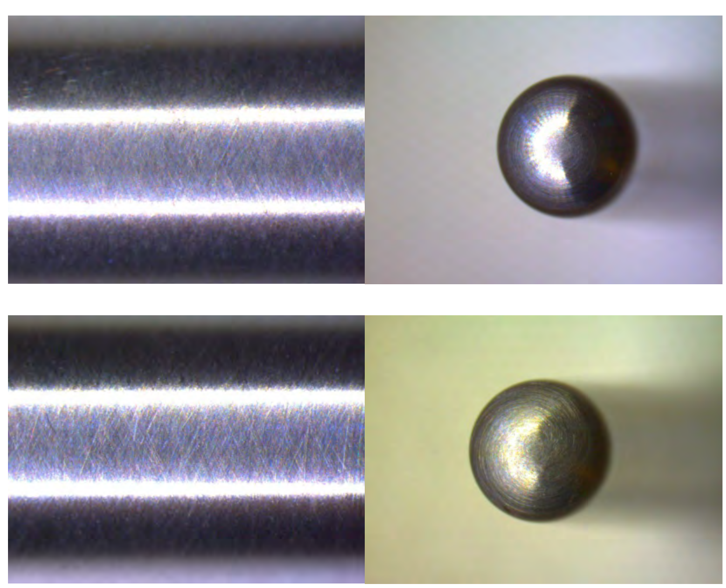
Reference 13	Temperature	40	°C
Test 17	pH	10.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.9	107.0874
Sodium nitrite	$NaNO_2$	69.00	0.675	65.2050
Sodium chloride	NaCl	58.44	0.0115	0.9409
Sodium sulfate	Na_2SO_4	142.04	0.323	64.2305
Sodium carbonate	$Na_2(CO_3)$	106.00	0.236	35.0224
Sodium bicarbonate	$NaHCO_3$	84.00	0.438	51.5088

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



Test 17

Test 17D

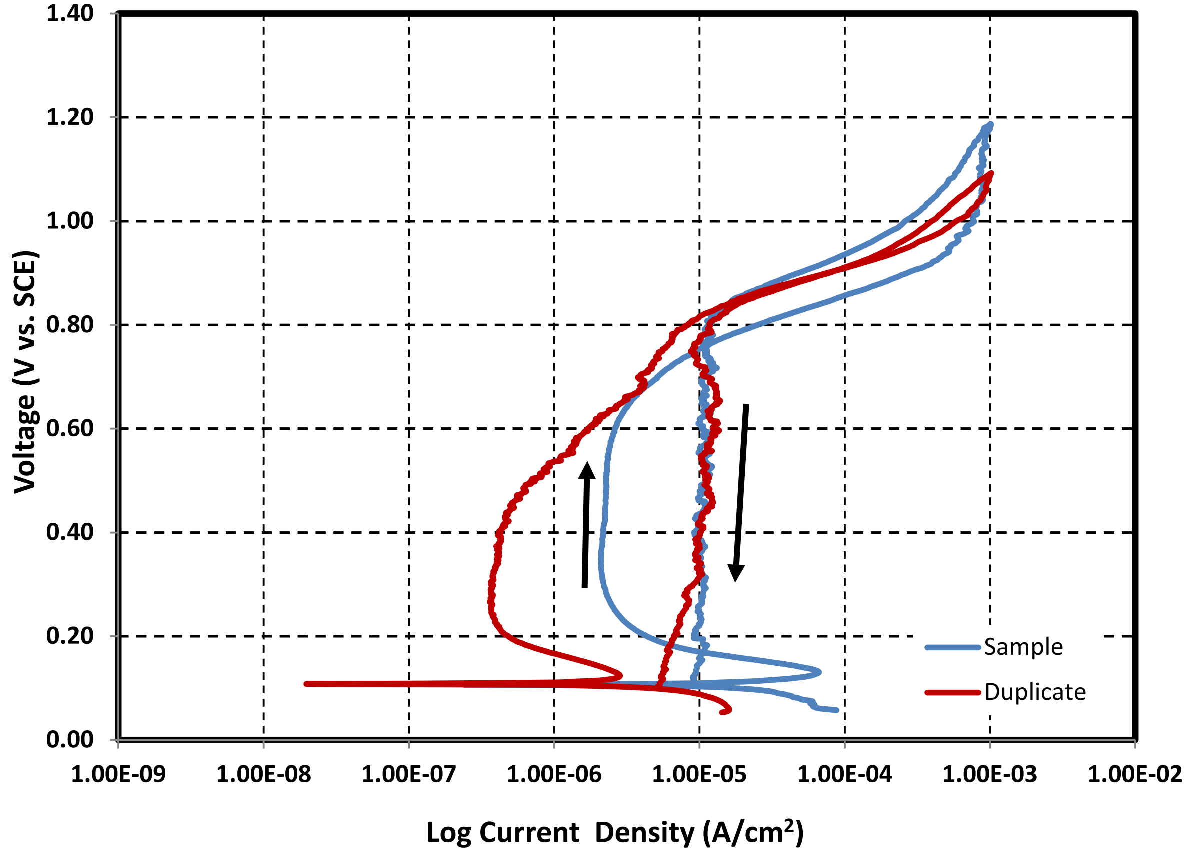
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion -Test 18

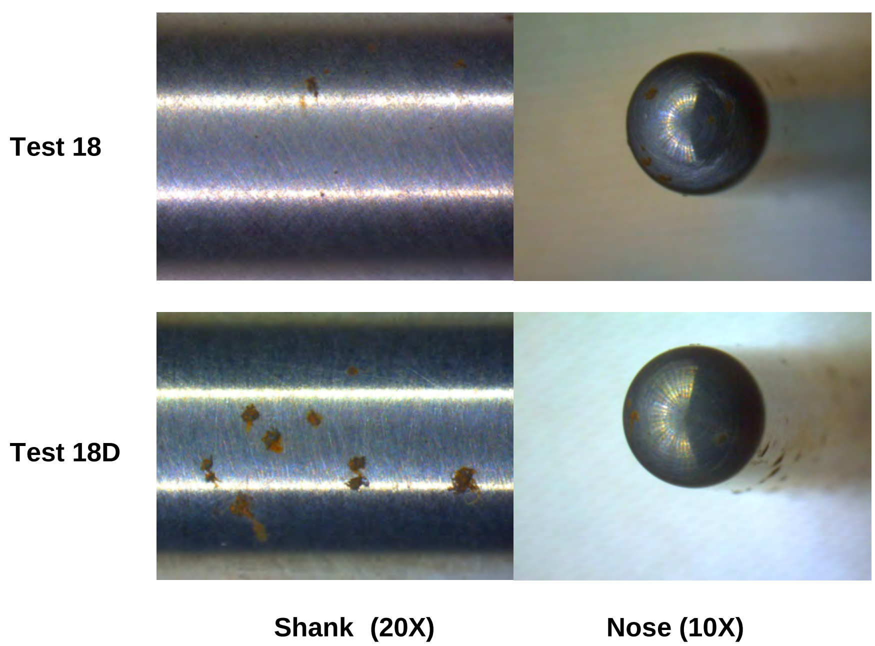
Reference 3	Temperature	40	°C
Test 18	pH	9.6	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.13	0.014928158	7.8400
Ferric Nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.004945	2.7969
Sodium hydroxide	NaOH	40.00	0.0915	5.1240
Sodium nitrate	$NaNO_3$	85.00	0	0
Sodium nitrite	$NaNO_2$	69.00	0.039971014	3.8612
Sodium oxalate	$Na_2(C_2O_4)$	134.00	0.008656716	1.6240
Sodium sulfate	Na_2SO_4	142.04	0.005941988	1.1816
Sodium carbonate	$Na_2(CO_3)$	106.00	0.014037736	2.0832
Sodium Bicarbonate	$NaHCO_3$	84.00	0.058	6.8208
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.12	0.000275071	0.1464
Calcium Carbonate	$CaCO_3$	100.00	0.0006604	0.0925
Sodium chloride	NaCl	58.44	0.001090008	0.0892
Sodium fluoride	NaF	42.00	0.000729524	0.0429
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	1.8452E-05	0.0063
Manganese Dioxide	MnO_2	86.94	0.001140097	0.1388
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	290.81	0.000520065	0.2117
Mercury (II) nitrate	$Hg(NO_3)_2$	342.62	0.00311	1.4918
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.000160141	0.0476
Zinc nitrate, 6-hydrate	$Zn(NO_3)_2.6H_2O$	297.49	4.11442E-05	0.0171
Lead nitrate	$Pb(NO_3)_2$	331.21	1.94439E-05	0.0090
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	2.45494E-05	0.0080

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

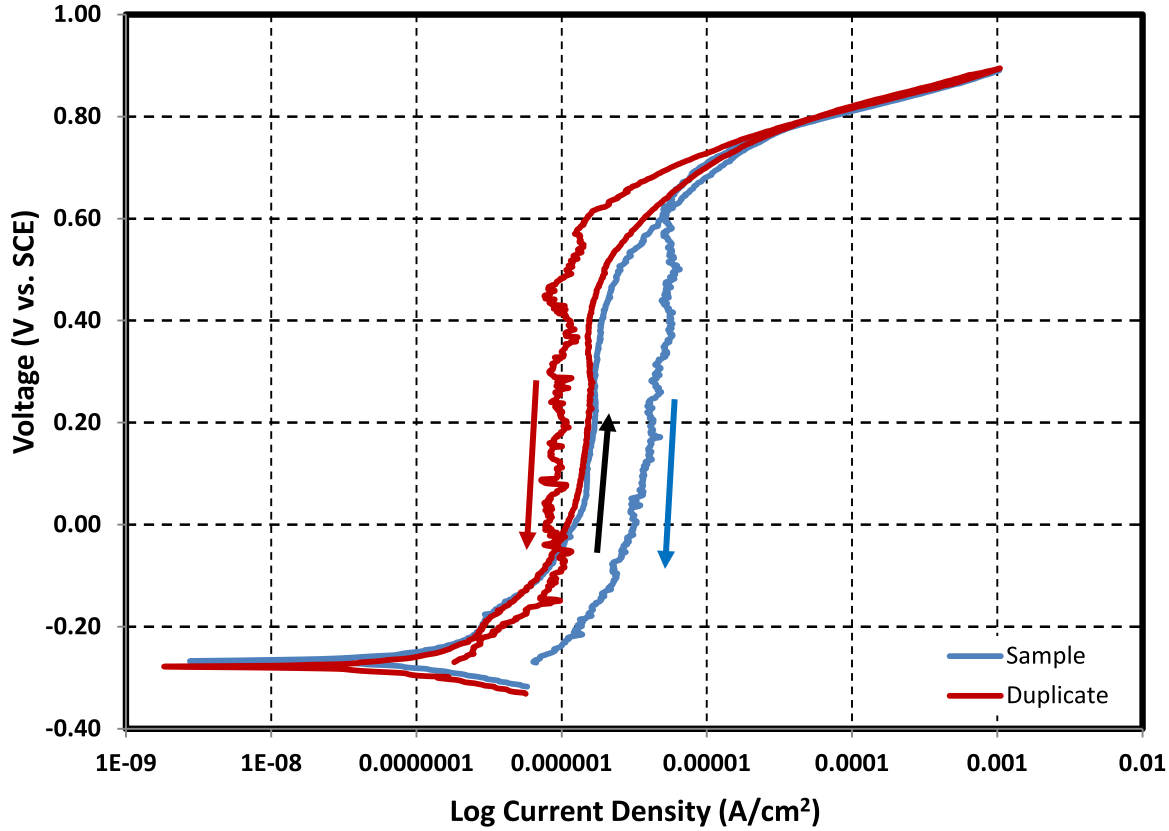


Composition of simulant for pitting corrosion -Test 19

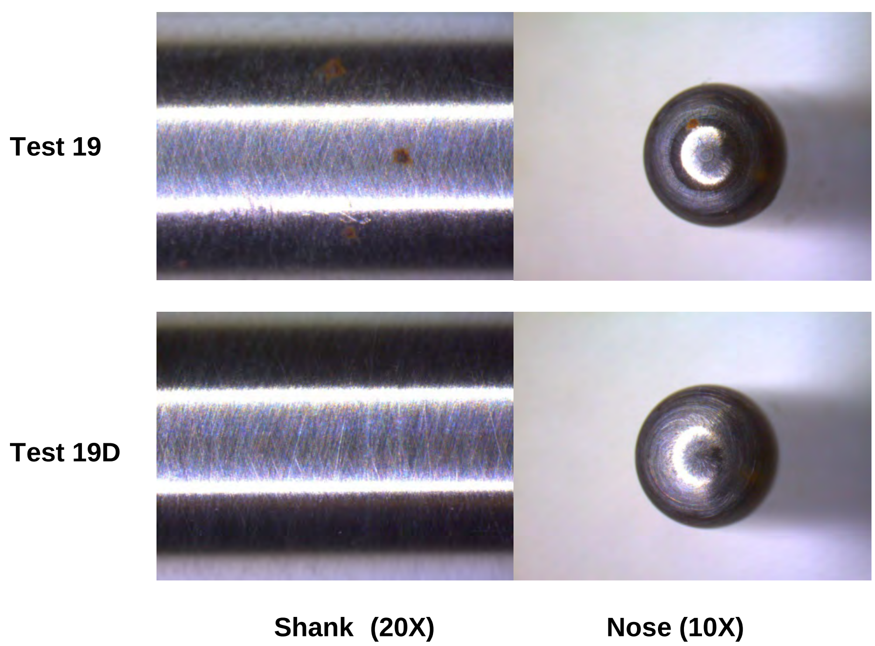
Reference 14	Temperature	40	**°C**
Test 19	pH	10.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.45	53.5437
Sodium nitrite	$NaNO_2$	69.00	0.225	21.7350
Sodium chloride	NaCl	58.44	0.0051	0.4173
Sodium sulfate	Na_2SO_4	142.04	0.0731	14.5364
Sodium carbonate	$Na_2(CO_3)$	106.00	0.0789	11.7088
Sodium bicarbonate	$NaHCO_3$	84.00	0.147	17.2872

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

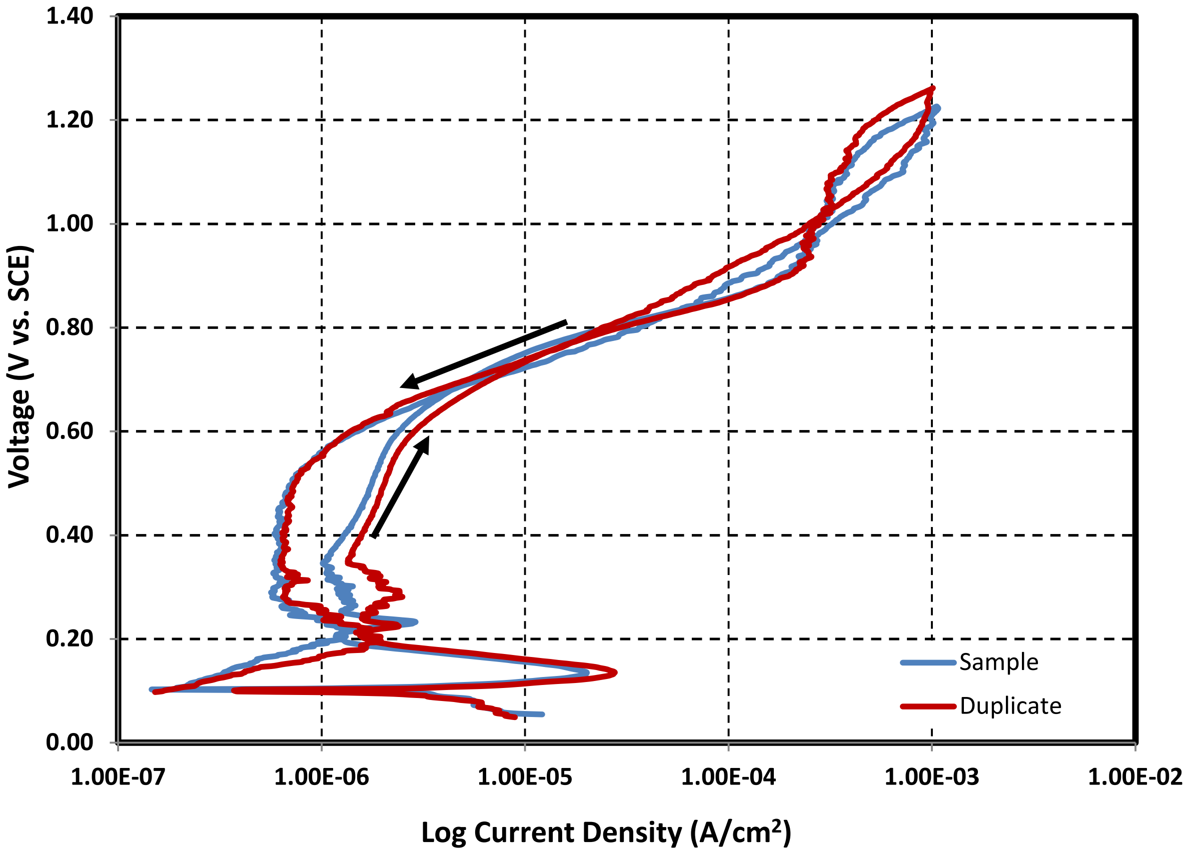


Composition of simulant for pitting corrosion -Test 20

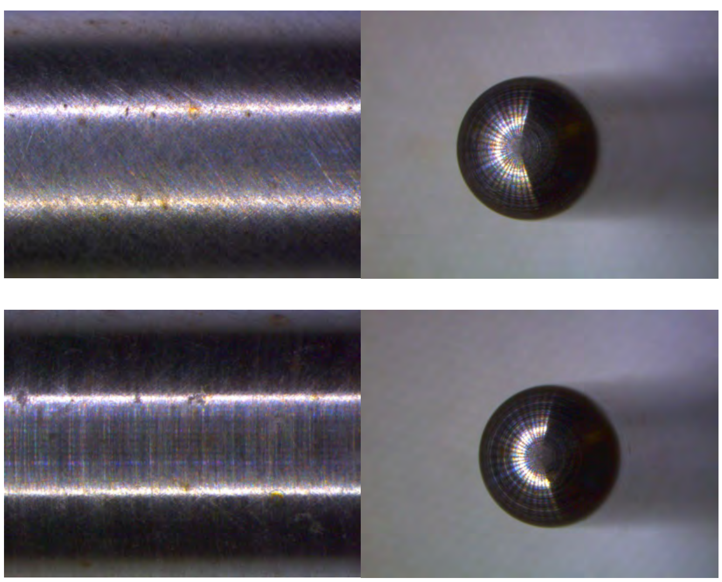
Reference 4	Temperature	40	°C
Test 20	pH	9.6	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.13	0.006842073	3.5933
Ferric Nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.001831683	1.0360
Sodium hydroxide	NaOH	40.00	0.0305	1.7080
Sodium nitrate	$NaNO_3$	85.00	0.001694317	0.2016
Sodium nitrite	$NaNO_2$	69.00	0.20057971	19.3760
Sodium oxalate	$Na_2(C_2O_4)$	134.00	0.002885572	0.5413
Sodium sulfate	Na_2SO_4	142.04	0.130019713	25.8552
Sodium carbonate	$Na_2(CO_3)$	106.00	0.004679245	0.6944
Sodium Bicarbonate	$NaHCO_3$	84.00	0.019333333	2.2736
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.12	9.16903E-05	0.0488
Calcium Carbonate	$CaCO_3$	100.00	0.000220133	0.0308
Sodium chloride	NaCl	58.44	0.000382729	0.0313
Sodium fluoride	NaF	42.00	0.000243175	0.0143
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	6.15066E-06	0.0021
Manganese Dioxide	MnO_2	86.94	0.000380032	0.0463
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	290.81	0.000173355	0.0706
Mercury (II) nitrate	$Hg(NO_3)_2$	342.62	0.000146	0.0700
Sodium silicate, 9-hydrate	$Na_2SiO_3.9H_2O$	284.00	5.33803E-05	0.0212
Zinc nitrate, 6-hydrate	$Zn(NO_3)_2.6H_2O$	297.49	1.37147E-05	0.0057
Lead nitrate	$Pb(NO_3)_2$	331.21	6.48129E-06	0.0030
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	8.18312E-06	0.0027

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



Test 20

Test 20D

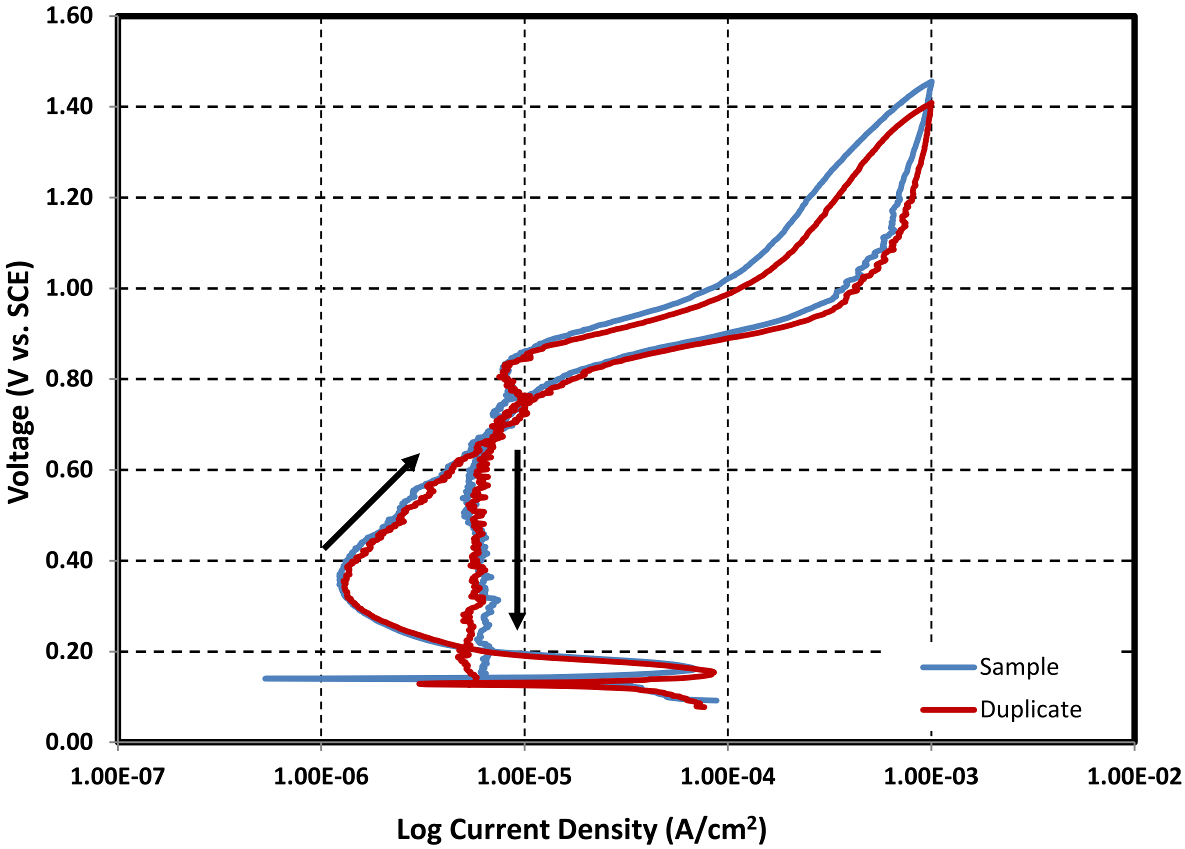
Shank (20X) **Nose (10X)**

Composition of simulant for pitting corrosion - Test 21

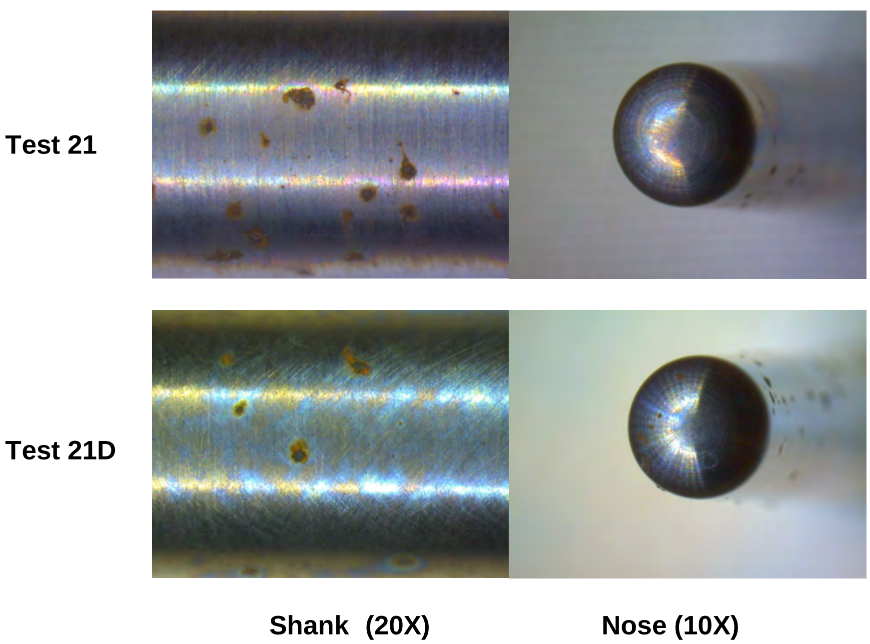
Reference 3	Temperature	40	°C
Test 21	pH	9.6	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.13	0.020526218	10.7800
Ferric Nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.004945	2.7969
Sodium hydroxide	$NaOH$	40.00	0.0915	5.1240
Sodium nitrate	$NaNO_3$	85.00	0	0.0000
Sodium nitrite	$NaNO_2$	69.00	0.024985507	2.4136
Sodium oxalate	$Na_2(C_2O_4)$	134.00	0.008656716	1.6240
Sodium sulfate	Na_2SO_4	142.04	0.005941988	1.1816
Sodium carbonate	$Na_2(CO_3)$	106.00	0.014037736	2.0832
Sodium Bicarbonate	$NaHCO_3$	84.00	0.058	6.8208
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.12	0.000275071	0.1464
Calcium Carbonate	$CaCO_3$	100.00	0.0006604	0.0925
Sodium chloride	$NaCl$	58.44	0.001090008	0.0892
Sodium fluoride	NaF	42.00	0.000729524	0.0429
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	1.8452E-05	0.0063
Manganese Dioxide	MnO_2	86.94	0.001140097	0.1388
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	290.81	0.000520065	0.2117
Mercury (II) nitrate	$Hg(NO_3)_2$	342.62	0.00311	1.4918
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.000160141	0.0476
Zinc nitrate, 6-hydrate	$Zn(NO_3)_2.6H_2O$	297.49	4.11442E-05	0.0171
Lead nitrate	$Pb(NO_3)_2$	331.21	1.94439E-05	0.0090
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	2.45494E-05	0.0080

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

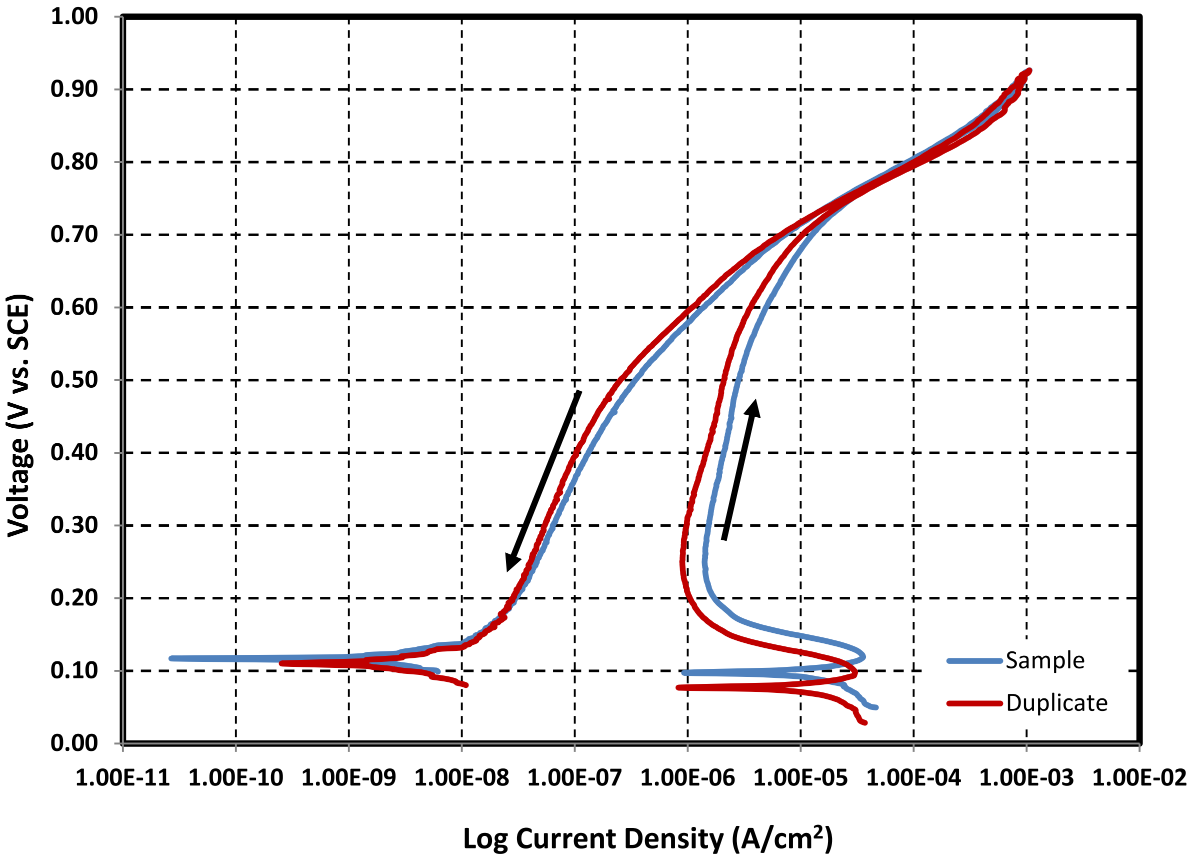


Composition of simulant for pitting corrosion -Test 22

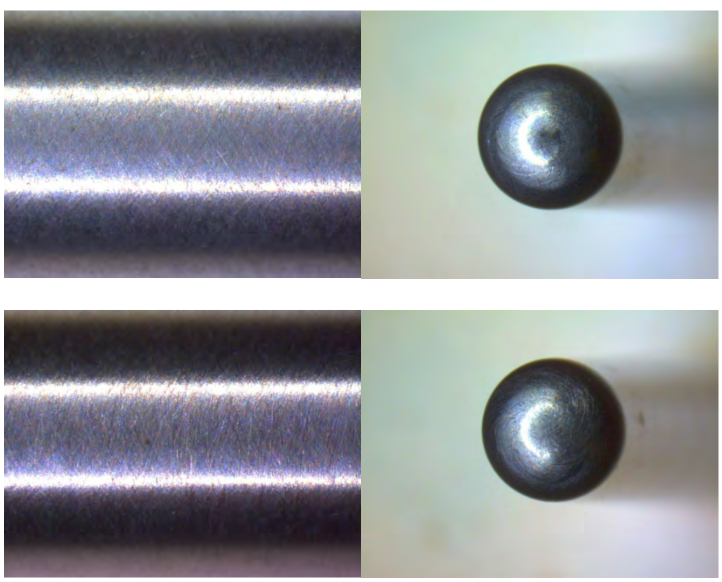
Reference 3	Temperature	40	°C
Test 22	pH	9.6	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.13	0.011196119	5.8800
Ferric Nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.004945	2.7969
Sodium hydroxide	NaOH	40.00	0.0915	5.1240
Sodium nitrate	$NaNO_3$	85.00	0.00701259	0.8345
Sodium nitrite	$NaNO_2$	69.00	0.100289855	9.6880
Sodium oxalate	$Na_2(C_2O_4)$	134.00	0.008656716	1.6240
Sodium sulfate	Na_2SO_4	142.04	0.005941988	1.1816
Sodium carbonate	$Na_2(CO_3)$	106.00	0.014037736	2.0832
Sodium Bicarbonate	$NaHCO_3$	84.00	0.058	6.8208
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.12	0.000275071	0.1464
Calcium Carbonate	$CaCO_3$	100.00	0.0006604	0.0925
Sodium chloride	NaCl	58.44	1.09E-03	0.0892
Sodium fluoride	NaF	42.00	0.000729524	0.0429
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	1.8452E-05	0.0063
Manganese Dioxide	MnO_2	86.94	0.001140097	0.1388
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	290.81	0.000520065	0.2117
Mercury (II) nitrate	$Hg(NO_3)_2$	342.62	0.00311	1.4918
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.000160141	0.0476
Zinc nitrate, 6-hydrate	$Zn(NO_3)_2.6H_2O$	297.49	4.11442E-05	0.0171
Lead nitrate	$Pb(NO_3)_2$	331.21	1.94439E-05	0.0090
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	2.45494E-05	0.0080

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests



Test 22

Test 22D

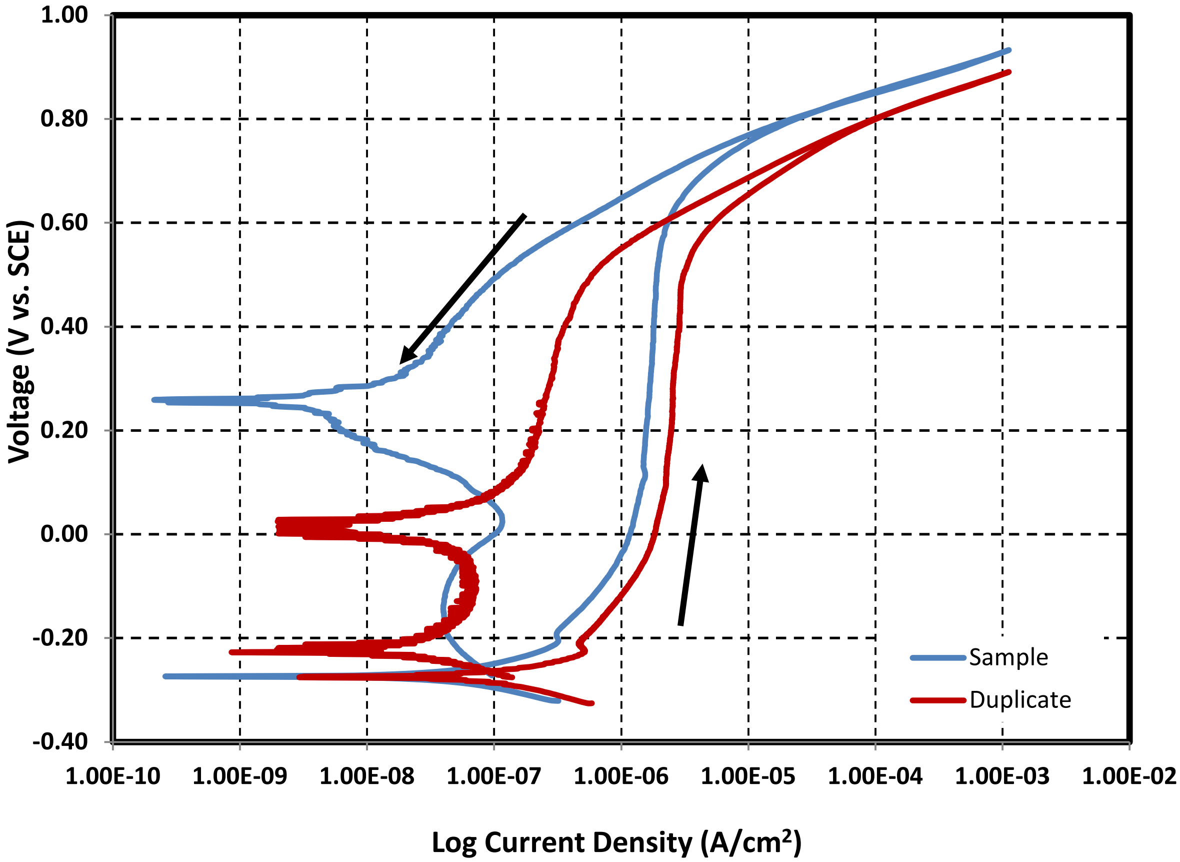
Shank (20X) **Nose (10X)**

Composition of simulant for pitting corrosion –Test 23

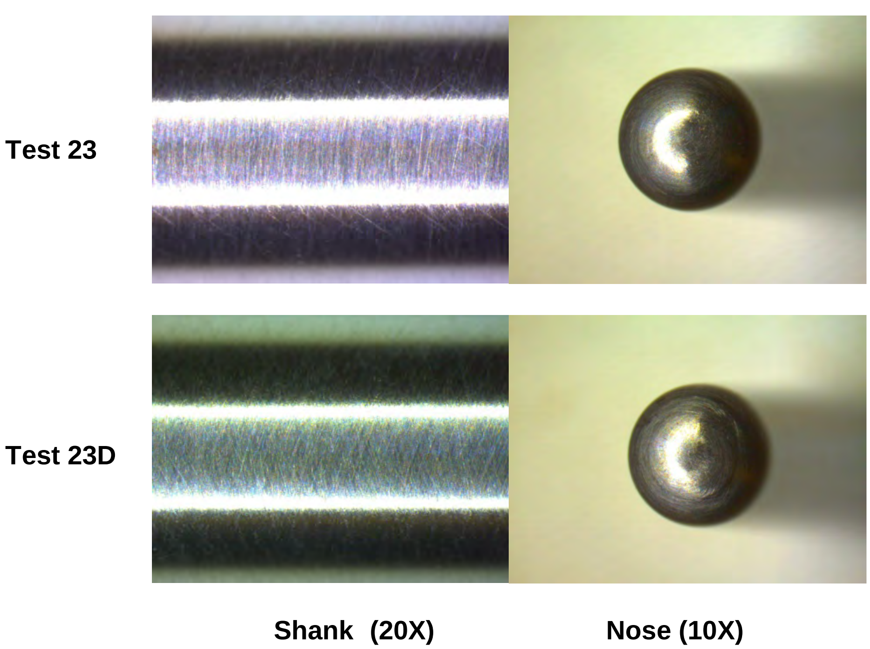
Reference 14	Temperature	40	°C
Test 23	pH	10.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.9	107.0874
Sodium nitrite	$NaNO_2$	69.00	0.9	86.9400
Sodium chloride	NaCl	58.44	0.0142	1.1618
Sodium sulfate	Na_2SO_4	142.04	0.3806	75.6846
Sodium carbonate	$Na_2(CO_3)$	106.00	0.3158	46.8647
Sodium bicarbonate	$NaHCO_3$	84.00	0.586	68.9136

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

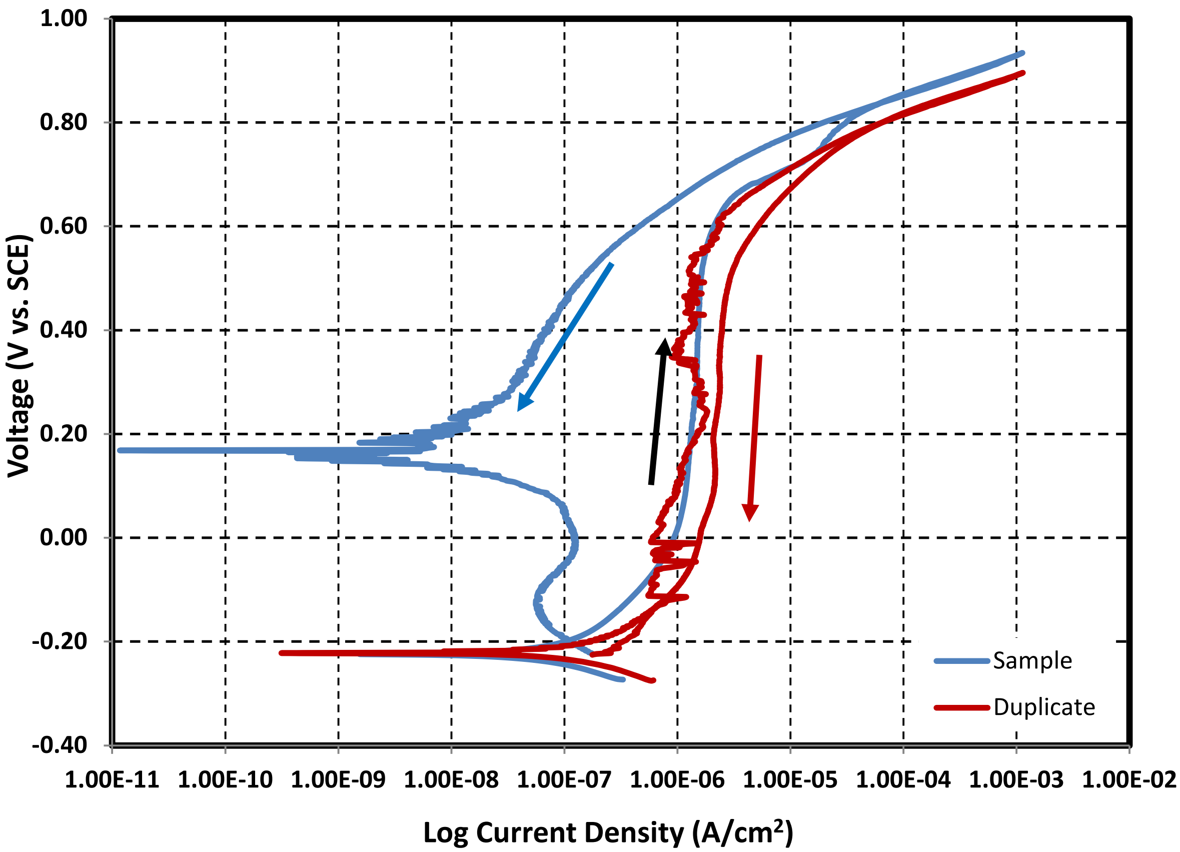


Composition of simulant for pitting corrosion –Test 24

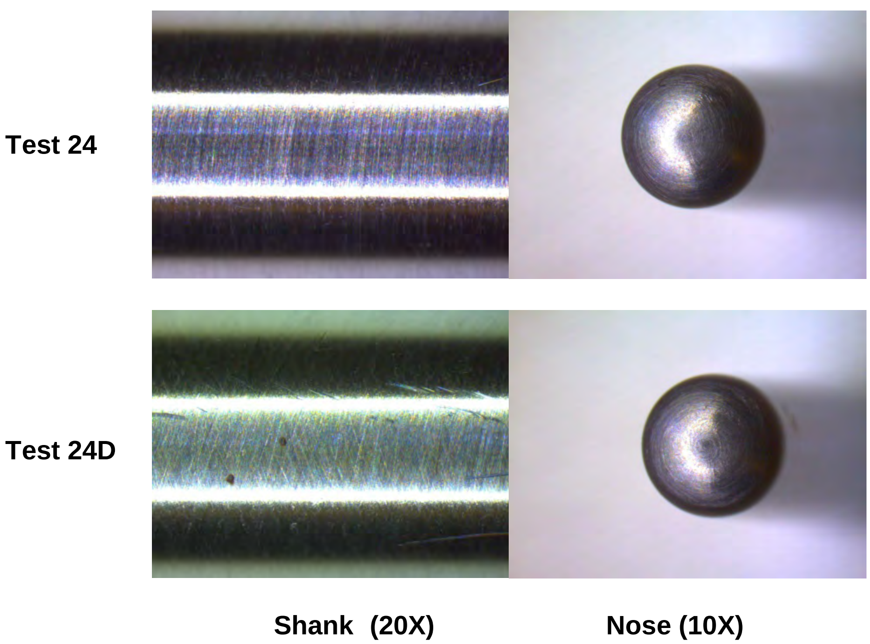
Reference 16	Temperature	40	**°C**
Test 24	pH	10.00	
Volume	1.4	L	

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.85	101.1381
Sodium nitrite	$NaNO_2$	69.00	0.425	41.0550
Sodium chloride	NaCl	58.44	0.011	0.9000
Sodium sulfate	Na_2SO_4	142.04	0.0425	8.4514
Sodium carbonate	$Na_2(CO_3)$	106.00	0.1491	22.1264
Sodium bicarbonate	$NaHCO_3$	84.00	0.277	32.5752

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

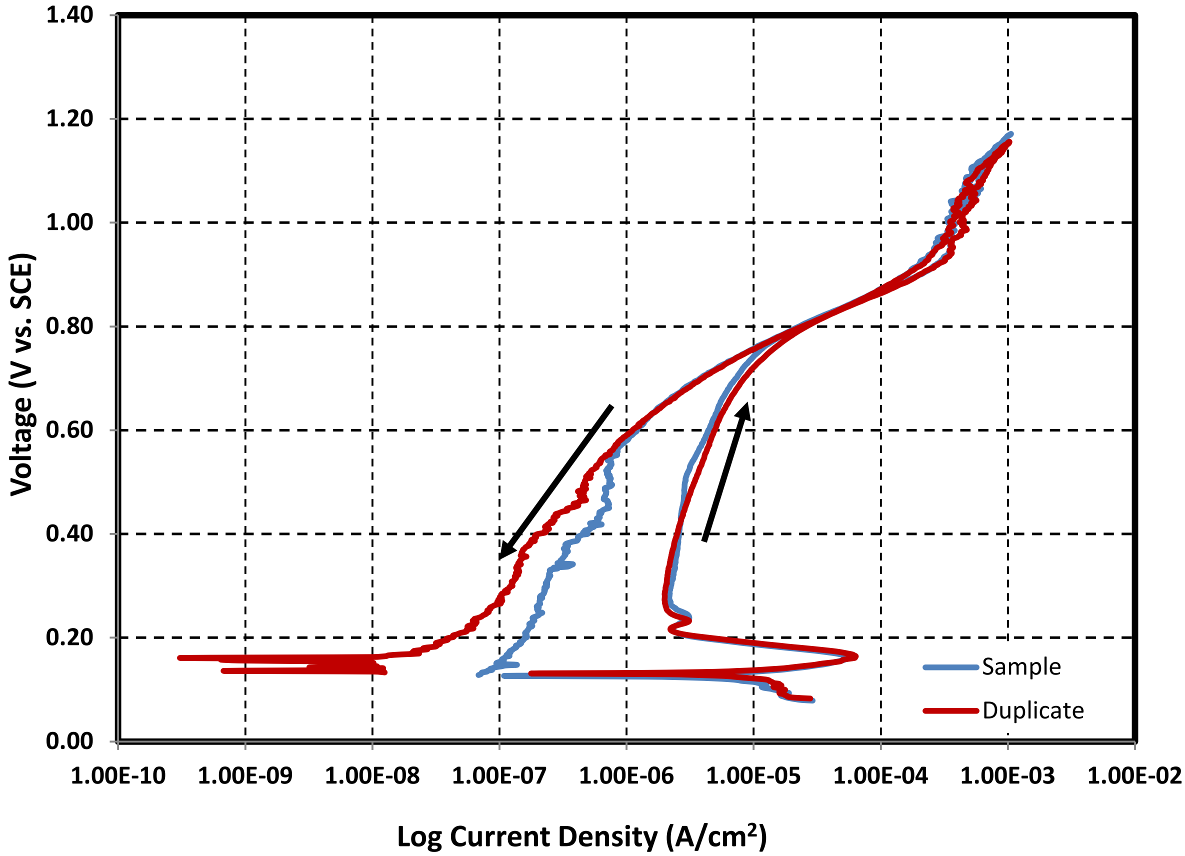


Composition of simulant for pitting corrosion –Test 25

Reference 1	Temperature	40	°C
Test 25	pH	9.66	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium carbonate	Na_2CO_3	106.00	0.0112	1.6621
Sodium bicarbonate	$NaHCO_3$	84.01	0.0353	4.1518
Sodium oxalate	$Na_2C_2O_4$	134.00	0.00014	0.0263
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	0.00000744	0.0025
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.0000567	0.0168
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.00	0.000161	0.0857
Sodium chloride	NaCl	58.40	0.000596	0.0487
Sodium fluoride	NaF	41.99	0.000298	0.0175
Sodium sulfate	Na_2SO_4	142.00	0.00261	0.5189
Sodium nitrate	$NaNO_3$	85.00	0.0394	4.6886
Sodium nitrite	$NaNO_2$	69.00	0.022	2.1252
Sodium aluminate	$NaAlO_2$	81.97	0.00045	0.0516
Cobalt nitrate, 6-hydrate	Co(NO3)2.6H2O	291.03	0.00003	0.0122
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.00	0.0015	0.6111
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.000248	0.1403
Mercury (II) nitrate	$Hg(NO_3)_2$	324.60	0.00025	0.1136
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	0.000043	0.0140
Manganese dioxide	MnO_2	86.94	0.00575	0.6999

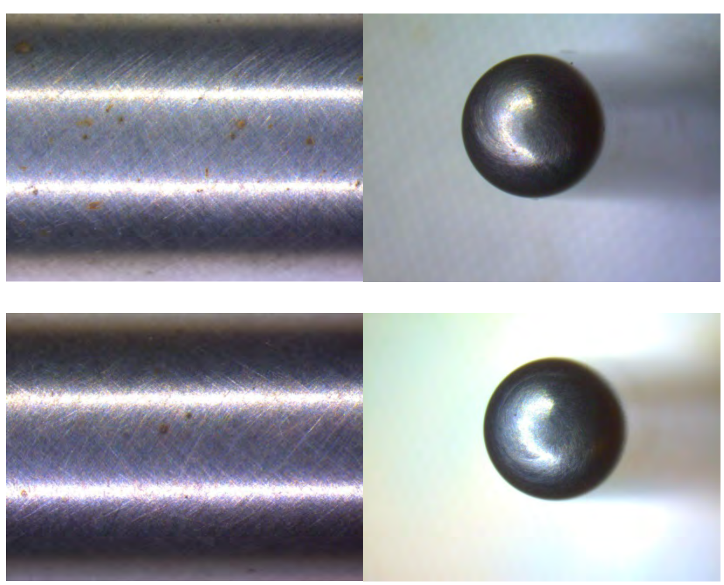
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 25

Test 25D



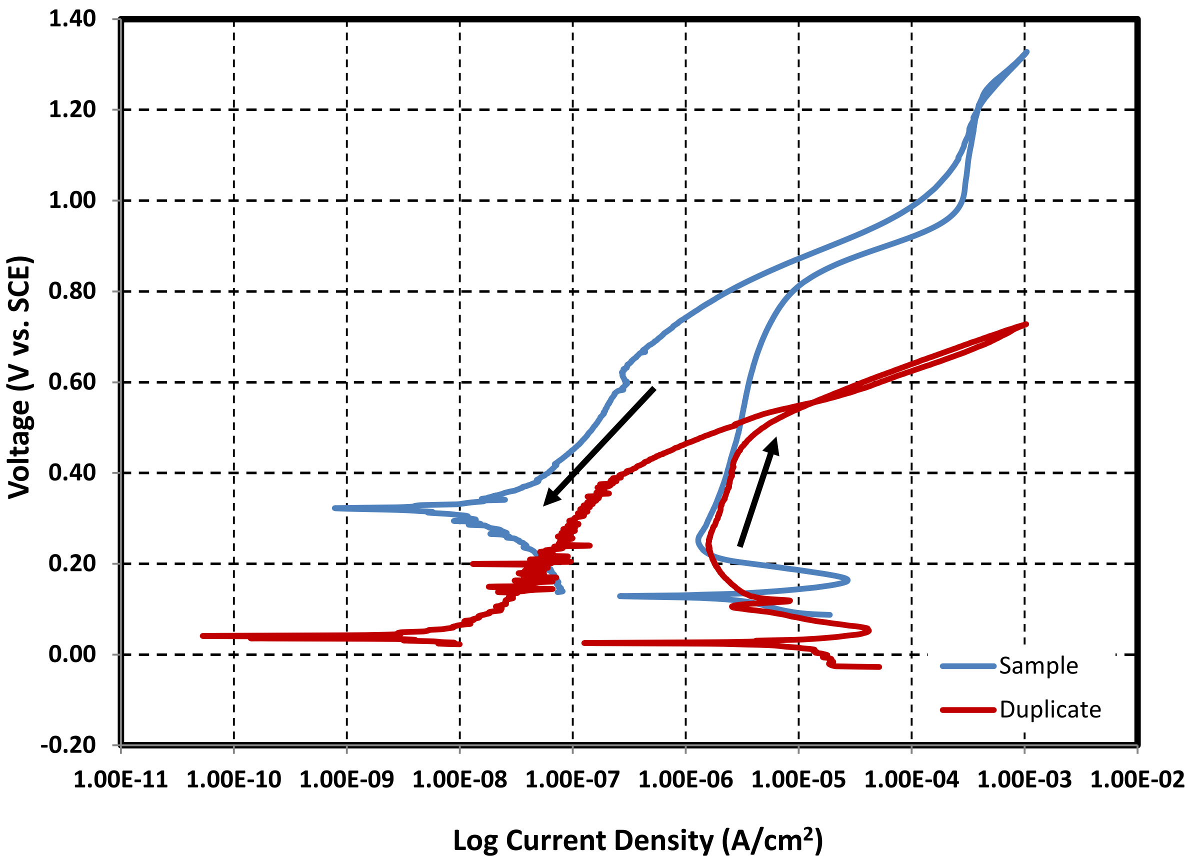
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion –Test 26

Reference 1	Temperature	50	°C
Test 26	pH	10.06	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium carbonate	Na_2CO_3	106.00	0.187	27.7508
Sodium bicarbonate	$NaHCO_3$	84.01	0.173	20.3472
Sodium oxalate	$Na_2C_2O_4$	134.00	0.00138	0.2589
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	0.0000733	0.0248
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.000559	0.1660
Sodium phosphate, 12-hydrate	$Na_3PO_{4.}12H_2O$	380.00	0.00158	0.8406
Sodium chloride	NaCl	58.40	0.00587	0.4799
Sodium fluoride	NaF	41.99	0.00294	0.1728
Sodium sulfate	Na_2SO_4	142.00	0.0258	5.1290
Sodium nitrate	$NaNO_3$	85.00	0.388	46.1720
Sodium nitrite	$NaNO_2$	69.00	0.7	67.6200
Sodium aluminate	$NaAlO_2$	81.97	0.00045	0.0516
Cobalt nitrate, 6-hydrate	Co(NO3)2.6H2O	291.03	0.00003	0.0122
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	291.00	0.0015	0.6111
Ferric nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.000248	0.1403
Mercury (II) nitrate	$Hg(NO_3)_2$	324.60	0.00025	0.1136
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	0.000043	0.0140
Manganese dioxide	MnO_2	86.94	0.00575	0.6999

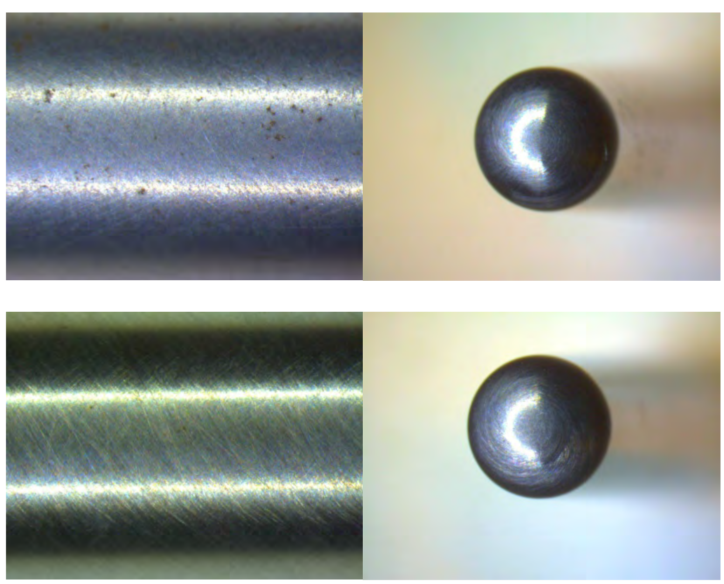
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 26

Test 26D



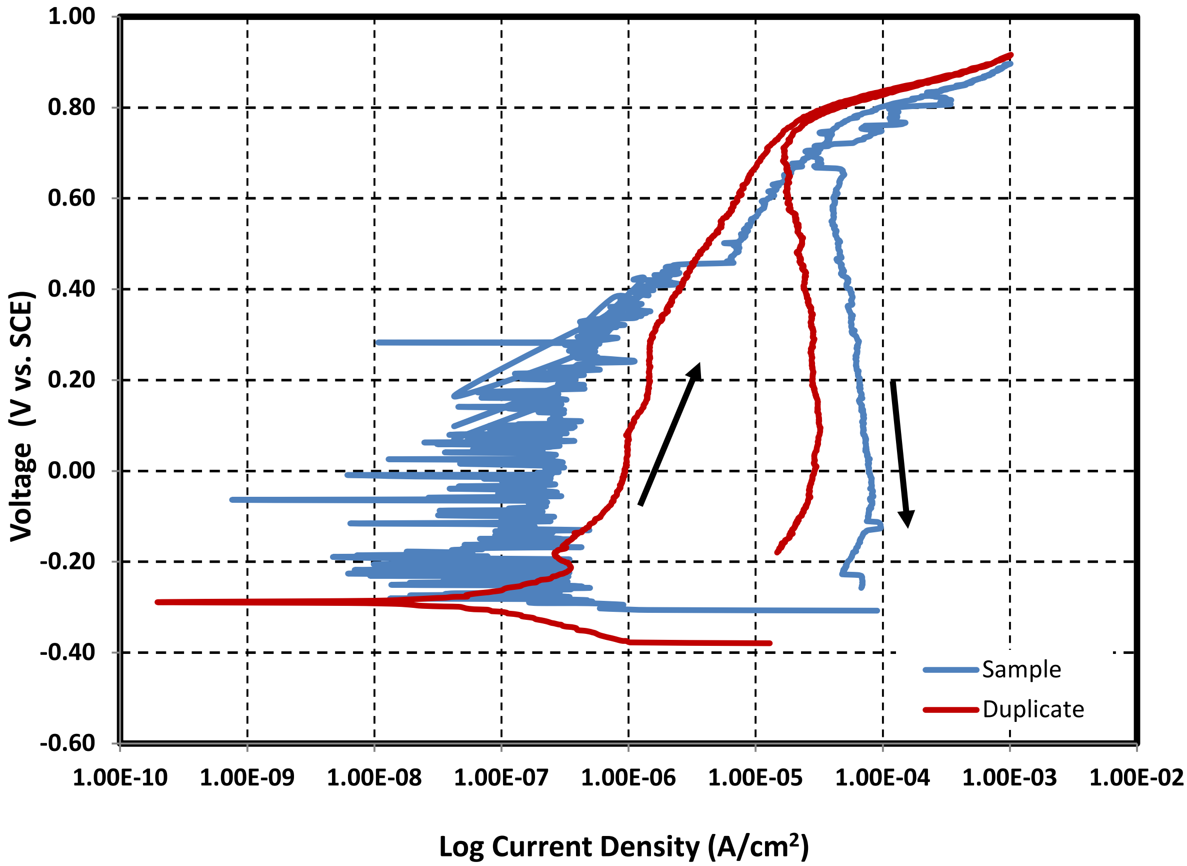
Shank (20X) **Nose (10X)**

Composition of simulant for pitting corrosion –Test 27

Reference 14	Temperature	40	°C
Test 27	pH	10.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.45	53.5437
Sodium nitrite	$NaNO_2$	69.00	0.113	10.9158
Sodium chloride	NaCl	58.44	0.003	0.2454
Sodium sulfate	Na_2SO_4	142.04	0.032	6.3634
Sodium carbonate	$Na_2(CO_3)$	106.00	0.0395	5.8618
Sodium bicarbonate	$NaHCO_3$	84.00	0.073	8.5848

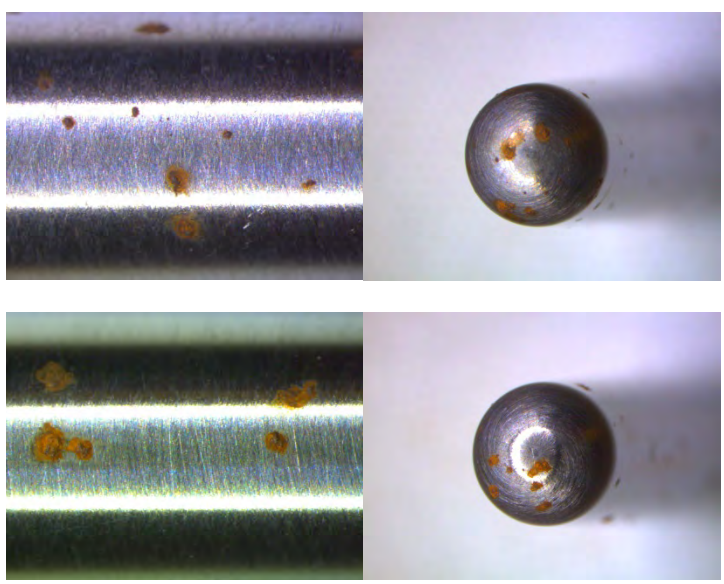
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 27

Test 27D



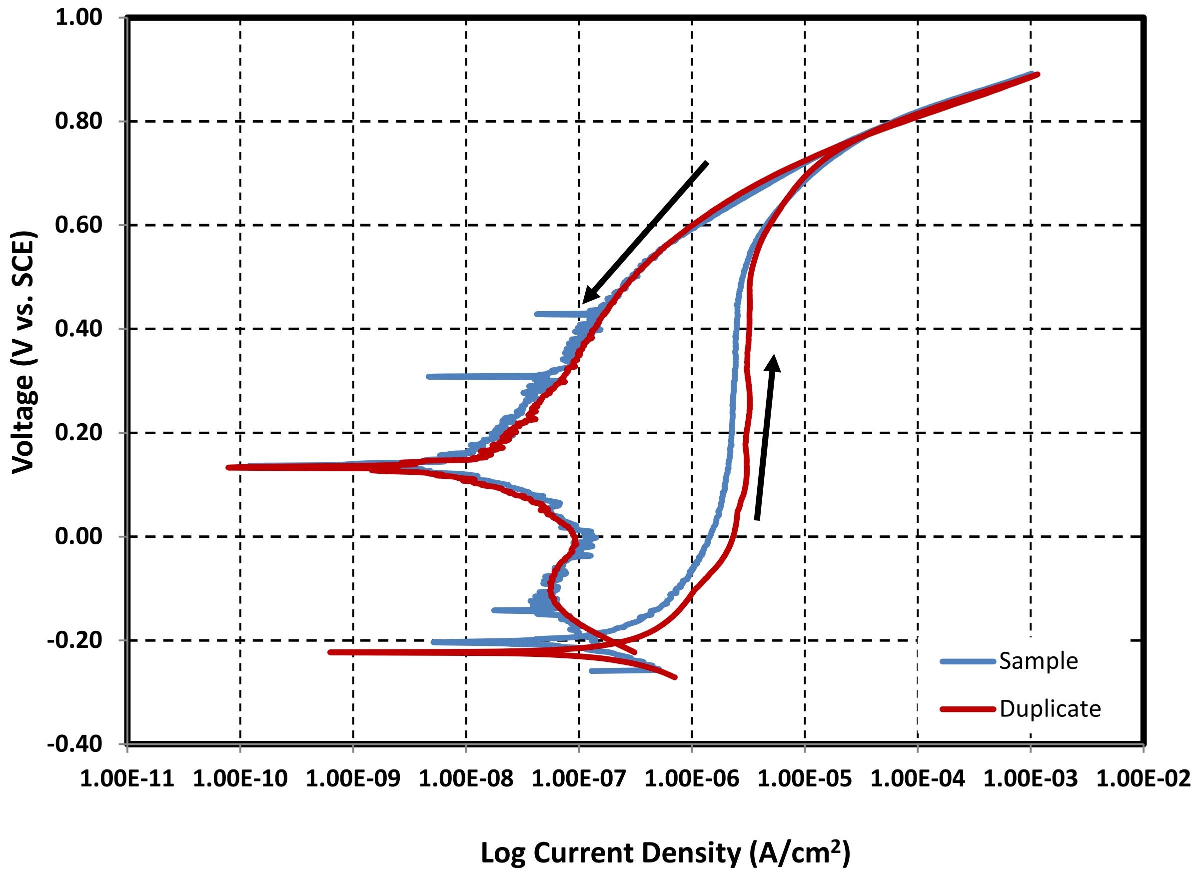
Shank (20X) **Nose (10X)**

Composition of simulant for pitting corrosion –Test 28

Reference 16	Temperature	40	°C
Test 28	pH	10.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.55	65.4423
Sodium nitrite	$NaNO_2$	69.00	0.55	53.1300
Sodium chloride	NaCl	58.44	0.007	0.5727
Sodium sulfate	Na_2SO_4	142.04	0.0275	5.4685
Sodium carbonate	$Na_2(CO_3)$	106.00	0.193	28.6412
Sodium bicarbonate	$NaHCO_3$	84.00	0.358	42.1008

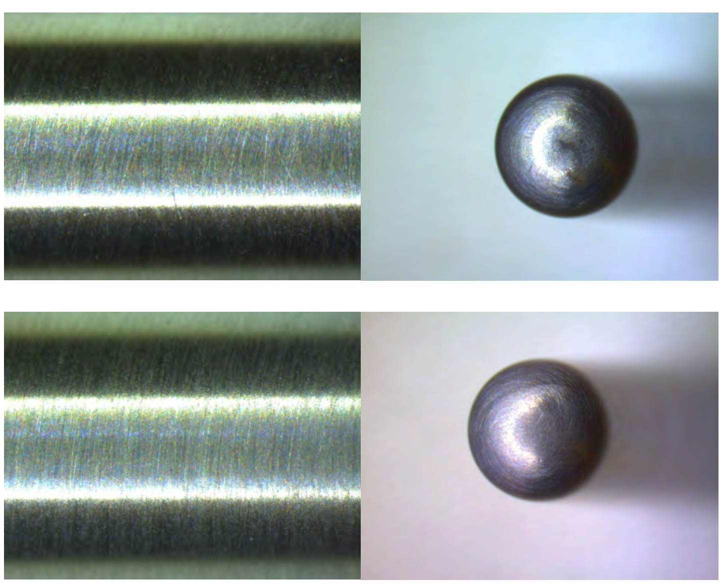
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 28

Test 28D



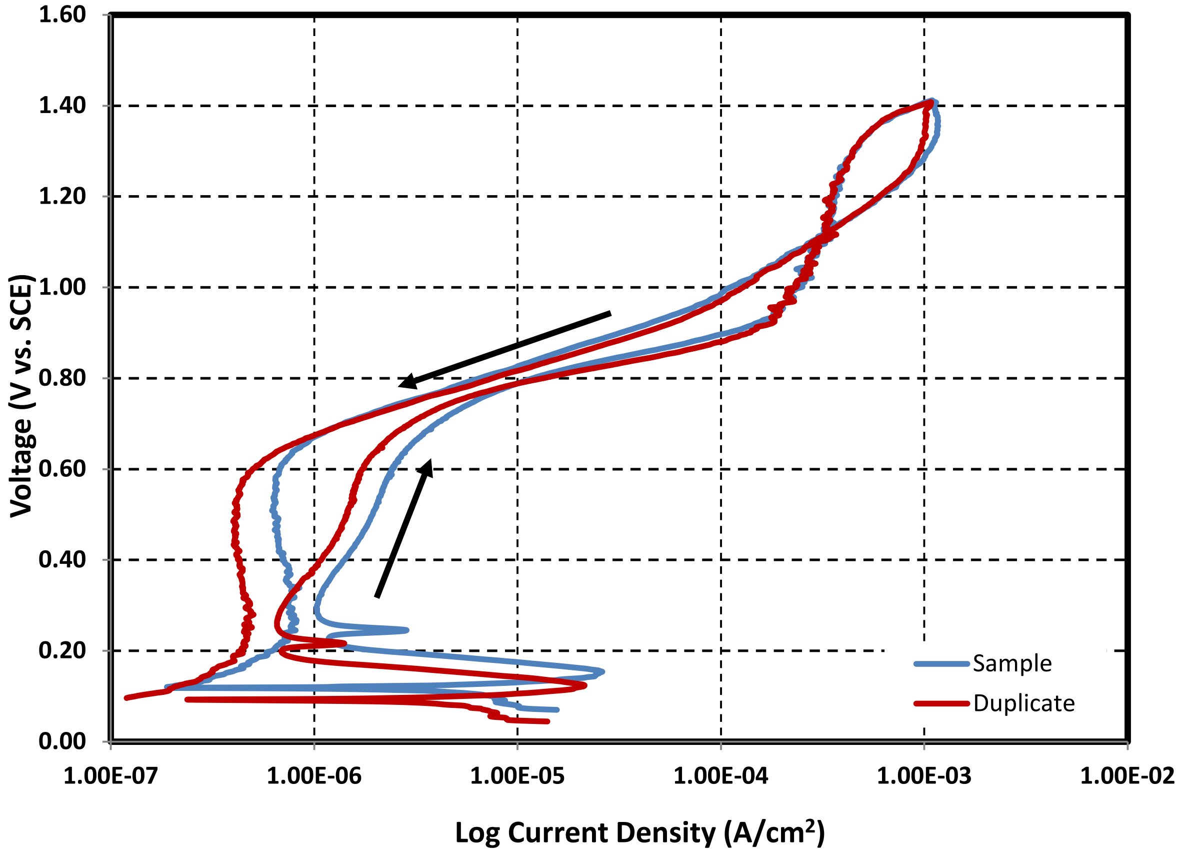
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion –Test 29

Reference 4	Temperature	40	°C
Test 29	pH	9.6	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.13	0.006842073	3.5933
Ferric Nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.001831683	1.0360
Sodium hydroxide	$NaOH$	40.00	0.0305	1.7080
Sodium nitrate	$NaNO_3$	85.00	0.001694317	0.2016
Sodium nitrite	$NaNO_2$	69.00	0.070202899	6.7816
Sodium oxalate	$Na_2(C_2O_4)$	134.00	0.002885572	0.5413
Sodium sulfate	Na_2SO_4	142.04	0.001980663	0.3939
Sodium carbonate	$Na_2(CO_3)$	106.00	0.004679245	0.6944
Sodium Bicarbonate	$NaHCO_3$	84.00	0.019333333	2.2736
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.12	9.16903E-05	0.0488
Calcium Carbonate	$CaCO_3$	100.00	0.000220133	0.0308
Sodium chloride	$NaCl$	58.44	0.000382729	0.0313
Sodium fluoride	NaF	42.00	0.000243175	0.0143
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	6.15066E-06	0.0021
Manganese Dioxide	MnO_2	86.94	0.000380032	0.0463
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	290.81	0.000173355	0.0706
Mercury (II) nitrate	$Hg(NO_3)_2$	342.62	0.000146	0.0700
Sodium silicate, 9-hydrate	$Na_2SiO_3.9H_2O$	284.00	5.33803E-05	0.0212
Zinc nitrate, 6-hydrate	$Zn(NO_3)_2.6H_2O$	297.49	1.37147E-05	0.0057
Lead nitrate	$Pb(NO_3)_2$	331.21	6.48129E-06	0.0030
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	8.18312E-06	0.0027

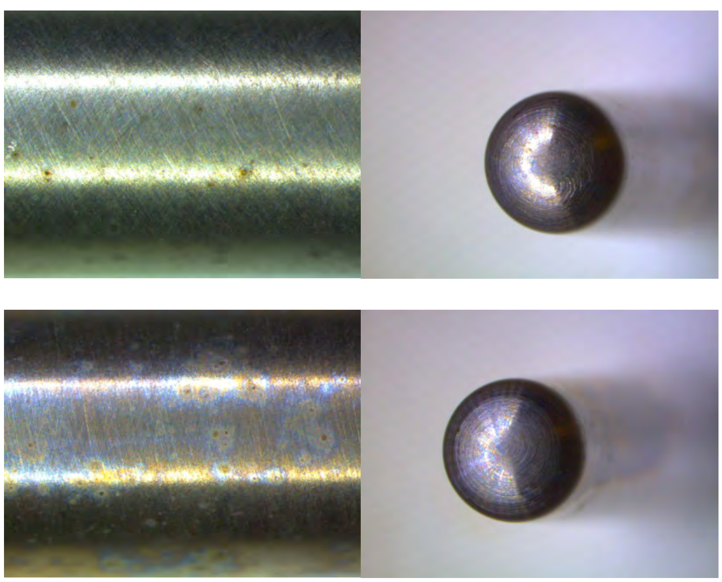
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 29

Test 29D



Shank (20X)

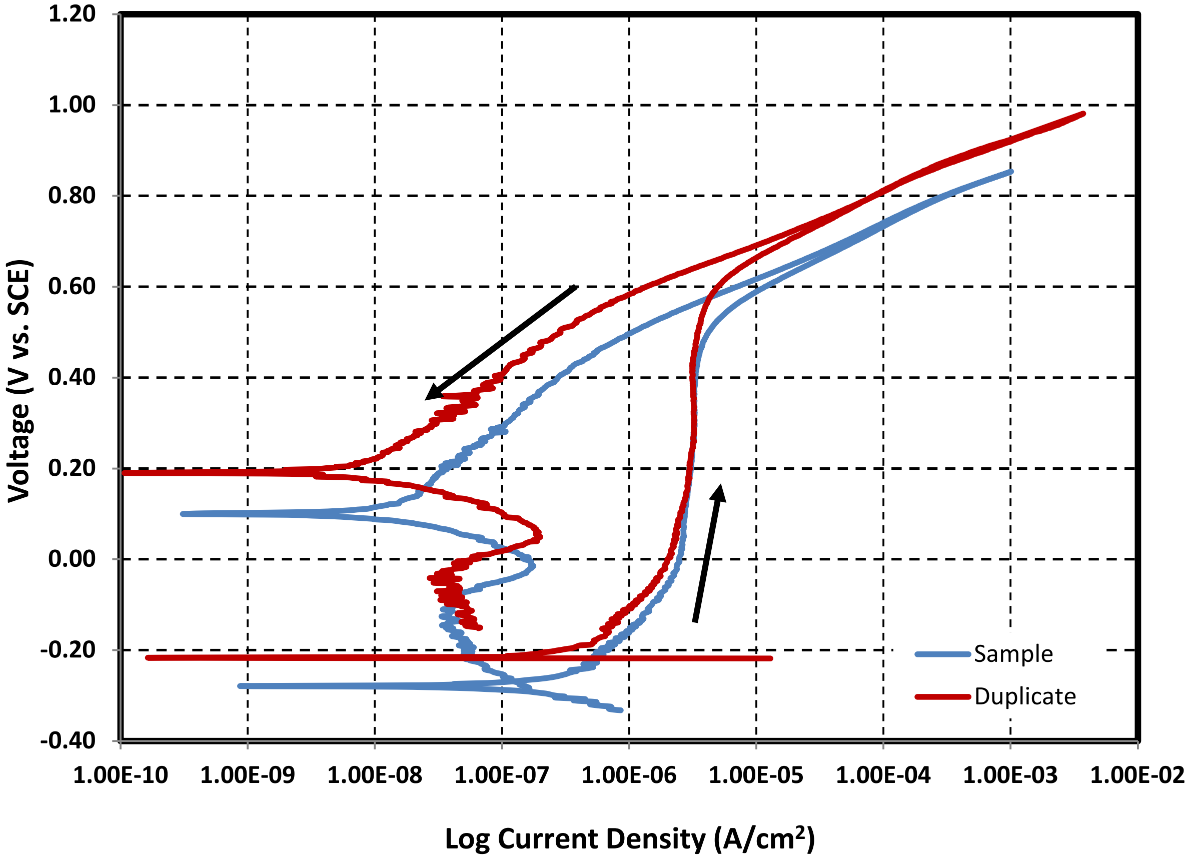
Nose (10X)

Composition of simulant for pitting corrosion –Test 30

Reference 16	Temperature	40	°C
Test 30	pH	10.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.25	29.7465
Sodium nitrite	$NaNO_2$	69.00	1.8	173.8800
Sodium chloride	NaCl	58.44	0.0175	1.4318
Sodium sulfate	Na_2SO_4	142.04	0.0375	7.4571
Sodium carbonate	$Na_2(CO_3)$	106.00	0.632	93.7888
Sodium bicarbonate	$NaHCO_3$	84.00	1.17	137.5920

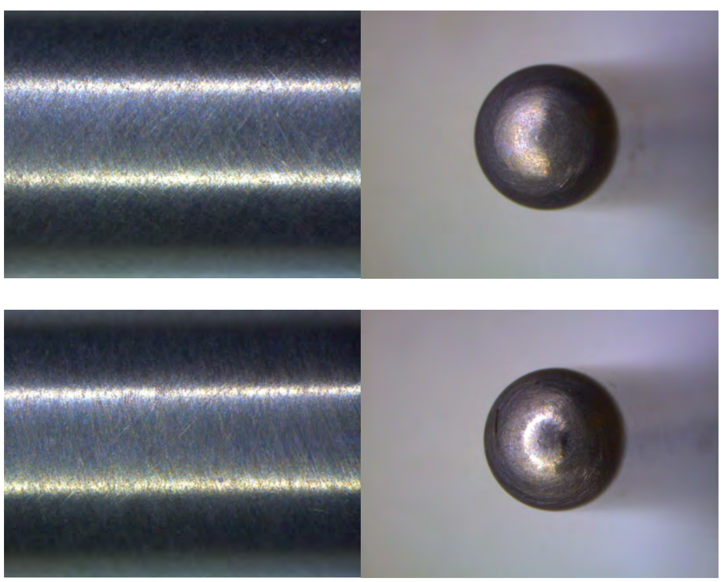
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 30

Test 30D



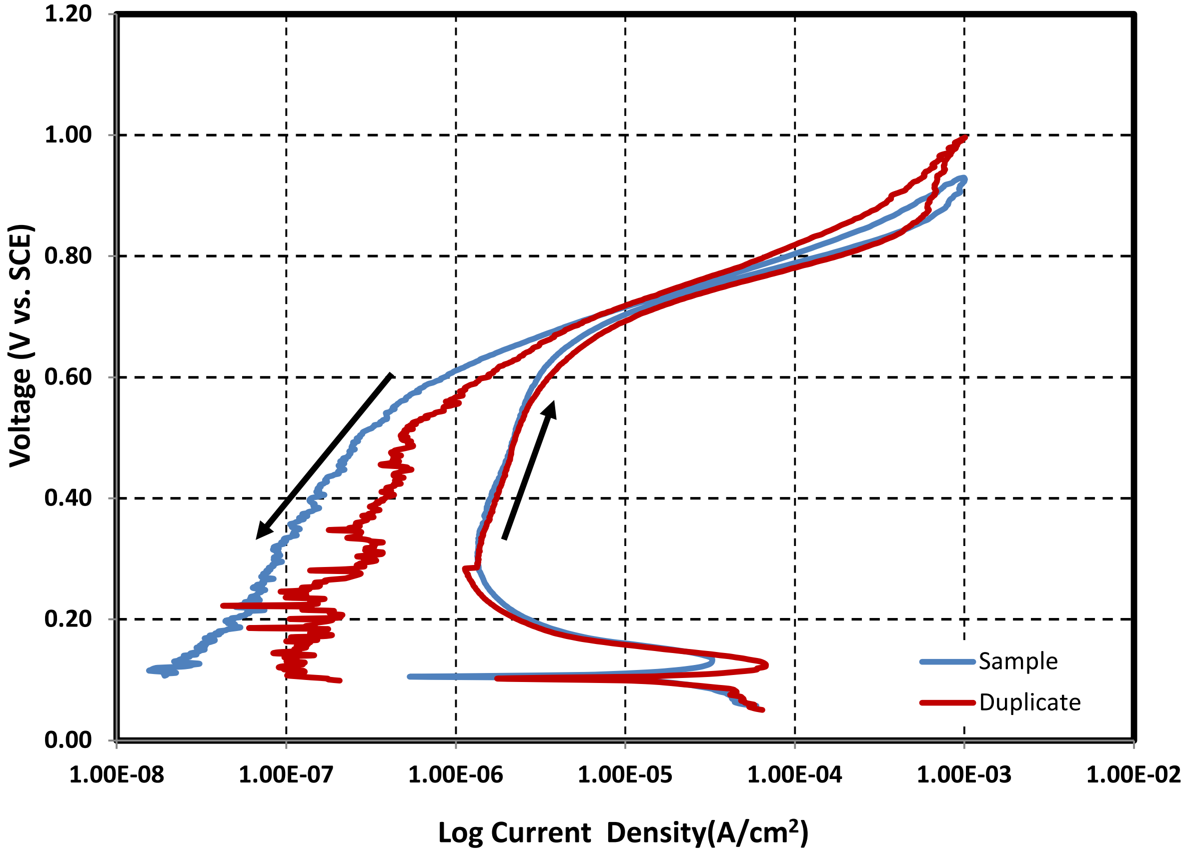
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion –Test 31

Reference 3	Temperature	40	°C
Test 31	pH	9.6	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.13	0.014928158	7.8400
Ferric Nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.004945	2.7969
Sodium hydroxide	NaOH	40.00	0.0915	5.1240
Sodium nitrate	$NaNO_3$	85.00	0	0.0000
Sodium nitrite	$NaNO_2$	69.00	0.06	5.7960
Sodium oxalate	$Na_2(C_2O_4)$	134.00	0.008656716	1.6240
Sodium sulfate	Na_2SO_4	142.04	0.005941988	1.1816
Sodium carbonate	$Na_2(CO_3)$	106.00	0.014037736	2.0832
Sodium Bicarbonate	$NaHCO_3$	84.00	0.058	6.8208
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.12	0.000275071	0.1464
Calcium Carbonate	$CaCO_3$	100.00	0.0006604	0.0925
Sodium chloride	NaCl	58.44	1.09E-03	0.0892
Sodium fluoride	NaF	42.00	0.000729524	0.0429
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	1.8452E-05	0.0063
Manganese Dioxide	MnO_2	86.94	0.001140097	0.1388
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	290.81	0.000520065	0.2117
Mercury (II) nitrate	$Hg(NO_3)_2$	342.62	0.00311	1.4918
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.000160141	0.0476
Zinc nitrate, 6-hydrate	$Zn(NO_3)_2.6H_2O$	297.49	4.11442E-05	0.0171
Lead nitrate	$Pb(NO_3)_2$	331.21	1.94439E-05	0.0090
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	2.45494E-05	0.0080

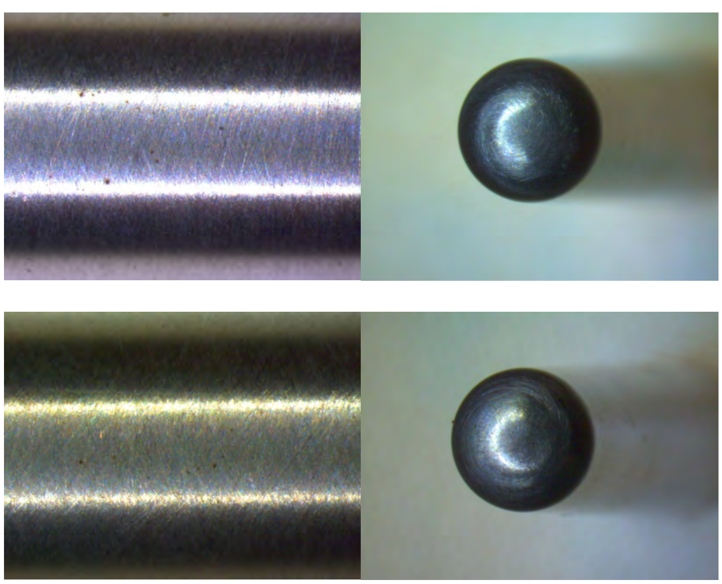
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 31

Test 31D



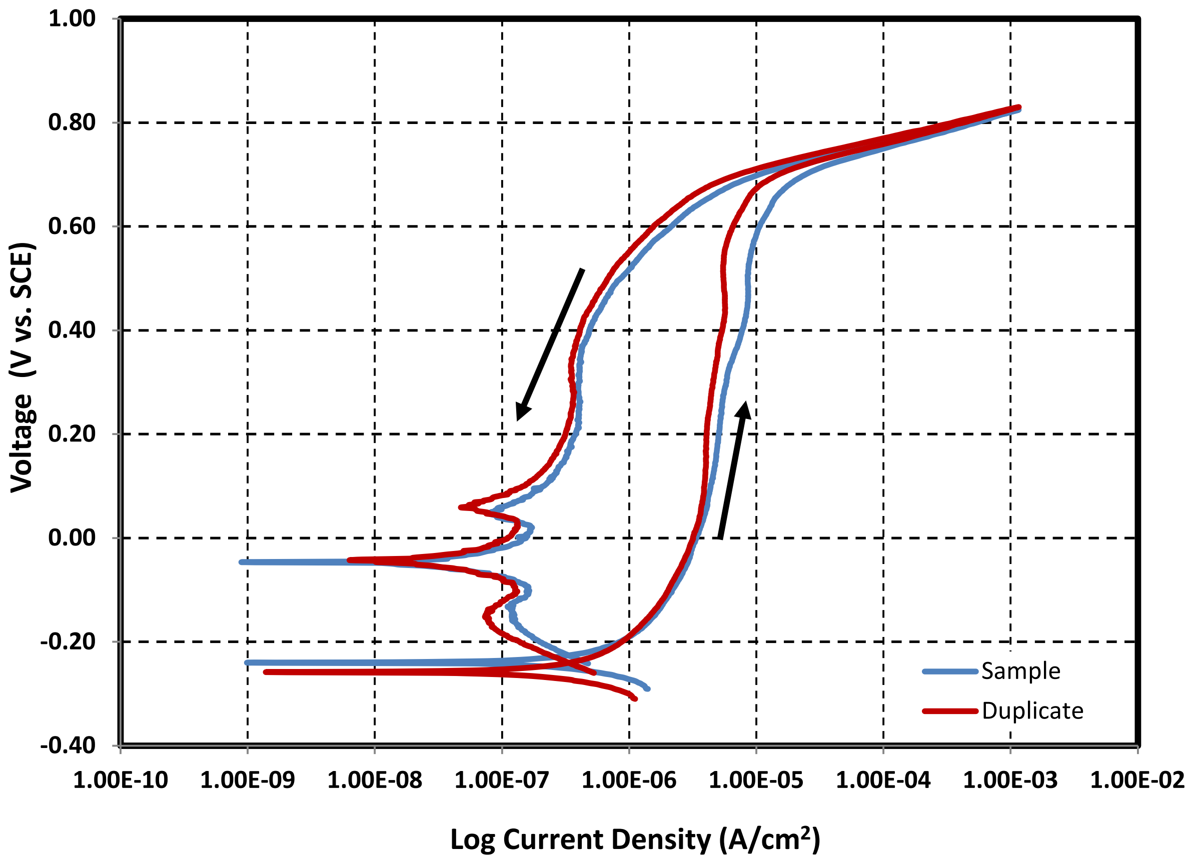
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion –Test 32

Reference 12	Temperature	80	°C
Test 32	pH	10.18	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.0098	1.1661
Sodium sulfate	Na_2SO_4	142.04	0.00264	0.5250
Sodium Iodide	NaI	149.89	0.00016	0.0336
Sodium fluoride	NaF	42.00	0.00267	0.1570
Sodium chloride	NaCl	58.44	0.0146	1.1945
Sodium nitrite	$NaNO_2$	69.00	0.022	2.1252
Sodium carbonate	$Na_2(CO_3)$	106.00	0.337	50.0108
Sodium bicarbonate	$NaHCO_3$	84.00	0.243	28.5768

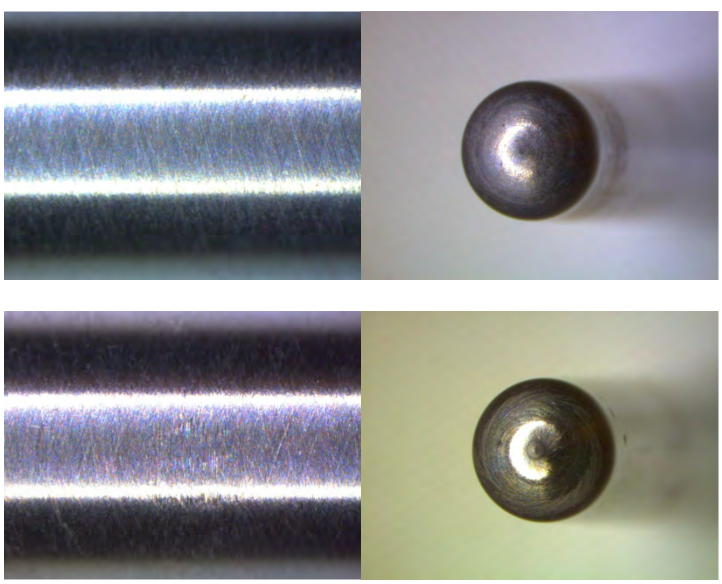
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 32

Test 32D



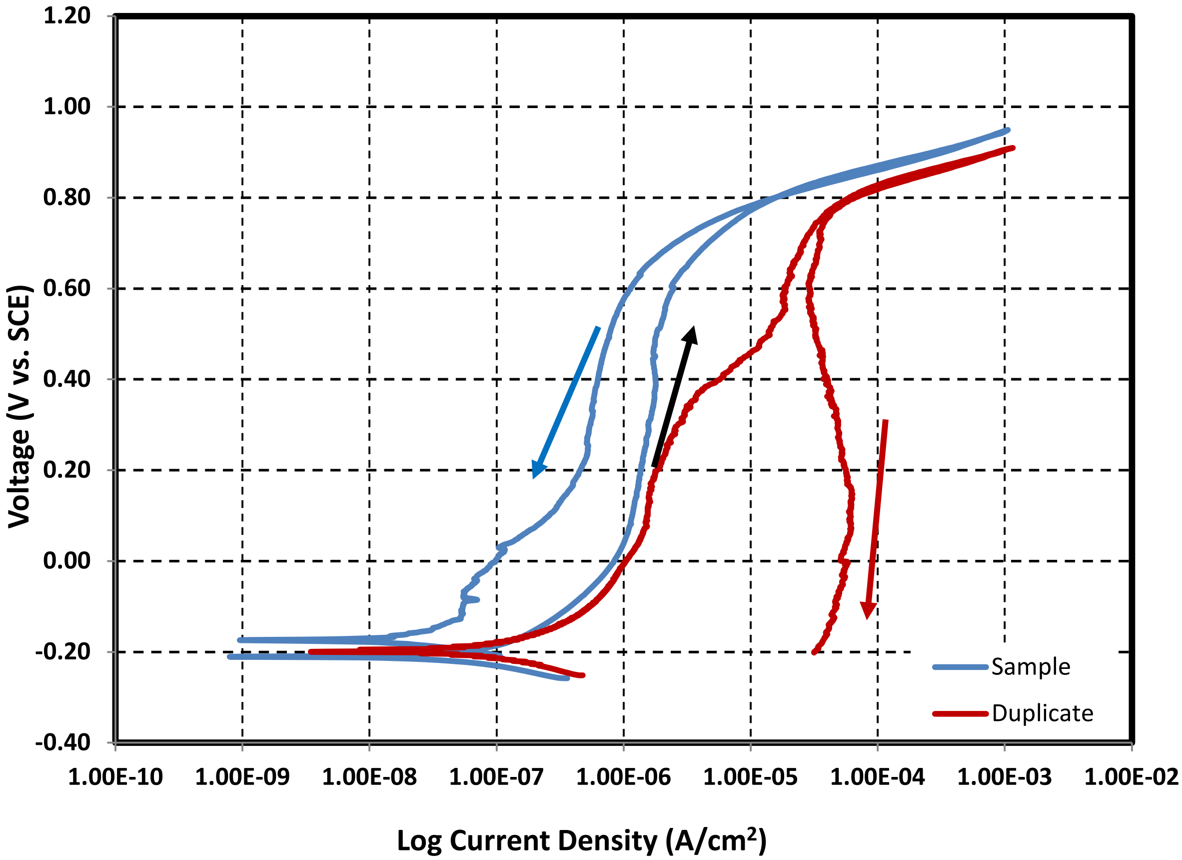
Shank (20X) **Nose (10X)**

Composition of simulant for pitting corrosion –Test 33

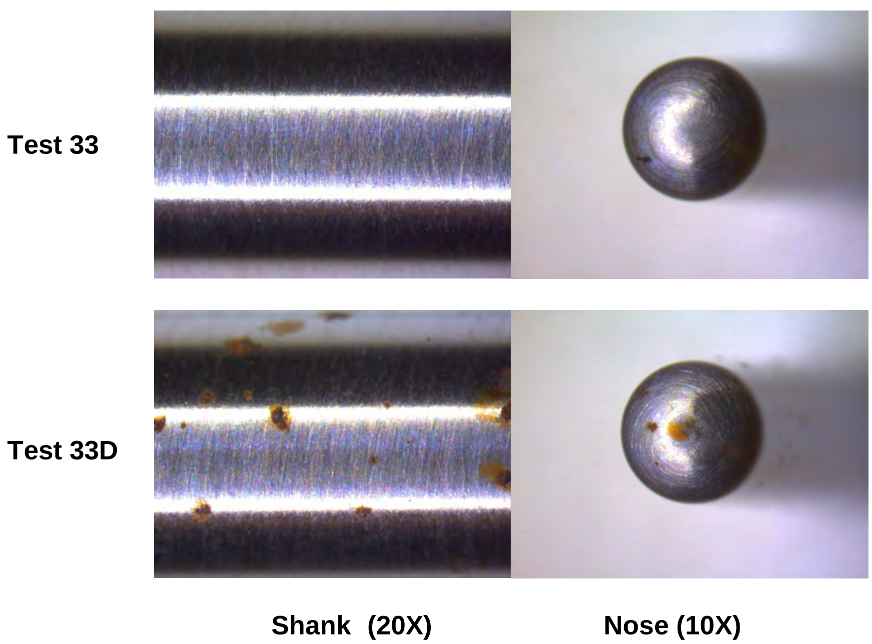
Reference 14	Temperature	40	°C
Test 33	pH	10.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.8	95.1888
Sodium nitrite	$NaNO_2$	69.00	0.2	19.3200
Sodium chloride	NaCl	58.44	0.0046	0.3764
Sodium sulfate	Na_2SO_4	142.04	0.0635	12.6274
Sodium carbonate	$Na_2(CO_3)$	106.00	0.0702	10.4177
Sodium bicarbonate	$NaHCO_3$	84.00	0.13	15.2880

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

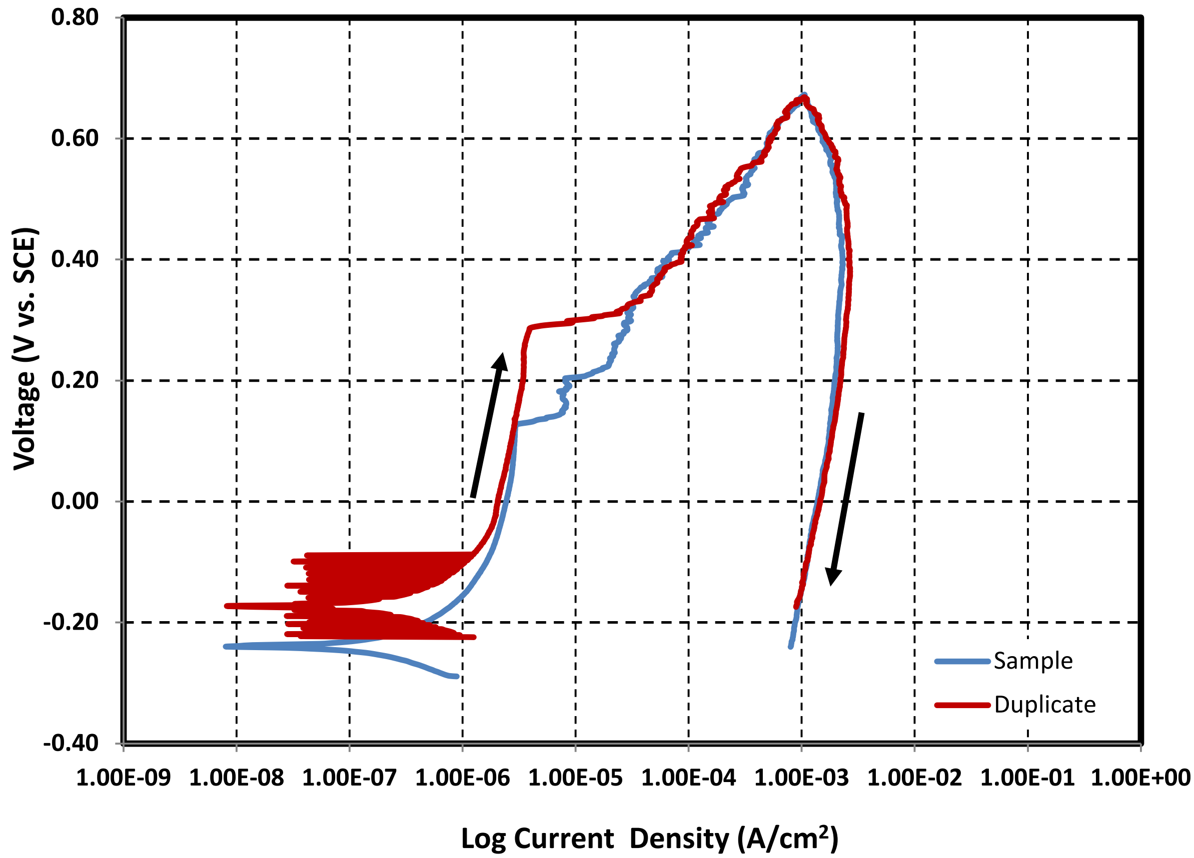


Composition of simulant for pitting corrosion –Test 34

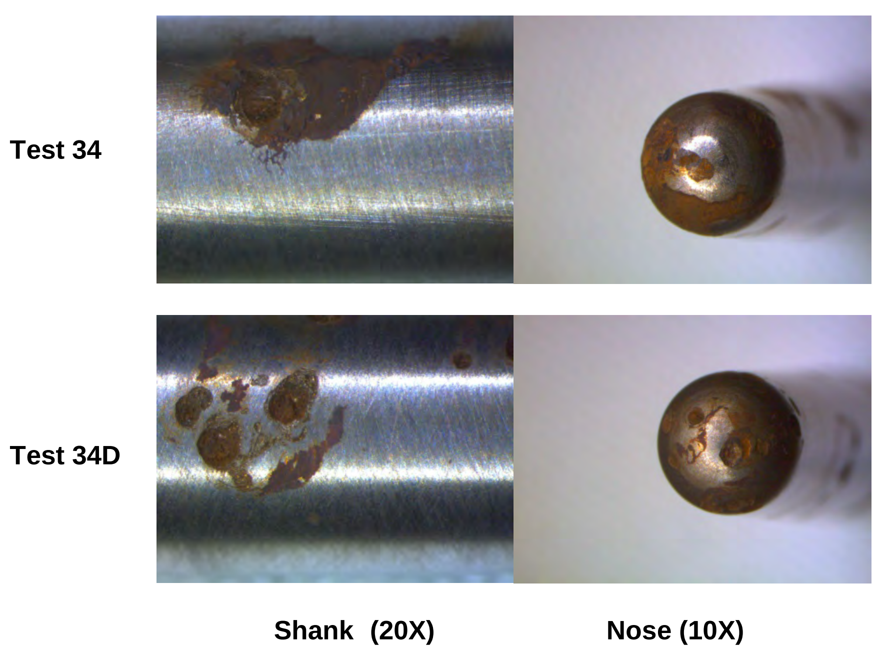
Reference 19	Temperature	77	°C
Test 34	pH	11.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.002	0.2380
Sodium chloride	NaCl	58.44	0.004	0.3273
Sodium fluoride	NaF	42.00	0.003	0.1764
Sodium nitrite	$NaNO_2$	69.00	0.001	0.0966
Sodium hydroxide	NaOH	40.00	0	0.0000
Sodium carbonate	$Na_2(CO_3)$	106.00	0	0.0000
Sodium sulfate	Na_2SO_4	142.04	0.018	3.5794
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.00	0.012	6.3840
Sodium aluminate	$NaAlO_2$	81.97	0.002	0.2295
Sodium oxalate	$Na_2C_2O_4$	134.00	0.033	6.1908
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.034	6.4736

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

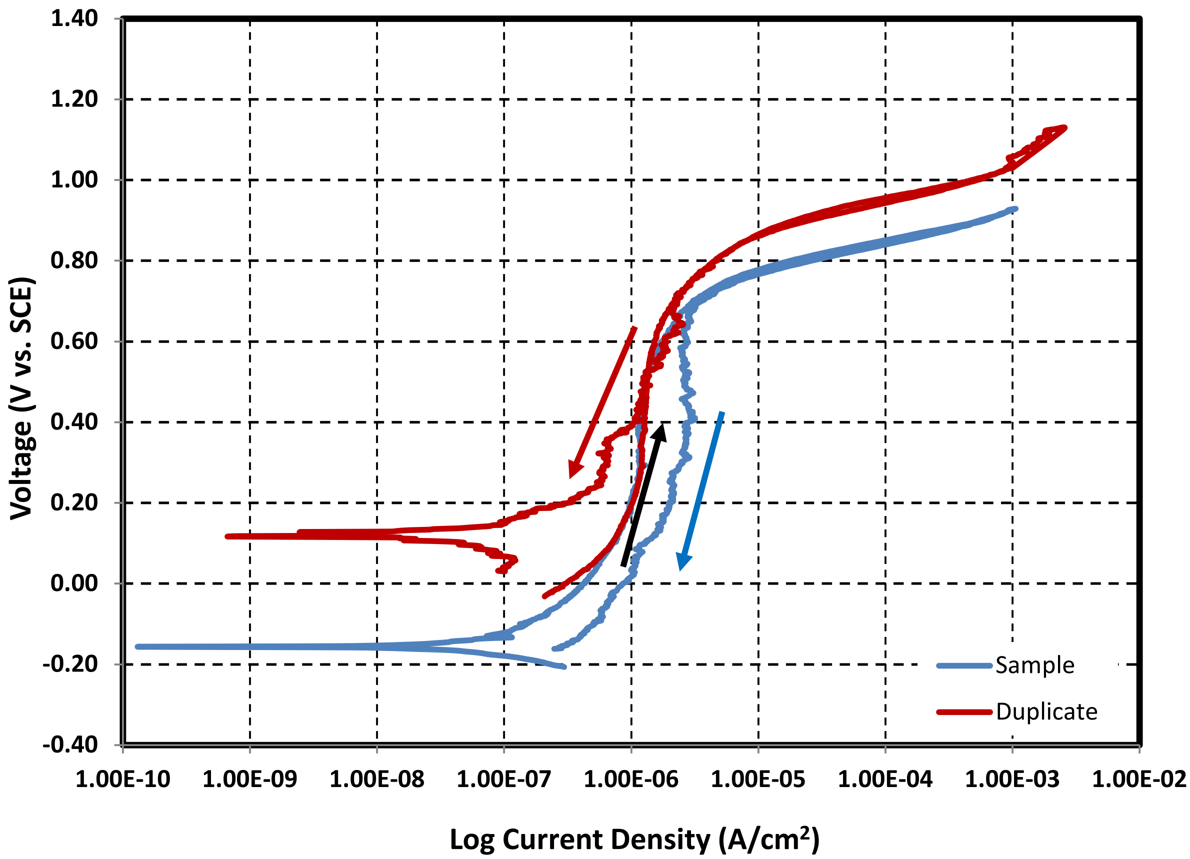


Composition of simulant for pitting corrosion –Test 35

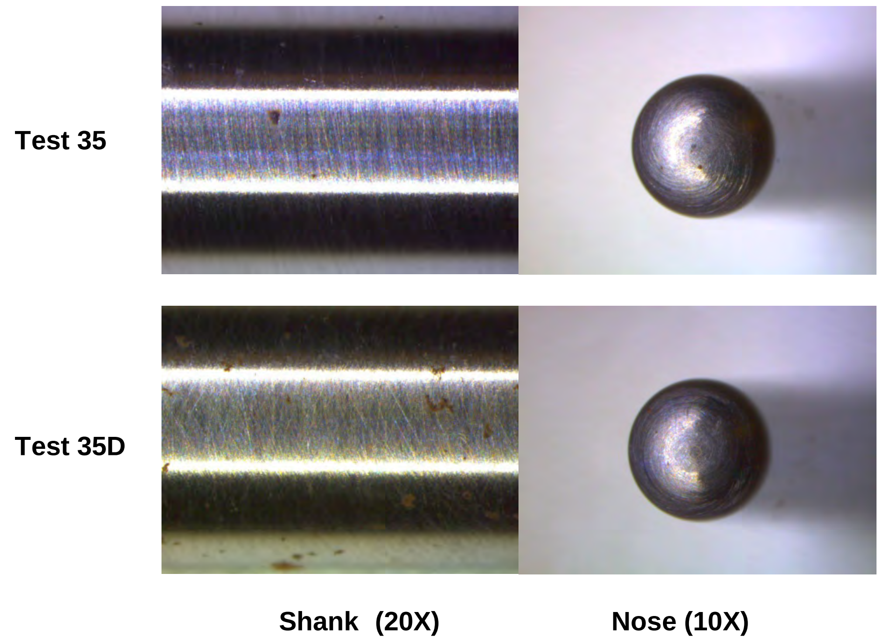
Reference 14	Temperature	40	°C
Test 35	pH	10.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.2	23.7972
Sodium nitrite	$NaNO_2$	69.00	0.1	9.6600
Sodium chloride	NaCl	58.44	0.0028	0.2291
Sodium sulfate	Na_2SO_4	142.04	0.0278	5.5282
Sodium carbonate	$Na_2(CO_3)$	106.00	0.0351	5.2088
Sodium bicarbonate	$NaHCO_3$	84.00	0.065	7.6440

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

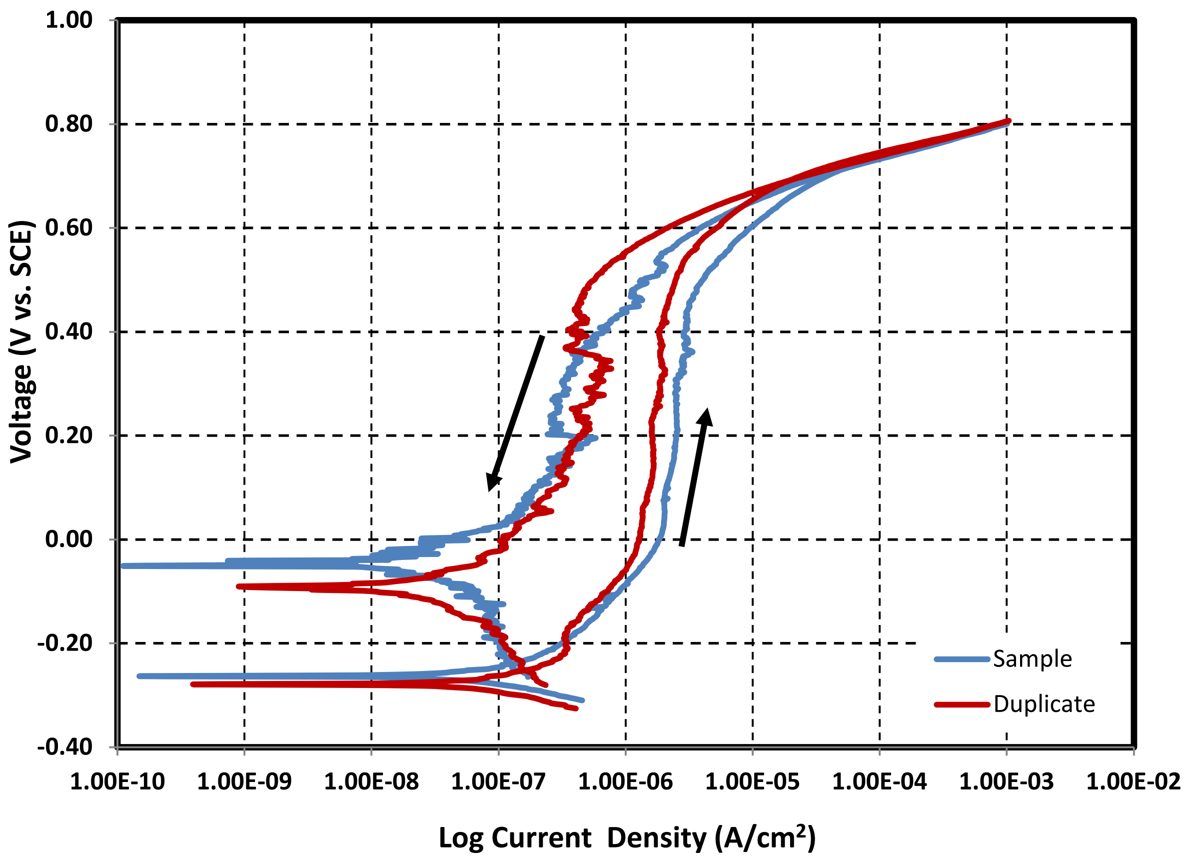


Composition of simulant for pitting corrosion –Test 36

Reference 15	Temperature	40	°C
Test 36	pH	10.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.8	95.1888
Sodium nitrite	$NaNO_2$	69.00	0.5	48.3000
Sodium chloride	NaCl	58.44	0.032	2.6181
Sodium sulfate	Na_2SO_4	142.04	0.121	24.0616
Sodium carbonate	$Na_2(CO_3)$	106.00	0.1754	26.0294
Sodium bicarbonate	$NaHCO_3$	84.00	0.326	38.3376

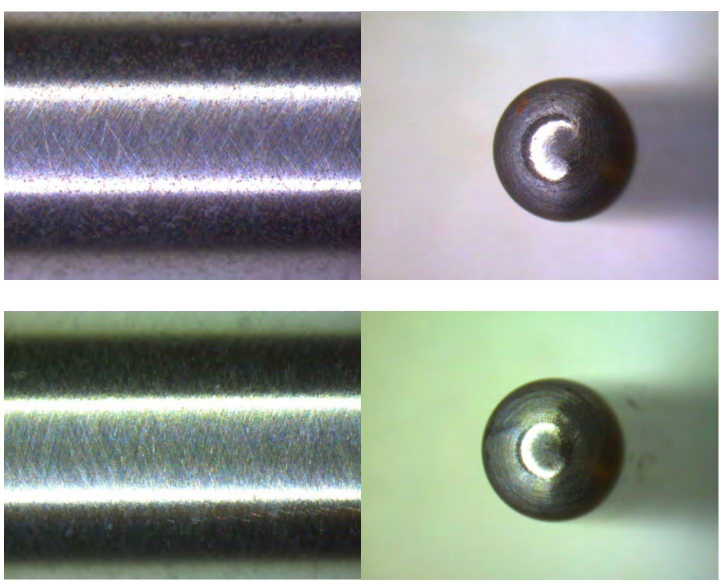
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 36

Test 36D



Shank (20X)

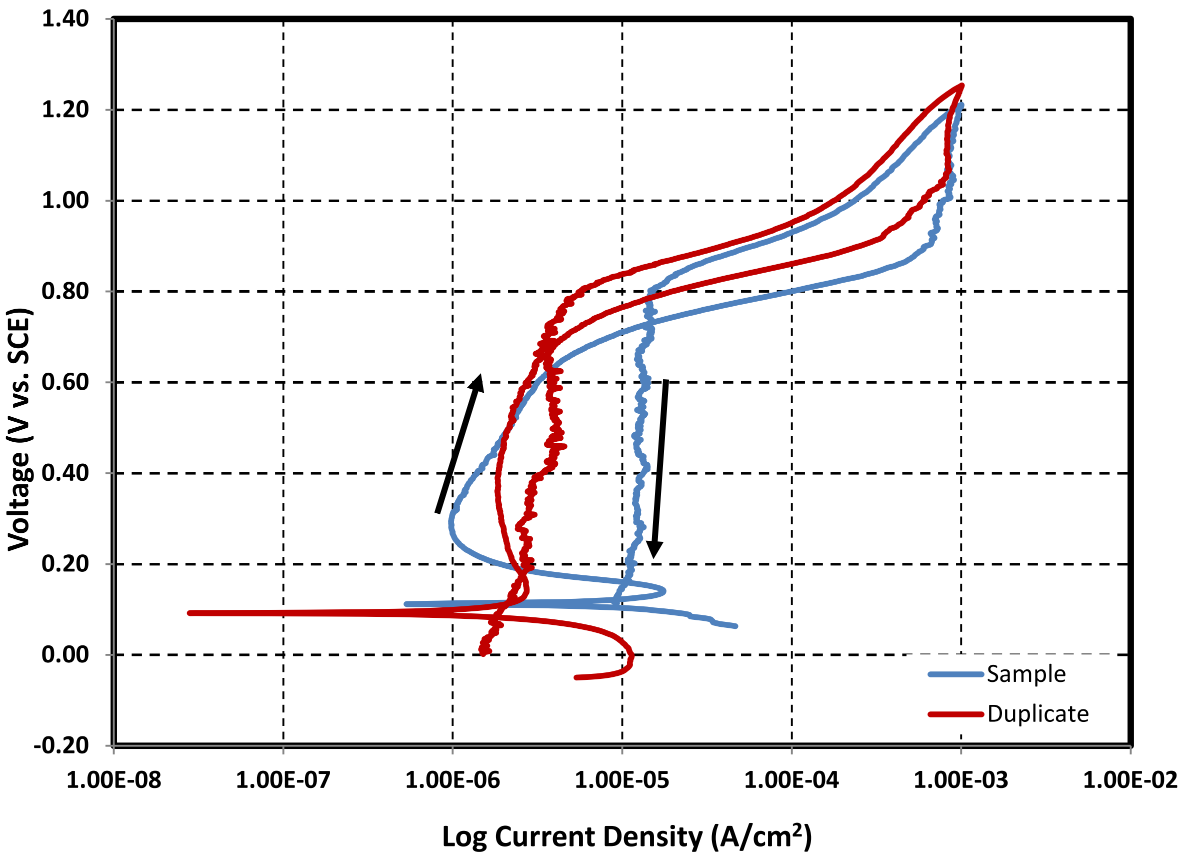
Nose (10X)

Composition of simulant for pitting corrosion –Test 37

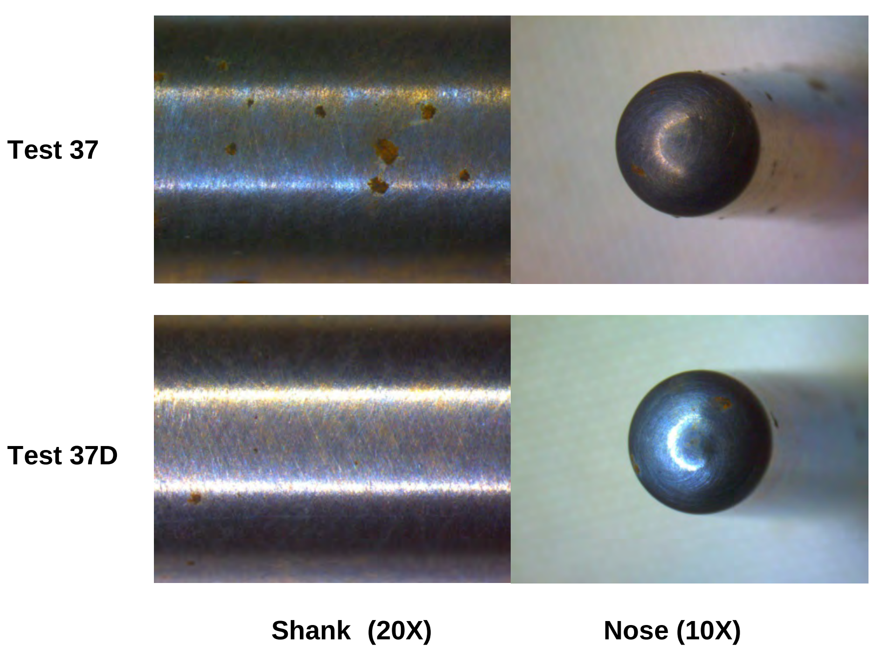
Reference 3	Temperature	40	**°C**
Test 37	pH	9.6	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.13	0.014928158	7.8400
Ferric Nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.004945	2.7969
Sodium hydroxide	NaOH	40.00	0.0915	5.1240
Sodium nitrate	$NaNO_3$	85.00	0.00701259	0.8345
Sodium nitrite	$NaNO_2$	69.00	0.04	3.8640
Sodium oxalate	$Na_2(C_2O_4)$	134.00	0.008656716	1.6240
Sodium sulfate	Na_2SO_4	142.04	0.005941988	1.1816
Sodium carbonate	$Na_2(CO_3)$	106.00	0.014037736	2.0832
Sodium Bicarbonate	$NaHCO_3$	84.00	0.058	6.8208
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.12	0.000275071	0.1464
Calcium Carbonate	$CaCO_3$	100.00	0.0006604	0.0925
Sodium chloride	NaCl	58.44	1.09E-03	0.0892
Sodium fluoride	NaF	42.00	0.000729524	0.0429
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	1.8452E-05	0.0063
Manganese Dioxide	MnO_2	86.94	0.001140097	0.1388
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	290.81	0.000520065	0.2117
Mercury (II) nitrate	$Hg(NO_3)_2$	342.62	0.00311	1.4918
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.000160141	0.0476
Zinc nitrate, 6-hydrate	$Zn(NO_3)_2.6H_2O$	297.49	4.11442E-05	0.0171
Lead nitrate	$Pb(NO_3)_2$	331.21	1.94439E-05	0.0090
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	2.45494E-05	0.0080

Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

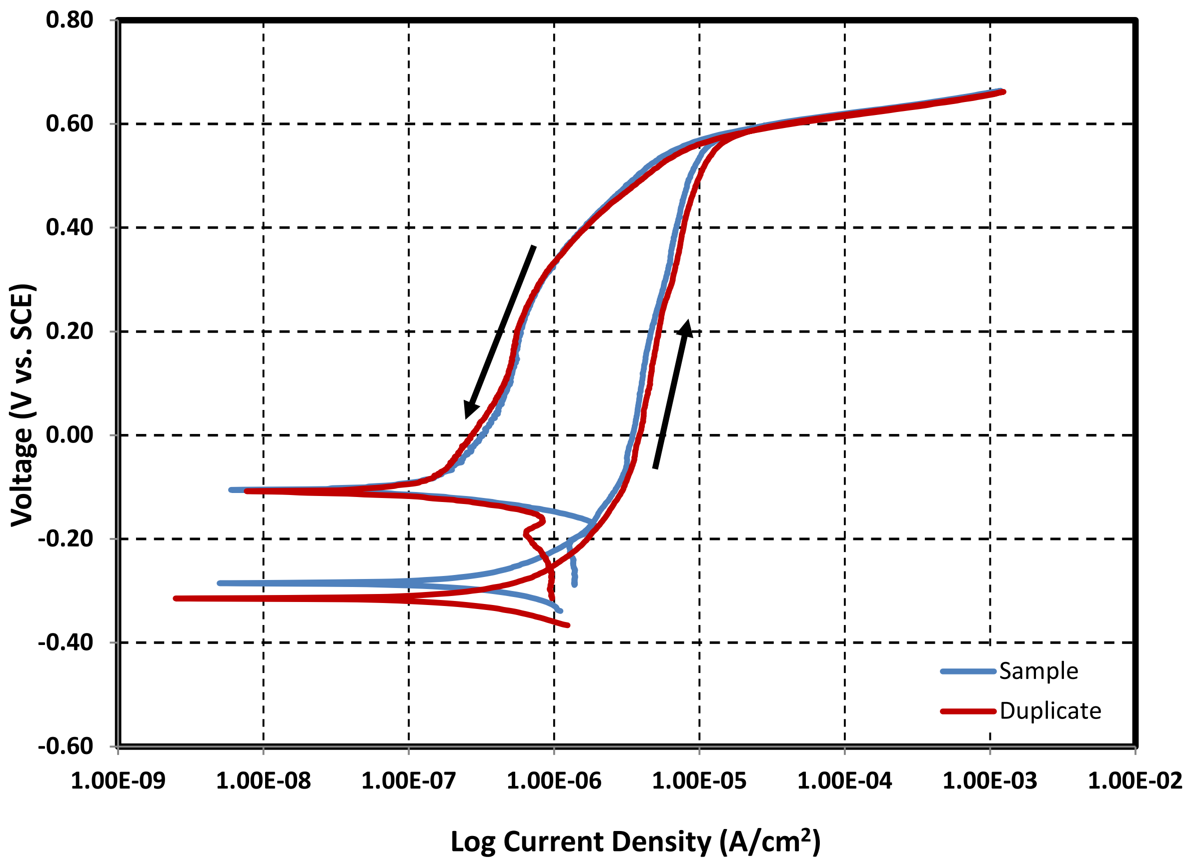


Composition of simulant for pitting corrosion –Test 38

Reference 19	Temperature	77	**°C**
Test 38	pH	11.00	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Sodium nitrate	$NaNO_3$	84.99	0.002	0.2380
Sodium chloride	NaCl	58.44	0.004	0.3273
Sodium fluoride	NaF	42.00	0.003	0.1764
Sodium nitrite	$NaNO_2$	69.00	0	0.0000
Sodium hydroxide	NaOH	40.00	0	0.0000
Sodium carbonate	$Na_2(CO_3)$	106.00	1.028	152.5552
Sodium sulfate	Na_2SO_4	142.04	0.018	3.5794
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.00	0.012	6.3840
Sodium aluminate	$NaAlO_2$	81.97	0.002	0.2295
Sodium oxalate	$Na_2C_2O_4$	134.00	0.033	6.1908
Sodium acetate, 3-hydrate	$Na(C_2H_3O_2).3H_2O$	136.0000	0.034	6.4736

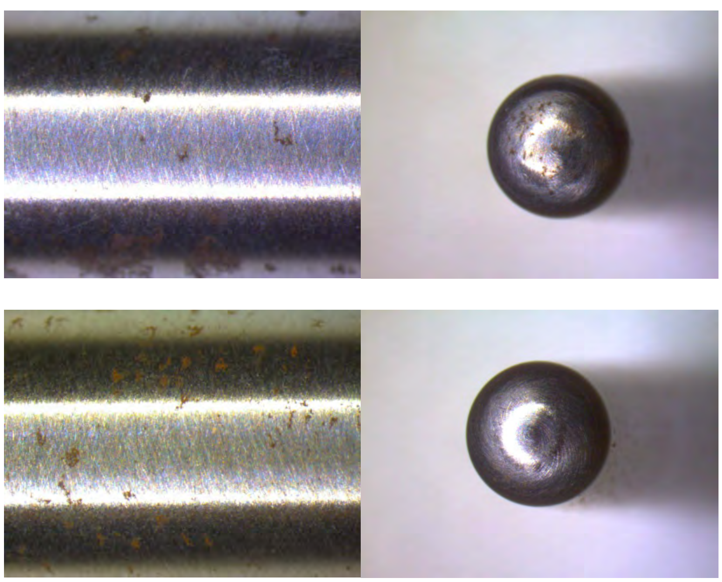
Cyclic Potentiodynamic Polarization-C



Images of bullet samples after electrochemical tests

Test 38

Test 38D



(Pits we not found after the test and they may have developed over time)

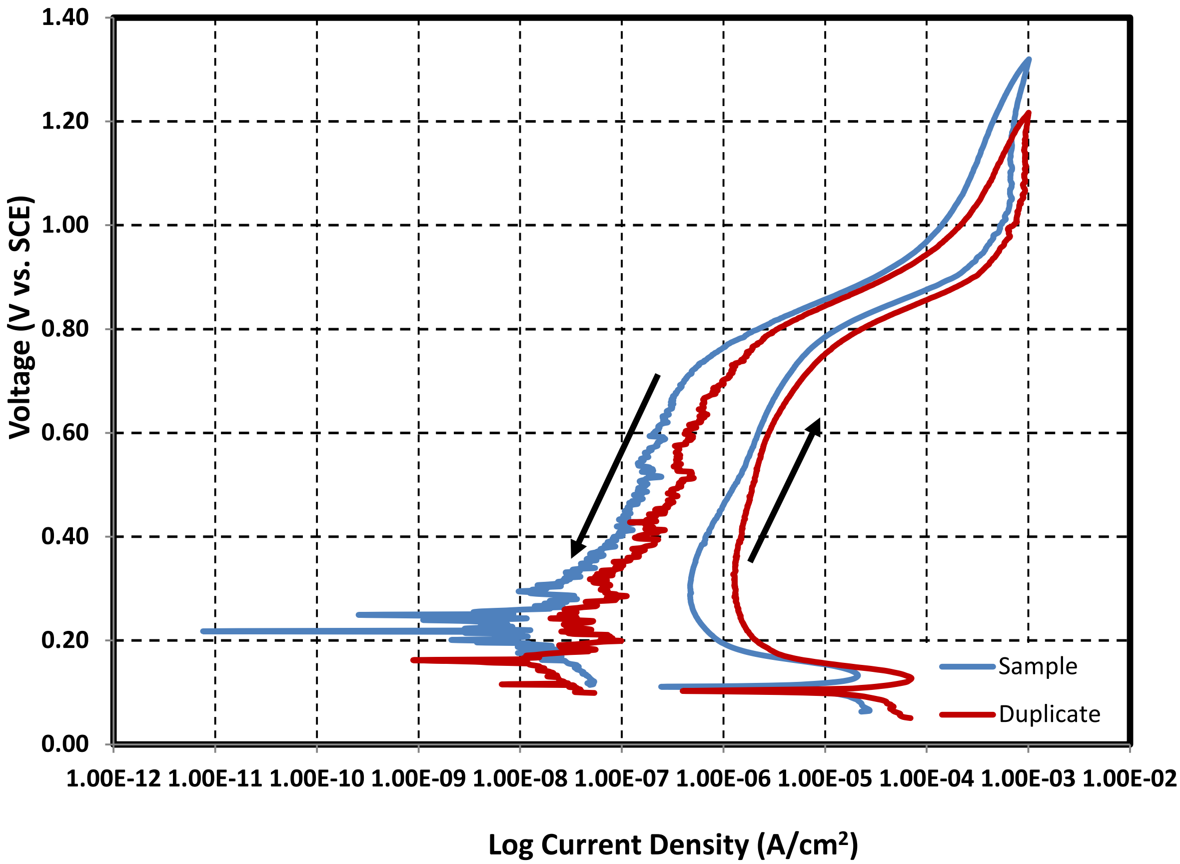
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion –Test 39

Reference 3	Temperature	40	**°C**
Test 39	pH	9.6	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.13	0.014928158	7.8400
Ferric Nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.004945	2.7969
Sodium hydroxide	NaOH	40.00	0.0915	5.1240
Sodium nitrate	$NaNO_3$	85.00	0.00701259	0.8345
Sodium nitrite	$NaNO_2$	69.00	0.06	5.7960
Sodium oxalate	$Na_2(C_2O_4)$	134.00	0.008656716	1.6240
Sodium sulfate	Na_2SO_4	142.04	0.005941988	1.1816
Sodium carbonate	$Na_2(CO_3)$	106.00	0.014037736	2.0832
Sodium Bicarbonate	$NaHCO_3$	84.00	0.058	6.8208
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.12	0.000275071	0.1464
Calcium Carbonate	$CaCO_3$	100.00	0.0006604	0.0925
Sodium chloride	NaCl	58.44	0.001090008	0.0892
Sodium fluoride	NaF	42.00	0.000729524	0.0429
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	1.8452E-05	0.0063
Manganese Dioxide	MnO_2	86.94	0.001140097	0.1388
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	290.81	0.000520065	0.2117
Mercury (II) nitrate	$Hg(NO_3)_2$	342.62	0.00311	1.4918
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	0.000160141	0.0476
Zinc nitrate, 6-hydrate	$Zn(NO_3)_2.6H_2O$	297.49	4.11442E-05	0.0171
Lead nitrate	$Pb(NO_3)_2$	331.21	1.94439E-05	0.0090
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	2.45494E-05	0.0080

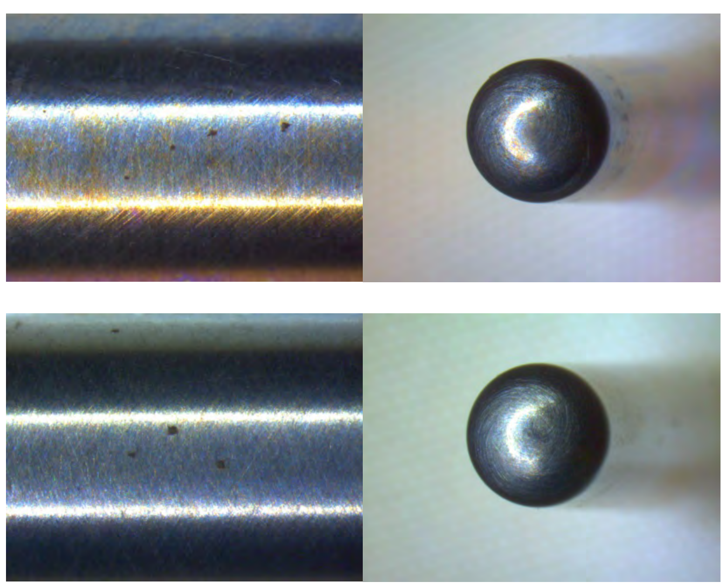
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 39

Test 39D



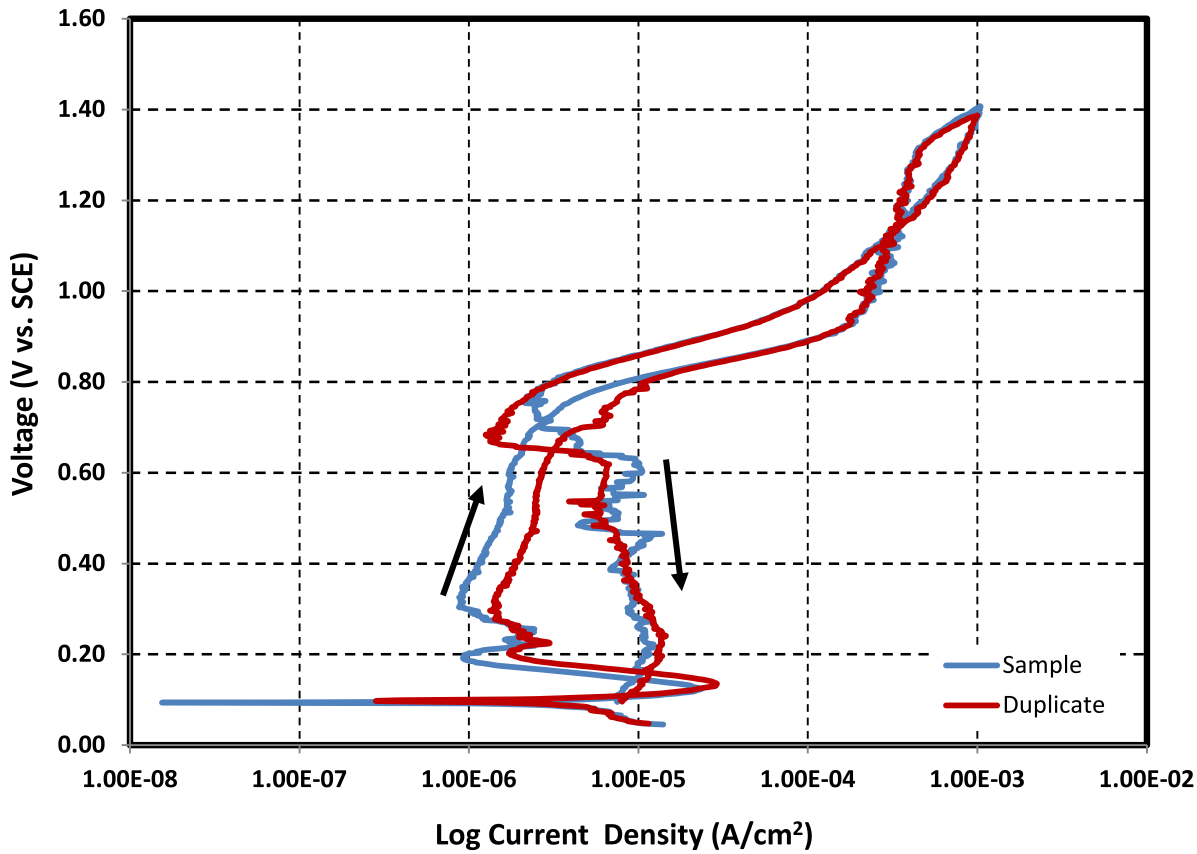
Shank (20X) Nose (10X)

Composition of simulant for pitting corrosion –Test 40

Reference 4	Temperature	40	**°C**
Test 40	pH	9.6	
	Volume	1.4	L

Simulant Source	Formula	Molecular Weight (g/mol)	Concentration (M)	weight required (g)
Aluminum nitrate, 9-hydrate	$Al(NO_3)_3.9H_2O$	375.13	0.006842073	3.5933
Ferric Nitrate, 9-hydrate	$Fe(NO_3)_3.9H_2O$	404.00	0.001831683	1.0360
Sodium hydroxide	NaOH	40.00	0.0305	1.7080
Sodium nitrate	$NaNO_3$	85.00	0.001694317	0.2016
Sodium nitrite	$NaNO_2$	69.00	0.020057971	1.9376
Sodium oxalate	$Na_2(C_2O_4)$	134.00	0.002885572	0.5413
Sodium sulfate	Na_2SO_4	142.04	0.030019713	5.9696
Sodium carbonate	$Na_2(CO_3)$	106.00	0.004679245	0.6944
Sodium Bicarbonate	$NaHCO_3$	84.00	0.019333333	2.2736
Sodium phosphate, 12-hydrate	$Na_3PO_4.12H_2O$	380.12	9.16903E-05	0.0488
Calcium Carbonate	$CaCO_3$	100.00	0.000220133	0.0308
Sodium chloride	NaCl	58.44	0.000382729	0.0313
Sodium fluoride	NaF	42.00	0.000243175	0.0143
Sodium molybdate, dihydrate	$Na_2MoO_4.2H_2O$	241.95	6.15066E-06	0.0021
Manganese Dioxide	MnO_2	86.94	0.000380032	0.0463
Nickel nitrate, 6-hydrate	$Ni(NO_3)_2.6H_2O$	290.81	0.000173355	0.0706
Mercury (II) nitrate	$Hg(NO_3)_2$	342.62	0.000146	0.0700
Sodium metasilicate, 5-hydrate	$Na_2SiO_3.5H_2O$	212.14	5.33803E-05	0.0159
Zinc nitrate, 6-hydrate	$Zn(NO_3)_2.6H_2O$	297.49	1.37147E-05	0.0057
Lead nitrate	$Pb(NO_3)_2$	331.21	6.48129E-06	0.0030
Cupric nitrate, 2.5 hydrate	$Cu(NO_3)_2.2.5H_2O$	233.00	8.18312E-06	0.0027

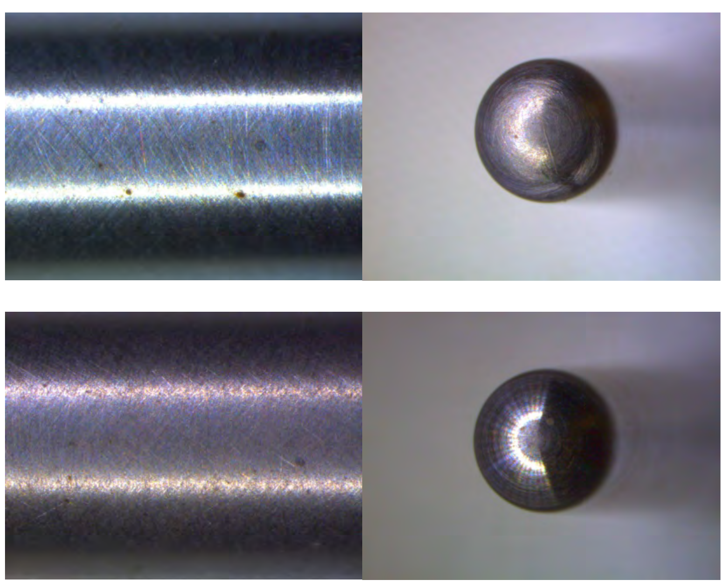
Cyclic Potentiodynamic Polarization



Images of bullet samples after electrochemical tests

Test 40

Test 40D



Shank (20X) **Nose (10X)**

Appendix H

Test Conditions from Previous Electrochemical Results (Task 4)

Cyclic Potentiodynamic Polarization Parameters, and Sample Geometry and Preparation of Historical Data

Reference	Potential Stabilization (hrs)	Initial Potential (V vs. Ecorr)	Scan Rate (mV/s)	Vertex Threshold (mA/cm^2 or V vs. ref.)	Final Potential (V vs. Ecorr)	Sample Geometry	Surface Preparation	Potentiostat	Counter electrode	Reference Electrode	Material
34, 35	0.5	-0.05	0.166	0.9 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Graphite	SCE with Luggin Probe filled with test solution.	A537
36	0.5	-0.05	0.166	1.0 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Platinum	SCE with Luggin Probe filled with test solution.	A537
37	0.5	-0.05	0.166	1.0 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Platinum	SCE with Luggin Probe filled with test solution.	A537
38	0.5	-0.05	0.166	1.0 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Platinum	SCE with Luggin Probe filled with test solution.	A537
39	0.5	-0.05	0.166	1.0 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Platinum	SCE with Luggin Probe filled with test solution.	A537
40	0.5	-0.05	0.166	1.0 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Platinum	SCE with Luggin Probe filled with test solution.	A537
41	0.5	-0.05	0.166	1.0 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Platinum	SCE with Luggin Probe filled with test solution.	A537

Cyclic Potentiodynamic Polarization Parameters, and Sample Geometry and Preparation of Historical Data (continued 1)

Reference	Potential Stabilization (hrs)	Initial Potential (V vs. Ecorr)	Scan Rate (mV/s)	Vertex Threshold (mA/cm^2 or V vs. ref.)	Final Potential (V vs. Ecorr)	Sample Geometry	Surface Preparation	Potentiostat	Counter electrode	Reference Electrode	Material
42	0.5	-0.05	0.166	1.0 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Platinum	SCE with Luggin Probe filled with test solution.	A537
43	0.5	-0.05	0.166	1.0 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Platinum	SCE with Luggin Probe filled with test solution.	A537
44	0.5	-0.05	0.166	1.0 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Platinum	SCE with Luggin Probe filled with test solution.	A537
45	0.5	-0.05	0.166	1.0 V	0	0.625" disk	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Platinum	SCE with Luggin Probe filled with test solution.	A537
46	2	-0.1	0.5	1.2 V	0	0.625" disk	800 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Graphite	SCE with Luggin Probe filled with test solution for some tests. Ag/AgCl for other tests.	A537
47	2	-0.1	0.5	1.2 V	0	0.625" disk	800 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Graphite	SCE with Luggin Probe filled with test solution for some tests. Ag/AgCl for other tests.	A537

Cyclic Potentiodynamic Polarization Parameters, and Sample Geometry and Preparation of Historical Data (continued 2)

Reference	Potential Stabilization (hrs)	Initial Potential (V vs. Ecorr)	Scan Rate (mV/s)	Vertex Threshold (mA/cm^2 or V vs. ref.)	Final Potential (V vs. Ecorr)	Sample Geometry	Surface Preparation	Potentiostat	Counter electrode	Reference Electrode	Material
48	2	-0.1	0.5	1.2 V	0	0.625" disk	800 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Graphite	SCE with Luggin Probe filled with test solution for some tests. Ag/AgCl for other tests.	A537
28	2.5	-0.1	0.5	1.2 V or 1 mA/cm^2	0	0.625" disk	800 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Graphite	SCE with Luggin Probe filled with test solution for some tests. Ag/AgCl for other tests.	A537
49	2 or 168	-0.05	0.5	1.0 V vs. OCP	0	rectangular electrode	600 grit, cleaned with acetone and distilled H_2O before use.	PAR 273	Graphite	Ag/AgCl	A537
50	NA	-0.15	0.167	5 mA/cm^2	Scan was run until the current on the reverse scan was less than the current on the forward scan at the same potential	Cylindrical	600 grit, cleaned with acetone and distilled H_2O before use.	NA	Platinum	Ag/AgCl	A537

Cyclic Potentiodynamic Polarization Parameters, and Sample Geometry and Preparation of Historical Data (continued 3)

Reference	Potential Stabilization (hrs)	Initial Potential (V vs. Ecorr)	Scan Rate (mV/s)	Vertex Threshold (mA/cm^2 or V vs. ref.)	Final Potential (V vs. Ecorr)	Sample Geometry	Surface Preparation	Potentiostat	Counter electrode	Reference Electrode	Material
51	18	-0.1	0.167	1.0 V vs. ref or 1 mA/cm^2	-0.1 V	Bullet	600 grit, ultrasonically cleaned with isopropanol for 5 min., rinsed with DI, dried with N_2.	PAR 273	Platinum	SCE	Tank Car Steel
52	18	-0.5	0.167	1.0 V vs. ref or 1 mA/cm^2	-0.1 V	Bullet	600 grit, ultrasonically cleaned with isopropanol for 5 min., rinsed with DI, dried with N_2.	PAR 273	Platinum	SCE	A537
53	2	-0.1	0.167	1 mA/cm^2	-0.1 V	Bullet	600 grit, ultrasonically cleaned with isopropanol for 5 min., rinsed with DI, dried with N_2.	NA	Platinum	SCE	A537
54	2	-0.1	0.167	1 mA/cm^2	-0.1 V	Bullet	600 grit, ultrasonically cleaned with isopropanol for 5 min., rinsed with DI, dried with N_2.	NA	Platinum	SCE	A537

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
34, 35	1	23	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.002	9.51	2
34, 35	2	23	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.004	9.51	1
34, 35	3	23	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.005	9.51	0
34, 35	4	23	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.01	9.51	0
34, 35	5	30	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.002	9.51	2
34, 35	6	30	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.005	9.51	2
34, 35	7	30	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.007	9.51	2
34, 35	8	30	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.01	9.51	0
34, 35	9	40	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.005	9.51	2
34, 35	10	40	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.01	9.51	1
34, 35	11	40	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.015	9.51	0
34, 35	12	50	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.01	9.51	0
34, 35	13	50	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.015	9.51	1
34, 35	14	50	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.02	9.51	0
34, 35	15	50	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.03	9.51	0
34, 35	16	60	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.1	9.51	1
34, 35	17	60	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.15	9.51	1
34, 35	18	60	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.3	9.51	0
34, 35	19	60	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.4	9.51	1
34, 35	20	60	0.0046	0.022	NA	0.000084	0.00031	0.00015	0.0013	0.021	0.5	9.51	0
34, 35	21	40	0.0073	0.028	NA	0.00012	0.00043	0.00022	0.0019	0.028	0.01	9.59	2
34, 35	22	40	0.0073	0.028	NA	0.00012	0.00043	0.00022	0.0019	0.028	0.014	9.59	1
34, 35	23	40	0.0073	0.028	NA	0.00012	0.00043	0.00022	0.0019	0.028	0.022	9.59	0
34, 35	24	40	0.011	0.035	NA	0.00016	0.0006	0.0003	0.0026	0.039	0.022	9.66	1
34, 35	25	40	0.011	0.035	NA	0.00016	0.0006	0.0003	0.0026	0.039	0.03	9.66	1

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 1)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
34, 35	26	40	0.011	0.035	NA	0.00016	0.0006	0.0003	0.0026	0.039	0.039	9.66	0
34, 35	27	23	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.005	9.73	2
34, 35	28	23	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.009	9.73	2
34, 35	29	23	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.01	9.73	1
34, 35	30	23	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.015	9.73	1
34, 35	31	23	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.03	9.73	0
34, 35	32	23	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.05	9.73	0
34, 35	33	30	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.005	9.73	2
34, 35	34	30	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.009	9.73	2
34, 35	35	30	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.01	9.73	2
34, 35	36	30	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.015	9.73	2
34, 35	37	30	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.03	9.73	2
34, 35	38	30	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.042	9.73	0
34, 35	39	30	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.05	9.73	0
34, 35	40	40	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.02	9.73	2
34, 35	41	40	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.03	9.73	1
34, 35	42	40	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.042	9.73	0
34, 35	43	40	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.05	9.73	0
34, 35	44	40	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.055	9.73	0
34, 35	45	50	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.042	9.73	2
34, 35	46	50	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.05	9.73	0
34, 35	47	50	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.06	9.73	2
34, 35	48	50	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.09	9.73	0
34, 35	49	50	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.15	9.73	2
34, 35	50	50	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.2	9.73	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 2)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
34, 35	51	50	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.25	9.73	1
34, 35	52	50	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.3	9.73	0
34, 35	53	50	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.35	9.73	0
34, 35	54	60	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.042	9.73	2
34, 35	55	60	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.06	9.73	1
34, 35	56	60	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.09	9.73	1
34, 35	57	60	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.13	9.73	2
34, 35	58	60	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.3	9.73	0
34, 35	59	60	0.017	0.045	NA	0.00022	0.00083	0.00041	0.0036	0.055	0.35	9.73	0
34, 35	60	40	0.026	0.056	NA	0.00031	0.0012	0.00057	0.005	0.076	0.03	9.79	2
34, 35	61	40	0.026	0.056	NA	0.00031	0.0012	0.00057	0.005	0.076	0.058	9.79	0
34, 35	62	40	0.026	0.056	NA	0.00031	0.0012	0.00057	0.005	0.076	0.075	9.79	0
34, 35	63	40	0.039	0.071	NA	0.00043	0.0016	0.00079	0.007	0.105	0.081	9.85	1
34, 35	64	40	0.039	0.071	NA	0.00043	0.0016	0.00079	0.007	0.105	0.105	9.85	0
34, 35	65	23	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.01	9.91	2
34, 35	66	23	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.03	9.91	1
34, 35	67	23	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.05	9.91	0
34, 35	68	23	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.075	9.91	0
34, 35	69	30	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.01	9.91	2
34, 35	70	30	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.05	9.91	1
34, 35	71	30	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.075	9.91	0
34, 35	72	30	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.1	9.91	2
34, 35	73	30	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.15	9.91	0
34, 35	74	40	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.085	9.91	1
34, 35	75	40	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.112	9.91	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 3)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
34, 35	76	40	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.13	9.91	0
34, 35	77	40	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.15	9.91	0
34, 35	78	50	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.1	9.91	2
34, 35	79	50	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.5	9.91	1
34, 35	80	50	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.75	9.91	1
34, 35	81	50	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	1	9.91	2
34, 35	82	50	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	1.5	9.91	1
34, 35	83	50	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	2.25	9.91	0
34, 35	84	60	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.1	9.91	2
34, 35	85	60	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.5	9.91	0
34, 35	86	60	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	0.75	9.91	2
34, 35	87	60	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	1.5	9.91	1
34, 35	88	60	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	2.25	9.91	0
34, 35	89	60	0.058	0.089	NA	0.00059	0.0022	0.0011	0.01	0.146	3	9.91	0
34, 35	90	40	0.086	0.111	NA	0.00082	0.0031	0.0015	0.013	0.202	0.156	9.96	1
34, 35	91	40	0.086	0.111	NA	0.00082	0.0031	0.0015	0.013	0.202	0.18	9.96	0
34, 35	92	40	0.13	0.139	NA	0.0011	0.0042	0.0021	0.019	0.28	0.216	10.01	2
34, 35	93	40	0.13	0.139	NA	0.0011	0.0042	0.0021	0.019	0.28	0.28	10.01	0
34, 35	94	23	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.03	10.06	1
34, 35	95	23	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.05	10.06	0
34, 35	96	23	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.1	10.06	0
34, 35	97	30	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.05	10.06	2
34, 35	98	30	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.1	10.06	0
34, 35	99	30	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.1	10.06	0
34, 35	100	30	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.15	10.06	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 4)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
34, 35	101	40	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.299	10.06	1
34, 35	102	40	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.35	10.06	1
34, 35	103	40	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.45	10.06	0
34, 35	104	50	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.7	10.06	1
34, 35	105	50	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.8	10.06	1
34, 35	106	50	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	1	10.06	0
34, 35	107	50	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	1.3	10.06	0
34, 35	108	60	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.4	10.06	2
34, 35	109	60	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	0.8	10.06	2
34, 35	110	60	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	1	10.06	2
34, 35	111	60	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	2	10.06	2
34, 35	112	60	0.187	0.173	NA	0.0016	0.0059	0.0029	0.026	0.388	3	10.06	0
34, 35	113	40	0.272	0.216	NA	0.0022	0.0081	0.0041	0.036	0.538	0.415	10.12	1
34, 35	114	40	0.272	0.216	NA	0.0022	0.0081	0.0041	0.036	0.538	0.5	10.12	1
34, 35	115	40	0.272	0.216	NA	0.0022	0.0081	0.0041	0.036	0.538	0.65	10.12	0
34, 35	116	40	0.398	0.268	NA	0.003	0.011	0.0056	0.059	0.746	0.3	10.17	2
34, 35	117	40	0.398	0.268	NA	0.003	0.011	0.0056	0.059	0.746	0.4	10.17	1
34, 35	118	40	0.398	0.268	NA	0.003	0.011	0.0056	0.059	0.746	0.45	10.17	0
34, 35	119	40	0.398	0.268	NA	0.003	0.011	0.0056	0.059	0.746	0.575	10.17	0
34, 35	120	40	0.575	0.332	NA	0.0042	0.016	0.0078	0.069	1.03	0.5	10.22	0
34, 35	121	40	0.575	0.332	NA	0.0042	0.016	0.0078	0.069	1.03	0.798	10.22	0
34, 35	122	40	0.575	0.332	NA	0.0042	0.016	0.0078	0.069	1.03	1.03	10.22	0
34, 35	123	40	0.831	0.409	NA	0.0059	0.022	0.011	0.095	1.44	0.6	10.28	1
34, 35	124	40	0.831	0.409	NA	0.0059	0.022	0.011	0.095	1.44	1.11	10.28	0
36	125	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.002	0.010	9.6	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 5)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
36	126	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.002	0.015	9.6	2
36	127	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.002	0.020	9.6	2
36	128	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.002	0.025	9.6	0
36	129	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0085	0.015	9.6	2
36	130	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0085	0.025	9.6	1
36	131	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0200	0.020	9.6	1
36	132	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0300	0.025	9.6	2
36	133	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0400	0.025	9.6	1
36	134	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0500	0.025	9.6	2
36	135	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0500	0.050	9.6	0
36	136	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0600	0.025	9.6	2
36	137	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0600	0.040	9.6	2
36	138	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0600	0.050	9.6	1
36	139	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0600	0.060	9.6	0
36	140	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0600	0.120	9.6	0
36	141	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0600	0.220	9.6	0
36	142	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0700	0.070	9.6	0
36	143	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.0800	0.080	9.6	0
36	144	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.2000	0.025	9.6	2
36	145	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.3000	0.100	9.6	1
36	146	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.3000	0.150	9.6	0
36	147	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0032	0.085	0.040	9.6	2
36	148	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0032	0.085	0.060	9.6	0
36	149	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0060	0.085	0.025	9.6	2
36	150	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0060	0.085	0.040	9.6	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 6)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
36	151	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0060	0.085	0.050	9.6	1
36	152	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0060	0.085	0.060	9.6	0
36	153	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0060	0.085	0.080	9.6	0
36	154	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0060	0.085	0.100	9.6	0
36	155	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0085	0.085	0.040	9.6	2
36	156	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0085	0.085	0.060	9.6	0
36	157	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0085	0.085	0.100	9.6	0
36	158	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0100	0.085	0.025	9.6	2
36	159	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0120	0.085	0.025	9.6	2
36	160	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0120	0.085	0.040	9.6	2
36	161	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0120	0.085	0.060	9.6	0
36	162	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0170	0.085	0.025	9.6	2
36	163	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0170	0.085	0.040	9.6	2
36	164	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0200	0.085	0.060	9.6	1
36	165	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0300	0.085	0.070	9.6	0
36	166	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0300	0.085	0.080	9.6	0
36	167	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0400	0.085	0.070	9.6	1
36	168	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0600	0.085	0.060	9.6	1
36	169	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0700	0.085	0.100	9.6	0
36	170	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0900	0.085	0.040	9.6	2
36	171	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0900	0.085	0.065	9.6	1
36	172	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0900	0.085	0.080	9.6	1
36	173	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.1800	0.085	0.080	9.6	2
36	174	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.1800	0.085	0.100	9.6	2
36	175	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.2000	0.085	0.120	9.6	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 7)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
36	176	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.2000	0.085	0.150	9.6	1
36	177	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.2000	0.085	0.170	9.6	0
36	178	40	0.013	0.058	NA	0.00039	0.0003	0.00073	0.0059	0.085	0.040	9.6	1
36	179	40	0.013	0.058	NA	0.00039	0.0003	0.00073	0.0059	0.085	0.060	9.6	0
36	180	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.085	0.025	9.6	2
36	181	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.085	0.040	9.6	2
36	182	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.085	0.050	9.6	1
36	183	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.085	0.060	9.6	0
36	184	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.085	0.110	9.6	0
36	185	40	0.013	0.058	NA	0.00039	0.0015	0.00073	0.0059	0.085	0.040	9.6	2
36	186	40	0.013	0.058	NA	0.00039	0.0015	0.00073	0.0059	0.085	0.060	9.6	0
36	187	40	0.013	0.058	NA	0.00039	0.0015	0.00073	0.0059	0.085	0.080	9.6	0
36	188	40	0.013	0.058	NA	0.00039	0.0015	0.00073	0.0059	0.085	0.100	9.6	0
36	189	40	0.013	0.058	NA	0.00039	0.0015	0.00073	0.0059	0.085	0.110	9.6	0
36	190	40	0.013	0.058	NA	0.00039	0.0017	0.00073	0.0059	0.085	0.040	9.6	1
36	191	40	0.013	0.058	NA	0.00039	0.0017	0.00073	0.0059	0.085	0.060	9.6	0
36	192	40	0.013	0.058	NA	0.00039	0.0017	0.00073	0.0059	0.085	0.080	9.6	0
36	193	40	0.013	0.058	NA	0.00039	0.0017	0.00073	0.0059	0.085	0.110	9.6	0
36	194	40	0.013	0.058	NA	0.00039	0.0017	0.00073	0.0059	0.085	0.170	9.6	0
36	195	40	0.013	0.058	NA	0.00039	0.0060	0.00073	0.0059	0.085	0.065	9.6	0
36	196	40	0.013	0.058	NA	0.00039	0.0075	0.00073	0.0059	0.085	0.065	9.6	0
36	197	40	0.013	0.058	NA	0.00039	0.0090	0.00073	0.0059	0.085	0.065	9.6	1
36	198	40	0.013	0.058	NA	0.00039	0.0100	0.00073	0.0059	0.085	0.050	9.6	2
36	199	40	0.013	0.058	NA	0.00039	0.0105	0.00073	0.0059	0.085	0.120	9.6	0
36	200	40	0.013	0.058	NA	0.00039	0.0110	0.00073	0.0059	0.085	0.100	9.6	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 8)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
36	201	40	0.013	0.058	NA	0.00039	0.0120	0.00073	0.0059	0.085	0.200	9.6	0
36	202	40	0.013	0.058	NA	0.00039	0.0150	0.00073	0.0059	0.085	0.300	9.6	0
36	203	40	0.013	0.058	NA	0.00039	0.0200	0.00073	0.0059	0.085	0.060	9.6	2
36	204	40	0.013	0.058	NA	0.00039	0.0200	0.00073	0.0059	0.085	0.200	9.6	2
36	205	40	0.013	0.058	NA	0.00039	0.0200	0.00073	0.0059	0.085	0.300	9.6	0
36	206	40	0.013	0.058	NA	0.00039	0.0220	0.00073	0.0059	0.085	0.300	9.6	2
36	207	40	0.013	0.058	NA	0.00039	0.0220	0.00073	0.0059	0.085	0.350	9.6	2
36	208	40	0.013	0.058	NA	0.00039	0.0400	0.00073	0.0059	0.085	0.060	9.6	2
36	209	40	0.013	0.058	NA	0.00039	0.0400	0.00073	0.0059	0.085	0.100	9.6	2
36	210	40	0.013	0.058	NA	0.00039	0.0400	0.00073	0.0059	0.085	0.200	9.6	2
36	211	40	0.013	0.058	NA	0.00039	0.0011	0.00024	0.0059	0.085	0.050	9.6	1
36	212	40	0.013	0.058	NA	0.00039	0.0011	0.00024	0.0059	0.085	0.060	9.6	0
36	213	40	0.013	0.058	NA	0.00039	0.0011	0.0005	0.0059	0.085	0.050	9.6	2
36	214	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.085	0.025	9.6	2
36	215	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.085	0.040	9.6	2
36	216	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.085	0.050	9.6	1
36	217	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.085	0.060	9.6	0
36	218	40	0.013	0.058	NA	0.00039	0.0011	0.00073	0.0059	0.085	0.080	9.6	0
36	219	40	0.013	0.058	NA	0.00039	0.0011	0.0011	0.0059	0.085	0.060	9.6	0
36	220	40	0.013	0.058	NA	0.00039	0.0011	0.0013	0.0059	0.085	0.060	9.6	1
36	221	40	0.013	0.058	NA	0.00039	0.0011	0.0013	0.0059	0.085	0.070	9.6	0
36	222	40	0.013	0.058	NA	0.00039	0.0011	0.0013	0.0059	0.085	0.080	9.6	0
36	223	40	0.013	0.058	NA	0.00039	0.0011	0.002	0.0059	0.085	0.065	9.6	0
36	224	40	0.013	0.058	NA	0.00039	0.0011	0.004	0.0059	0.085	0.050	9.6	0
36	225	40	0.013	0.058	NA	0.00039	0.0011	0.004	0.0059	0.085	0.065	9.6	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 9)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
36	226	40	0.013	0.058	NA	0.00039	0.0011	0.01	0.0059	0.085	0.050	9.6	2
36	227	40	0.013	0.058	NA	0.00039	0.0011	0.01	0.0059	0.085	0.065	9.6	0
36	228	40	0.013	0.058	NA	0.00039	0.0011	0.025	0.0059	0.085	0.065	9.6	0
36	229	40	0.013	0.058	NA	0.00039	0.0011	0.03	0.0059	0.085	0.065	9.6	1
36	230	40	0.013	0.058	NA	0.00039	0.0011	0.04	0.0059	0.085	0.075	9.6	2
36	231	40	0.013	0.058	NA	0.00039	0.0011	0.04	0.0059	0.085	0.085	9.6	0
36	232	40	0.013	0.058	NA	0.00039	0.0011	0.05	0.0059	0.085	0.065	9.6	2
36	233	40	0.013	0.058	NA	0.00039	0.0011	0.05	0.0059	0.085	0.100	9.6	0
36	234	40	0.013	0.058	NA	0.00039	0.0011	0.1	0.0059	0.085	0.110	9.6	2
36	235	40	0.013	0.058	NA	0.00039	0.0011	0.1	0.0059	0.085	0.120	9.6	1
36	236	40	0.013	0.058	NA	0.00039	0.0011	0.1	0.0059	0.085	0.150	9.6	1
36	237	40	0.013	0.058	NA	0.00039	0.0011	0.1	0.0059	0.085	0.170	9.6	0
37	238	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0008	0.0020	9.6	2
37	239	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0008	0.0080	9.6	1
37	240	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0008	0.0100	9.6	1
37	241	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0008	0.0110	9.6	0
37	242	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0008	0.0200	9.6	0
37	243	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0040	0.0100	9.6	0
37	244	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0100	0.0100	9.6	1
37	245	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0100	0.0120	9.6	0
37	246	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0100	0.0220	9.6	0
37	247	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0150	0.0180	9.6	0
37	248	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0280	0.0100	9.6	2
37	249	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0280	0.0180	9.6	1
37	250	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0280	0.0280	9.6	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 10)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
37	251	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0280	0.0380	9.6	0
37	252	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0500	0.0380	9.6	0
37	253	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0600	0.0280	9.6	1
37	254	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0600	0.0380	9.6	0
37	255	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0800	0.0380	9.6	0
37	256	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.1000	0.0380	9.6	1
37	257	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.1500	0.0680	9.6	0
37	258	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.1500	0.0580	9.6	1
37	259	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.1500	0.0680	9.6	0
37	260	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.3000	0.0480	9.6	2
37	261	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.3000	0.0680	9.6	2
37	262	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.3000	0.0880	9.6	2
37	263	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.3000	0.1000	9.6	0
37	264	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0100	9.6	2
37	265	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0200	9.6	1
37	266	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0300	9.6	0
37	267	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0400	9.6	0
37	268	40	0.0042	0.019	NA	0.00013	0.00100	0.00024	0.0020	0.028	0.0200	9.6	1
37	269	40	0.0042	0.019	NA	0.00013	0.00100	0.00024	0.0020	0.028	0.0300	9.6	0
37	270	40	0.0042	0.019	NA	0.00013	0.00200	0.00024	0.0020	0.028	0.0300	9.6	1
37	271	40	0.0042	0.019	NA	0.00013	0.00200	0.00024	0.0020	0.028	0.0400	9.6	0
37	272	40	0.0042	0.019	NA	0.00013	0.00400	0.00024	0.0020	0.028	0.0700	9.6	0
37	273	40	0.0042	0.019	NA	0.00013	0.00400	0.00024	0.0020	0.028	0.1000	9.6	0
37	274	40	0.0042	0.019	NA	0.00013	0.00500	0.00024	0.0020	0.028	0.0400	9.6	2
37	275	40	0.0042	0.019	NA	0.00013	0.00500	0.00024	0.0020	0.028	0.0700	9.6	1

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 11)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
37	276	40	0.0042	0.019	NA	0.00013	0.00600	0.00024	0.0020	0.028	0.2000	9.6	0
37	277	40	0.0042	0.019	NA	0.00013	0.00800	0.00024	0.0020	0.028	0.2000	9.6	0
37	278	40	0.0042	0.019	NA	0.00013	0.01000	0.00024	0.0020	0.028	0.2000	9.6	2
37	279	40	0.0042	0.019	NA	0.00013	0.01000	0.00024	0.0020	0.028	0.2500	9.6	0
37	280	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0284	0.0100	9.6	2
37	281	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0284	0.0200	9.6	1
37	282	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0284	0.0300	9.6	0
37	283	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.0284	0.0400	9.6	0
37	284	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0080	0.0284	0.0300	9.6	0
37	285	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0080	0.0284	0.0500	9.6	0
37	286	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0100	0.0284	0.0200	9.6	1
37	287	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0300	0.0284	0.0200	9.6	2
37	288	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0300	0.0284	0.0300	9.6	2
37	289	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0300	0.0284	0.0350	9.6	1
37	290	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0300	0.0284	0.0450	9.6	0
37	291	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0500	0.0284	0.0450	9.6	1
37	292	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0600	0.0284	0.1000	9.6	0
37	293	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0800	0.0284	0.0550	9.6	2
37	294	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0800	0.0284	0.0750	9.6	2
37	295	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0800	0.0284	0.1000	9.6	1
37	296	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.1000	0.0284	0.0450	9.6	2
37	297	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.1300	0.0284	0.2000	9.6	0
37	298	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.1400	0.0284	0.2000	9.6	0
37	299	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.1500	0.0284	0.2000	9.6	1
38	300	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.70	9.6	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 12)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
38	301	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.80	9.6	2
38	302	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.90	9.6	2
38	303	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	1.10	9.6	0
38	304	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.26	10.5	2
38	305	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.26	11	2
38	306	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.50	11.1	2
38	307	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.70	11.1	2
38	308	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.90	11.1	2
38	309	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.26	11.5	2
38	310	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.50	11.5	1
38	311	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.70	11.5	1
38	312	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.80	11.5	0
38	313	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.26	12.2	0
38	314	40	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.26	12.6	0
38	315	40	0.03	0.14	NA	0.00098	0.0027	0.0018	0.015	0.21	0.100	9.6	2
38	316	40	0.03	0.14	NA	0.00098	0.0027	0.0018	0.015	0.21	0.180	9.6	0
38	317	40	0.03	0.14	NA	0.00098	0.0027	0.0018	0.015	0.21	0.240	9.6	0
38	318	40	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.22	9.6	1
38	319	40	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.28	9.6	0
38	320	40	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.42	9.6	0
38	321	40	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.56	9.6	0
38	322	40	0.09	0.43	NA	0.00293	0.0082	0.0055	0.045	0.64	0.32	9.6	2
38	323	40	0.09	0.43	NA	0.00293	0.0082	0.0055	0.045	0.64	0.45	9.6	1
38	324	40	0.09	0.43	NA	0.00293	0.0082	0.0055	0.045	0.64	0.60	9.6	0
38	325	40	0.09	0.43	NA	0.00293	0.0082	0.0055	0.045	0.64	0.82	9.6	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 13)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
39	326	60	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.05	10.1	2
39	327	60	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.10	10.1	2
39	328	60	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.30	10.1	2
39	329	60	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.40	10.1	2
39	330	60	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.50	10.1	0
39	331	60	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.60	10.1	0
39	332	60	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	1.00	10.1	0
39	333	60	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	3.00	10.1	0
39	334	80	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.10	10.1	2
39	335	80	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.30	10.1	2
39	336	80	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.35	10.1	2
39	337	80	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.75	10.1	1
39	338	80	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	0.90	10.1	1
39	339	80	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	1.00	10.1	0
39	340	80	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	1.25	10.1	0
39	341	80	0.06	0.29	NA	0.00195	0.0054	0.0036	0.030	0.43	3.00	10.1	0
39	342	60	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.10	10.2	2
39	343	60	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.50	10.2	0
39	344	60	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.65	10.2	2
39	345	60	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.80	10.2	1
39	346	60	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	1.00	10.2	0
39	347	60	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	1.50	10.2	0
39	348	60	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	3.00	10.2	0
39	349	80	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	0.30	10.2	2
39	350	80	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	1.00	10.2	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 14)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
39	351	80	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	1.20	10.2	1
39	352	80	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	1.50	10.2	0
39	353	80	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	2.00	10.2	0
39	354	80	0.13	0.58	NA	0.00390	0.011	0.007	0.059	0.85	4.00	10.2	0
40	355	60	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0300	9.6	2
40	356	60	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.6500	9.6	0
40	357	60	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.8000	9.6	1
40	358	60	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	1.0000	9.6	0
40	359	80	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0800	9.6	2
40	360	80	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.1000	9.6	2
40	361	80	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.1500	9.6	2
40	362	80	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.2500	9.6	2
40	363	80	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.3000	9.6	2
40	364	80	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.5000	9.6	2
40	365	80	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	1.0000	9.6	0
40	366	80	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	1.5000	9.6	0
41	367	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0400	9.6	2
41	368	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0600	9.6	1
41	369	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0700	9.6	0
41	370	50	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0700	9.6	2
41	371	50	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0800	9.6	0
41	372	60	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0800	9.6	2
41	373	60	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0900	9.6	2
41	374	60	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.1000	9.6	1
41	375	60	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.1200	9.6	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 15)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
42	376	2	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0050	9.45	2
42	377	2	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0085	9.45	0
42	378	23	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0050	9.45	2
42	379	23	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0085	9.45	2
42	380	23	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0120	9.45	0
42	381	30	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0050	9.45	2
42	382	30	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0085	9.45	2
42	383	30	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0120	9.45	2
42	384	30	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0200	9.45	0
42	385	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0085	9.45	2
42	386	40	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0300	9.45	0
42	387	50	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0085	9.45	2
42	388	50	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0120	9.45	2
42	389	50	0.0042	0.019	NA	0.00013	0.00036	0.00024	0.0020	0.028	0.0300	9.45	0
43	390	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.004	0.003	12.5	2
43	391	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.004	0.004	12.5	2
43	392	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.004	0.008	12.5	0
43	393	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.004	0.010	12.5	0
43	394	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.01	0.004	12.5	2
43	395	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.01	0.007	12.5	1
43	396	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.01	0.008	12.5	1
43	397	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.01	0.010	12.5	0
43	398	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.015	0.010	12.5	2
43	399	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.015	0.007	12.5	0
43	400	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.015	0.010	12.5	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 16)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
43	401	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.022	0.012	12.5	1
43	402	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.022	0.015	12.5	0
43	403	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.022	0.042	12.5	0
43	404	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.015	12.5	1
43	405	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.030	12.5	1
43	406	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.040	12.5	1
43	407	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.045	12.5	0
43	408	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.050	12.5	0
43	409	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.055	12.5	0
43	410	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.060	12.5	0
43	411	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.200	12.5	0
43	412	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.250	12.5	0
43	413	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.300	12.5	0
43	414	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.11	0.050	12.5	1
43	415	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.11	0.070	12.5	0
43	416	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.11	0.090	12.5	0
43	417	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	1.00	0.700	12.5	1
43	418	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	1.00	0.800	12.5	0
43	419	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	5.00	2.500	12.5	0
43	420	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	5.00	3.000	12.5	0
43	421	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0026	0.04	0.040	12.5	1
43	422	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0026	0.04	0.050	12.5	0
43	423	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.01	0.04	0.060	12.5	0
43	424	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.02	0.04	0.040	12.5	2
43	425	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.03	0.04	0.060	12.5	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 17)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
43	426	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.04	0.04	0.060	12.5	2
43	427	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.05	0.04	0.060	12.5	2
43	428	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.07	0.04	0.100	12.5	0
43	429	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.09	0.04	0.100	12.5	1
43	430	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.1	0.04	0.120	12.5	1
43	431	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.1	0.04	0.150	12.5	1
43	432	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.1	0.04	0.180	12.5	0
43	433	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.2	0.04	0.200	12.5	2
43	434	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.2	0.04	0.250	12.5	2
43	435	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.2	0.04	0.300	12.5	0
43	436	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.016	12.5	2
43	437	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.030	12.5	2
43	438	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.040	12.5	2
43	439	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.045	12.5	0
43	440	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.050	12.5	0
43	441	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.055	12.5	0
43	442	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.060	12.5	0
43	443	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.200	12.5	0
43	444	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.250	12.5	0
43	445	40	0.0015	NA	NA	0.00008	0.00032	0.000153	0.0014	0.04	0.300	12.5	0
43	446	40	0.0015	NA	NA	0.00008	0.00060	0.000153	0.0014	0.04	0.045	12.5	0
43	447	40	0.0015	NA	NA	0.00008	0.00100	0.000153	0.0014	0.04	0.040	12.5	2
43	448	40	0.0015	NA	NA	0.00008	0.00100	0.000153	0.0014	0.04	0.045	12.5	0
43	449	40	0.0015	NA	NA	0.00008	0.00130	0.000153	0.0014	0.04	0.040	12.5	2
43	450	40	0.0015	NA	NA	0.00008	0.00130	0.000153	0.0014	0.04	0.045	12.5	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 18)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
43	451	40	0.0015	NA	NA	0.00008	0.00140	0.000153	0.0014	0.04	0.045	12.5	0
43	452	40	0.0015	NA	NA	0.00008	0.00150	0.000153	0.0014	0.04	0.045	12.5	0
43	453	40	0.0015	NA	NA	0.00008	0.00200	0.000153	0.0014	0.04	0.050	12.5	0
43	454	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.045	12.5	2
43	455	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.050	12.5	2
43	456	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.055	12.5	2
43	457	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.060	12.5	2
43	458	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.070	12.5	2
43	459	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.080	12.5	0
43	460	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.100	12.5	0
43	461	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.105	12.5	0
43	462	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.115	12.5	0
43	463	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.200	12.5	0
43	464	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.250	12.5	0
43	465	40	0.0015	NA	NA	0.00008	0.00320	0.000153	0.0014	0.04	0.300	12.5	0
43	466	40	0.0015	NA	NA	0.00008	0.00600	0.000153	0.0014	0.04	0.045	12.5	2
43	467	40	0.0015	NA	NA	0.00008	0.00600	0.000153	0.0014	0.04	0.065	12.5	2
43	468	40	0.0015	NA	NA	0.00008	0.00600	0.000153	0.0014	0.04	0.080	12.5	2
43	469	40	0.0015	NA	NA	0.00008	0.00600	0.000153	0.0014	0.04	0.090	12.5	2
43	470	40	0.0015	NA	NA	0.00008	0.01000	0.000153	0.0014	0.04	0.065	12.5	2
43	471	40	0.0015	NA	NA	0.00008	0.01000	0.000153	0.0014	0.04	0.090	12.5	2
43	472	40	0.0015	NA	NA	0.00008	0.01000	0.000153	0.0014	0.04	0.100	12.5	2
43	473	40	0.0015	NA	NA	0.00008	0.01000	0.000153	0.0014	0.04	0.200	12.5	2
43	474	40	0.0015	NA	NA	0.00008	0.01000	0.000153	0.0014	0.04	0.300	12.5	2
43	475	40	0.0015	NA	NA	0.00008	0.01000	0.000153	0.0014	0.04	0.325	12.5	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 19)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
43	476	40	0.0015	NA	NA	0.00008	0.01000	0.000153	0.0014	0.04	0.350	12.5	0
43	477	40	0.0015	NA	NA	0.00008	0.01000	0.000153	0.0014	0.04	0.400	12.5	0
43	478	40	0.0015	NA	NA	0.00008	0.01000	0.000153	0.0014	0.04	0.600	12.5	0
43	479	40	0.0015	NA	NA	0.00008	0.02500	0.000153	0.0014	0.04	0.800	12.5	2
43	480	40	0.0015	NA	NA	0.00008	0.02500	0.000153	0.0014	0.04	0.900	12.5	2
43	481	40	0.0015	NA	NA	0.00008	0.02500	0.000153	0.0014	0.04	1.000	12.5	2
43	482	40	0.0015	NA	NA	0.00008	0.02500	0.000153	0.0014	0.04	1.200	12.5	0
43	483	40	0.0015	NA	NA	0.00008	0.02500	0.000153	0.0014	0.04	1.500	12.5	0
43	484	40	0.0015	NA	NA	0.00008	0.02500	0.000153	0.0014	0.04	2.000	12.5	0
43	485	40	0.0015	NA	NA	0.00008	0.05000	0.000153	0.0014	0.04	1.000	12.5	2
43	486	40	0.0015	NA	NA	0.00008	0.05000	0.000153	0.0014	0.04	1.500	12.5	2
43	487	40	0.0015	NA	NA	0.00008	0.05000	0.000153	0.0014	0.04	1.750	12.5	2
43	488	40	0.0015	NA	NA	0.00008	0.05000	0.000153	0.0014	0.04	2.000	12.5	2
43	489	40	0.0015	NA	NA	0.00008	0.05000	0.000153	0.0014	0.04	3.000	12.5	0
43	490	40	0.0015	NA	NA	0.00008	0.05000	0.000153	0.0014	0.04	4.000	12.5	0
44	491	40	0.5000	NA	NA	NA	0.00170	NA	0.03	0.3	0.400	9.73	1
44	492	50	0.5000	NA	NA	NA	0.00170	NA	0.03	0.3	0.400	9.73	2
44	493	50	0.5000	NA	NA	NA	0.00170	NA	0.03	0.3	0.500	9.73	0
44	494	55	0.5000	NA	NA	NA	0.00170	NA	0.03	0.3	0.700	9.73	0
44	495	60	0.5000	NA	NA	NA	0.00170	NA	0.03	0.3	0.500	9.73	2
44	496	60	0.5000	NA	NA	NA	0.00170	NA	0.03	0.3	0.750	9.73	2
44	497	60	0.5000	NA	NA	NA	0.00170	NA	0.03	0.3	1.250	9.73	2
44	498	60	0.5000	NA	NA	NA	0.00170	NA	0.03	0.3	1.500	9.73	2
44	499	60	0.5000	NA	NA	NA	0.00170	NA	0.03	0.3	2.000	9.73	0
45	500	40	0.1490	0.151	NA	NA	0.0000	0.00267	0.00264	0.0098	0.000	10.07	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 20)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
45	501	40	0.3370	0.243	NA	NA	0.0000	0.00267	0.00264	0.0098	0.000	10.18	0
45	502	40	0.1490	0.151	NA	NA	0.0009	0.00267	0.00264	0.0098	0.022	10.07	2
45	503	70	0.1490	0.151	NA	NA	0.0000	0.00267	0.00264	0.0098	0.000	10.07	2
45	504	70	0.3370	0.243	NA	NA	0.0000	0.00267	0.00264	0.0098	0.000	10.18	0
45	505	70	0.1490	0.151	NA	NA	0.0009	0.00267	0.00264	0.0098	0.022	10.07	2
45	506	70	0.3370	0.243	NA	NA	0.0009	0.00267	0.00264	0.0098	0.022	10.18	0
45	507	70	0.1490	0.151	NA	NA	0.0015	0.00267	0.00264	0.0098	0.044	10.07	0
45	508	70	0.3370	0.243	NA	NA	0.0015	0.00267	0.00264	0.0098	0.045	10.18	0
45	509	70	0.4190	0.275	NA	NA	0.0007	0.00267	0.00264	0.0098	0.015	10.21	0
45	510	70	0.5180	0.311	NA	NA	0.0004	0.00267	0.00264	0.0098	0.007	10.24	0
45	511	70	0.2880	0.222	NA	NA	0.0009	0.00267	0.00264	0.0098	0.022	10.16	0
45	512	70	0.2230	0.191	NA	NA	0.0009	0.00267	0.00264	0.0098	0.022	10.12	0
45	513	80	0.1490	0.151	NA	NA	0.0000	0.00267	0.00264	0.0098	0.000	10.07	2
45	514	80	0.3370	0.243	NA	NA	0.0000	0.00267	0.00264	0.0098	0.000	10.18	2
45	515	80	0.1490	0.151	NA	NA	0.0009	0.00267	0.00264	0.0098	0.022	10.07	2
45	516	80	0.3370	0.243	NA	NA	0.0009	0.00267	0.00264	0.0098	0.022	10.18	0
45	517	80	0.1490	0.151	NA	NA	0.0015	0.00267	0.00264	0.0098	0.044	10.07	2
45	518	80	0.3370	0.243	NA	NA	0.0015	0.00267	0.00264	0.0098	0.045	10.18	0
46	519	40	0.0050	0.009	NA	NA	0.0007	NA	0.003	0.02	0.015	10.00	2
46	520	40	0.0090	0.017	NA	NA	0.0010	NA	0.006	0.05	0.025	10.00	2
46	521	40	0.0180	0.033	NA	NA	0.0016	NA	0.015	0.05	0.050	10.00	0
46	522	40	0.0090	0.017	NA	NA	0.0010	NA	0.006	0.1	0.025	10.00	2
46	523	40	0.0260	0.048	NA	NA	0.0022	NA	0.024	0.1	0.075	10.00	2
46	524	40	0.0440	0.082	NA	NA	0.0033	NA	0.043	0.1	0.125	10.00	2
46	525	40	0.0260	0.048	NA	NA	0.0022	NA	0.024	0.15	0.075	10.00	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 21)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
46	526	40	0.0530	0.098	NA	NA	0.0037	NA	0.054	0.15	0.15	10.00	0
46	527	40	0.0180	0.033	NA	NA	0.0016	NA	0.015	0.2	0.05	10.00	2
46	528	40	0.0530	0.098	NA	NA	0.0037	NA	0.054	0.2	0.15	10.00	2
46	529	40	0.0880	0.163	NA	NA	0.0055	NA	0.099	0.2	0.25	10.00	2
46	530	40	0.0440	0.082	NA	NA	0.0033	NA	0.043	0.25	0.125	10.00	2
46	531	40	0.0880	0.163	NA	NA	0.0055	NA	0.099	0.25	0.25	10.00	2
46	532	40	0.0260	0.048	NA	NA	0.0022	NA	0.024	0.3	0.075	10.00	2
46	533	40	0.0790	0.147	NA	NA	0.0051	NA	0.087	0.3	0.225	10.00	0
46	534	40	0.1310	0.243	NA	NA	0.0074	NA	0.16	0.3	0.375	10.00	2
46	535	40	0.0610	0.113	NA	NA	0.0042	NA	0.065	0.35	0.175	10.00	2
46	536	40	0.1230	0.228	NA	NA	0.0070	NA	0.148	0.35	0.35	10.00	2
46	537	40	0.0350	0.065	NA	NA	0.0028	NA	0.033	0.4	0.1	10.00	0
46	538	40	0.1050	0.195	NA	NA	0.0063	NA	0.123	0.4	0.3	10.00	2
46	539	40	0.1750	0.325	NA	NA	0.0092	NA	0.226	0.4	0.5	10.00	2
46	540	40	0.0790	0.147	NA	NA	0.0051	NA	0.087	0.45	0.225	10.00	2
46	541	40	0.1580	0.293	NA	NA	0.0085	NA	0.199	0.45	0.45	10.00	2
46	542	40	0.0440	0.082	NA	NA	0.0033	NA	0.043	0.5	0.125	10.00	2
46	543	40	0.1310	0.243	NA	NA	0.0074	NA	0.16	0.5	0.375	10.00	2
46	544	40	0.2190	0.407	NA	NA	0.0109	NA	0.294	0.5	0.625	10.00	0
46	545	40	0.0960	0.178	NA	NA	0.0059	NA	0.11	0.55	0.275	10.00	2
46	546	40	0.1930	0.358	NA	NA	0.0099	NA	0.253	0.55	0.55	10.00	0
46	547	40	0.0530	0.098	NA	NA	0.0037	NA	0.054	0.6	0.15	10.00	2
46	548	40	0.1580	0.293	NA	NA	0.0085	NA	0.199	0.6	0.45	10.00	2
46	549	40	0.2630	0.488	NA	NA	0.0124	NA	0.366	0.6	0.75	10.00	0
46	550	40	0.1140	0.212	NA	NA	0.0067	NA	0.135	0.65	0.325	10.00	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 22)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
46	551	40	0.2280	0.423	NA	NA	0.0112	NA	0.308	0.65	0.65	10.00	0
46	552	40	0.0610	0.113	NA	NA	0.0042	NA	0.065	0.7	0.175	10.00	0
46	553	40	0.1840	0.342	NA	NA	0.0095	NA	0.239	0.7	0.525	10.00	2
46	554	40	0.3060	0.568	NA	NA	0.0140	NA	0.439	0.7	0.875	10.00	0
46	555	40	0.1310	0.243	NA	NA	0.0074	NA	0.16	0.75	0.375	10.00	2
46	556	40	0.2630	0.488	NA	NA	0.0124	NA	0.366	0.75	0.75	10.00	2
46	557	40	0.0700	0.130	NA	NA	0.0046	NA	0.076	0.8	0.2	10.00	2
46	558	40	0.2100	0.390	NA	NA	0.0105	NA	0.28	0.8	0.6	10.00	2
46	559	40	0.3500	0.650	NA	NA	0.0154	NA	0.515	0.8	1	10.00	0
46	560	40	0.1490	0.277	NA	NA	0.0081	NA	0.186	0.85	0.425	10.00	2
46	561	40	0.2980	0.553	NA	NA	0.0137	NA	0.424	0.85	0.85	10.00	0
46	562	40	0.0790	0.147	NA	NA	0.0051	NA	0.087	0.9	0.225	10.00	0
46	563	40	0.2360	0.438	NA	NA	0.0115	NA	0.186	0.9	0.675	10.00	2
46	564	40	0.3940	0.732	NA	NA	0.0168	NA	0.593	0.9	1.125	10.00	2
46	565	40	0.1660	0.308	NA	NA	0.0088	NA	0.212	0.95	0.475	10.00	0
46	566	40	0.3330	0.618	NA	NA	0.0148	NA	0.485	0.95	0.95	10.00	2
46	567	40	0.0880	0.163	NA	NA	0.0055	NA	0.099	1	0.25	10.00	2
46	568	40	0.2630	0.488	NA	NA	0.0124	NA	0.366	1	0.75	10.00	0
46	569	40	0.4380	0.813	NA	NA	0.0182	NA	0.672	1	1.25	10.00	0
47	570	40	0.0035	0.007	NA	NA	0.0005	NA	0.0018	0.02	0.010	10.00	2
47	571	40	0.0053	0.010	NA	NA	0.0007	NA	0.0029	0.02	0.015	10.00	2
47	572	40	0.0070	0.013	NA	NA	0.0008	NA	0.0041	0.02	0.020	10.00	2
47	573	40	0.0044	0.008	NA	NA	0.0006	NA	0.0023	0.05	0.013	10.00	2
47	574	40	0.0088	0.016	NA	NA	0.0010	NA	0.0053	0.05	0.025	10.00	2
47	575	40	0.0132	0.024	NA	NA	0.0013	NA	0.0087	0.05	0.038	10.00	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 23)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
47	576	40	0.0175	0.033	NA	NA	0.0016	NA	0.0122	0.05	0.050	10.00	2
47	577	40	0.0219	0.041	NA	NA	0.0019	NA	0.0159	0.05	0.063	10.00	0
47	578	40	0.0088	0.016	NA	NA	0.0010	NA	0.0053	0.1	0.025	10.00	2
47	579	40	0.0175	0.033	NA	NA	0.0016	NA	0.0122	0.1	0.050	10.00	2
47	580	40	0.0263	0.049	NA	NA	0.0022	NA	0.0198	0.1	0.075	10.00	2
47	581	40	0.0351	0.065	NA	NA	0.0028	NA	0.0278	0.1	0.100	10.00	2
47	582	40	0.0439	0.081	NA	NA	0.0033	NA	0.0363	0.1	0.125	10.00	2
47	583	40	0.0132	0.024	NA	NA	0.0013	NA	0.0087	0.15	0.038	10.00	2
47	584	40	0.0263	0.049	NA	NA	0.0022	NA	0.0198	0.15	0.075	10.00	2
47	585	40	0.0395	0.073	NA	NA	0.0030	NA	0.0320	0.15	0.113	10.00	2
47	586	40	0.0526	0.098	NA	NA	0.0037	NA	0.0451	0.15	0.150	10.00	0
47	587	40	0.0658	0.122	NA	NA	0.0044	NA	0.0588	0.15	0.188	10.00	2
47	588	40	0.0175	0.033	NA	NA	0.0016	NA	0.0122	0.2	0.050	10.00	2
47	589	40	0.0351	0.065	NA	NA	0.0028	NA	0.0278	0.2	0.100	10.00	2
47	590	40	0.0526	0.098	NA	NA	0.0037	NA	0.0451	0.2	0.150	10.00	2
47	591	40	0.0702	0.130	NA	NA	0.0046	NA	0.0635	0.2	0.200	10.00	2
47	592	40	0.0877	0.163	NA	NA	0.0055	NA	0.0828	0.2	0.250	10.00	2
47	593	40	0.0219	0.041	NA	NA	0.0019	NA	0.0159	0.25	0.063	10.00	2
47	594	40	0.0439	0.081	NA	NA	0.0033	NA	0.0363	0.25	0.125	10.00	2
47	595	40	0.0658	0.122	NA	NA	0.0044	NA	0.0588	0.25	0.188	10.00	2
47	596	40	0.0877	0.163	NA	NA	0.0055	NA	0.0828	0.25	0.250	10.00	2
47	597	40	0.1096	0.204	NA	NA	0.0065	NA	0.1080	0.25	0.313	10.00	2
47	598	40	0.0263	0.049	NA	NA	0.0022	NA	0.0198	0.3	0.075	10.00	2
47	599	40	0.0526	0.098	NA	NA	0.0037	NA	0.0451	0.3	0.150	10.00	2
47	600	40	0.0789	0.147	NA	NA	0.0051	NA	0.0731	0.3	0.225	10.00	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 24)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
47	601	40	0.1053	0.195	NA	NA	0.0063	NA	0.1029	0.3	0.300	10.00	2
47	602	40	0.1316	0.244	NA	NA	0.0074	NA	0.1342	0.3	0.375	10.00	2
47	603	40	0.0307	0.057	NA	NA	0.0025	NA	0.0237	0.35	0.088	10.00	2
47	604	40	0.0614	0.114	NA	NA	0.0042	NA	0.0542	0.35	0.175	10.00	2
47	605	40	0.0921	0.171	NA	NA	0.0057	NA	0.0878	0.35	0.263	10.00	2
47	606	40	0.1228	0.228	NA	NA	0.0070	NA	0.1236	0.35	0.350	10.00	2
47	607	40	0.1535	0.285	NA	NA	0.0083	NA	0.1613	0.35	0.438	10.00	2
47	608	40	0.0351	0.065	NA	NA	0.0028	NA	0.0278	0.4	0.100	10.00	0
47	609	40	0.0702	0.130	NA	NA	0.0046	NA	0.0635	0.4	0.200	10.00	2
47	610	40	0.1053	0.195	NA	NA	0.0063	NA	0.1029	0.4	0.300	10.00	2
47	611	40	0.1404	0.261	NA	NA	0.0078	NA	0.1449	0.4	0.400	10.00	2
47	612	40	0.1754	0.326	NA	NA	0.0092	NA	0.1891	0.4	0.500	10.00	2
47	613	40	0.0395	0.073	NA	NA	0.0030	NA	0.0320	0.45	0.113	10.00	2
47	614	40	0.0789	0.147	NA	NA	0.0051	NA	0.0731	0.45	0.225	10.00	2
47	615	40	0.1184	0.220	NA	NA	0.0069	NA	0.1184	0.45	0.338	10.00	2
47	616	40	0.1579	0.293	NA	NA	0.0085	NA	0.1668	0.45	0.450	10.00	2
47	617	40	0.1974	0.367	NA	NA	0.0100	NA	0.2175	0.45	0.563	10.00	2
47	618	40	0.0439	0.081	NA	NA	0.0033	NA	0.0363	0.5	0.125	10.00	2
47	619	40	0.0877	0.163	NA	NA	0.0055	NA	0.0828	0.5	0.250	10.00	2
47	620	40	0.1316	0.244	NA	NA	0.0074	NA	0.1342	0.5	0.375	10.00	2
47	621	40	0.1754	0.326	NA	NA	0.0092	NA	0.1891	0.5	0.500	10.00	2
47	622	40	0.2193	0.407	NA	NA	0.0109	NA	0.2466	0.5	0.625	10.00	0
47	623	40	0.0482	0.090	NA	NA	0.0035	NA	0.0407	0.55	0.138	10.00	2
47	624	40	0.0965	0.179	NA	NA	0.0059	NA	0.0928	0.55	0.275	10.00	2
47	625	40	0.1447	0.269	NA	NA	0.0080	NA	0.1504	0.55	0.413	10.00	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 25)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
47	626	40	0.1930	0.358	NA	NA	0.0099	NA	0.2118	0.55	0.550	10.00	0
47	627	40	0.2412	0.448	NA	NA	0.0117	NA	0.2762	0.55	0.688	10.00	0
47	628	40	0.0526	0.098	NA	NA	0.0037	NA	0.0451	0.6	0.150	10.00	2
47	629	40	0.1053	0.195	NA	NA	0.0063	NA	0.1029	0.6	0.300	10.00	2
47	630	40	0.1579	0.293	NA	NA	0.0085	NA	0.1668	0.6	0.450	10.00	2
47	631	40	0.2105	0.391	NA	NA	0.0105	NA	0.2349	0.6	0.600	10.00	0
47	632	40	0.2632	0.489	NA	NA	0.0124	NA	0.3063	0.6	0.750	10.00	0
47	633	40	0.0570	0.106	NA	NA	0.0040	NA	0.0496	0.65	0.163	10.00	2
47	634	40	0.1140	0.212	NA	NA	0.0067	NA	0.1132	0.65	0.325	10.00	0
47	635	40	0.1711	0.318	NA	NA	0.0090	NA	0.1834	0.65	0.488	10.00	0
47	636	40	0.2281	0.424	NA	NA	0.0112	NA	0.2584	0.65	0.650	10.00	0
47	637	40	0.2851	0.529	NA	NA	0.0132	NA	0.3370	0.65	0.813	10.00	0
47	638	40	0.0614	0.114	NA	NA	0.0042	NA	0.0542	0.7	0.175	10.00	0
47	639	40	0.1228	0.228	NA	NA	0.0070	NA	0.1236	0.7	0.350	10.00	2
47	640	40	0.1842	0.342	NA	NA	0.0095	NA	0.2004	0.7	0.525	10.00	2
47	641	40	0.2456	0.456	NA	NA	0.0118	NA	0.2822	0.7	0.700	10.00	0
47	642	40	0.3070	0.570	NA	NA	0.0140	NA	0.3681	0.7	0.875	10.00	0
47	643	40	0.0658	0.122	NA	NA	0.0044	NA	0.0588	0.75	0.188	10.00	2
47	644	40	0.1316	0.244	NA	NA	0.0074	NA	0.1342	0.75	0.375	10.00	2
47	645	40	0.1974	0.367	NA	NA	0.0100	NA	0.2175	0.75	0.563	10.00	2
47	646	40	0.2632	0.489	NA	NA	0.0124	NA	0.3063	0.75	0.750	10.00	2
47	647	40	0.3289	0.611	NA	NA	0.0147	NA	0.3996	0.75	0.938	10.00	0
47	648	40	0.0702	0.130	NA	NA	0.0046	NA	0.0635	0.8	0.200	10.00	2
47	649	40	0.1404	0.261	NA	NA	0.0078	NA	0.1449	0.8	0.400	10.00	0
47	650	40	0.2105	0.391	NA	NA	0.0105	NA	0.2349	0.8	0.600	10.00	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 26)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
47	651	40	0.2807	0.521	NA	NA	0.0131	NA	0.3308	0.8	0.800	10.00	0
47	652	40	0.3509	0.652	NA	NA	0.0154	NA	0.4315	0.8	1.000	10.00	0
47	653	40	0.0746	0.138	NA	NA	0.0049	NA	0.0683	0.85	0.213	10.00	2
47	654	40	0.1491	0.277	NA	NA	0.0081	NA	0.1558	0.85	0.425	10.00	2
47	655	40	0.2237	0.415	NA	NA	0.0110	NA	0.2525	0.85	0.638	10.00	2
47	656	40	0.2982	0.554	NA	NA	0.0137	NA	0.3556	0.85	0.850	10.00	0
47	657	40	0.3728	0.692	NA	NA	0.0161	NA	0.4638	0.85	1.063	10.00	0
47	658	40	0.0789	0.147	NA	NA	0.0051	NA	0.0731	0.9	0.225	10.00	2
47	659	40	0.1579	0.293	NA	NA	0.0085	NA	0.1668	0.9	0.450	10.00	2
47	660	40	0.2368	0.440	NA	NA	0.0115	NA	0.2702	0.9	0.675	10.00	2
47	661	40	0.3158	0.586	NA	NA	0.0142	NA	0.3806	0.9	0.900	10.00	0
47	662	40	0.3947	0.733	NA	NA	0.0168	NA	0.4964	0.9	1.125	10.00	0
47	663	40	0.0833	0.155	NA	NA	0.0053	NA	0.0779	0.95	0.238	10.00	2
47	664	40	0.1667	0.310	NA	NA	0.0088	NA	0.1779	0.95	0.475	10.00	0
47	665	40	0.2500	0.464	NA	NA	0.0120	NA	0.2882	0.95	0.713	10.00	0
47	666	40	0.3333	0.619	NA	NA	0.0148	NA	0.4059	0.95	0.950	10.00	2
47	667	40	0.4167	0.774	NA	NA	0.0175	NA	0.5294	0.95	1.188	10.00	0
47	668	40	0.0877	0.163	NA	NA	0.0055	NA	0.0828	1	0.250	10.00	2
47	669	40	0.1754	0.326	NA	NA	0.0092	NA	0.1891	1	0.500	10.00	0
47	670	40	0.2632	0.489	NA	NA	0.0124	NA	0.3063	1	0.750	10.00	0
47	671	40	0.3509	0.652	NA	NA	0.0154	NA	0.4315	1	1.000	10.00	0
47	672	40	0.4386	0.815	NA	NA	0.0182	NA	0.5628	1	1.250	10.00	0
48	673	40	0.3509	0.652	NA	NA	0.015	NA	0.43	0.6	1	10.00	0
48	674	40	0.3509	0.652	NA	NA	0.015	NA	0.43	0.65	1	10.00	0
48	675	40	0.3509	0.652	NA	NA	0.015	NA	0.43	0.7	1	10.00	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 27)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
48	676	40	0.3509	0.652	NA	NA	0.015	NA	0.43	0.75	1	10.00	0
48	677	40	0.3509	0.652	NA	NA	0.015	NA	0.43	0.8	1	10.00	0
48	678	40	0.3509	0.652	NA	NA	0.015	NA	0.43	0.85	1	10.00	0
48	679	40	0.3509	0.652	NA	NA	0.015	NA	0.43	0.9	1	10.00	0
48	680	40	0.3509	0.652	NA	NA	0.015	NA	0.43	0.95	1	10.00	0
48	681	40	0.3509	0.652	NA	NA	0.015	NA	0.43	1	1	10.00	0
48	682	40	0.1754	0.326	NA	NA	0.002	NA	0.025	0.2	0.5	10.00	0
48	683	40	0.2105	0.391	NA	NA	0.002	NA	0.025	0.2	0.6	10.00	0
48	684	40	0.1754	0.326	NA	NA	0.005	NA	0.055	0.4	0.5	10.00	0
48	685	40	0.2105	0.391	NA	NA	0.005	NA	0.055	0.4	0.6	10.00	0
48	686	40	0.2632	0.489	NA	NA	0.005	NA	0.055	0.4	0.75	10.00	0
48	687	40	0.2105	0.391	NA	NA	0.025	NA	0.09	0.6	0.6	10.00	0
48	688	40	0.2632	0.489	NA	NA	0.025	NA	0.09	0.6	0.75	10.00	0
48	689	40	0.1754	0.326	NA	NA	0.032	NA	0.121	0.8	0.5	10.00	2
48	690	40	0.2105	0.391	NA	NA	0.032	NA	0.121	0.8	0.6	10.00	1
48	691	40	0.2632	0.489	NA	NA	0.032	NA	0.121	0.8	0.75	10.00	0
28	692	40	0.0175	0.033	NA	NA	0.0005	NA	0.015	0.1	0.05	10.00	2
28	693	40	0.0439	0.081	NA	NA	0.00125	NA	0.0375	0.25	0.125	10.00	0
28	694	40	0.0702	0.130	NA	NA	0.002	NA	0.06	0.4	0.2	10.00	2
28	695	40	0.0965	0.179	NA	NA	0.00275	NA	0.0825	0.55	0.275	10.00	0
28	696	40	0.1228	0.228	NA	NA	0.0035	NA	0.105	0.7	0.35	10.00	0
28	697	40	0.1491	0.277	NA	NA	0.00425	NA	0.1275	0.85	0.425	10.00	0
28	698	40	0.1754	0.326	NA	NA	0.005	NA	0.15	1	0.5	10.00	0
28	699	40	0.2105	0.391	NA	NA	0.006	NA	0.18	1.2	0.6	10.00	0
28	700	40	0.0351	0.065	NA	NA	0.0005	NA	0.015	0.1	0.1	10.00	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 28)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
28	701	40	0.0877	0.163	NA	NA	0.00125	NA	0.0375	0.25	0.25	10.00	0
28	702	40	0.1404	0.261	NA	NA	0.002	NA	0.06	0.4	0.4	10.00	0
28	703	40	0.1930	0.358	NA	NA	0.00275	NA	0.0825	0.55	0.55	10.00	0
28	704	40	0.2456	0.456	NA	NA	0.0035	NA	0.105	0.7	0.7	10.00	0
28	705	40	0.2982	0.554	NA	NA	0.00425	NA	0.1275	0.85	0.85	10.00	0
28	706	40	0.3509	0.652	NA	NA	0.005	NA	0.15	1	1	10.00	0
28	707	40	0.4211	0.782	NA	NA	0.006	NA	0.18	1.2	1.2	10.00	0
28	708	40	0.0526	0.098	NA	NA	0.0005	NA	0.015	0.1	0.15	10.00	0
28	709	40	0.1316	0.244	NA	NA	0.00125	NA	0.0375	0.25	0.375	10.00	0
28	710	40	0.2105	0.391	NA	NA	0.002	NA	0.06	0.4	0.6	10.00	0
28	711	40	0.2895	0.538	NA	NA	0.00275	NA	0.0825	0.55	0.825	10.00	0
28	712	40	0.3684	0.684	NA	NA	0.0035	NA	0.105	0.7	1.05	10.00	0
28	713	40	0.4474	0.831	NA	NA	0.00425	NA	0.1275	0.85	1.275	10.00	0
28	714	40	0.5263	0.977	NA	NA	0.005	NA	0.15	1	1.5	10.00	0
28	715	40	0.6316	1.173	NA	NA	0.006	NA	0.18	1.2	1.8	10.00	0
28	716	40	0.0175	0.033	NA	NA	0.007	NA	0.015	0.1	0.05	10.00	2
28	717	40	0.0439	0.081	NA	NA	0.0175	NA	0.0375	0.25	0.125	10.00	2
28	718	40	0.0702	0.130	NA	NA	0.028	NA	0.06	0.4	0.2	10.00	2
28	719	40	0.0965	0.179	NA	NA	0.0385	NA	0.0825	0.55	0.275	10.00	2
28	720	40	0.1228	0.228	NA	NA	0.049	NA	0.105	0.7	0.35	10.00	2
28	721	40	0.1491	0.277	NA	NA	0.0595	NA	0.1275	0.85	0.425	10.00	2
28	722	40	0.1754	0.326	NA	NA	0.07	NA	0.15	1	0.5	10.00	2
28	723	40	0.2105	0.391	NA	NA	0.084	NA	0.18	1.2	0.6	10.00	2
28	724	40	0.0351	0.065	NA	NA	0.007	NA	0.015	0.1	0.1	10.00	2
28	725	40	0.0877	0.163	NA	NA	0.0175	NA	0.0375	0.25	0.25	10.00	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 29)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
28	726	40	0.1404	0.261	NA	NA	0.028	NA	0.06	0.4	0.4	10.00	2
28	727	40	0.1930	0.358	NA	NA	0.0385	NA	0.0825	0.55	0.55	10.00	0
28	728	40	0.2456	0.456	NA	NA	0.049	NA	0.105	0.7	0.7	10.00	0
28	729	40	0.2982	0.554	NA	NA	0.0595	NA	0.1275	0.85	0.85	10.00	0
28	730	40	0.3509	0.652	NA	NA	0.07	NA	0.15	1	1	10.00	0
28	731	40	0.4211	0.782	NA	NA	0.084	NA	0.18	1.2	1.2	10.00	0
28	732	40	0.0526	0.098	NA	NA	0.007	NA	0.015	0.1	0.15	10.00	0
28	733	40	0.1316	0.244	NA	NA	0.0175	NA	0.0375	0.25	0.375	10.00	0
28	734	40	0.2105	0.391	NA	NA	0.028	NA	0.06	0.4	0.6	10.00	0
28	735	40	0.2895	0.538	NA	NA	0.0385	NA	0.0825	0.55	0.825	10.00	0
28	736	40	0.3684	0.684	NA	NA	0.049	NA	0.105	0.7	1.05	10.00	0
28	737	40	0.4474	0.831	NA	NA	0.0595	NA	0.1275	0.85	1.275	10.00	0
28	738	40	0.5263	0.977	NA	NA	0.07	NA	0.15	1	1.5	10.00	0
28	739	40	0.6316	1.173	NA	NA	0.084	NA	0.18	1.2	1.8	10.00	0
28	740	40	0.0175	0.033	NA	NA	0.00125	NA	0.005	0.1	0.05	10.00	2
28	741	40	0.0439	0.081	NA	NA	0.003125	NA	0.0125	0.25	0.125	10.00	2
28	742	40	0.0702	0.130	NA	NA	0.005	NA	0.02	0.4	0.2	10.00	2
28	743	40	0.0965	0.179	NA	NA	0.006875	NA	0.0275	0.55	0.275	10.00	2
28	744	40	0.1228	0.228	NA	NA	0.00875	NA	0.035	0.7	0.35	10.00	2
28	745	40	0.1491	0.277	NA	NA	0.010625	NA	0.0425	0.85	0.425	10.00	2
28	746	40	0.1754	0.326	NA	NA	0.0125	NA	0.05	1	0.5	10.00	0
28	747	40	0.2105	0.391	NA	NA	0.015	NA	0.06	1.2	0.6	10.00	2
28	748	40	0.0351	0.065	NA	NA	0.00125	NA	0.005	0.1	0.1	10.00	2
28	749	40	0.0877	0.163	NA	NA	0.003125	NA	0.0125	0.25	0.25	10.00	2
28	750	40	0.1404	0.261	NA	NA	0.005	NA	0.02	0.4	0.4	10.00	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 30)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
28	751	40	0.1930	0.358	NA	NA	0.006875	NA	0.0275	0.55	0.55	10.00	0
28	752	40	0.2456	0.456	NA	NA	0.00875	NA	0.035	0.7	0.7	10.00	0
28	753	40	0.2982	0.554	NA	NA	0.010625	NA	0.0425	0.85	0.85	10.00	0
28	754	40	0.3509	0.652	NA	NA	0.0125	NA	0.05	1	1	10.00	0
28	755	40	0.4211	0.782	NA	NA	0.015	NA	0.06	1.2	1.2	10.00	0
28	756	40	0.0526	0.098	NA	NA	0.00125	NA	0.005	0.1	0.15	10.00	0
28	757	40	0.1316	0.244	NA	NA	0.003125	NA	0.0125	0.25	0.375	10.00	2
28	758	40	0.2105	0.391	NA	NA	0.005	NA	0.02	0.4	0.6	10.00	0
28	759	40	0.2895	0.538	NA	NA	0.006875	NA	0.0275	0.55	0.825	10.00	0
28	760	40	0.3684	0.684	NA	NA	0.00875	NA	0.035	0.7	1.05	10.00	0
28	761	40	0.4474	0.831	NA	NA	0.010625	NA	0.0425	0.85	1.275	10.00	0
28	762	40	0.5263	0.977	NA	NA	0.0125	NA	0.05	1	1.5	10.00	0
28	763	40	0.6316	1.173	NA	NA	0.015	NA	0.06	1.2	1.8	10.00	0
28	764	40	0.0175	0.033	NA	NA	0.00125	NA	0.05	0.1	0.05	10.00	2
28	765	40	0.0439	0.081	NA	NA	0.003125	NA	0.125	0.25	0.125	10.00	2
28	766	40	0.0702	0.130	NA	NA	0.005	NA	0.2	0.4	0.2	10.00	2
28	767	40	0.0965	0.179	NA	NA	0.006875	NA	0.275	0.55	0.275	10.00	2
28	768	40	0.1228	0.228	NA	NA	0.00875	NA	0.35	0.7	0.35	10.00	0
28	769	40	0.1491	0.277	NA	NA	0.010625	NA	0.425	0.85	0.425	10.00	0
28	770	40	0.1754	0.326	NA	NA	0.0125	NA	0.5	1	0.5	10.00	2
28	771	40	0.2105	0.391	NA	NA	0.015	NA	0.6	1.2	0.6	10.00	0
28	772	40	0.0351	0.065	NA	NA	0.00125	NA	0.05	0.1	0.1	10.00	2
28	773	40	0.0877	0.163	NA	NA	0.003125	NA	0.125	0.25	0.25	10.00	0
28	774	40	0.1404	0.261	NA	NA	0.005	NA	0.2	0.4	0.4	10.00	0
28	775	40	0.1930	0.358	NA	NA	0.006875	NA	0.275	0.55	0.55	10.00	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 31)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
28	776	40	0.2456	0.456	NA	NA	0.00875	NA	0.35	0.7	0.7	10.00	0
28	777	40	0.2982	0.554	NA	NA	0.010625	NA	0.425	0.85	0.85	10.00	0
28	778	40	0.3509	0.652	NA	NA	0.0125	NA	0.5	1	1	10.00	0
28	779	40	0.4211	0.782	NA	NA	0.015	NA	0.6	1.2	1.2	10.00	2
28	780	40	0.0526	0.098	NA	NA	0.00125	NA	0.05	0.1	0.15	10.00	0
28	781	40	0.1316	0.244	NA	NA	0.003125	NA	0.125	0.25	0.375	10.00	0
28	782	40	0.2105	0.391	NA	NA	0.005	NA	0.2	0.4	0.6	10.00	0
28	783	40	0.2895	0.538	NA	NA	0.006875	NA	0.275	0.55	0.825	10.00	0
28	784	40	0.3684	0.684	NA	NA	0.00875	NA	0.35	0.7	1.05	10.00	0
28	785	40	0.4474	0.831	NA	NA	0.010625	NA	0.425	0.85	1.275	10.00	0
28	786	40	0.5263	0.977	NA	NA	0.0125	NA	0.5	1	1.5	10.00	0
28	787	40	0.6316	1.173	NA	NA	0.015	NA	0.6	1.2	1.8	10.00	0
28	788	40	0.6316	1.173	NA	NA	0.007	NA	0.015	0.1	1.8	10.00	0
28	789	40	0.6316	1.173	NA	NA	0.0175	NA	0.0375	0.25	1.8	10.00	0
28	790	40	0.6316	1.173	NA	NA	0.028	NA	0.06	0.4	1.8	10.00	0
28	791	40	0.6316	1.173	NA	NA	0.0385	NA	0.0825	0.55	1.8	10.00	0
28	792	40	0.6316	1.173	NA	NA	0.049	NA	0.105	0.7	1.8	10.00	0
28	793	40	0.6316	1.173	NA	NA	0.0595	NA	0.1275	0.85	1.8	10.00	0
28	794	40	0.6316	1.173	NA	NA	0.07	NA	0.15	1	1.8	10.00	0
28	795	40	0.6316	1.173	NA	NA	0.084	NA	0.18	1.2	1.8	10.00	0
49	796	25	0.1000	NA	NA	0.05000	0.1	NA	0.1	5.5	0.01	12.00	2
49	797	25	0.1000	NA	NA	0.05000	0.1	NA	0.1	5.5	0.1	13.00	2
49	798	25	0.1000	NA	NA	0.05000	0.1	NA	0.1	5.5	0.2	13.80	0
49	799	25	0.1000	NA	NA	0.05000	0.1	NA	0.1	7	0.01	12.00	2
49	800	25	0.1000	NA	NA	0.05000	0.1	NA	0.1	7	0.1	13.00	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 32)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
49	801	25	0.1000	NA	NA	0.05000	0.1	NA	0.1	7	0.2	13.80	0
49	802	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	5.5	0.01	12.00	2
49	803	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	5.5	0.1	13.00	2
49	804	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	5.5	0.2	13.80	0
49	805	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	7	0.01	12.00	2
49	806	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	7	0.1	13.00	2
49	807	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	7	0.2	13.80	0
49	808	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	8.5	0.01	12.00	2
49	809	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	8.5	0.1	13.00	2
49	810	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	8.5	0.2	13.80	0
49	811	25	0.1000	NA	NA	0.05000	0.1	NA	0.1	4.5	0.01	12.00	2
49	812	25	0.1000	NA	NA	0.05000	0.1	NA	0.1	4.5	0.1	13.00	2
49	813	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	4.5	0.01	12.00	2
49	814	50	0.1000	NA	NA	0.05000	0.1	NA	0.1	4.5	0.1	13.00	2
50	815	40	0.2000	NA	0.6	0.00050	0.01	0.003	0.1	0.1	0.5	11.57	0
50	816	40	0.2000	NA	0.04	0.00050	0.01	0.003	0.005	5	0.02	11.36	2
50	817	40	0.0200	NA	0.6	0.05000	0.01	0.003	0.005	5	0.5	10.67	0
50	818	40	0.2000	NA	0.04	0.05000	0.01	0.05	0.005	0.1	0.5	11.45	0
50	819	40	0.0200	NA	0.6	0.00050	0.01	0.05	0.1	5	0.02	10.79	2
50	820	40	0.0200	NA	0.04	0.00050	0.06	0.05	0.1	0.1	0.02	11.08	2
50	821	40	0.0200	NA	0.04	0.00050	0.06	0.05	0.1	5	0.5	10.35	2
50	822	40	0.0200	NA	0.6	0.00050	0.4	0.003	0.005	0.1	0.02	10.84	2
50	823	40	0.2000	NA	0.04	0.05000	0.4	0.003	0.1	0.1	0.5	11.30	2
50	824	40	0.2000	NA	0.6	0.00050	0.4	0.003	0.005	5	0.5	11.47	2
50	825	40	0.0200	NA	0.04	0.00050	0.4	0.02	0.1	0.1	0.1	10.77	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 33)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
50	826	40	0.2000	NA	0.04	0.05000	0.4	0.05	0.1	5	0.02	10.85	2
50	827	40	0.0200	NA	0.04	0.05000	0.01	0.003	0.1	0.1	0.1	11.87	0
50	828	40	0.2000	NA	0.6	0.00050	0.01	0.02	0.1	5	0.5	12.27	0
50	829	40	0.2000	NA	0.04	0.05000	0.01	0.05	0.005	0.7	0.1	11.68	2
50	830	40	0.2000	NA	0.04	0.05000	0.06	0.02	0.1	0.7	0.02	11.70	2
50	831	40	0.0200	NA	0.6	0.00050	0.4	0.05	0.005	0.1	0.5	12.12	2
50	832	40	0.0200	NA	0.6	0.00050	0.01	0.003	0.005	0.7	0.1	13.15	0
50	833	40	0.2000	NA	0.04	0.00050	0.01	0.003	0.1	5	0.5	13.11	0
50	834	40	0.0200	NA	0.04	0.05000	0.01	0.02	0.005	0.1	0.02	13.06	0
50	835	40	0.0200	NA	0.04	0.00050	0.01	0.05	0.1	0.1	0.5	13.03	0
50	836	40	0.2000	NA	0.6	0.05000	0.01	0.05	0.005	5	0.02	13.20	2
50	837	40	0.2000	NA	0.6	0.05000	0.06	0.02	0.005	0.1	0.1	13.15	0
50	838	40	0.2000	NA	0.6	0.00050	0.4	0.003	0.1	0.1	0.02	13.17	2
50	839	40	0.0200	NA	0.04	0.00050	0.4	0.003	0.005	0.1	0.5	12.98	2
50	840	40	0.0200	NA	0.6	0.05000	0.4	0.003	0.1	5	0.02	13.09	2
50	841	40	0.0200	NA	0.04	0.05000	0.4	0.02	0.005	5	0.5	12.98	2
50	842	40	0.0200	NA	0.04	0.05000	0.4	0.05	0.1	0.1	0.02	12.92	2
50	843	40	0.2000	NA	0.6	0.05000	0.4	0.05	0.1	0.7	0.5	13.03	2
50	844	40	0.2000	NA	0.04	0.00050	0.4	0.05	0.005	5	0.02	13.07	2
51	845	50	1.0280	NA	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11.00	0
51	846	77	1.0280	NA	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11.00	0
51	847	50	1.0280	NA	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11.00	0
51	848	77	1.0280	NA	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11.00	0
51	849	50	1.0280	NA	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11.00	0
51	850	77	1.0280	NA	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11.00	0

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 34)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
51	851	77	0.0000	NA	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11.00	2
51	852	77	0.0000	NA	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11.00	2
51	853	77	1.0280	NA	NA	0.01200	0.004	0.003	0.018	0.002	0	11.00	0
51	854	77	1.0280	NA	NA	0.01200	0.004	0.003	0.018	1.967	0.001	11.00	2
51	855	50	0.4700	NA	NA	0.00900	0.046	0.084	0.028	2.13	0.98	14+	0
51	856	77	0.4700	NA	NA	0.00900	0.046	0.084	0.028	2.13	0.98	14+	0
51	857	77	0.4700	NA	NA	0.00900	0.046	0.084	0.028	2.13	0.49	14+	0
51	858	77	0.4700	NA	NA	0.00900	0.046	0.084	0.028	2.13	0.49	14+	0
51	859	77	1.0000	NA	NA	0.00900	0.046	0.084	0.028	0.21	0.049	13.6	0
51	860	50	1.1180	NA	NA	0.00900	0.046	0.084	0.028	1.635	1.27	14+	0
51	861	77	0.9350	0.203	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11	0
51	862	77	0.9350	0.203	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11	0
51	863	77	0.9350	0.203	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11	0
51	864	77	0.9350	0.203	NA	0.01200	0.004	0.003	0.018	0.002	0.001	11	0
51	865	77	1.2420	NA	NA	0.01100	0.043	0.079	0.027	1.532	1.2	14	0
51	866	50	0.4770	NA	NA	0.00900	0.046	0.084	0.028	1.967	0.938	14+	0
51	867	50	0.4770	NA	NA	0.00900	0.046	0.084	0.028	1.967	0.938	14+	0
51	868	50	0.0000	NA	NA	0.00900	0.046	0.084	0.028	1.967	0.938	14+	0
51	869	50	0.4770	NA	NA	0.00900	0.046	0.084	0.028	1.967	0	14	0
51	870	50	0.0000	NA	NA	0.00900	0.046	0.084	0.028	1.967	0	14	0
51	871	50	0.0000	NA	NA	0.00900	0.046	0.084	0.028	1.967	0.938	14	0
51	872	50	0.4770	NA	NA	0.00900	0.046	0.084	0.028	1.967	0.938	14+	0
51	873	50	0.4770	NA	NA	0.00900	0.046	0.084	0.028	1.967	0.938	14+	0
51	874	50	0.2010	NA	NA	0.05000	0.018	0.014	0.02	1.33	0.205	13	0
52	875	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	1.2	7	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 35)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
52	876	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	1.2	9.5	2
52	877	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	1.2	10	2
52	878	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	1.2	11	0
52	879	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	1.2	12	0
52	880	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	1.2	13	0
52	881	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	1.2	13.5	0
52	882	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	0	11	2
52	883	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	0.35	11	2
52	884	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	0.875	11	2
52	885	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	1.035	11	2
52	886	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	2.4	2.3	10	0
52	887	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	3.5	11	0
52	888	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	7	11	0
52	889	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	1.5	0.75	11	0
52	890	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	3.7	3.5	11	0
52	891	50	1.4000	NA	NA	0.00120	0.1	0.0069	0.086	1.5	1.5	11	0
52	892	50	1.4000	NA	NA	0.00120	0.05	0.0069	0.086	3.7	1.2	11	0
52	893	50	1.4000	NA	NA	0.00120	0.2	0.0069	0.086	3.7	1.2	11	2
52	894	50	1.4000	NA	NA	0.00120	0.2	0.0069	0.086	3.7	1.2	11	2
53	895	50	1.1400	NA	0.088	0.05800	0.1	NA	0.14	3	1	13+	2
53	896	40	1.1400	NA	0.088	0.05800	0.1	NA	0.14	3	1	13+	2
53	897	30	1.1400	NA	0.088	0.05800	0.1	NA	0.14	3	1	13+	2
53	898	50	1.1400	NA	0.088	0.05800	0.1	NA	0.14	3	1	13+	2
53	899	50	1.1400	NA	0.088	0.05800	0.1	NA	0.14	3	1	10.3	2
53	900	50	1.1400	NA	0.088	0.05800	0.1	NA	0.14	2.9	1.94	13+	2

Cyclic Potentiodynamic Polarization Conditions, and Chemical Composition and pH of Historical Data (continued 36)

Reference	Test	Temperature (°C)	Carbonate (M)	Bi-carbonate (M)	Citrate (M)	Phosphate (M)	Chloride (M)	Fluoride (M)	Sulfate (M)	Nitrate (M)	Nitrite (M)	pH	Pit ID*
53	901	30	1.1400	NA	0.088	0.05800	0.1	NA	0.14	3.2	1.9	13+	2
53	902	30	1.1400	NA	0.088	0.05800	0.1	NA	0.14	3.2	1.9	13+	2
53	903	30	1.1400	NA	0.088	0.05800	0.1	NA	0.14	3.2	1.9	13+	2
54	904	45	NA	NA	NA	NA	NA	NA	NA	0.91	0.68	11	2
54	905	45	NA	NA	NA	NA	NA	NA	NA	0.91	0.68	11.5	2
54	906	50	NA	NA	NA	NA	NA	NA	NA	0.91	0.68	11.5	2
54	907	50	NA	NA	NA	NA	NA	NA	NA	0.91	0.68	12	2
54	908	55	NA	NA	NA	NA	NA	NA	NA	0.91	0.68	11.5	2
54	909	55	NA	NA	NA	NA	NA	NA	NA	0.91	0.68	12	2
54	910	60	NA	NA	NA	NA	NA	NA	NA	0.91	0.68	12	2
54	911	60	NA	NA	NA	NA	NA	NA	NA	0.91	0.68	12.5	0
54	912	40	NA	NA	NA	NA	NA	NA	NA	0.88	0.86	11.5	0
54	913	40	NA	NA	NA	NA	NA	NA	NA	0.88	0.86	12	0
54	914	50	NA	NA	NA	NA	NA	NA	NA	0.88	0.86	11	2
54	915	50	NA	NA	NA	NA	NA	NA	NA	0.88	0.86	11.5	0
54	916	50	NA	NA	NA	NA	NA	NA	NA	0.88	0.86	12	0
54	917	55	NA	NA	NA	NA	NA	NA	NA	0.88	0.86	11	2
54	918	55	NA	NA	NA	NA	NA	NA	NA	0.88	0.86	11.5	0
54	919	55	NA	NA	NA	NA	NA	NA	NA	0.88	0.86	12	0
54	920	60	NA	NA	NA	NA	NA	NA	NA	0.88	0.86	12	0

*The Pit ID corresponds to number of tests that pits were observed for a total of two tests. This means:

Pit ID of 0: none of the two tests performed showed pits.
Pit ID of 1: only one of the two tests performed showed pits.
Pit ID of 2: the two tests performed showed pits.